Dec. 14, 1948. J. I. BELLAMY 2,456,169

ELECTROMAGNETIC COUNTING DEVICE

Filed Jan. 12, 1946 4 Sheets-Sheet 1

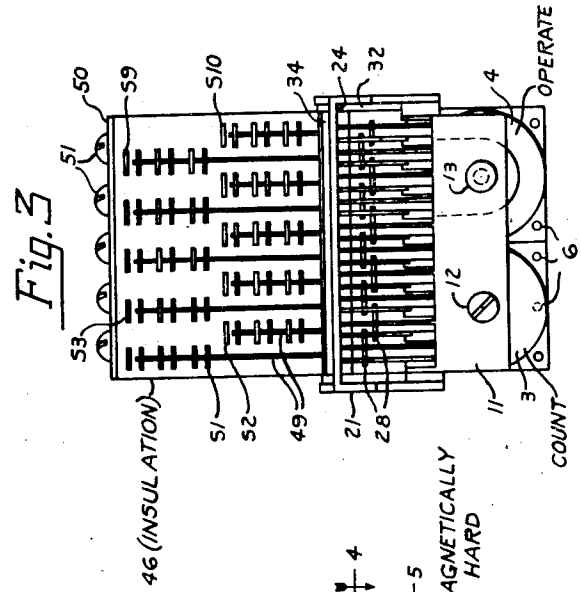


Fig. 3

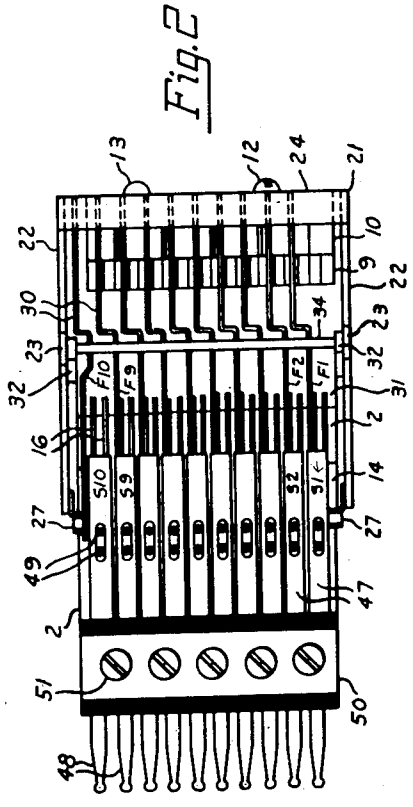


Fig. 2

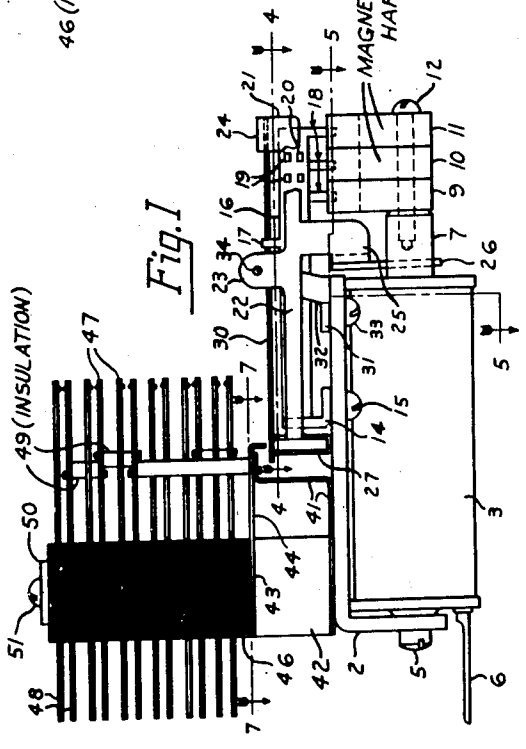


Fig. 1

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ELECTROMAGNETIC COUNTING DEVICE

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Fig. 4

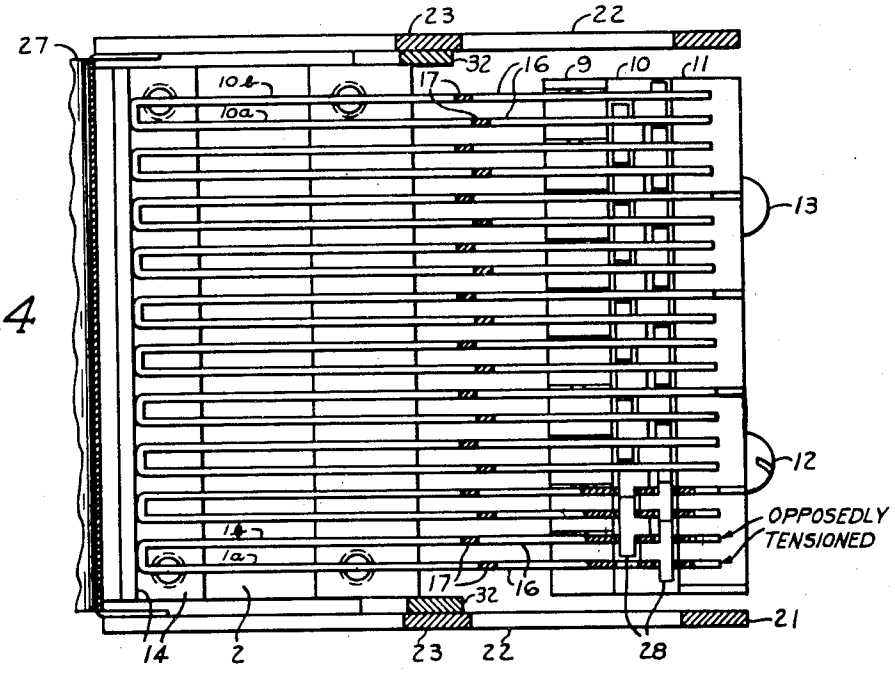
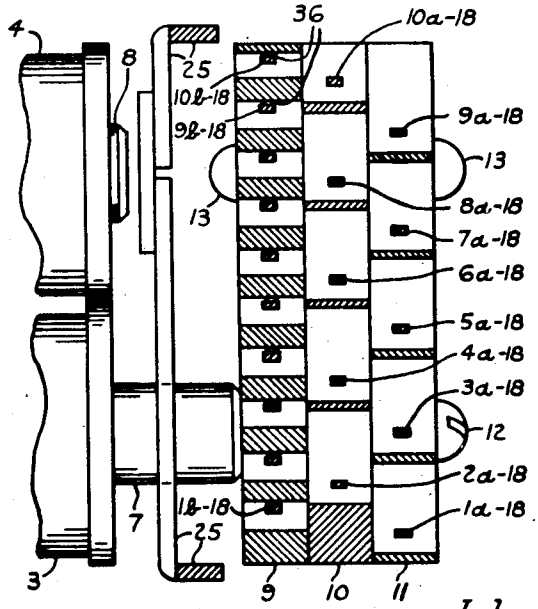


