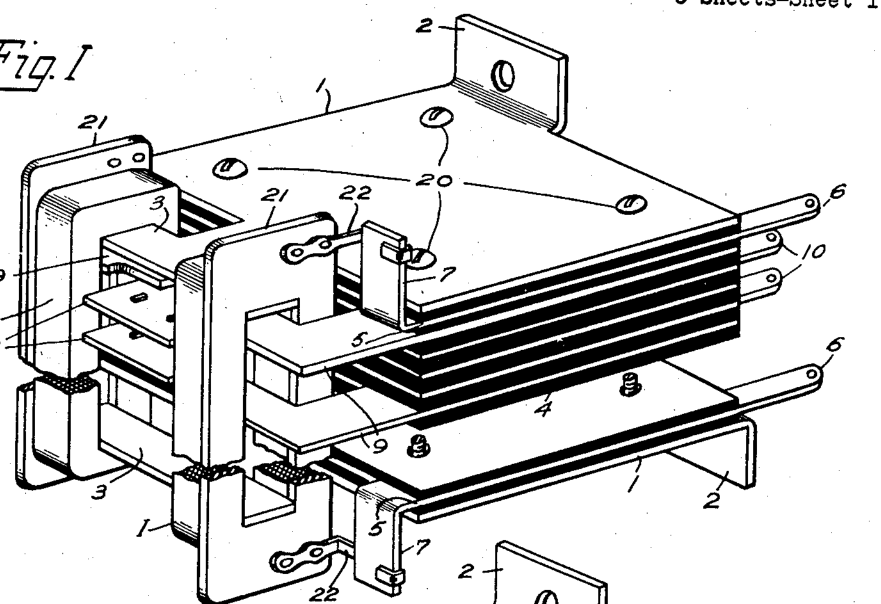
Jan. 23, 1951 J. I. BELLAMY 2,538,815

ELECTROMAGNETIC COUNTING DEVICE

Filed Aug. 25, 1945 3 Sheets-Sheet 1

Fig. I



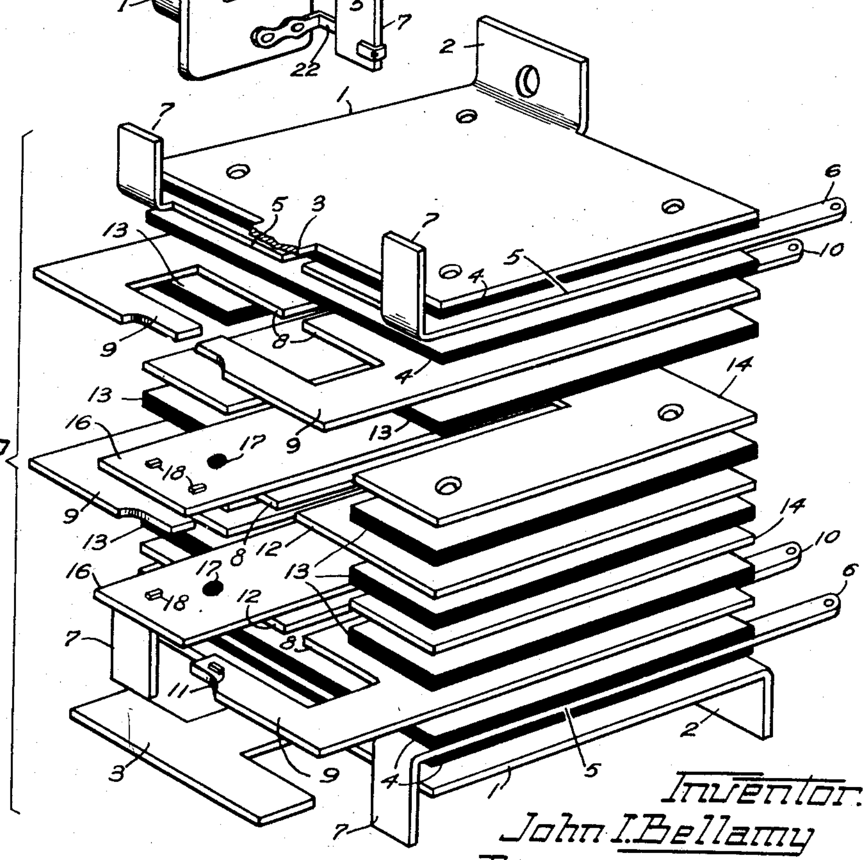


Fig. 2

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ELECTROMAGNETIC COUNTING DEVICE

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Fig. 3.

