Nov. 4, 1952 F. WESTERVELD 2,616,958

PULSE COUNTING CIRCUIT

Filed Jan. 26, 1949 3 Sheets-Sheet 1

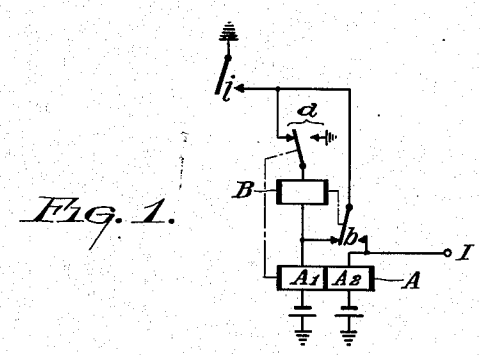


Fig. 1.

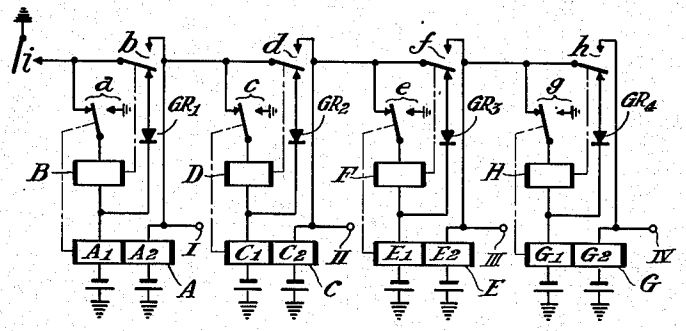


Fig. 2.

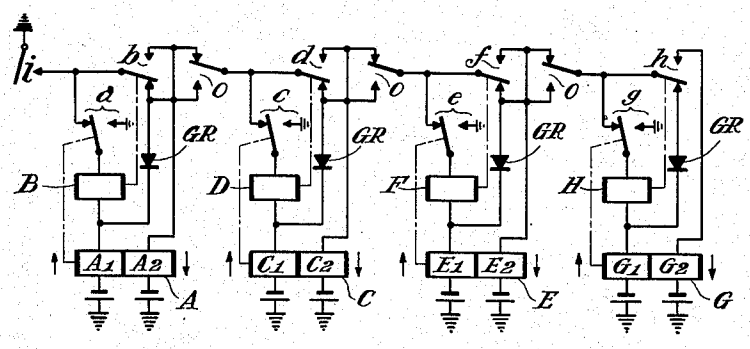


Fig. 4.

INVENTOR.
FRANS WESTERVELD
BY Fred M Vogel
AGENT.

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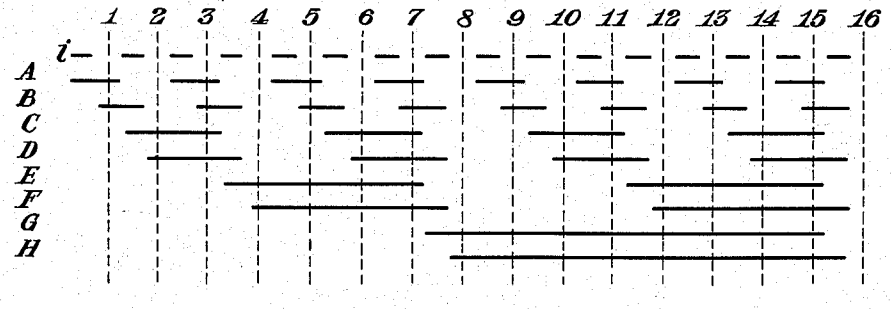


Fig. 3.

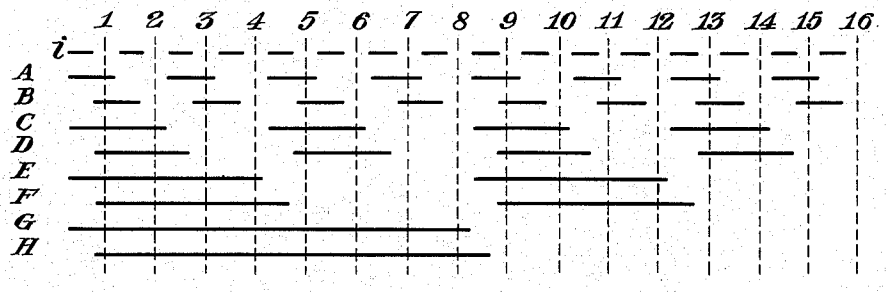


Fig. 5.

INVENTOR.
FRANS WESTERVELD
BY Fred M Vogel
AGENT.