Fig. 5



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ELECTROMAGNETIC COUNTING DEVICE

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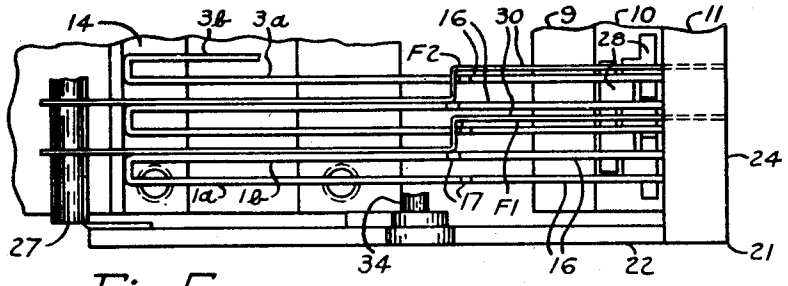


Fig. 6

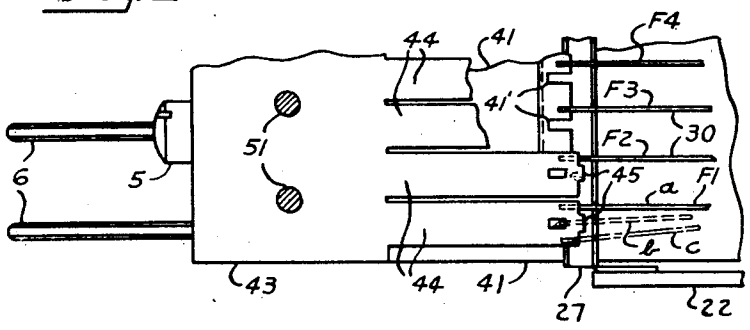


Fig. 7

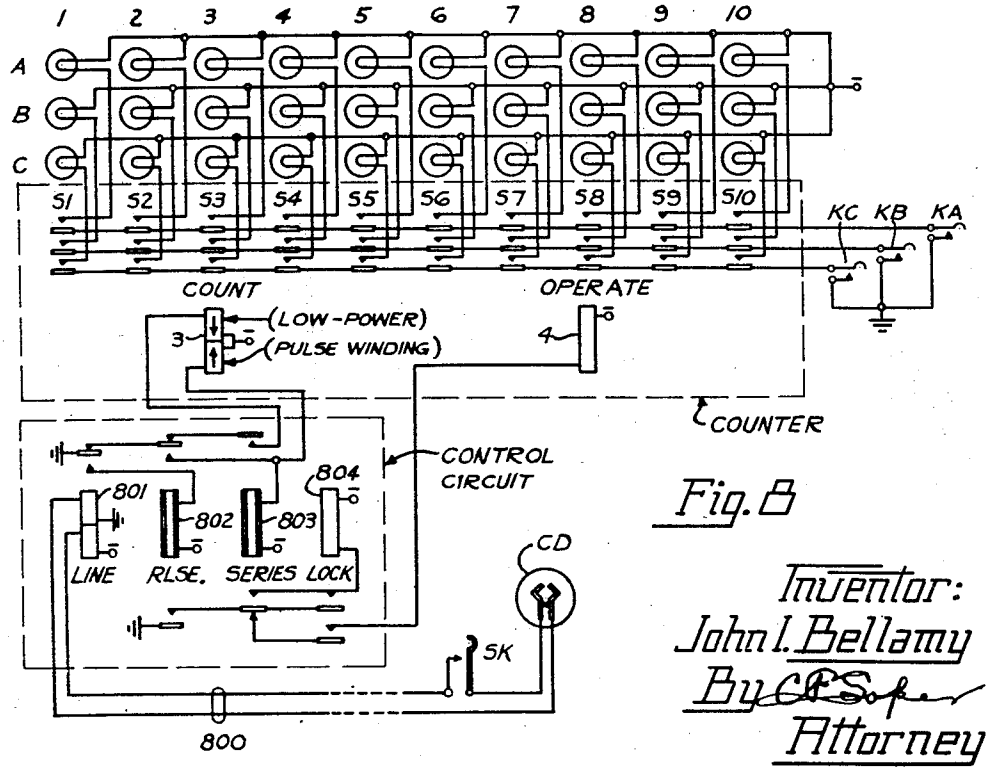


Fig. 8

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ELECTROMAGNETIC COUNTING DEVICE

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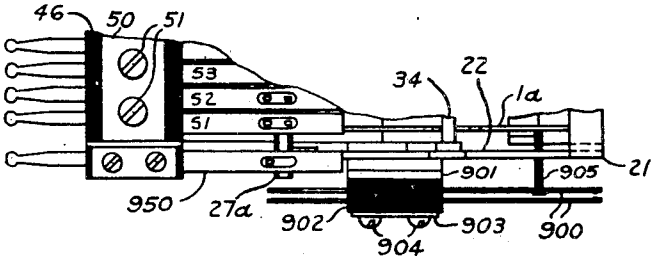