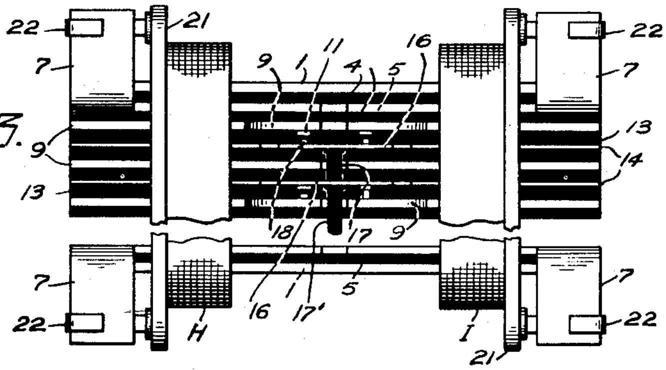

Fig. 4

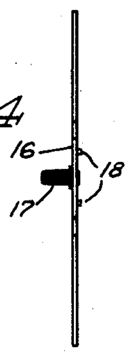

Fig. 5

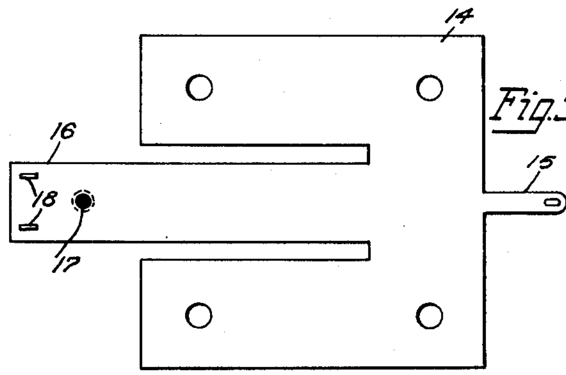

Fig. 8

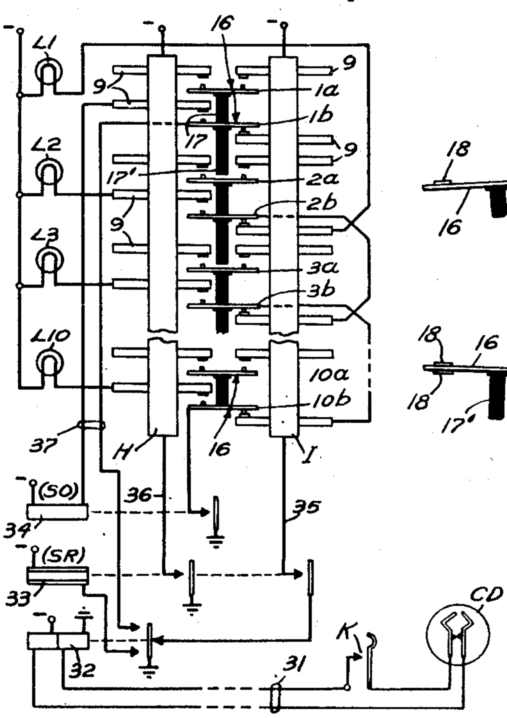

Fig. 6

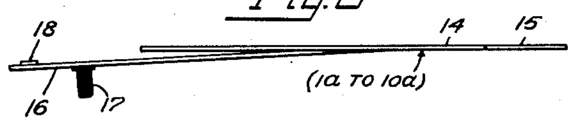

Fig. 7

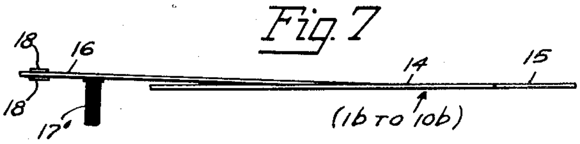

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Fig. 9

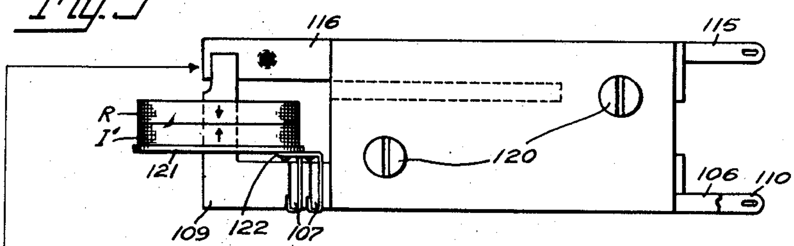
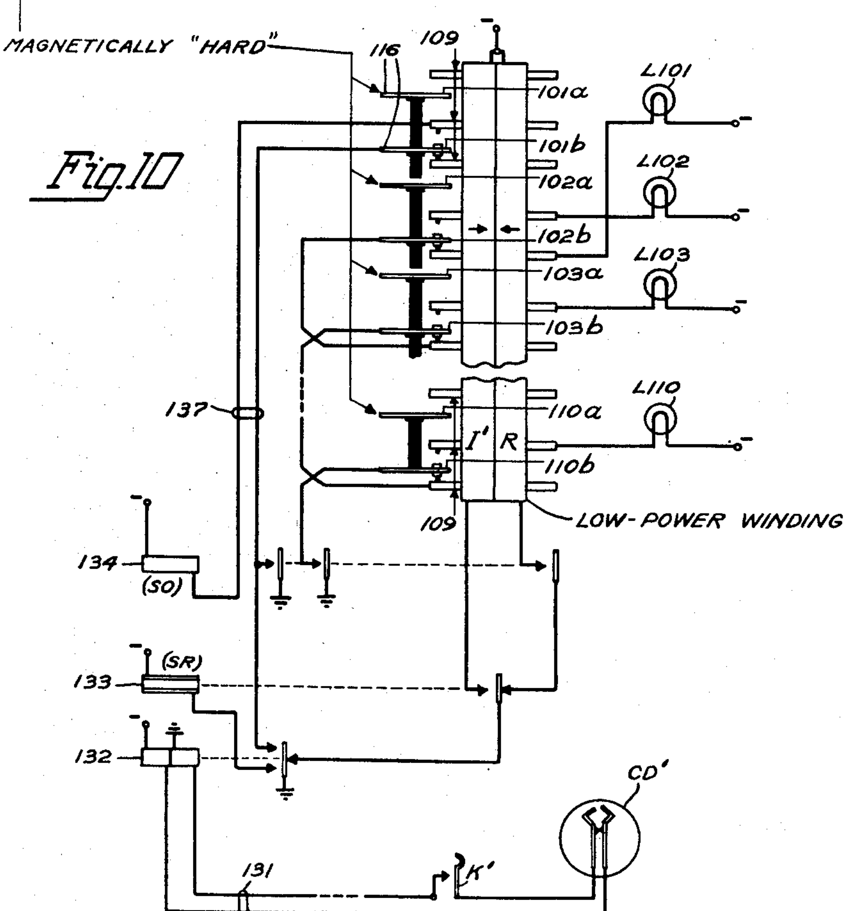


