Jan. 23, 1951 J. I. BELLAMY 2,538,817

ELECTROMAGNETIC COUNTING DEVICE

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FIG. 4

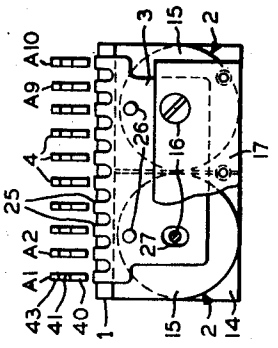


FIG. 3

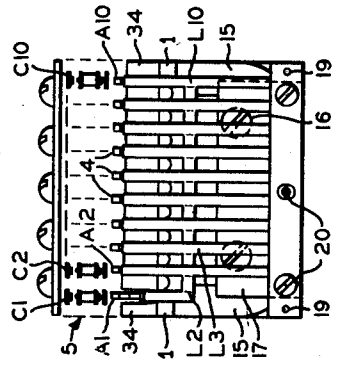


FIG. 1

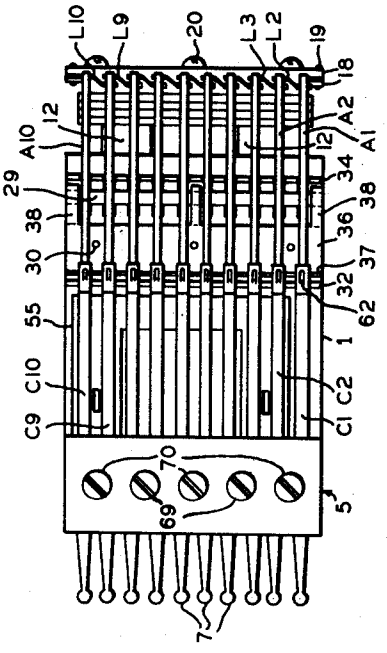
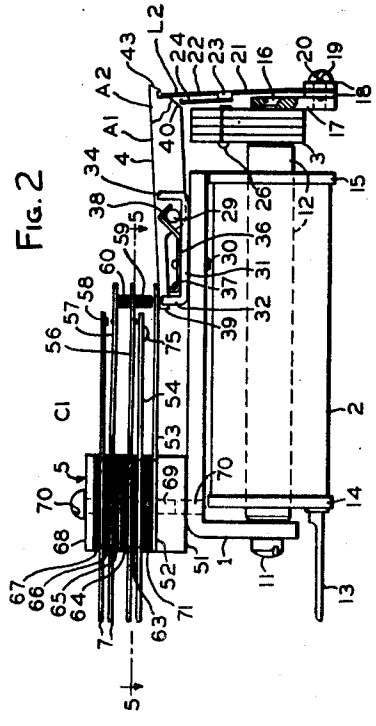


FIG. 2



INVENTOR:
JOHN I. BELLAMY
BY
ATTORNEY

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ELECTROMAGNETIC COUNTING DEVICE