Fig. 9

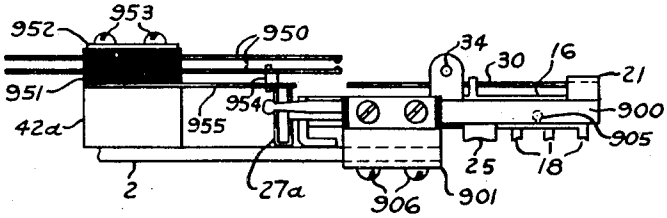


Fig. 10

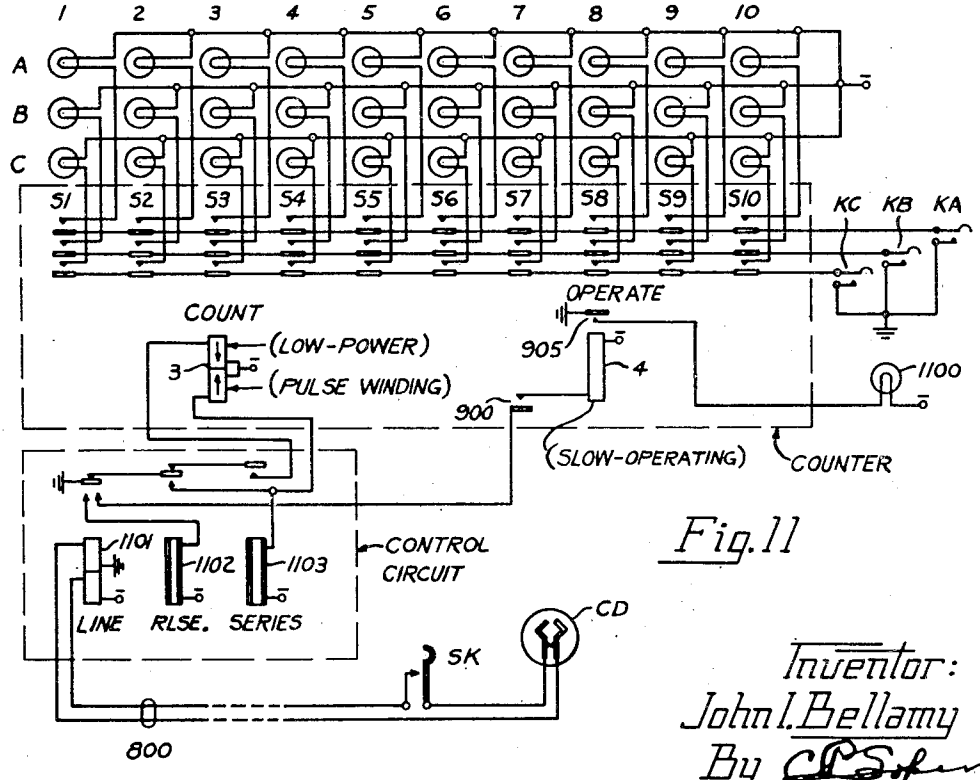


Fig. 11

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UNITED STATES PATENT OFFICE

2,456,169

ELECTROMAGNETIC COUNTING DEVICE

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

Application January 12, 1946, Serial No. 640,797

10 Claims. (Cl. 177—353)

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This invention relates to electromagnetic counting devices. Its object is to provide a simple, reliable, and compact electromagnetic counting device employing a local source of power to actuate a set of electrical contacts selected according to the number of electrical impulses received, whereby the power required for actuating a selected contact set bears no particular relationship to the power required to be expended in the controlling electrical impulse circuit.

A feature of the invention is that a set of successively operable counting members is electromagnetically controlled to count the number of impulses in a received series and to select, without operating, the corresponding one of a series of sets of contacts, following which actuating power is locally applied to actuate the selected set.

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

The accompanying drawings, comprising Figs. 1 to 11, illustrate a preferred embodiment of the invention and a desirable modification thereof; Figs. 1 to 8 pertain to the unmodified arrangement, while Figs. 9 to 11 pertain to the modified form.

It has been chosen to illustrate the invention as applied to a structure of the general form disclosed in my prior application for Electromagnetic counting devices Serial No. 493,312, filed July 2, 1943, now U. S. Letters Patent 2,441,001, dated May 4, 1948, but employing a system of counting members operating more nearly in accordance with my further application for Electromagnetic counting devices Serial No. 612,689, filed August 25, 1945.

Figs. 1, 2, and 3 are respectively a left-side view, a top view, and a front view, of the basic embodiment of the invention.

Fig. 4 is an enlarged top sectional view of the device of Figs. 1 to 3 taken generally along the line 4—4 of Fig. 1, with the rear portion of the device omitted.

Fig. 5 is an enlarged top sectional view of the front portion of the device of Figs. 1 to 3 taken along the line 5—5 of Fig. 1.

Fig. 6 is an enlarged top view of the left-hand front portion of the device of Figs. 1 to 3, showing more clearly the progressive action of the selecting fingers.

Fig. 7 is an enlarged top sectional view of the left-hand rear portion of the device of Figs. 1 to 3, taken generally along the line 7—7 of Fig. 1, showing more clearly how the desired one of the several sets of contacts is selected by the

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progressive action of the select fingers during the receipt and counting of impulses.

Fig. 8 is a circuit diagram of a simple signalling system in which the counting device of Figs. 1 to 3 is of utility.

Fig. 9 is a top view of the left-hand side of the device of Figs. 1 to 3 modified by the addition of what may be termed off-normal contact set 900 and 950.

Fig. 10 is a left-side fragmentary view of the device according to Fig. 9, further illustrating how the added contact sets 900 and 950 are applied to the structure.

Fig. 11 is a circuit diagram of a system generally according to Fig. 8 but modified and simplified to incorporate the modified counting device of Figs. 9 and 10.

Construction—Basic device

Referring first to the basic device as illustrated in Figs. 1 to 3, with the aid of auxiliary views of Figs. 4 to 7, the device is assembled around an L-shaped part 2 of magnetic material, commonly termed a heel plate. A pair of electromagnets 3 and 4 are secured to the heel plate, as by screws 5, and have terminals 6 extending to the rear of the device.

Electromagnet 3 may be termed the count magnet in that it has a winding which receives the impulses to be counted, while electromagnet 4 may be termed the operate magnet in that it is energized to bring about operation of a contact set selected by the counting operation.

The iron core 7 on which the winding of count magnet 3 is wound, extends forwardly as shown clearly in Fig. 1 and has three magnetic operate yokes 9 to 11 attached thereto by screw 12. As shown best in Figs. 3 and 5 these yokes are further secured together by rivet 13.

Operate magnet 4 has a considerably shorter iron core 8, which attracts armature 26 when the magnet is energized.

Pursuant to counting the impulses received by count magnet 3, ten pairs of counting armatures 16 are provided, as shown best in Fig. 4, the number of pairs of armatures being equal to the maximum number of impulses in a series to be received and counted. For convenience, the counting armatures 16 are labeled 1*a*, 1*b*, 2*a*, 2*b*, and so forth to 10*a* and 10*b*. Each such pair of armatures takes the form of a flat magnetic reed bent to a U-shape. The two arms of any such reed comprise the two counting armatures of the concerned pair. These U-shaped reeds are secured at the rear to magnetic bracket 14, as by welding

which bracket is secured to heel plate 2 by a pair of screws 15.