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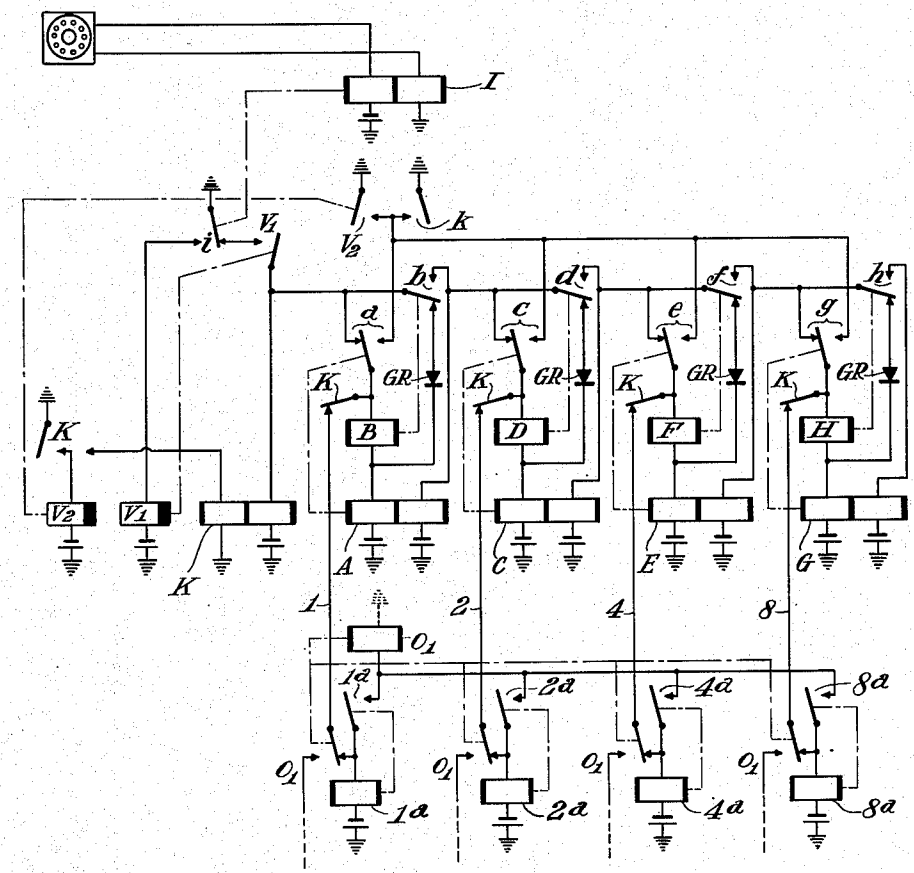


Fig. 6.

INVENTOR.
FRANS WESTERVELD
BY Fred M Vogel
AGENT

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PULSE COUNTING CIRCUIT

Frans Westerveld, Eindhoven, Netherlands, assignor to Hartford National Bank and Trust Company, Hartford, Conn., as trustee

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5 Claims. (Cl. 177—353)

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The invention relates to a circuit-arrangement comprising two relays to which pulses can be supplied with the use of a pulse contact, said arrangement being such that it recurs to its initial position after two pulses. For the sake of simplicity a circuit-arrangement of this kind will be referred to as a counting element and the two relays will be described as a counting relay and an auxiliary relay.

The circuit-arrangement according to the invention is characterized in that the first relay (counting relay) comprises two opposed windings, one of which is connected in series with the winding of the second relay (auxiliary relay), with the break-contact of a make-before-break contact of the first relay and with the pulse contact and in that the said break-contact is shunted, in series with the winding of the auxiliary relay, by a break-contact of the auxiliary relay, the make-contact of the make-before-break contact of the first relay being connected on the one hand to the junction of the winding of the auxiliary relay and the first-mentioned break-contact and on the other hand to the battery terminals on the side of the pulse contact, and in that the other side of the pulse contact and the other battery terminal have connected between them the series combination of a make contact of the auxiliary relay and the second winding of the first relay.

In a known circuit-arrangement both the counting and the auxiliary relays are provided with two opposed windings, whereas in the circuit-arrangement according to the invention only the counting relay comprises two differentially connected windings, the auxiliary relay having one winding, so that its construction is more simple. The number of required contacts of the two relays is particularly restricted. Compared with the known circuit-arrangement, the arrangement according to the invention has the additional advantage that it ensures more rapid operation of the counting relay, since it has supplied to it a high energizing current, so that it responds quickly, it being then held in a circuit of reduced current strength with the result that, on being de-energized with the use of the second winding, it can be rapidly released.