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FIG. 5

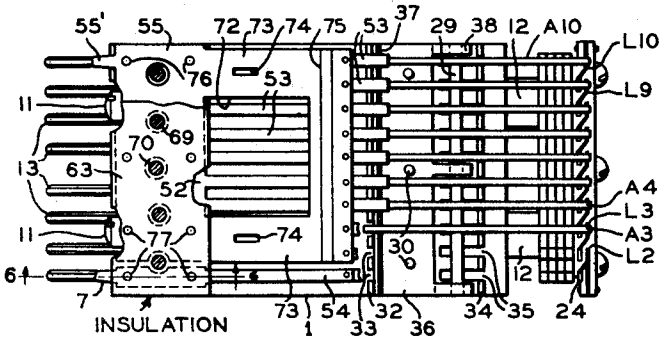


FIG. 6

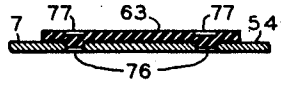


FIG. 7

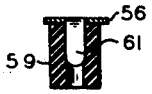


FIG. 8

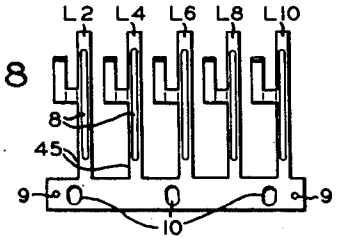


FIG. 9

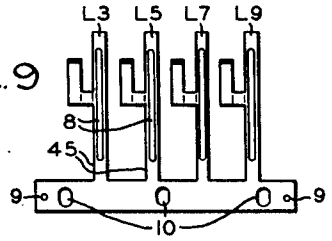


FIG. 10

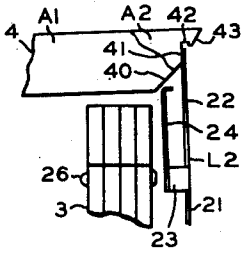


FIG. 11

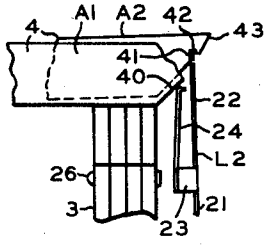


FIG. 12

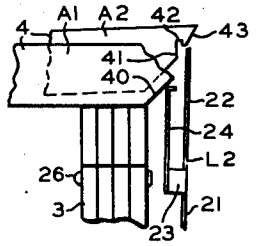
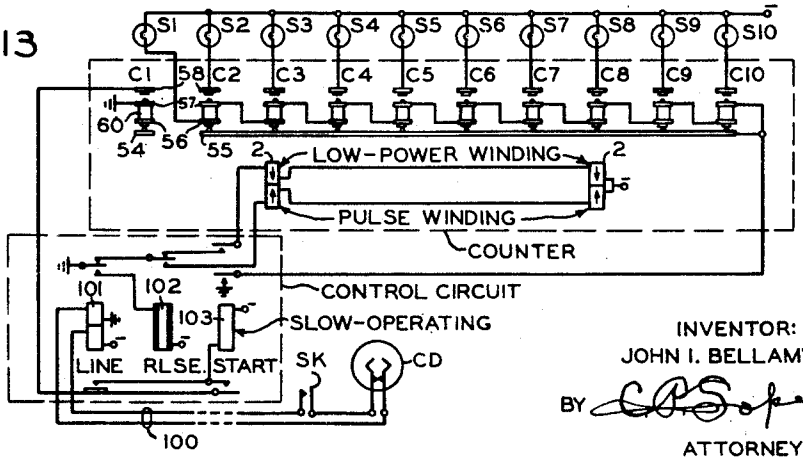


FIG. 13



INVENTOR:
JOHN I. BELLAMY
BY
ATTORNEY

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FIG. 14

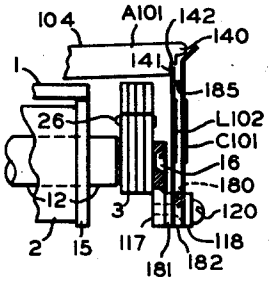


FIG. 15

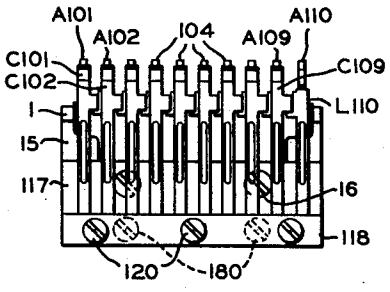


FIG. 16

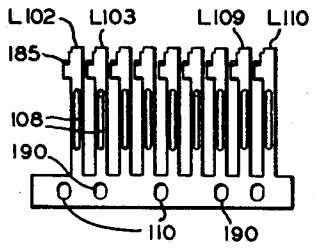


FIG. 17

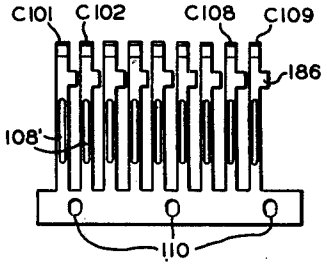


FIG. 18

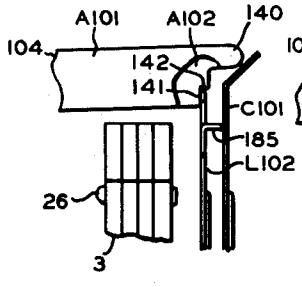


FIG. 19

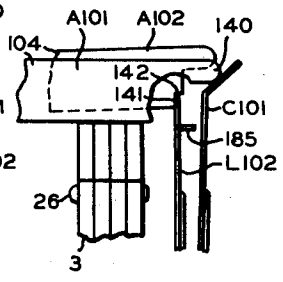
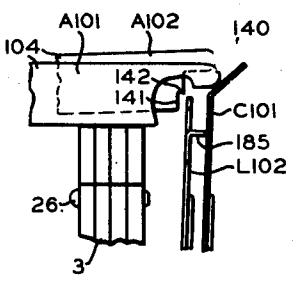


FIG. 20



INVENTOR:
JOHN I. BELLAMY
BY C. P. Sopher
ATTORNEY

Patented Jan. 23, 1951

2,538,817

UNITED STATES PATENT OFFICE

2,538,817

ELECTROMAGNETIC COUNTING DEVICE

John I. Bellamy, Brookfield, Ill., assignor to Kellogg Switchboard and Supply Company, Chicago, Ill., a corporation of Illinois

Application November 20, 1946, Serial No. 711,111

10 Claims. (Cl. 177—353)

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This application is a continuation in part of my prior application for electromagnetic counting devices, Serial No. 699,456, filed September 26, 1946, now Patent No. 2,487,015, dated November 1, 1949.

This invention relates to electromagnetic counting devices. Its object is to provide an improved form of electromagnetic devices for counting a received series of electrical impulses and for controlling contact sets in accordance with the number of impulses therein.

This invention is in the nature of a further improvement on the counting device disclosed in my prior application for electromagnetic counting devices, Serial No. 647,896, filed February 15, 1946.

The principal feature of the present invention resides in a mechanical latching arrangement which renders unnecessary the sequence armatures of the previously identified prior application. By this latching arrangement, each armature after the first is maintained latched until the immediately preceding armature has operated and its operating impulse has subsided. An important advantage of this arrangement is that the magnetic flux required in the previous device to control the sequence armatures can be utilized herein to operate the work armatures more powerfully, such work armatures having a suitably increased cross-sectional area for this purpose.

Other features of the invention relate (1) to an improved construction for promoting the magnetic efficiency of the armatures by concentrating the flux in their respective operating air gaps, (2) an improved pivoting, guiding, and back-stop arrangement for the armatures, and (3) an improved arrangement for providing the required number of contact sets side by side in the same plane and for rendering them readily adjustable after the device is assembled.

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

Of the drawings, Figs. 1 to 9 show the construction of one embodiment of the improved counting device; Figs. 10 to 12 show successive operational steps thereof; Fig. 13 shows a wiring diagram of a simple signaling system employing the improved counting device; Figs. 14 to 17 show the device modified with respect to the latching-control arrangement; and Figs. 18 to 20 show successive operational steps of the modified device.