During the counting operation, the twenty counting armatures 16 move successively to the right, one such armature for the beginning of any impulse and another at the termination thereof, each such armature remaining in its alternate position thereafter until the device is cleared out.

The armatures 16 are normally held uniformly spaced from each other by spacing studs 28 arranged as shown best in Fig. 4, considered in connection with Fig. 1. Studs 28 may be brass or other non-magnetic material. Each spacing stud 28 has an intermediate laterally offset spacing portion lying between its end portions. The end portions lie loosely within openings in armatures 16. Each armature 16 has an upper pair of openings 19 (Fig. 1) for this purpose, and a lower pair 20. When the separation studs 28 are placed in position, starting at one end of the row, the first pair is placed within the upper openings 19 of the concerned armature 16; the second pair within the lower pair of openings 20 in the concerned armatures; the third pair within the upper openings 19; and so forth. Such an arrangement of separation studs 28 avoids the necessity of a riveting, welding, or a similar operation. The provision on the two sets of retaining openings 19 and 20 enables a compact arrangement to be adopted, which permits a comparatively great movement of one armature with respect to the next without the danger of the concerned separation stud 28 dropping out of position.

Each counting armature 16 has an upwardly extending tab 17 for selection-controlling purposes, and a downwardly extending tab 18 for operational purposes. The downwardly extending tabs 18 operatively lie along side of the upwardly extending pole portions of magnetic yokes 9, 10, and 11, as shown by Figs. 1 and 5, considered together.

The rear yoke 9 may be termed the retaining yoke, and is preferably made of magnetically soft material. The yokes 10 and 11 may be termed operate yokes, and are preferably made of magnetically hard material to the end that any armature 16 attracted into engagement with an upwardly extending pole portion thereof is further held in its operated position by residual magnetism. Yoke 10 may be further termed the even-operate yoke in that it pertains to the operation of even-numbered ones of the counting armatures 16, while yoke 11 may be termed the odd-operate yoke in that it pertains to the operation of odd-numbered ones of the counting armatures 16.

As is indicated by the note associated with the first pair of counting armatures 16 (armatures 1*a* and 1*b*), the two armatures 16 of any pair are opposedly tensioned. For example: armature 1*b* is so tensioned that, when unrestrained, it will move to the left to a sufficient distance to execute its counting movement. On the other hand, the other armature (1*a*) of the same pair is tensioned in the opposite direction with sufficient strength to overcome the noted tension of armature 1*b* and restore it to its illustrated normal position, the restoring action being accomplished through the concerned one of the spacing studs 28.

The counting operation

At this point, the operation of counting armature 16 during the receipt of a series of impulses (ten impulses for example) by count magnet 3 will be described. Each time magnet 3 becomes

energized, yokes 9, 10, and 11 correspondingly become magnetized with respect to the return heel plate 2, to which the rear end of armatures 16 are magnetically connected through magnetic counting bracket 14. Each time magnet 3 becomes deenergized, yokes 9 to 11 responsively become demagnetized, except that the upwardly extending pole portions of magnetically hard yokes 10 and 11, tend to retain such magnetic flux as may have passed through any one of them incident to a depending tab 18 of a counting armature having been attracted into engagement therewith.

The first impulse begins

When the first impulse of a series is received by count magnet 3, the resulting magnetization of yoke 9 and the upwardly extending pole portions thereof, attracts each depending tab 18 of the second (or *b*) armature 16 to the right, holding each of the counting armatures 1*b*, 2*b*, and so forth in normal position. As shown in Fig. 5, a non-magnetic piece 36 may be attached to each concerned depending tab 18 to form a normal residual cap between it and the associated face of restraining yoke 9, to the end that any concerned armature will not be held in normal position between impulses by residual magnetism.

As a further result of the arrival of the first impulse, the consequent magnetization of odd operate yoke 11 causes the first upstanding pole thereof to attract the first armature (1*a*) to the left, through the medium of its depending tab 1*a*—18 Fig. 5. The remaining *a* armatures are at the same time urged toward operated position (to the left), by their respective depending tabs 18. These tabs are the *a* tabs 2*a*—18 to 10*a*—18. None of the remaining *a* armatures however can respond at this time because each of them is held in normal position by its immediately preceding *b* armature, all *b* armatures being held in normal position as previously described by the interaction between tabs 1*b*—18 to 10*b*—18 and restraining yoke 9.

First impulse ends

When the first impulse ends, yokes 9, 10, and 11 respectively demagnetize, except that the upstanding pole portion of yoke 11, engaged by the leftward movement of depending tab 1*a*—18 of the first armature 1*a*, retains sufficient magnetic flux to hold armature 1*a* in its operated position.

As a further result of the end of the first impulse, restraining yoke 9 no longer restrains armatures 1*b* to 10*b*. Armature 1*a* being held in operated position as described, armature 1*b* now moves to the left to the same extent that armature 1*a* has been moved. Such movement occurs by virtue of the stored tension of armature 1*b*, and carries the armature to its fully operated position. None of the remaining armatures 16 moves at this time. For example, armature 2*a* does not move since the release movement of its immediately preceding armature 1*b* occurs between impulses, at a time when count magnet 3 and the attached yokes 9 to 11 are deenergized.

Second impulse begins

When the second impulse is received, yokes 9 to 11 are again operatively magnetized. The magnetization of restraining yoke 9 is effective at this time to restrain armatures 2*b* to 10*b* against movement, but has little effect on armature 1*b*, whose depending tab 1*b*—18 has now moved to operated position, where substantially

the only effect on it is to hold it more firmly in operated position.

Armature 1b having executed its counting movement, between the end of the first impulse and the beginning of the second, armature 2a now executes its counting movement responsive to the magnetic force exerted on its depending tab 2a—18 by its associated pole face of even operate yoke 10. None of the remaining counting armatures moves at this time for reasons similar to those previously stated in connection with the first impulse.

Second impulse ends

At the end of the second impulse, yokes 9 to 11 are again deenergized. The concerned upwardly extending pole portion of yoke 10 retains sufficient magnetic flux to hold the second armature operated through its depending tab 2a—18. With armature 2a in operated condition the demagnetization of restraining yoke 9 at the end of the second impulse permits armature 2b to move to the left into operated position, the action being similar to the action that described the movement of armature 1b at the end of the first impulse.