Fig. 10



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Patented Jan. 23, 1951

2,538,815

UNITED STATES PATENT OFFICE

2,538,815

ELECTROMAGNETIC COUNTING DEVICE

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Application August 25, 1945, Serial No. 612,689

9 Claims. (Cl. 177—353)

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This invention relates to electromagnetic counting devices. Its object is to provide a simple and reliable electromagnetic device for counting received electrical impulses, and for controlling electrical contacts in accordance with the number of impulses in a counted series.

This invention is an improvement on that disclosed in my prior application for electromagnetic counting devices Serial #493,312, filed July 2, 1943, now Patent 2,441,001, dated May 4, 1948. In the light of my prior application, a specific object of this invention is to provide a counting device of the same general class wherein a single impulse-receiving magnet serves to control two armatures for each received impulse, one armature responding to the commencement of the impulse, while the other armature responds to the termination thereof.

A feature of the invention is that the two armatures which pertain respectively to the commencement and termination of the same impulse are tensioned against each other, whereby the second armature of the pair tends to follow the counting movement of the first, but is prevented by the pole structure from doing so until the current impulse is terminated.

Other objects and features of the invention will appear as the description progresses.

The accompanying drawings, comprising Figures 1 to 10, illustrate two embodiments of the invention, Figures 1 to 8 pertaining to the first, while Figures 9 and 10 pertain to the second.

It has been chosen to illustrate the invention as applied to a structure of the type illustrated generally in the Hickman et al. Patent 2,293,823, and in the Stibitz Patent 2,305,450, wherein the relay structure comprises a body built up of superposed laminations of magnetic material electrically separated from each other by interspersed laminations of insulating material.

Figure 1 shows the first embodiment of the counting device in perspective, with an intermediate portion thereof omitted.

Figure 2 is what may be termed an exploded view of the laminations shown in Figure 1.

Figure 3 is a front view of the device shown in Figure 1.

Figures 4 and 5 are a front view and a plan view respectively of an armature lamination of the device of Figures 1 to 3.

Figure 6 is a side view of an armature lamination of Figure 4 adapted for use as the first armature of a pair.

Figure 7 is a similar view of an armature lamination adapted to serve as a second armature of a pair.

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Figure 8 is a circuit diagram of a simple indicating system employing a counting device of Figures 1 to 7.

Figure 9 is a top view of a modified counting device generally similar to the device of Figures 1 to 7.

Figure 10 is a circuit diagram of a simple indicating system employing the modified counting device of Figure 8.

Briefly, the device of Figures 1 to 8 employs a holding coil H to retain the armatures operated incident to the receipt of impulses by impulse coil I, while the device of Figures 8 and 9 utilizes so-called residual magnetism to maintain the armatures operated, clearing out being accomplished by mild reversed magnetism effected by release winding R.

Figures 1 to 8

Referring first to Figures 1 to 8, the counting device shown structurally in Figures 1 to 7 includes a pair of electromagnet coils H and I (Figures 1 to 3), supported in front of the laminated structure comprising the principal portion of the counting device. Coils H and I are wound upon, or otherwise fixed with, a pair of coil supports **21**.

The laminations forming the general body of the structure include a pair of end plates **1**. The assembly is secured together by bolts **20** passing entirely there through, the several laminations being provided with suitable aligned holes for this purpose. The holes in the conducting laminations other than end plates **1** are preferably enlarged to maintain such parts out of contact with the assembly.

Each end plate **1** has a rear tab **2** for use in mounting the device, and has a front extension member **3** of a generally T-shaped outline which enters coil forms **21**, to support them in their illustrated position. End plates **1** are succeeded, inwardly, by insulation laminations **4**, followed by two pairs of coil-terminal laminations **5**, each of which has a rear tab **6** to which an external conductor may be attached, and a front portion **7** to which one winding end of the concerned coil may be connected, as by connecting member **22**. As seen best in Figure 2 the terminal laminations **5** of the upper pair lie side by side in the assembly out of contact with each other. The laminations of the lower pair are similarly disposed.