More in particular, Figs. 1, 2, and 3 are respectively a top view, a side view, and a front view of the improved counting device;

Fig. 4 is a further front view with certain parts removed;

Fig. 5 is a further top view with certain parts removed;

Fig. 6 is a partial sectional view taken along line 6—6 of Fig. 5;

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Fig. 7 is a partial sectional view showing how the insulating control studs are attached to the traveling blades in the contact sets;

Figs. 8 and 9 show a modified construction of the latch springs;

Fig. 10 is an enlarged view of the upper front portion of the device in normal position; Fig. 11 is a similar view of the parts after the first impulse has arrived and before it has terminated; and Fig. 12 shows the same parts after the termination of the first impulse;

Fig. 14 is a partial side view of the modified device;

Fig. 15 is a front view of the device of Fig. 14; and

Figs. 16 and 17 show respectively the latch springs and the cam springs of Figs. 14 and 15 detached.

DETAILED DESCRIPTION

A. *General arrangement*

Referring first to Figs. 1 to 7, and more particularly to Figs. 1 to 3, the improved counting device includes a generally rectangular magnetic structure of which magnetic return plate 1 comprises the rear limb and the principal portion of the upper limb; ten armatures 4 comprise the remaining portion of the upper limb; two parallel electromagnets 2 comprise the lower limb; and laminated pole member 3 comprises the front limb. All the remaining parts of the structure are preferably non-magnetic, except that the screws 69 and 70, and parts 51 and 68, in bank assembly 5 may be of steel if desired. Parts 1, 12, and 3 may be of soft cold-rolled steel, but armatures 4 are magnetically hard. They may be made of annealed tool-steel sheet.

As seen best in Fig. 2, each of the electromagnets includes the usual iron core 12, a rear spool head 14, a front spool head 15, and a pair of concentric windings (not separately shown) wound between the spool heads. As seen best in Figs. 2 and 5, each of the rear spool heads is provided with four winding terminals 13, a separate pair for each of the two windings of the associated electromagnet. Electromagnets 2 are assembled with return plate 1 by a pair of screws 11 (Figs. 2 and 5).

Actuating pole member 3 may be conveniently formed of a number of similar laminations secured together by rivets 26 (Figs. 2 and 4). Pole member 3 is attached to the front of the cores 12 by a pair of screws 16 which are countersunk in the overlying nonmagnetic bracket 17, which affords a location for attaching the nine armature latches L2 to L10 which cooperate with the armatures to cause them to respond respectively to successive impulses in a series received by electromagnets 2.

Bank assembly 5, attached to return plate 1, supports ten similar sets of contact members C1

to C10, one for each of the ten armatures 4. External connections to the contact members may be made through their rear terminal portions 7.

B. *The armatures*

The ten armatures 4 are referred to individually as armatures A1 to A10. They are positioned along the common pivot rod 29, on which they are freely rotatable. Pivot rod 29 is supported on the upper surface of guide bracket 31, and is held in place by the three overlying arms 38 of pivot bracket 36. Parts 1, 31, and 36 are held in the illustrated assembled position by three rivets 30.

Each of the armatures 4 comprises a main armature portion surrounding pivot rod 29, and extending forwardly therefrom, and a contact-actuating tail portion 39 which extends to the rear and underlies its associated one of the contact sets C1 to C10. Pivot bracket 36 ends at the rear in an upstanding portion 37, the top edge of which underlies tails 39 to serve as a common backstop for the armatures.

The upturned rear portion 32 of guide bracket 31 is slotted at ten points 33 (Fig. 5) to provide individual rear guide slots for the armatures 4. The upturned front portion 34 of the guide bracket is similarly slotted at points 35 to provide individual front guide slots for the armatures 4. As is shown best in Fig. 5, the front guide slots 35 extend rearwardly in the forward horizontal portion of guide bracket 36 to a point to the rear of the location of pivot rod 29 so as to receive the lower edge of the main portion of each armature 4. The intervening space between any armature 4 and return plate 1 serves as the return air gap for the concerned armature 4. The parts are preferably so dimensioned that only a small amount of this air gap (.010 inch, for example) remains after any armature 4 has fully operated to lie substantially parallel to return plate 1.

In the assembly of the device, the ten armatures 4 are placed in their respective slots in upstanding portions 32 and 34, and are then secured pivotally in place by sliding pivot pin 29 endwise into position. The part 36 is made of sufficiently thin stock that retaining arms 38 spring outwardly sufficiently to permit pivot rod 29 to be forced endwise into position, but are still rigid enough to retain the pin firmly in its illustrated assembled position.

C. *Front pole member*

Front pole member 3, comprising the illustrated laminations held together by rivets 26, may next be attached to the forward end of cores 12, by screws 16, along with bracket member 17, before the assembly including latches L2 to L0 has been attached.

As shown best in Fig. 3, the upper edge of pole member 4 is slotted to provide teeth 25 respectively underlying the armatures 4. This arrangement provides a higher concentration of flux between the pole member and the armatures than is afforded by a flat, common pole face, thereby increasing the tractive force on the armatures.

The openings in pole member 3 for screws 16 are slotted vertically to permit of vertical adjustment of the pole member. Preferably, a thickness gauge (.010 inch, for example) is inserted between armatures 4 and the forward portion of return plate 1. Then, armatures A1 and A10 may be held operated by hand against the thickness gauge to bring the lower edge thereof substantially parallel to return plate 1, and the pole member 3 may be brought directly into contact with the lower edge of these armatures. Screws 16 may be tightened firmly with the parts in this position, whereupon, the thickness gauge may be removed. All armatures will then be able to come directly into contact with the upper surface of pole member 3 despite normal manufacturing variations.