Succeeding impulses

As the succeeding impulses of the series are received by count magnet 3 and yokes 9 to 11, the succeeding armatures 16 operate successively, the next succeeding *a* armature moving to the left, to operated position, at the beginning of each impulse, and the next succeeding *b* armature moving to the left, into operated position, at the end of the impulse.

It may be here mentioned that, if desired, yokes 10 and 11 may be made of magnetically soft material provided the counting armatures are constructed of material with sufficient magnetic hardness that they remain thereby operated by residual magnetism after their respective operating impulses have subsided.

Contact set selection

Depending upon the number of impulses in a received series, as determined by the counting operation of armatures 16, one or another of the contact sets, S1 to S10, of the device is to be selected pursuant to its subsequent operation responsive to energization of operate magnet 4. To this end, ten select fingers 30 are provided as seen in Figs. 1 and 2. For convenience, these fingers are labeled F1 to F10, there being a separate one for each pair of counting armatures 16, or a separate one for each of the contact sets, S1 to S10. The select fingers 30 may take the form of pieces of wire of the configuration indicated in Figs. 2 and 6. Each such finger may be mounted on the structure by being attached underneath cross member 24 of the pivoted operating structure 21. As will be hereinafter explained more fully, each of the contact sets, S1 to S10, is arranged to be operated responsive to an elevation of the U-shape trough-like member 27 underlying the contact sets, but only if the associated selecting finger occupies a position directly underneath the relatively narrow depending actuating tab 45 of the actuating blade 44 which underlies the contact set. Normally, each finger 30 occupies a position slightly to the right of its associated depending actuating tab 45. The selecting operation is such that, upon the receipt and termination of the first impulse, the first selecting finger F1 moves to the left to an intermediate position,

where it underlies the center of its associated actuating tab 45. But, if another impulse arrives, the select finger in question moves a further distance, to the left, passing beyond selecting position. That is, it passes from underneath its associating selecting tab 45. As a result, when a given series of impulses has ended, only the last selecting finger operated will then be in selecting position, all preceding selecting fingers having been moved beyond selection position, into post-select position. Therefore, only a single contact set will be operated—namely, the contact set corresponding to the last impulse in the received series.

Referring particularly to Figs. 2 and 6, each of the selecting fingers 30 is so tensioned that it tends to move to the left from its illustrated normal position, being held in its normal position by the upstanding tab 17 of the associated counting armature such as 1b, 2b, and so forth. It may be noted that the fingers 30 are preferably of comparatively light gauge wire, relatively smaller than the drawing indicates, wherefore they exert only an insignificant force on counting armatures 16. Referring further to Fig. 7, each of the select fingers 30 normally occupies a position such as is indicated at *a* for finger F1. It normally lies to the right of its select position (indicated at *b* for finger F1) beneath the associated select tab 45.

When armature 1b moves to the left to assume its operated position, at the end of the first received impulse of a series, the tensioned finger F1 of the select fingers 30 follows the movement (see Fig. 6) to the left until such finger engages the upstanding tab 17 on the then unoperated counting armature 2a. Finger F1 is then in the dotted line position indicated at *b* in Fig. 7, the selecting position for such finger. The first contact set S1 Figs. 2 and 3 is thereby selected.

When counting armature 2a executes its counting movement (moves to the left), at the beginning of the second impulse, select finger F1 continues its partially executed movement. Such continued movement is terminated when finger F1 again engages the upstanding tab 17 on the previously operated counting armature 1b. Finger F1 is then in its post-select position indicated at *c* in Fig. 7. That is, it has now moved to the left of actuating tab 45 of its associated contact set S1.

It will be understood of course that, when the received series constitutes only a single impulse, select finger F1 is left standing in its selecting position indicated at *b* in Fig. 7.

When armature 2b executes its counting movement, at the end of the second impulse in a received series, the second select finger F2 moves from its illustrated normal position to its intermediate (select) position. It remains in that position, or advances further, to its post-select position, depending upon whether the impulse series contains only two impulses, or contains more than two impulses.

For a series containing more than two impulses, the concerned ones of the succeeding fingers F2 to F10 operate in their turn in the manner described for fingers F1 and F2. Each such succeeding finger moves from normal position into select position upon the termination of the corresponding impulse in the series, and further advances from select position to post-select position responsive to the beginning of the next succeeding impulse of the series.

Upon referring to Fig. 2, it will be observed that the final select finger F10 has a slightly different configuration from the preceding select

fingers. The rear portion of finger F10 is offset somewhat to the right. Finger 10 undergoes a full movement to the left upon the termination of the tenth impulse of a series, since there is no further counting armature beyond armature 10b, which alone controls select finger F10. The offset in select finger F10 is such that the full movement thereof at the end of the tenth impulse of the series brings it into its desired select position.

Contact set construction and operation

The contact blades 47 which comprise the ten contact sets S1 to S10 are mounted at the rear of the device. They are illustrated as passing through a block of insulation 46, but it will be understood that this block may be made up in strip form in the usual manner of contact-bank construction, such as is disclosed for example in my previously noted prior application Serial No. 493,312, filed July 2, 1943. Each blade 47 has a wiring terminal 48 at the rear of block 46.

Insulation block 46 is supported on spacer block 42, supported in turn on the rear portion of heel plate 2. Actuating comb 43 lies between blocks 46 and 42, while spring support bracket 41 lies between block 42 and the heel plate 2. Insulation block 46 is surmounted by a cap plate 50, the entire assembly being held together by screws 51 which pass through the parts and are threadedly engaged in suitable tapped openings (not shown) in heel plate 2.

It will be observed that each of the contact sets, S1 to S10, comprises three normally open contact pairs. As shown best in Fig. 3, a staggered arrangement of the contact sets is employed to substantially halve the lateral distance occupied. For example the even-numbered contact sets, S2 to S10, are spaced apart in normal manner along the bottom of the contact bank, while the odd-numbered contact sets, S1 to S9, are spaced apart in normal manner along the upper portion of the contact bank, but are laterally offset from the even-numbered contact sets so that the center of any odd-numbered contact set after the first lies directly above the center of the separation space between the associated even-numbered sets. In this way, the actuating studs 49 for the odd-numbered contact sets pass freely alongside the even-numbered contact sets. By this arrangement, the ten sets of contacts, while occupying additional space vertically, occupy but little more than the horizontal space normally required by half the number of contact sets. This provision enables the device to be mounted more compactly in conjunction with the associated device, such as ordinary telephone relays, indicated schematically in at 801 to 804 Fig. 8.