Laminations **5** are succeeded inwardly by a further pair of insulating laminations **4**, between which lie the several field laminations **8** and armature laminations 14. With their interspersed laminations, they form the major part of the structure.

Each field lamination 8, has a main portion of a size comparable to the main portion of any terminal lamination 5, whereby a pair of them may lie side by side out of electrical contact with each other as is illustrated in Figure 2 for the upper pair of field laminations 8.

Each lamination 8 is provided with a rear terminal tab 10, and with a front pole portion 9 located so as to extend inwardly through the concerned one of the coils H and I.

A U-shaped insulating lamination 13 lies immediately below the uppermost pair of field laminations 8, having the front central portion cut out to permit vertical movement of the reed portion 16 of an adjacent armature lamination 14.

The uppermost U-shaped insulator lamination 13 is followed by an armature lamination 14 as seen in Figure 2. Each armature lamination 14 has a profile as shown in Figure 5. It has a rear terminal tab 15 to which an external conductor may be attached. Additionally, it has a reed member 16 which extends forward beyond the general body portion thereof to interact magnetically and electrically with one or more pole portions 9. Each reed 16 is provided with a depending insulating stud 17, or 17′ as shown in Figures 3 to 7. Additionally, each reed 13 is provided with a pair of raised contacts 18, which are both on the upper side, or one on each side, of the reed, depending upon whether the reed is to function as the first armature or the second armature of an impulse pair.

The uppermost armature lamination 14 is followed by a further U-shaped insulator lamination 13, followed in turn by a field lamination 8 in the left-hand position, alongside of field spacer lamination 12, in the right-hand position.

The last-named parts are followed by a further armature lamination 14, between a pair of U-shaped insulator laminations 13, followed by a field lamination 8 lying in the right-hand position alongside a field-separator lamination 12 in the left-hand position. This pair is followed by a further insulator lamination 4 (Figure 1).

The foregoing set of field and armature laminations, make up the first group thereof, concerned with the counting of the first impulse of a series. Following this group, a number of similar impulse groups of laminations appear, depending on the number of impulses for which device is designed. When the device is used as a counting device in an automatic telephone system, it may comprise 10 sets of the laminations in question, having a counting capacity of 10 impulses in a series.

The parts of the device following the final impulse set of laminations are similar to the parts lying above the first impulse set of laminations.

Figure 8 illustrates the counting device of Figures 1 to 7 as having ten pairs of reeds 16 (hereinafter termed armatures for convenience), together with their associated poles 9 of field laminations 8, providing a counting capacity of ten impulses in a series. Only the first three pairs of armatures and the last pair are shown. The armatures 16 comprising the first pair are labeled 1*a* and 1*b*; the armatures comprising the second pair are labeled 2*a* and 2*b*; the armatures comprising the third pair are labeled 3*a* and 3*b*; and the armatures comprising the last pair are labeled 10*a* and 10*b*.

The first or "*a*" armature 16 of each pair is tensioned downwardly, as by being preformed according to Figure 6, while the second or "*b*" armature of any pair is tensioned upwardly, as by being preformed according to Figure 7. The upward tension of any "*b*" armature however is less than the downward tension of the associated "*a*" armature, whereby each "*a*" armature, in the assembled position of the device, normally maintains the associated "*b*" armature pressed downwardly into contact with its immediately underlying pole 9.

The relationship of the parts, including the length of the insulating studs 17 (Figures 4 to 6) may be such that the armatures (reeds) 16 normally are substantially in alignment with the arms of their respective corresponding laminations 14. Any insulating stud 17′ while somewhat longer than any insulating stud 17, is of insufficient length to contact the "*a*" armature of the next succeeding pair, in normal position, whereby each of the "*b*" armatures is held individually in contact with its immediately underlying pole 9 in spite of such minor manufacturing variations as may readily occur.

In the system of Figure 8, the counting device is arranged to cooperate with the associated control relays 32 and 34 to light the one of lamps L1 to L10 which corresponds to the number of impulses in a series transmitted over line 31 by calling device CD. Calling device CD may be of the form ordinarily used at subscriber stations in an automatic telephone system. It can, therefore, transmit a series comprising any number of impulses from one to ten.

Of the relays 32 to 34, 32 is the line relay, responding directly to the impulses received over line 31 and acting to repeat them over impulse conductor 35 to the counting device; 33 is the slow-restoring release relay, operating upon initial closure of the line and remaining operated throughout a series of interruption impulses; and 34 is the so-called second slow relay, operating only upon the termination of a series of transmitted impulses.

When a desired one of the normally extinguished lamps L1 to L10 is to be lighted, the operator first closes the key K (corresponding to hookswitch contacts of an automatic telephone set) and then manipulates the calling device CD to transmit a series containing the corresponding number of impulses.

When key K is closed, line relay 32 operates over line 31 in series with devices K and CD, being supplied with current from the ungrounded pole of a current source indicated by the usual negative symbol. Release relay 33 thereupon operates through the lower front contact of line relay 32. At its outer contacts, relay 33 prepares an impulse circuit over conductor 35, while at its inner contacts, it closes a circuit, over conductor 36, for holding coil H of the counting device. Thereupon, all the poles 9 at the left of the device, and encircled by coil H, become magnetized.