D. *The contact bank*

Contact bank 5 may next be assembled with return plate 1 by three screws 70 which pass downwardly through the bank and enter tapped openings in the return plate. This bank assembly is arranged to be held together as a preassembled unit by two screws 69, which pass downwardly through cap plate 68 and threadedly engage the comparatively thick base plate 51, within which they end. The intervening parts include comb 52 to which restoring springs 53 are integrally attached, base insulator strip 71, spacing insulator strip 65, and sub-assembly insulating strips 63, 64, 66, and 67 to which the the contact members are attached in layers. For example, as is seen best in Figs. 5 and 6, insulating strip 63 has individual contact blade 54 attached thereto at a pair of points 77, and has the laterally displaced contact plate 55 attached thereto at further points 77, wherefore parts 63, 54, and 55 comprise a preassembled strip which may be placed at the indicated position in the bank assembly as a unit. The preassembling operation is preferably accomplished by providing pairs of punched openings 76 in parts 54 and 55, and by using these openings as dies to cooperate with punch members employed at points 77 to semi-perforate strip 63 to force material therefrom into openings 76. The parts are thereby held together firmly enough for handling as a unit for assembly into the contact bank. Each of the other layers of contact members is similarly fixed with the concerned one of the insulating strips 64, 66, and 67.

The traveling blades 56 and 57 are preferably comparatively thin and are pretensioned (bent downwardly prior to assembly of the bank strips together) to exert the desired downward pressure to maintain closed the back contacts associated respectively with the ten blades 56.

Comb 52 and restoring springs 53 are preferably of thin material, and springs 53 are pretensioned, by being bent downwardly a substantial amount, to provide a sufficient, but comparatively light, downward restoring pressure on tails 39 of armature 4.

Fig. 7, which is a cross-sectional view through any traveling blade 56 and its attached stud 59, shows how studs 59 are attached to blades 56. Each such blade 56 has a depending tongue 61 struck downwardly therefrom. Each stud 59 has a hole vertically therethrough of a diameter slightly less than the width of tongue 61. When any such tongue 61 is forced into its stud 59, the resulting distortion of the insulating material (such as a suitable plastic or hard rubber) of the stud causes the parts to remain firmly in the illustrated assembled position. Studs 60 are fixed with traveling blades 57 in a similar manner. The openings in the forward ends of blades 57 resulting from striking down their tongues 61 may be seen in Fig. 1.

After the preassembled contact bank 5, with its ten forwardly extending sets of contact blades C1 to C10, and its rearwardly extending terminal portions 7, has been attached, by the three assembly screws 70, and before latch springs L2 to L10 are attached, the contact sets C1 to C10 may be adjusted for operation. The height of backstop portion 37 of pivot bracket 36 is preferably so chosen that a desired working air gap (.064 inch, for example) exists between any armature 4 and the upper face of pole member 3 when the armatures are held in their normal position by restoring springs 53. On the forward stroke of any armature, its traveling blade 57 engages its make-contact blade 58 when only a small amount of working air gap remains (.005 inch, for example). The thickness of the blades 58 is preferably such that the desired contact pressure is built up between blades 57 and 58 incident to a small deflection movement of the order stated. Since the front-contact blades 58 lie uppermost in the assembly, they are readily accessible for bending up or down to secure make-contact closure at the desired point in the armature travel.

On the forward stroke of any armature, its associated traveling blade 56 should separate from its underlying back-contact blade 54 slightly before the front contact controlled by the associated traveling blade 57 closes. Such separation may occur when, for example, .015 inch of the armature stroke remains. This adjustment is accomplished for the first stackup C1 by bending individual blade 54 upwardly or downwardly as desired. This can be accomplished after assembly by employing a suitable tool which grips blade 54 from the side near the base thereof, such as a "spring bender" commonly employed for adjusting the contact blades of telephone relays. Adjustment of the point at which the back contacts separate in contact sets C2 to C10 is controlled by raising or lowering the forward end of back-contact plate 55, seen best in Fig. 5, for this contact plate carries the nine back-contact points for the nine contact sets C2 to C10, being provided with a single rear terminal 55'. Raising and lowering the front edge of plate 55 is accomplished by bending upwardly or downwardly support arms 73 extending alongside the cutout portion 72. Plate 55 is strengthened along the front edge by having a downwardly offset rib 75 (Figs. 2 and 5) formed therein. The above-mentioned bending of arms 73 to accomplish the desired back-contact adjustment is facilitated by slots 74, Figs. 1 and 5, into which a suitable tool may be inserted which is thin enough to pass between the concerned contact sets.

As a result of adjustment of the contact sets C1 to C10 as described, a substantial clearance gap exists between the lower end of any stud 59 and the opposed face of restoring spring 53, wherefore any armature 4 executes a large portion of its forward stroke before engaging control stud 59. This arrangement provides considerable latitude in adjusting the latches L2 to L10 and their attached cam-spring portions 24.

E. *The latches*

Latches L2 to L10 may now be applied to the structure and adjusted. The latches may be formed of spring material having only sufficient rigidity to reliably resist substantial bowing under the downward pressure exerted by the armatures when latched thereby. Each latch includes a main latch portion 21, 22 and a laterally displaced rearwardly offset camming spring portion 24, connected to the main portion by the diagonally extending portion 23. Portions 24 of latches L3 to L10 lie directly behind the main portion of latches L2 to L9 respectively. In the embodiment of the device as shown in Figs. 1 to 7, L2 to to L10 may comprise separate members soldered or similarly secured to one or both of the plates 18 (Figs. 1 to 3). The two plates 18 may be riveted together at points 19. The latch assembly is secured to bracket 17 by three screws 20, and may be adjusted vertically before screws 20 are finally tightened by virtue of the clearance between such screws and the vertically elongated openings in parts 18 through which they pass. The adjustment is preferably such that a forward movement of any armature A2 to A10 on the order of .015 inch occurs before its notched portion 42 encounters the end of the associated latch 21, 22. Then any latched armature is brought to a stop by its associated latch when its unfinished forward stroke is on the order of .031 inch when the total stroke is as previously indicated.