Preferably, the lower contact blade of any pair 47 is of relatively thin flexible stock, while its associated contact blade with which it engages, when operated, is of relatively thick rigid stock. Each rigid contact blade may have a generally oblong opening to permit actuating studs 49 to pass freely therethrough. These studs are of the same general outline as the spacing studs 28 Fig. 4, and are held in place by openings in the flexible contact blades, through which their terminal portions pass relatively freely. As shown in Figs. 1 and 3, the lower actuating stud 49 of any odd-numbered contact set is comparatively long owing to the increased distance from its associated actuating blade 44 to the first flexible spring of the concerned odd-numbered contact set.

As shown in Figs. 1, 3, and 7, the lower end of the lowermost actuating stud of each contact set, S1 to S10, rests on a separate one of the actuating springs 44, the terminal portion thereof being received within an opening in such actuating spring. The actuating springs are integrally attached to common member 43, which lies between blocks 42 and 46, Fig. 1. The forward portion of actuating springs 44 rest lightly on spring-support bracket 41, which is notched as at 41' to avoid interference with the terminal portion of the lowermost actuating studs 49.

The forward end of each actuating spring 44 has a relatively narrow centrally located tab 45 extending downwardly therefrom above the longitudinal center line of the actuating cross member 27. When the actuating cross member 27 is raised, the two arms thereof pass alongside any actuating tab 45 without engaging it, with the exception of the tab of the selected contact set. That tab is raised, because the associated selecting finger 30 lies directly underneath it to bridge across the two arms of actuating cross member 27, thereby raising actuating spring 44 of that contact set. Raising any actuating spring 44 closes the contact pairs in the concerned actuating set through the consequent vertical movement of the actuating stud 49 thereof.

The actuating system

The mechanical system for actuating any selected contact set includes actuating yoke 21, having front cross member 24 formed integrally with side members 22 thereof. The rear, or actuating, U-shaped cross member 27 may be attached to the rear portion of side arms 22 as by the illustrated tabs which overlap the side arms and which may be secured thereto as by rivets, welding, and the like.

Side members 22 have upwardly extending pivot portions 23 formed integrally therewith through which pivot member 34 passes. The actuating yoke 21 is held pivotally in position by pivot bracket 31, which is secured to the forward end of heel plate 2 by a pair of screws 33. Bracket 31 has a pair of side arms 32 which extend upwardly and forwardly. Pivot 34 passes through openings in these side arms.

As seen best in Figs. 1 and 5, side arms 22 have arms 25 formed integrally therewith, which extend downwardly and then toward each other. These inward extensions nearly meet at the vertical center line of armature 26, which may be attached thereto by rivets or by welding.

Clearing out

When the selected contact set is to be actuated, operate magnet 4 is then energized to attract armature 26. The operate assembly is thereby rotated about pivot pin 34, the front end of the assembly moving downward, while the rear end moves upwardly to carry the U-shaped rear cross member 27 upwardly pursuant to actuation of the selected contact set as previously described.

When the actuated device is to be cleared out, deenergization of operate magnet 4 permits the pivoted actuating assembly to restore to natural position, thereby restoring the actuated contact set. Restoration of counting armatures 16 to normal position, along with select fingers 30 is accomplished by a temporary mild reverse magnetization of count magnet 3. The residual magnetism which has been maintaining the actuated counting armatures 16 in operated position is

thereby neutralized, whereupon all counting armatures 16 return to normal position, carrying the associated select fingers 30 to normal position.

The system of Figure 8

In the system of Fig. 8, magnetic impulse counter of Figs. 1 to 3 is shown within the rectangle labeled "Counter." The contact sets, S1 to S10, of the counter are indicated diagrammatically within this rectangle, along with count magnet 3 and operate magnet 4. The contact sets are connected respectively in circuit with ten sets of indicating lamps 1 to 10, each such set containing three lamps *a* to *c*, corresponding respectively to the contacts in the set. Control keys KA, KB, and KC respectively control whether an *a* lamp, a *b* lamp, or a *c* lamp in any selected set is to be lighted or not.

The impulse counter is controlled from a control station having a telephone type calling device CD and a switch key SK, over line 800, through the medium of the control circuit comprising relays 801 to 804.

Calling device CD may be an impulse sender of the dial control type, common in automatic telephone systems. It may transmit an impulse series containing any number from one to ten impulses. The switch key SK corresponds to the hookswitch ordinarily used at a telephone substation.

In the control circuit, relay 801 corresponds to the line relay customarily used in the automatic telephone system; relay 802 corresponds to the so-called release relay; relay 803 corresponds to the so-called series (impulse series) relay; and relay 804 is a locking relay, which assists in the so-called changeover operation common in switchboard circuits in automatic telephone systems.

Release and series relays 802 and 803 are of the so-called slow-restoring type and are indicated diagrammatically as having a copper sleeve surrounding the core between it and the winding.

Count magnet 3 is shown in Fig. 8 as having two differentially connected windings. The lower one is the pulse winding, the one which receives the impulses to be counted. The upper winding is a relatively low-powered winding employed to clear out the counting portion of the structure.

Assume now that one or more lamps in set 10, associated with contact set 10 of the counter are to be lighted as a signal indication, this operation is effected from the control station by first closing key SK and then manipulating the calling device CD to transmit a series of ten impulse interruptions over line 800 to line relay 801.

Line relay 801 operates responsive to the closure of switch key SK, responsive to which release relay 802 operates. At its upper armature release relay 802 prepares a circuit for the lower winding of count magnet 3, in parallel with the winding of series relay 803. Being slow-restoring, release relay 802 remains operated through the series of ten momentary restorations of line relay 801 incident to the assumed operation of calling device CD.

Upon each momentary restoration of line relay 801, current flows through the back contact of line relay 801 and through the front contact of the upper armature of release relay 802 through the winding of series relay 803, in parallel with the pulse winding of count magnet 3. Relay 803 operates responsive to the first closure of this circuit. Being slow-restoring it remains operated through the series of impulses. Locking relay 804 operates through the front contact of the lower armature of relay 803, in series with the lower contact pair of relay 802. At its inner contact pair relay 804 locks itself, operated independent of contacts of relay 803.