None of the armatures 16 changes position as a result of energization of holding coil H. Considering the first pair (armatures 1*a* and 1*b*), armature 1*a* stands normally slightly closer to its immediately underlying left-hand pole 9 than to its opposed immediately overlying pole 9, wherefore the net effect upon armature 1*a* is a slight downward pull at this time. Armature 1*b* receives a slight upward pull from its immediately overlying left-hand pole 9 but this is at least balanced by the slight net downward pull on armature 1a. The concerned insulating stud 17 therefore continues to hold armature 1b in its illustrated normal position. The same condition obtains with respect to the remaining pairs of armatures.

When the calling device CD is manipulated to transmit the desired series of impulses, line relay 32 restores momentarily responsive to each impulse (circuit interruption) of the series. Release relay 33 remains operated, however, being rendered slow releasing as by the conventionally indicated conductive sleeve underlying its winding.

Each time it momentarily restores, line relay 32 closes a circuit, through the outer contacts of the operated release relay 33, and over conductor 35, for impulse coil I of the counting device. At the end of the series of impulses, line relay 32 comes to rest in operated position.

First impulse

Upon the commencement of the first impulse delivered over conductor 35 to coil I, armature 1a operates fully, as it is attracted upwardly by its immediately overlying right-hand pole 9, to come into contact with that pole and with its immediately overlying left-hand pole. The lower end of the insulating stud 17 carried thereby is thus brought out of engagement with armature 1b, leaving armature 1b mechanically free to move upwardly. Armature 1b, however, is then restained magnetically from moving upwardly by its immediately underlying right-hand pole 9.

When the first impulse subsides, impulse coil I consequently becomes demagnetized, and all of the right-hand poles 9 of the counting device responsively become demagnetized. The operated armature 1a is held in operated position by its immediately overlying left-hand pole 9, held continually magnetized by holding coil H. At this point (the first inter-impulse interval), armature 1b moves upwardly into contact with its immediately overlying left-hand pole 9 for two reasons: (1) it is preformed as shown in Figure 7 to give it a natural tendency to move upwardly when permitted to do so; and (2) it is attracted upwardly by the associated pole 9 controlled by coil H. Preferably, in order to insure firm electrical contact, through concerned contact elements 11 and 18, Figure 2, the parts are so adjusted that armature 1b stops against its immediately overlying pole 9 before it has moved far enough to engage the lower end of the insulating stud 17 carried by armature 1a.

As a further result of the commencement of the first impulse delivered over wire 35, each remaining "a" armature tends to move upwardly, but each is prevented from moving effectively by the insulating stud 17' carried by its immediately overlying "b" armature. For example, armature 2a moves upwardly in response to the first impulse until it closes the slight gap separating it from the lower end of insulating stud 17' carried by armature 1b, whereupon its slight movement is arrested.

As a further result of the termination of the first impulse, each partially operated "a" armature restores to normal position, not having advanced far enough to be attracted upwardly by the poles controlled by holding coil H. It will be recalled that this is the point (the first inter-impulse interval) at which armature 1b moves upwardly from normal position to its operated position.

Second impulse

At the commencement of the second impulse delivered over conductor 35, armature 2a operates fully, being attracted upwardly by its immediately overlying right-hand pole, and being no longer restrained by immediately overlying stud 17'. The relationship and the adjustment of the parts is such that armature 2a comes to rest in its fully operated position slightly before it engages the lower end of the now raised insulating stud 17', fixed with armature 1b. Armature 2b remains temporarily in normal position for reasons explained in connection with armature 1b.

When the second impulse subsides, armature 2b operates fully, coming into electrical engagement with its immediately overlying pole 9 controlled by holding coil H.

Succeeding impulses

For each additional impulse received, a further one of the "a" armatures operates at the commencement of the impulse, and its associated "b" armature operates at the termination thereof. Each operated armature is held in operated position by flux emanating from its immediately overlying left-hand pole 9, controlled by holding coil H.

In practice, it is preferable to arrange that holding coil H is only moderately magnetized (has only a moderate number of ampere-turns) whereby, it does not exert a particularly effective pull on the associated armatures prior to their movement into final operated position. On the other hand, impulse coil I should become rather strongly magnetized on each impulse (be provided with a rather large number of ampere-turns), whereby the effect of the magnetization of the impulse coil greatly predominates over the effect of the holding coil. This does not require a marked increase in overall power consumption as the impulse coil I is energized only momentarily.

Series termination

Upon the described operation of armature 1b, which occurs upon the first reoperation of line relay 32 (in the first inter-impulse interval), a circuit is closed for slow-operating changeover relay 34, through the upper front contact of line relay 32, by way of armature 1b and its immediately overlying pole 9. So long as the impulses continue to arrive, line relay 32 remains operated only momentarily, whereby relay 34 does not have time to operate. Relay 34 is preferably provided with a somewhat highly inductive winding, and is so stiffly adjusted that it fails to operate respective to a momentary closure to its circuit.