The final adjustment steps with respect to the latches L2 to L10 include bending the lower portion 21 of each inwardly or outwardly near the base portion to insure that the upper portion 22 thereof (see Figs. 2 and 10 to 12) lies snugly against the face of vertical stop portion 41 of its associated armature 4, but with only the desired relatively light tension, and includes bending camming spring portion 24 inwardly or outwardly to a point where operation of the concerned preceding armature results finally in the forward movement of the top of the main portion of any latch member just sufficiently to reliably unlatch the associated armature. When this adjustment has been accomplished, no camming portion 24 is engaged by the camming surface 40 of the concerned armature until such armature has completed a large portion of its total forward stroke.

F. *Alternate latch construction*

Figs. 8 and 9 show an alternate construction wherein assembly of the latches between strips 18 of Figs. 1 to 3 is facilitated by forming the five even-numbered latches L2 to L10 in one piece with a common interconnecting member as shown in Fig. 8, and by forming the four odd-numbered latches L3 to L9 in one piece with a further common interconnecting member as shown in Fig. 9. Each of the common interconnecting members is provided with a pair of openings 9 to receive rivets 19 through which they may be preassembled with strips 18, and each is provided with vertically elongated openings 10 through which assembly screws 20 may pass.

In the construction as shown in Figs. 8 and 9, the latches may be formed of somewhat thinner material than in the construction shown in Figs. 1 to 3 because of the stiffening effect of raised rib portions 8. Such rib portions strengthen the main portion of each latch member, while leaving their camming side-arm portions of unimpaired flexibility. Each stiffening portion 8 ends a short distance above the base of the latch, leaving a flexible hinge portion 45 to permit the latch to swing out readily when released as described.

It will be understood, of course, that one of the parts shown in Figs. 8 and 9 is laid over the other, with corresponding openings 9 and 10 aligned. The main portions of latches L3 to L9 then lie in front of the laterally-and-rearwardly offset camming side arms of latches L4 to L10,

respectively, as is shown in Figs. 1, 3, and 5. The camming side arms of latches L3 to L8 lie behind latches L2 to L8, respectively.

G. *The counting operation*

It will be noted that electromagnets 2 are connected magnetically in parallel between return plate 1 and pole member 3. The impulse windings of these two magnets are intended to be so interconnected (in series, for example) that the arrival of an impulse to be counted results in the energization of both electromagnets 2 in the same sense, whereby they both present the same polarity of magnetomotive force to pole member 3.

Normally, the armatures 4, pole member 3, and the latches such as L2 are relatively positioned about as indicated on an enlarged scale in Fig. 10.

G1. *First impulse begins*

On the receipt by electromagnets 2 of the first magnetizing impulse of a series, each of the armatures A1 to A10 is thereby attracted downwardly by the resulting magnetization of pole member 3. Each armature is held in normal position only by the relatively light restraining force of restoring springs 53, keeping in mind that a substantial clearance normally exists between each restoring spring 53 and its overlying control stud 59, and that a substantial clearance normally exists between each camming arm 24 and the camming face 40 of its associated armature. Accordingly, all armatures 4 start to move substantially together.

Before any armature has moved sufficiently to encounter either its associated contact-control stud 59 or its associated camming spring portion 24, the forward movement of each armature A2 to A10 is arrested, by the slightly undercut latch portion 42 thereof coming into contact with the upper end of the main portion of its associated latch L2 to L10. The first armature A1, however, having no latch, continues its forward movement until it comes into engagement with pole member 3 as shown in Fig. 11.

As the movement of the first armature A1 continues from the point in its travel at which the slight forward premovement of the latched armatures A2 to A10 is arrested, its camming face 40 engages the upper end of the associated camming spring arm 24 of latch L2. This engagement may occur at midtravel of the armature, or slightly before. The further movement of armature A1 toward its final fully operated position causes the upper end of camming spring arm 24 to be moved forwardly. This forward movement is accompanied by a flexing of arm 24 and by a similar flexing of the upper portion 22 of latch L2, resulting in latch L2 assuming a position substantially as is indicated in Fig. 11. The downward force being exerted on the upper end of latch L2 by portion 43 of armature A2 holds the latch in the tensioned condition indicated in Fig. 11 so long as the operating impulse endures. This holding action is enhanced by notching the lower surface of the forward portion of the armatures to provide the illustrated retaining hook against which the latch engages when it tends to move forward in notch 42. This hook arrangement counteracts any tendency for the wave motion set up by the outward camming action to whip the free end of the latch forward.

With the parts relatively adjusted according to the previous description, when armature A1 has completed about two-thirds its stroke, its tail portion 39 brings restoring spring 53 into contact with the stud 59, thereby immediately lifting traveling blade 56 from in engagement with the relatively rigid underlying blade 54, thereby opening the back contact represented by these two blades.

Just before armature A1 completes its stroke, stud 60 forces traveling blade 57 into engagement with the associated comparatively rigid blade 58, thereby closing the front contacts represented by blades 57 and 58.