The counter responds to the impulses received by the lower winding of count magnet 3 by operating its counting armatures 16 successively as hereinbefore described, select fingers 30 responding as described.

Since ten impulses are contained in the assumed series, all counting armatures 16 are operated at the end thereof and all select fingers 30 are responsively shifted to their extreme operated position. Under this condition, select fingers F1 to F9 are each in post-select position, while the specially formed tenth select finger F10 is in its select position, contact set S10 being thereby selected for operation.

Shortly after line relay 801 comes to rest in an operated condition at the end of the tenth and final impulse in the transmitted series, series relay 803 restores. Upon so doing it closes a circuit through the back contact of its lower armature and through the lower contact pair of the operated lock relay 804 for operate magnet 4 of the counter. The resultant energization of operate magnet 4 causes the operate structure 21 to execute its previously described movement, including the raising of the U-shape actuating cross member 27. All fingers 30 are thereby raised, but only the final finger F10 thereof performs a useful operation at this time, since it is the only one in select position underneath its associated actuating tab 45. Such actuating tab is thereby raised by the bridging action of finger F10 to thereby secure the actuation of the three contact pairs in set S10. Assuming that keys KA, KB, and KC are all closed each of the lamps *a*, *b*, and *c* in lamp-set 10 are lighted.

When the lighted lamps are to be extinguished switch key SK is opened. When this occurs, line relay 801 restores, followed a moment later by the restoration of slow-restoring release relay 802. During the interval required for relay 802 to restore a further impulse is transmitted to the lower winding of count magnet 3, in parallel with the winding of series relay 803. The energization at this time of count magnet 3 is a useless, but harmless operation which could be avoided if desired by providing the further pair of contacts on lock relay 804 to disconnect the pulse winding of magnet 3. Upon the operation of series relay 803, operate magnet 4 is open circuited whereupon such magnet deenergizes to permit restoration of the actuated contact set S10, extinguishing the associated lamps. As a further result of its operation relay 803 prepares a circuit, at its upper contacts, for the upper winding of count magnet 3. Upon the described restoration of release relay 802 lock relay 804 restores. Additionally, the upper armature of relay 802 open circuits series relay 803 and the pulse winding of the count magnet, at the same time closing the circuit through the upper contacts of relay 803 for the upper winding of count magnet 3. This latter circuit remains closed for the interval required for slow-restoring relay 803 to restore after its circuit is opened. The low-powered upper winding of magnet 3 now produces a mild reversed magnetism, which permits the operated counting armature 16 to restore to normal condition, clearing out the counting device by restoring select fingers 30 to normal position.

It is believed to be obvious from the foregoing

that a much larger number of contact pairs could be provided in each of the contact sets S1 to S10 if desired, and that this provision would have no direct bearing on the ease with which the preselecting counting operation hereinbefore described is performed. Its principal effect would be to increase the power required to be obtained from an energization of operate magnet 4, which is of course readily accomplished.

The modified structure

The basic structure hereinbefore described, as modified according to Figs. 9 and 10 will now be described.

Off-normal contact set 900 comprises a pair of normally open contact springs mounted by screws 904 onto bracket 901, insulating plates 902 being interspersed between bracket 901 and cap plate 903. Bracket 901 is generally L-shape, the horizontal portion being secured underneath the left-hand edge of heel plate 2 by screws 906. Actuating stud 905 is attached to the inner contact spring 900 and rests lightly against the first counting armature 15*a* of group 15. When armature 15*a* is moved to the left upon the receipt of the first impulse of a series it closes contact pair 900 through movement of stud 905. The inner spring of pair 900 is preferably of thin flexible material, whereby the counting movement is not substantially impeded. Contacts 900 reopen when the device is cleared out as hereinbefore described.

Contact pair 950 is mounted on the left-hand end of spacing member 42*a*, which is similar to spacing member 42 but made slightly longer and suitably drilled and tapped for this purpose. Retaining screws 953 hold the assembly in place, which includes cap plate 952 and insulating plates 951. Besides off-normal contact pair 950, the contact set under discussion includes actuating spring 955 which rests lightly on the top of the U-shaped actuating cross member 27*a*, which is similar to member 27 of the principal embodiment except that the left-hand end is extended somewhat for the purpose at hand. Actuating bushing 954 interconnects actuating spring 955, which is similar to member 44, with the lower spring of pair 950, whereby contact pair 950 is closed each time actuating cross member 27*a* is raised to actuate any selected one of the selective contact sets S1 to S10.

The system of Figure 11

Signalling system of Fig. 11 is generally similar to the previously described system of Fig. 8, differing only in that the modified counting device structure of Figs. 9 and 10 is employed in place of the earlier described basic structure, and the control circuit of Fig. 11 has been suitably revised and simplified in accordance therewith.

In Fig. 11 the control relays comprise line, release, and series relays 1101, 1102, and 1103 corresponding respectively to relays 801 to 803. It will be noted that the lower contact sets of relays 802 and 803 are missing in Fig. 11. They are omitted because they are rendered unnecessary when the modified structure is used. Additionally, lock relay 804 has no counterpart in the system of Fig. 11.

When the switch key SK is closed in the system of Fig. 11, line relay 1101 operates over line 800, whereupon release relay 1102 operates to prepare an impulsing circuit as described in connection with Fig. 8.

When line relay 1101 restores momentarily a number of times incident to the transmission of a desired impulse series at calling device CD, it transmits a corresponding series of impulses to the lower winding of count magnet 3, in parallel with the winding of series relay 1103. The counting operation thereupon proceeds as hereinbefore described. Relay 1103 operates and remains operated throughout the series of impulses, but its operation is of no utility at this time.

Off-normal contacts 900 close upon receipt of the first impulse, preparing a circuit for operate magnet 4. Thereafter, each reoperation of line relay 1101 results in the closure of the circuit for operate magnet 4 through contacts 900. When used in the system of Fig. 11 the magnet 4 is preferably provided with a comparatively highly inductive winding and the actuating system is preferably "stiffly adjusted" so as to render it slow operating, as is indicated by the parenthetical note applied to operate magnet 4 in Fig. 11. This "stiff" adjustment may be readily made by giving actuating spring 955 Fig. 10 a relatively heavy downward tension, the thickness of the material being suitably selected for this purpose.