When line relay 32 comes to rest in operated position at the end of the impulse series, relay 34 operates over its above-noted circuit, thereby closing a circuit for the one of the lamps L1 to L10 which corresponds to the number of impulses in the series. Suppose, for example, that the series of impulses just received comprise three impulses. Then, armatures 1a to 3b are in operated condition, while the remaining armatures are in normal position. Under this condition, the operation of relay 34 closes a circuit for lamp L3 which includes armature 10b and its back contact, armatures 9b to 4b (not shown) and their respective back contacts, and armature 3b and its front contact.

On the other hand, when the transmitted series contains only two impulses, lamp 2 is lighted over a circuit as previously traced to armature 3b, extending thence through the back contact of armature 3b to lamp L2, by way of armature 2b and its front contact. Finally, if the series contains but a single impulse, only the armatures of the first pair are operated, in which case the lamp circuit is through armature 2b and its back contact to the first lamp L1.

It will be observed that the first "b" armature (1b) does not directly control any lamp circuit acting merely to control relay 34, while the second "b" armature (2b) acts to disconnect lamp L1 and substitute lamp L2. Each succeeding "b" armature acts similarly to break the chain circuit over which the preceding lamp is controlled and to substitute its corresponding lamp. By this arrangement the ten "b" armatures suffice to control the current supplied to the ten lamp leads, in addition to controlling what may be termed an off-normal circuit (conductors 37) for control relay 34.

When the device is to be cleared out, key K is opened whereupon line relay 32 restores to (1) open-circuit relays 33 and 34, and (2) to transmit a further impulse over conductor 35, a purely incidental operation. Relay 34 restores immediately, removing ground from the lamp control circuits. A moment later slow-restoring release relay 33 restores, open-circuiting coils H and I. All poles 9 thereupon become demagnetized whereupon all armatures 16 restore to their illustrated normal position.

Figures 9 and 10

In the modification shown in Figures 9 and 10, the holding coil H of Figures 1 to 8 is omitted, being rendered unnecessary by arranging that each "a" armature of a pair is retained in its operated position by residual magnetism. For this purpose, each "a" armature of Figures 9 and 10 is arranged to come directly into contact with its corresponding overlying pole (instead of being held slightly out of magnetic contact by non-magnetic electrical contact elements). The residual holding effect of these armatures may be increased to any desired extent by constructing either the armature or its associated overlying pole of a material possessing the desired degree of magnetic hardness.

In order to effect a restoration of the device of Figures 9 and 10, a release winding R is located adjacent to impulse winding I'. Temporary mild energization of this release winding magnetizes the structure mildly in a reverse direction, whereby the residual magnetism is destroyed.

It may be noted that the parts 102, 106, 107, 109, 110, 115, 116, 120 to 122, 131 to 134, and 137, of Figures 9 and 10 correspond respectively to parts 2, 6, 7, 9, 10, 15, 16, 20 to 22, 31 to 34, and 37 of Figures 1 to 8. Additionally, parts 101a to 110a, 101b to 110b, and L101 to L110 of Figure 10 correspond respectively to parts 1a to 10a, 1b to 10b, and L1 to L10 of Figure 8.

In the system of Figure 10, when a desired one of the lamps L101 to L110 is to be lighted, the operator first closes the key K', and then manipulates the calling device CD' to transmit a series containing a number of impulses corresponding to the identity of the lamp to be lighted.

When the key K' is closed, line relay 132 operates over line 131, operating slow-release relay 133.

When the calling device CD' is operated, line relay 132 restores momentarily responsive to each resulting interruption impulse, slow-release relay 133 remaining operated. Upon each restoration of line relay 132, impulse winding I', being a comparatively high power winding, becomes magnetized comparatively strongly in a circuit including the back contact of relay 132 and the outer contact pair of relay 133. Upon each such energization, all poles 109 of the device become rather strongly magnetized.

At the end of the impulse series, line relay 132 comes to rest in an operated condition.

First impulse

Upon the transmission of the first impulse of a series, all armatures 101a to 110a are attracted upwardly, each by its immediately overlying pole 109, while each of the armatures 101b to 110b is attracted downwardly, each by its immediately underlying pole 109. The first "a" armature (101a) operates fully at this time, coming directly into contact with its immediately overlying pole 109, whereby the reluctance of the magnetic path through this armature and pole is so reduced that the armature can remain in its operated position by residual magnetism, being somewhat "hard" magnetically.

Each of the "a" armatures 102a to 110a is, at this time, prevented from operating fully by the insulating stud attached to the immediately overlying "b" armature.

When the first impulse subsides, the fully operated armature 101a remains held in operated position by residual magnetism, but each of the succeeding "a" armatures immediately restores to its illustrated normal position, since it has not been brought near enough to its immediately overlying pole to permit residual magnetism to retain it.

As a further result of the termination of the first impulse, armature 101b operates fully—moves upwardly out of contact with its immediately underlying pole 109 and comes into electrical engagement with its immediately overlying pole 109, this movement being by spring action resulting from the form illustrated in Figure 7. It will be noted that the distance which armature 101b must travel to complete its movement from normal position to fully operated position, is slightly less than the distance travelled by its associated overlying armature 101a, whereby the insulating stud carried by the latter armature cannot interfere with the completion of the movement of armature 101b.