G1*a*. *First impulse ends*

When the first impulse ends, armature A1 is held in its fully operated position by the residual magnetism which it retains by virtue of the composition and treatment of the material of which it is composed, notwithstanding the restoring pressure at that time exerted by the combined action of its restoring spring 53 and associated contact blades 56 to 58, and the slight restoring action of arm 24 of latch L2. Each of the remaining armatures A2 to A10, however, not having been permitted to come close to pole member 3, is immediately restored through the short distance required to reengage upstanding backstop portion 37 of pivot bracket 36. Incident to the restoring action of armature A2, and to the consequent release of the restraining force previously applied to the upper end of latch L2 by the slightly overhanging hook portion of the armature, parts 22 and 24 of latch L2 immediately straighten out to move the upper end of latch portion 22 outwardly to a position such as is indicated in Fig. 12, wherein it is out of reach of armature A2. Latch L2 is maintained in this position thereafter until the device is cleared out.

G2. *Second impulse begins*

At the beginning of the second impulse of the series, the already operated armature A1 is attracted still more firmly, and each of the unopened armatures A2 to A10 starts to move toward pole member 3 as previously described. Each of the armatures A3 to A10 is arrested (each by its associated one of the latches L3 to L10) after it is moved only the previously described short distance, but armature A2 operates fully at this time as previously described for armature A1, its associated latch L2 having been moved outwardly, as described, to a position such as is shown in Fig. 12.

Incident to its above-noted complete movement, armature A2 flexes latch L3 as described for armature A1 and latch L2, thereby preparing to unlatch armature A3. Additionally, armature A2, through its tail portion 39, actuates the contact members in contact set C2 as described for armature A1 and contact set C1.

G2*a*. *Second impulse ends*

When the second impulse of the instant series ends, the upper portion 22 of latch L3 is thereby released, permitting such latch to spring outwardly to an ineffective position such as is illustrated in Fig. 12 for latch L2.

G3. *Succeeding impulses*

As the succeeding impulses of the series arrive, the armature 4 corresponding to any such impulse operates as previously described and tensions the associated latch preparatory to the unlatching of the next succeeding armature when such impulse ends. The counting operation is thereby continued as described. The device is

capable of counting the impulse of a series equal in number to the number of armatures 4, ten being provided in the illustrated example.

G4. *Clearing out*

When the operated counting device is to be cleared out, the electromagnets 2 are given a mild reversed magnetization to neutralize the residual magnetism of the operated armatures 4, which restore immediately by virtue of the stored downward tension in the operated ones of the contact sets C1 to C10, assisted by the light restoring tension of restoring springs 53.

H. *The system of Fig. 13*

Fig. 13 illustrates use of the improved counting device in a simple signaling system. In this system, the counting device is illustrated in circuit diagram within the rectangle labeled "Counter," and a relay group for controlling the operation of the system is shown within a further rectangle labeled "Control Circuit." The impulse counter is controlled over line 100, through the illustrated control circuit, to light signal lamps S1 to S10 selectively. The control is exercised from a remote control station, including the switch key SK and calling device CD. Calling device CD can transmit a series containing from one to ten interruption impulses, being of the type usually employed in automatic telephone systems.

In the control circuit, relay 101 corresponds to the line relay customarily employed in automatic telephone systems; relay 102 corresponds to the slow-restoring release relay; and relay 103 is a slow-operating start relay which refrains from operating until a transmitted series of impulses has terminated.

Electromagnets 2 are each shown in Fig. 13 as having two differentially connected windings. The lower winding is the one which receives impulses to be counted, while the upper one is the relatively low-powered demagnetizing winding used for clearing out the device.

Assume now that a desired one of signal lamps S1 to S10 is to be lighted to display a corresponding signal. This operation is effected from the control station by first closing key SK and then manipulating calling device CD to transmit a corresponding series of interruption impulses over line 100. Line relay 101 responds to the closure of key SK by operating release relay 102 to prepare an impulse circuit for the counter. Being slow restoring, release relay 102 remains operated throughout the series of restorations of line relay 101 incident to the assumed operation of calling device CD.

Line relay 101 restores momentarily each time calling device CD interrupts line 100. Each time it does so, it closes a circuit for the impulse windings of electromagnets 2, by way of the front contact of the armature of the operated release relay 102. The impulses thus delivered to electromagnets 2 causes a counting operation to occur as hereinbefore described. Accordingly, concerned ones of contact sets C1 to C10 are actuated successively, beginning with contact set C1.

Upon the actuation of contact C1 (separation of its members 54 and 56, and closure of its members 57 and 58) incident to the receipt of the first impulse of the series, a circuit is prepared for slow-operating start relay 103. This circuit is closed momentarily upon each reoperation of line relay 101 during the transmission of the impulse series. Being slow restoring, start relay 103 does not respond to these momentary closures of its circuit, but delays until its circuit is closed relatively permanently, when line relay 101 comes to rest in an operated condition at the end of the impulse series.

Upon operating, at the end of the transmitted impulse series, start relay 103 closes a self-locking circuit at its lower contacts, independent of the lower contacts of line relay 101; prepares a clearout circuit for the counter at its upper contacts; and at its inner upper contacts, it applies ground potential to the signal conductor extending to the counter, thereby completing a lighting circuit for the one of the signal lamps S1 to S10 which corresponds to the last-operated one of the contact sets C1 to C10.

If, for example, the received impulse series contained only a single impulse, only contact set C1 has been operated. In this event, lamp S1 is lighted in a circuit through the contact member 55 (common to contact sets C2 to C10) and the associated contact member 56 in contact set C2. On the other hand, if two impulses have been received, contact C2 is operated along with contact set C1. Then, lamp S1 is disconnected (by the separation of member 56 from member 55), and lamp S2 is substituted, being connected to common member 55 by way of members 57 and 58 of contact set C2 and member 56 of contact set C3.