Circuit-arrangements are known in which a number of counting elements are combined in cascade arrangement to form a circuit-arrangement which permits of the number of closures of a pulse contact being registered in the form of a combination of energized counting relays which is characteristic of this number. Such counting arrangements are used inter alia in registers and

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in relay selectors for an automatic telephone system. They are based on the binary system in such manner that the first counting relay registers the number of units, the second the number of doubles, the third the number of quadruples, the fourth the number of octuples, and so forth of the number of pulses fed to the counting arrangement. A non-energized counting relay is counted as zero and an energized counting relay as one.

According to one embodiment of the invention such a cascade arrangement of counting elements may be built up from a very small number of relay contacts, since the pulse circuit is connected through by way of one of the contacts already available of the auxiliary relay of a preceding counting element to the next following counting element.

In one embodiment of the invention it is possible to arrange the circuit to be such that the number of pulses may be registered either in an additive sense or a subtractive sense at will.

In order that the invention may be more clearly understood and readily carried into effect, it will now be described more fully with reference to the accompanying drawing, in which

Fig. 1 diagrammatically shows a counting element according to the invention.

Fig. 2 shows a counting arrangement comprising four cascade-connected counting elements.

Fig. 3 shows in what order the relays of the arrangement shown in Fig. 2 are energized when pulses are fed to this arrangement.

Fig. 4 shows a circuit-arrangement derived from the circuit-arrangement shown in Fig. 2 and permitting of registering the number of supplied pulses at will in a sense of addition or of subtraction.

Fig. 5 shows in what order the relays of the arrangement of Fig. 4 are energized, when the arrangement is such that the pulses supplied are registered in the sense of subtraction.

Fig. 6 shows, by way of example, one embodiment of the invention, which permits of recording, with the use of the arrangement of Fig. 2, the number of dial pulses emitted by a subscriber.

Fig. 1 shows diagrammatically a counting element according to the invention. The element comprises a counting relay A having two windings A_1 and A_2 which counteract one another and in addition an auxiliary relay B. In the condition shown in the figure the two relays are non-energized. The arrangement shown operates as follows:

In the closing position of pulse contact *i*, the

left-hand winding A_1 of the metering relay A is energized through a resting contact *b*, so that this relay becomes operative. Relay A prepares a holding circuit for itself through the winding of the auxiliary relay and through the make-side of a change-over contact *a*, which is formed as a make-before-break contact. However, the auxiliary relay B cannot yet respond, since it is short-circuited through its own resting contact and the pulse contact *i*. As soon as the pulse contact is opened, the short-circuit of B is removed, so that this relay responds and, by means of its change-over contact opening, on the one hand opens the said short-circuit and on the other hand connects the second, differentially connected winding A_2 of relay A to the pulse contact. The next time the pulse contact is in closing position the second winding of relay A takes current, so that this relay releases. Even in released condition the first winding of relay A remains alive through the resting side of the change-over contact *a* so that this relay remains de-energized, whereas relay B remains operated so long as the pulse contact is closed. In the second opening position of the pulse contact, relay B also releases and the circuit-arrangement has resumed its rest position.

In addition to the use in the counting circuit-arrangement of Fig. 2 described hereinafter, the single circuit-arrangement of Fig. 1 has various further ranges of possible employment. If the pulse contact is assumed to be replaced, for example, by the contact of a press button, the arrangement may be utilised where a definite operation is required to be started by pressing the key and to be undone by re-pressing the key, for example, in consultation circuits in automatic telephony, it being frequently customary for a telephone instrument connected to an exchange line to be changed over to call-back with the use of a press button fitted on the instrument and to be re-connected to the exchange line by re-pressing the said button.

Fig. 2 shows a counting arrangement according to the invention in which a number of elementary counting elements according to the arrangement shown in Fig. 1 are connected in cascade. In considering the arrangement it is found that the making contacts *b*, *d* and *f* of the auxiliary relays B, D and F connect the pulse circuit to the next following counting element. This will take place at the moment when the auxiliary relay associated with the contact is energized that is to say at the end of a pulse fed to the counting element concerned. However, the next following counting element is not energized until after the pulse contact *i* is reclosed, the second windings of the counting relays of the preceding counting elements being connected into circuit at the same time, so that they are released. Upon opening of the pulse contact *i*, the associated auxiliary relays are also released. The operation of the arrangement is, consequently, such that on energization of the next following counting element invariably all the preceding counting elements are operated to the rest position so that the latter must completely repeat their performance before a new counting element can be energized. The order in which the various relays are energized, when the pulse contact supplies a number of pulses to the circuit is shown in Fig. 3.