Second impulse

When the second impulse arrives, the resulting magnetization of the poles 109 of the structure causes each of the "a" armatures 102a to 110a to move upwardly. The upward movement at this time, of armatures 103a to 110a, is a partial movement as explained above in connection with the first impulse. Armature 102a, however, executes a full upward movement at this time, coming directly into contact with its immediately overlying pole 109, whereby it is thereafter retained in operated position by residual magnetism.

It will be recalled that armature 101b moved upwardly a slightly less distance than armature 101a. Accordingly, if the insulating stud depending from armature 101b were not of the indicated reduced length, to provide a gap between it and armature 102a, the latter could not execute a full movement of the extent of the movement of armature 101a. The gap referred to is of such dimensions that, added to the movement of armature 101b, a clearance space results which is slightly in excess of the distance required to be travelled by armature 102a from its illustrated normal position to its described fully operated position. The described arrangement for inter-action between armatures 101a and 101b, and for inter-action between armatures 101b and 102a, is repeated for the remaining armatures.

When the second impulse subsides, armature 102b, upon being responsively released by its immediately underlying pole 109, operates fully, coming into electrical engagement with its immediately overlying pole 109. The illustrated gap, between the lower end of the stud carried by armature 102b, and armature 103a, is increased to a width slightly in excess of the movement required for armature 103a, when it moves upwardly in response to the third impulse in a series containing three or more.

Succeeding impulses

As the succeeding impulses of a series arrive, the corresponding "a" and "b" armatures respond in succession in the manner described above, resulting in the operation of as many pairs of armatures as there are impulses in the series.

Series termination

When line relay 132 comes to rest in an operated condition, at the end of the series of impulses, slow-operating relay 134 operates through the upper front contact of line relay 132, over conductors 137, in series with armature 101b and its front contact. Upon operating, relay 134, at its inner contact pair, closes a self-locking circuit independent of the contacts of line relay 132; at its outer contact pair, it prepares a circuit for release winding R, to be later closed; and at its middle contact pair, it closes the prepared lamp circuit. This circuit is through armature 110b and its upper contact if lamp 110 is to be lighted, and it is through armature 110b and its lower contact for one of the preceding lamps in the chain, if one of those is to be lighted. This lamp-lighting circuit is similar to that described hereinbefore, in connection with Figure 8.

When the device is to be cleared out, key K' is opened, whereupon relays 132 and 133 restore successively. Incidentally, a further impulse is transmitted to winding I' during the interval required for slow-release relay 133 to restore after relay 132 restores. Following the restoration of relay 132, relay 134 remains operated temporarily in its self-locking circuit.

When relay 133 restores, it open-circuits winding I' and closes a circuit for release winding R, through the outer contact pair of relay 134. Winding R thereupon sets up flux in the reverse direction through the magnetic structure. Preferably, the winding R is sufficiently inductive that the reverse flux is built up comparatively gradually, permitting the operated armatures to release when the residual magnetism previously established nears zero. Because of the low power of winding R, the released armatures remain in restored condition.

Responsive to the restoration of armature 101b, relay 134 restores, opening the lamp-control circuit and open-circuiting release winding R. This completes the clearing out of the system, leaving the apparatus in readiness for further operation.

I claim:

1. In a magnetic counting device including a pole structure and means for transmitting a series of magnetizing impulses thereto, a series of armatures associated with the pole structure, said armatures being movable successively responsive to said magnetizing impulses to count them, said armatures comprising successive armature pairs corresponding respectively to said impulses, mechanical inter-armature linking means between the succeeding armatures normally preventing each armature following the first armature of the series from moving to count an impulse, movement of any armature preceding the last to count its corresponding impulse nullifying the said preventing effect of said linking means with respect to the next succeeding armature, the first armature of any said pair being so related to the pole structure that it is movable at the beginning of its corresponding impulse to count such impulse, the second armature of any said pair being so related to the pole structure that it is restrained from moving to count its corresponding impulse until the end thereof, each said second armature being biased to move to count its corresponding impulse by means independent of said pole structure acting continuously from the beginning of the series of impulses, any said second armature executing its counting movement, under the urge of its said continuous bias, responsive simply and directly to the termination of its corresponding impulse of magnetizing force.

2. In a magnetic counting device including a pole structure and means for transmitting a series of magnetizing impulses thereto, a series of armatures associated with the pole structure, said armatures being movable successively responsive to said magnetizing impulses to count them, said armatures comprising successive armature pairs corresponding respectively to said impulses, means including mechanical inter-armature linking means between the succeeding armatures for controlling each armature following the first armature of the series to cause it to move in its turn to count an impulse, the movement of any armature preceding the last to count its corresponding impulse acting through said linking means to prepare the next succeeding armature for its counting movement, the first armature of any said pair being so related to the pole structure that it is movable at the beginning of its corresponding impulse to count such impulse, the second armature of any said pair being so related to the pole structure that it is restrained from moving to count its corresponding impulse until the end thereof, the said means for controlling the armatures following the first including means independent of said pole structure responsive to the counting movement of the first armature of any said pair for effectively applying a bias to the second armature of the same pair and for maintaining such bias after the concerned impulse ends, said bias serving to move the last said second armature to count the concerned impulse when the said restraint ends at the end of the last said impulse, any said second armature executing its counting movement, under the urge of its said bias, responsive simply and directly to the termination of its corresponding impulse of magnetizing force.