Operation of any succeeding contact set C3 to C10 results in the disconnection of the signal lamp associated with the preceding contact set and in the substitution of the locally associated signal lamp.

When the system of Fig. 13 is to be cleared out, switch key SK is reopened, permitting line and release relays 101 and 102 to restore successively. Incidentally, a further actuating impulse is delivered to the impulse counter during the interval required for relay 102 to restore following the restoration of relay 101 which may be avoided, when desired, by providing a pair of normally closed contacts on start relay 103 in series with the impulse windings of electromagnets 2.

Start relay 103 remains operated (through the upper contacts in set C1, and through its own lower contacts) notwithstanding the restoration of line relay 101. With relays 101 and 102 both restored, a clearout circuit exists through the upper contacts of relays 101 to 103 for the low-power demagnetizing windings of electromagnets 2. Responsive to the flow of current through these windings, the counting device clears out as previously described, all operated ones of the contact sets C1 to C10 returning to their illustrated normal condition. When this occurs, the opening of the upper contact pair in set C1 causes start relay 103 to restore to open the clearout circuit, returning the system of Fig. 13 to its illustrated normal condition.

I. *The modified device*

Figs. 14 and 15 show the front portion of the modified device, the rear portion being the same as that of the described embodiment. In the modified device, production and adjustment are facilitated by providing the latches and cam springs as separate structures. Additionally, the tendency for wave motion set up by the camming operation to cause premature unlatching is overcome by arranging the cam springs to hold the latches in effective position, and to release them in sequence, instead of impelling them toward unlatched position.

The armatures of the modified device are re-

ferred to collectively as 104, and individually as A101 to A110. The forward end of each such armature is modified, as illustrated, to conform with the modified latching-control arrangement.

Armatures A102 to A110 are provided respectively with latches L102 to L110. Each latch is outwardly tensioned so as to cause it to stand forwardly out of reach of the armature (see Fig. 20), unless restrained. Normally, the latches are respectively held in effective latching position by the inwardly tensioned cam springs C101 to C109.

Referring to Figs. 14 and 15, latch bracket 117 is similar to bracket 17 of the previously described embodiment, and is tapped to receive two additional screws, 180, provided to permit the latches to be assembled and adjusted before the cam springs are applied. The common portion connecting latches L102 to L110 together (Fig. 16) is placed between plates 181 and 182 and assembled to bracket 117 by two screws 180 whose heads are countersunk into plate 182. The latches may be adjusted vertically before screws 180 are tightened by virtue of the vertically elongated openings 190 (Fig. 16) through which screws 180 pass. Additionally, the assembled latches may be inspected to see that each, when unrestrained, stands forwardly out of effective latching position slightly more than is shown in Fig. 20 for latch L102.

The cam-spring assembly of Fig. 17 is next assembled between plates 182 and 118, and held by three screws 120. Vertical adjustment of the cam springs is permitted by elongated openings 110 before screws 120 are fully tightened.

Upon assembly, the cam springs may be inspected for sufficient light inward tension (resulting preferably from controlled preforming) to reliably bring their respective latches rearwardly to the effective position shown in Figs. 14 and 18.

The latches and cam springs may be provided with raised stiffening rib portions 108 and 108'.

Referring particularly to Fig. 15, the first cam spring (C101) is aligned with the first armature (A101), and the final cam spring is aligned with the pre-final armature, the ninth. On the other hand, the first latch (L102) is aligned with the second armature (A102), and the final latch is aligned with the final armature, the tenth. There is no latch for the first armature, nor is there then a cam spring for the final armature.

As seen in Figs. 15 and 17 each cam spring C101 to C109 has a side extension tab 186 attached thereto near the upper end thereof, extending to the right. Each such tab overlies, and normally engages the forward end of a tab 185 (Figs. 15 and 16) sheared forwardly from a side portion extending to the left from the latch underlying the next succeeding armature. This simple coupling arrangement permits the cam spring controlled by any armature to control the latch for the next succeeding armature, keeping in mind that each latch is pretensioned outwardly by a slight amount, while the cam spring which controls it is pretensioned inwardly slightly more.

J. *Operation*

With the device in its illustrated normal position, each cam spring is holding its associated latch inwardly against face 141 of its associated (see Fig. 18). The upwardly and outwardly inclined end portion of each cam spring is then somewhat out of contact with the rounded cam-control portion 140 of the associated armature, so as to delay the start of the unlatching motion for reasons discussed in connection with the previously described embodiment.

The first impulse of a series causes all armatures to start toward operated position. Each armature except the first is arrested, after moving only a short distance (see Fig. 18), when the upwardly and inwardly inclined shoulder portion 142 thereof encounters the end of its associated latch.

The first armature (A101), however, having no latch, moves unhindered to reach its fully operated position as shown in Fig. 19. Portion 140 of this armature engages the cam portion of the first cam spring C101, moving it forwardly to the position shown in Fig. 19.

So long as the first impulse endures, the outwardly tensioned first latch L102 cannot follow the outward movement of its controlling cam spring (C101) because held by the contact through which it latches armature A102 against operation.

When the first impulse ends, fully operated armature A101 remains operated, held by residual magnetism, but the remaining armatures restore, moving back through the slight distance separating latch position from normal position, removing effective pressure from their respective latches. Latch L102 being then unrestrained, since its control cam spring C101 has been moved forwardly, moves to its ineffective position shown in Fig. 20, thereby unlatching the second armature to enable it to operate fully responsive to the second impulse.