It will be seen there-from that all possible combinations of energized counting relays are performed in succession. A combination of *n* counting elements is thus generally capable of registering $2n-1$ pulses, if the combination in which all the elements are in rest position is not counted as a counting combination. It will furthermore be seen from Fig. 3 that the arrangement of Fig. 2 has resumed its rest position after 16 pulses.

The short-circuits of the auxiliary relays B, D, F and H include rectifying elements GR_1 to GR_4, which render satisfactory operation of each pair of relays independent of the further pairs of relays. These rectifying elements are included in each of the circuit-arrangements shown in Figs. 2, 4 and 6.

The arrangement of Fig. 4 is differentiated from that of Fig. 2 in that the cut-through circuit of the pulses includes a set of change-over contacts *o*. In the illustrated rest position of these contacts *o* the circuit-arrangement is identical with that of Fig. 2. By changing over the contacts *o* in the rest position of the arrangement all the counting relays are connected in parallel with the pulse contact, so that after one pulse all the relays are energized. Next the parallel combination is interrupted by the contacts of the auxiliary relay and at the second pulse A and B are released. The further operation of the circuit-arrangement is then such that invariably, on de-energization of the next following set of a counting relay and an auxiliary relay, the preceding sets are energized, after which the latter must repeat their performance completely before the next following set can be released. In other words, the operation of the arrangement is exactly opposite to that of Fig. 2.

Energization of the next following counting element must take place through the pulse contact and the break contacts of the auxiliary relays of the preceding counting elements. If the rectifying elements GR were not provided, a counting element could also receive current through the windings of the auxiliary relay and one of the making contacts, connected in series therewith, of preceding counting elements. The rectifying elements have the effect of obviating the relative action of the counting elements. If the counting relays A, C, E and G are assigned in succession the ordinal numerals 1, 2, 4 and 8, the number of registered pulses in the arrangement of Fig. 2 can invariably be found by addition of the ordinal numbers of the energized counting relays, the circuit-arrangement of Fig. 2 operating in an addition sense and the arrangement of Fig. 4 operating in a subtractive sense with the contacts *o* changed over.

Fig. 5 shows the order of operation of the relays of Fig. 4, the contacts *o* being changed over. It is once more evident therefrom that all combinations of Fig. 2 occur in Fig. 5 in the reversed order.

The circuit-arrangements described can not only be used for counting purposes, but also for frequency division. It is evident from Figs. 3 and 5 that the counting relay A is energized once if two pulses are supplied to the arrangement. Similarly the counting relay C is energized once per four pulses, counting relay E once per eight pulses.

In the circuit-arrangement of Fig. 2 every second pulse is consequently transmitted at point I, every fourth pulse at point II, every eight at point III and every sixteenth pulse at point IV.

In the registering arrangement of Fig. 6 the arrangement of Fig. 2 is used for registering a number of pulse series emitted by a telephone

instrument having a dial. The pulse relay I is energized here as soon as the subscriber removes the receiver. The relay V_1, which is de-energized in a delayed manner, is energized through the make-side of the pulse contact *i*. When the subscriber then selects a digit the relay I is de-energized once at each interruption of the line by the pulse contact of the dial and through back contact *i* and front contact V_1 a pulse is given to the counting arrangement comprising relays A to H. At the same time the relay K is energized which through a double make contact operates the slow-releasing relay V_2 and at the same time shortcircuits its own second winding with the result that it itself also becomes slow-releasing and remains operative during the sequence of pulses. After the termination of the sequence of pulses, the relays K and V_2 are de-energized in a delayed manner.

Assuming, the selected digit to be, for example, 4, only relays E and F are operated. During the time K has already been de-energized but V_2 is still operated, the following circuit is established: earth, making contact V_2, making contact *e*, spacing contact K, spacing contact *o*, winding relay 4_a, battery. When V_2 is also released, the hold-earth for the counting circuit-arrangement is interrupted, so that all the energized counting and auxiliary relays are de-energized; however, the registering relay 4_a remains held through its own making contact and the winding of the change-over relay O_1, which changes over the wires 1, 2 and 3 to the next following set of registering relays. A whole series of digits can be recorded by the register in a similar manner.

What I claim is:

1. A binary pulse counting system comprising a counting relay provided with first and second opposed windings, a primary switch having first and second switching positions and means causing said primary switch to normally occupy said first position, whereby said primary switch is shifted to said second position upon energization of said first winding and is returned to said first position upon energization of said second winding, an auxiliary relay provided with a third winding, a secondary switch having first and second switching positions and means causing said secondary switch to normally occupy said first position, whereby said secondary switch shifts to the second position thereof upon energization of said third winding and returns to said first position thereof upon de-energization of said third winding, a pulsing switch member actuated in accordance with the pulses being counted, and first and second voltage sources having terminals therefor, one end of said first and third windings being interconnected, one terminal of said first source being connected to the other end of said first winding, the other terminal of said first source being connected through said member and said secondary switch in the first position thereof to said interconnection, said other terminal of said first source being connected through said member and said primary switch in the first position thereof to the other end of said third winding and being connected through said primary switch in the second position thereof to said other end of said third winding, said second winding being connected through said secondary switch in the second position thereof and said switching member to the terminals of said second source.