3. In a counting system, a series of armatures arranged to be moved in succession to count the impulses of a series, said armatures comprising pairs corresponding respectively to said impulses,

spring means normally applying spring tension for holding the first armature of each pair by a given force against execution of its counting movement, spring means normally applying spring tension for urging the second armature of each pair by a lesser force to execute its counting movement, control means including the foregoing means for causing the said first armatures to move successively responsive to respective succeeding impulses to count such impulses, means included in said control means for restraining the second armature of any pair from executing its counting movement until the concerned one of said impulses subsides, and inter-armature coupling means included in said control means preventing any armature following the first armature of the series from executing its counting movement until the preceding armature in the series has executed its counting movement.

4. In a counting system, a pole structure, a series of armatures arranged to be operated in succession to count the impulses of a series delivered to said pole structure, each armature having a normal position and an operated position, means independent of said pole structure effective continuously from the beginning of the series of the impulses for normally urging each even-numbered armature toward operated position, means holding each even-numbered armature in normal position against said urging means, control means including the foregoing means for causing the odd-numbered armatures of the series to respond successively to respective succeeding impulses by moving from normal position to operated position, means included in said control means and controlled by each odd-numbered armature responsive to the said movement thereof for nullifying said holding means with respect to the next succeeding even-numbered armature, and further means included in said control means for temporarily holding any such released even-numbered armature in normal position until the end of the concerned impulse of the series, whereby it moves to operated position responsive simply to the end of the last said impulse.

5. In an impulse-counting device, a series of impulse-counting members each having a normal position and an operated position, means common to all said members for imparting a series of operating impulses thereto, each operating impulse acting similarly upon each unoperated one of said members and serving to move it from its normal position to its operated position unless the member is restrained from so moving, restraining means for each said member except the first in the form of a blocking element interposed in the path thereof and normally effective to restrain such member from moving to operated position responsive to any said impulse, and means independent of said common means for imparting operating impulses, responsive to the movement to operated position of any said member preceding the last, for effectively applying a force to the said blocking element of the next succeeding said member and for maintaining such force after the concerned impulses of the series ends, said force serving to move the last said blocking element to an ineffective position out of the path of its associated said member when not restrained from so doing, and means effective throughout the remainder of the concerned impulse and rendered ineffective by the termination thereof for restraining the last said blocking element in its effective blocking position, whereby the counting member next succeeding the last operated one is rendered free to operate in its turn responsive simply to the termination of the operating impulse of the last operated counting member.

6. In a system for counting impulses of current, counting members associated together in pairs corresponding respectively to impulses of a series being counted, an electromagnet common to all said pairs, the first members comprising armatures of said electromagnet, said electromagnet operating the first member of any pair responsive to the corresponding impulse of a series, means independent of said electromagnet responsive thereto for effectively applying an operating force to the second member of such pair and for maintaining it after such impulse ends, means for restraining such second member from operating responsive to such force so long as the current impulse of the series endures, said restraining means being thereupon rendered ineffective, thereby permitting the concerned second member to operate at the end of the last said impulse and means responsive to the operation of the second member of any pair preceding the last for rendering the first member of the next succeeding pair responsive to the next succeeding impulse.

7. In a counting system, a series of armatures and means for operating them in succession to count the impulses of a series of magnetizing impulses, said means including electromagnetic structure for applying each of said impulses to each armature and including inter-armature coupling means for securing the said successive operation of the armatures to count the impulses, each said armature being arranged to be maintained operated by residual flux after its operating flux has subsided, and means for applying flux in an opposed direction to neutralize said residual flux.

8. In a counting system, a series of armatures and a single electromagnetic means for operating them, control means including each of said armatures preceding the last for causing said electromagnetic operating means to operate the armatures successively to count a series of electrical impulses delivered to the electromagnetic operating means subject to each operated armature being held operated following the impulse which it operates to count, said electromagnetic operating means delivering a similar impulse to each currently unoperated one of said armatures responsive to each electrical impulse of said series, said control means serving to prevent premature operation of each said armature succeeding the first, each said armature being arranged to be held operated by residual flux after its operating flux has subsided, and means for applying flux in an opposed direction to neutralize the residual flux when the operated armatures are to be restored.

9. In a counting system, a series of armatures and a common electromagnet for operating them, control means including each of said armatures preceding the last for causing said electromagnet to operate the armatures successively to count a series of electrical impulses delivered to the electromagnet subject to each operated armature being held operated following the impulse which it operates to count, each said armature being arranged to be held operated by residual flux after its operating flux has subsided, and means for ap-

plying current to the electromagnet in an opposed direction to neutralize the residual flux when the operated armatures are to be restored.

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