The operation responsive to the second and succeeding impulses is in conformity with the foregoing, each armature operating fully in its turn.

The device is cleared out as hereinbefore described.

I claim:

1. 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 member and serving to move it from its normal position to its operated position unless the member is restrained from so moving, a separate latch for each member except the first normally interposed in its path and effective to latch it from moving to operated position responsive to any said impulse, and means responsive to the movement to operated position of any said member preceding the last, and further responsive to the termination of the concerned moving impulse, for inducing relative lateral movement between the next succeeding member and its said latch to place such latch laterally out of the path thereof.

2. 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 member and serving to move it from its normal position to its operated position unless the member is restrained from so moving, a separate means for each member except the first normally interposed in its path and effective to latch it from moving to operated position responsive to any said impulse, and means responsive to the

movement to operated position of any said member preceding the last, and further responsive to the termination of the effect of the concerned moving impulse on the next succeeding member, for inducing relative movement between the latter member and its said latch to render such latch ineffective.

3. 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 member and serving to move it from its normal position to its operated position unless the member is restrained from so moving, a separate latch for each member except the first normally interposed in its path and effective to latch it from moving to operated position responsive to any said impulse, and means controlled jointly by any member preceding the last and by the next succeeding member for rendering the latch of the latter member ineffective responsive to the termination of the operating impulse of the former member.

4. 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 member and serving to move it from its normal position to its operated position unless the member is restrained from so moving, a separate latch for each member except the first normally interposed in its path and effective to latch it from moving to operated position responsive to any said impulse, and means controlled by said members as the operating impulses arrive and subside for inducing relative lateral movement between the latched members and their respective latches successively to unlatch the latched members in timed relationship to the impulses.

5. In an impulse-counting device, a series of impulse-counting armatures each having a normal position and an operated position, means common to all said armatures for imparting a series of impulses of magnetic force thereto, each said impulse acting similarly upon each unoperated armature and constituting a thrust serving to move it from its normal position to its operated position unless the armature is restrained from so moving, means for restraining each armature except the first from moving to its operated position responsive to any said thrust, means responsive to the movement to operated position of each armature except the last for storing spring tension subject to release responsive to the cessation of the accompanying thrust imparted to the next succeeding armature, and means responsive to the said release of spring tension for removing the said next succeeding armature from under the control of said restraining means.

6. In an impulse-counting device, a series of impulse-counting armatures each having a normal position and an operated position, means common to all said armatures for imparting a series of impulses of magnetic force thereto, each said impulse acting similarly upon each unoperated armature and constituting a thrust serving to move it from its normal position to its operated position unless the armature is restrained from so moving, a separate latch for each armature except the first for restraining it from moving to its operated position responsive to any said thrust, normally untensioned springs operatively associated respectively with said latches, each such spring being effective to move its associated latch to an ineffective position when tensioned, means responsive to the movement to operated position of each armature except the last for tensioning the spring associated with the latch for the next succeeding armature, the accompanying thrust imparted to the said next succeeding armature acting to prevent the associated latch from moving before the current impulse subsides.

7. In an impulse-counting device, a series of impulse-counting armatures each having a normal position and an operated position, means common to all said armatures for imparting a series of impulses of magnetic force thereto, each said impulse acting similarly upon each unoperated armature and constituting a thrust serving to move it from its normal position to its operated position unless the armature is restrained from so moving, a separate latch for each armature except the first for restraining it from moving to its operated position responsive to any said thrust, means responsive to the movement to operated position of each armature except the last for applying spring tension to the latch for the next succeeding armature effective to move such latch to an ineffective position when no longer restrained, the accompanying thrust on the last-named armature serving to restrain the tensioned latch from so moving until the current impulse subsides.

8. In an electromagnetic structure, a generally rectangular magnetic structure, an L-shaped return plate comprising the rear limb and the principal portion of the upper limb of the structure, electromagnet means comprising the lower limb, a pole member comprising the front limb, a series of armatures arranged side by side and turnably supported on the return plate comprising the remaining portion of the upper limb, the armatures extending forwardly beyond the pole member, a series of armature latches yieldingly secured to the structure in front of the pole member and extending upwardly thereacross to latchingly engage the respective armatures except the first, and means controlled by movement of said armatures incidental to successive energizations of said electromagnet means for moving the latches successively forward out of latching engagement with their respective armatures.

9. In an electromagnetic counting device having armatures operable successively to count the respective impulses of a series, each impulse comprising an operating force applied similarly to each unoperated armature, a separate latch member for each armature except the first for preventing armature operation when in effective position, each latch member being biased to assume an ineffective position unless held in effective position, a holder for each latch serving normally to hold it in effective position, means responsive to the operation of any armature incident to an impulse for moving the holder for the latch associated with the next succeeding armature to an ineffective position, any such next succeeding armature serving thereafter to hold its associated latch in effective position so long as the instant impulse endures and to release such latch at the termination thereof.

10. In a counting device as set forth in claim 9, the armatures being supported in a horizontal row for individual downward counting movement,

the latch members comprising a row of upwardly extending spring blades supported along a horizontal row underlying the front end of the armatures and tensioned toward an ineffective forward position, the holding means comprising a row of similarly supported upwardly extending blades overlappingly disposed in front of the row of latch blades and tensioned rearwardly to hold their respective latch blades rearwardly in an effective latching position, each armature except the last having a portion which cammingly engages a holding blade during operation and moves it forwardly out of contact with its associated latch blade.

JOHN I. BELLAMY.

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