2. A system, as set forth in claim 1, further including a rectifier interposed between said interconnection and said secondary switch in said first position.

3. Pulse counting apparatus comprising a plurality of binary pulse counting systems connected in cascade relation, each system including a counting relay provided with first and second opposed windings, a primary switch having first and second switching positions and means causing said primary switch to normally occupy said first position, whereby said primary switch is shifted to said second position upon energization of said first winding and is returned to said first position upon energization of said second winding, an auxiliary relay provided with a third winding actuating a secondary switch having first and second switching positions and means causing said secondary switch to normally occupy said first position, whereby said secondary switch is shifted to the second position thereof upon energization of said third winding and is returned to said first position thereof upon de-energization of said third winding, a pulsing switch member actuated in accordance with the pulses being counted, and first and second voltage sources having terminals therefor, one end of said first and third windings being interconnected, one terminal of said first source being connected to the other end of said first winding, the other terminal of said first source being connected through said member and said second switch in the first position thereof to said interconnection, said other terminal of said first source being connected through said member and said primary switch in the first position thereof to the other end of said third winding and being connected through said primary switch in the second position thereof to said other end of said third winding, said second winding being connected through said secondary switch in the second position thereof and said switching member to the terminals of said second source, the pulsing switch member of the systems following the first system in the cascade thereof being constituted by the secondary switch in the second position.

4. A binary pulse counting system comprising a counting relay provided with first and second opposed windings and a primary switch actuated by said windings including first and second fixed contacts, a first movable contact and means normally causing said first fixed movable contact to engage said first fixed contact, said first movable contact engaging said second fixed contact upon energization of said first winding and re-engaging said first fixed contact upon energization of said second winding, an auxiliary relay provided with a third winding actuating a secondary switch including third and fourth fixed contacts, a second movable contact and means normally causing said second movable contact to normally engage said third fixed contact, said second movable contact engaging said fourth fixed contact upon energization of said third winding and re-engaging said third fixed contact upon de-energization of said third winding, a pulsing switch member actuated in accordance with the pulses being counted, and first and second voltage sources having terminals therefor, one end of said first and third windings being interconnected and being connected to said third fixed contact, said first fixed contact and said second movable contact both being connected through said switch member to one terminal of said first source, the other terminal of said first source being connected to the other end of said

first winding, said first movable contact being connected to the other end of said third winding, the second fixed contact being connected both to said one terminal of said first source and one terminal of said second source, the other terminal of said second source being connected to one end of said second winding, the other end of said second winding being connected to said fourth fixed contact.

5. Frequency division apparatus comprising a counting relay provided with first and second opposed windings and a primary switch actuated by said windings including first and second fixed contacts, a first movable contact and means causing said first movable contact to normally engage said first fixed contact, said first movable contact engaging said second fixed contact upon energization of said first winding and re-engaging said first fixed contact upon energization of said second winding, an auxiliary relay provided with a third winding actuating a secondary switch including third and fourth fixed contacts, a second movable contact and means causing said first movable contact to normally engage said third fixed contact, said second movable contact engaging said fourth fixed contact upon energization of said third winding and re-engaging said third fixed contact upon de-energization of said third winding, a pulsing switch member actuated in accordance with the frequency being divided, a rectifier, and first and second voltage sources having terminals therefor, one end of said first

and third windings being interconnected and being connected to said third fixed contact through said rectifier, said first fixed contact and said second movable contact both being connected through said switch member to one terminal of said first source, the other terminal of said first source being connected to the other end of said first winding, said first movable contact being connected to the other end of said third winding, the second fixed contact being connected both to said one terminal of said first source and one terminal of said second source, the other terminal of said second source being connected to one end of said second winding, the other end of said second winding being connected to said fourth fixed contact.

FRANS WESTERVELD.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,563,738	From	Dec. 1, 1925
2,009,405	Leich	July 30, 1935
2,067,151	Dicke	Jan. 5, 1937
2,088,793	Judge	Aug. 3, 1937
2,114,255	Powell	Apr. 12, 1938
2,325,151	Saunders	July 27, 1943
2,402,446	Pawell	June 18, 1946