As the result of the character of operate magnet 4 in Fig. 11 and the above noted adjustment, operate magnet 4 is unable to operate the actuating mechanism 21 during the receipt of the impulse series because of the relatively short circuit closures then occurring.

When line relay 1101 comes to rest in an operated condition at the end of the transmitted impulse series, operate magnet 4 becomes fully energized, by way of off-normal contacts 900, whereupon operation occurs as previously described to actuate the contact set.

Additionally, contacts 950 close at this time irrespective of which of the contact sets, S1 to S10, has been selected and actuated thereby lighting the common pilot light 1100 which may serve to attract attention to the fact that one or more of the lamps in the single bank shown above the counter has been lighted.

Conclusion

The disclosed apparatus having been described quite completely, it may be well to point out one or two features not particularly dwelt on in the course of the description. One feature concerns yokes 9 to 11 and their upwardly extending pole portions, through which the counting armatures 16 are controlled by their depending tabs 18. The disclosed arrangement permits lateral compactness of the counting system to be achieved with a comparatively great magnetic efficiency as compared for example to the counting structure of generally similar characteristics disclosed in my previously noted prior application Serial No. 612,689, filed August 12, 1945. For example, considering restraining yoke 9, the upwardly extending poles thereof, together with the tabs 18*b*—18 to 10*b*—18 comprise a comparatively compact row wherein parts can be spaced as desired without respect to the pole portions carried by the remaining yokes and their associated tabs 18. If all tabs and all poles of the three yokes 9 to 11 were placed in the same row and in regular interspersed relationship as in my prior application last referred to, the row would be considerably longer, which would require a considerably increased width for the device.

Referring now to the operate yokes 10 and 11 and their associated depending even-numbered

tabs 2a—18 to 10a—18 and 1a—18 to 9a—18, if all these parts were placed in a single row, instead of being placed in two parallel rows, that row would have to be much longer in order to avoid crowding, or else the magnetic efficiency would be greatly reduced if such crowding were permitted. For example, the pole face through which depending tab 1a—18 is operated is very near thereto as compared to the next succeeding pole piece, through which the next succeeding odd-numbered tab 3a—18 is actuated in its turn. Any such tab is therefore operated in its turn with comparatively little restraint from the pole portion through which the next succeeding tab in the same row is operated, which condition would not obtain if pole portions of yokes 10 and 11 and their associated tabs 18 comprised only a single row.

In addition to the foregoing, the disclosed structure of yokes 9 to 11 permits each of them to be produced economically as by a milling operation of bar stock to provide the desired upwardly extending pole portions.

By the previously described arrangement for moving any select fingers 30 beyond its selecting position to a post-select position, the arrangement of each of the contact sets beyond the first is greatly simplified, in that each such set otherwise would have to include contacts opened upon operation to cancel the selection of the preceding set, or some other arrangement to the same effect would have to be provided as in each of my prior applications hereinbefore referred to.

I claim:

1. In combination, an electromagnet having a winding for receiving series of impulses, a series of armatures for said electromagnet corresponding respectively to the impulses of a received series, means for causing the electromagnet to operate its armatures as it receives the impulses of a series, each such armature responding to its corresponding impulse of the series, a series of members mounted in association respectively with said armatures and corresponding respectively to the impulses of a received series, an actuating bar operatively associated with each said member subject to the corresponding associated armature being operated, and means initially effective following the termination of a received series of impulses for moving said bar, said movement selectively operating said members according to the number of received impulses as indicated by the armatures which have been operated.

2. In combination, means for receiving series of impulses, a series of counting members, means controlled by the receiving means for operating counting members successively to count the impulses of a series, a series of select members corresponding repectively to the impulses of a received series, each such select member having a normal position, a select position, and a post-select position, means controlled by the counting members for operating select members in succession during receipt of a series of impulses, each from its normal position to its select position responsive to its corresponding impulse, means controlled by the counting members for further operating select members in succession during receipt of a series of impulses, each from its select position to it post-select position responsive to the impulse of the series next succeeding the one to which such select member corresponds, a series of signal members corresponding respectively to the impulses of a received series, and means initially effective following the termination of a received series of impulses for selectively operating any signal member depending upon the corresponding select member being then in its select position.

3. In an electromagnetic counting device, a pair of electromagnets comprising a count magnet and an operate magnet, a series of armatures operable successively by said count magnet responsive to successive energizations thereof incidental to the receipt thereby of a series of impulses to be counted, a series of contact sets mounted on said device in association respectively with said armatures, and means responsive to an energization of said operate magnet, following the receipt of a series of impulses by said count magnet, for selectively operating said contact sets according to the ones of said armatures which have been operated incidental to the receipt of the impulse series.

4. In an electromagnetic counting device, a pair of electromagnets comprising a count magnet and an operate magnet, a series of armatures operable successively by said count magnet responsive to successive energizations thereof incidental to the receipt thereby of a series of impulses to be counted, a series of contact sets mounted on said device in association respectively with said armatures, and means responsive to an energization of said operate magnet, following the receipt of a series of impulses by said count magnet, for selectively operating the one of said contact sets which corresponds to the number of impulses received as indicated by the ones of said armatures which have been operated incidental to the receipt of the impulse series.

5. In an electromagnetic counting device, a pair of electromagnets comprising a count magnet and an operate magnet, a series of armatures operable successively by the count magnet to count the impulses of a series, a series of select fingers controlled by said armature and corresponding respectively to successive impulses of a received series, a series of contact sets associated respectively with said select fingers, and means responsive to the energization of said operate magnet after a series of impulses has been received by the device for selectively operating said contact sets under control of said select fingers.

6. In an electromagnetic counting device, a pair of electromagnets mounted on a common magnetic return plate and comprising a count magnet and an operate magnet, a series of armatures operable successively by the count magnet to count the impulses of a series, a series of select fingers controlled by said armatures and corresponding respectively to successive impulses of a received series, a series of contact sets associated respectively with said select fingers, and means responsive to the energization of said operate magnet after a series of impulses has been received by the device for selectively operating the contact set associated with the last operated select finger.

7. In an electromagnetic counting device, a pair of electromagnets mounted on a common magnetic return plate and comprising a count magnet and an operate magnet, a series of armatures operable successively by the count magnet to count the impulses of a series, a series of select fingers controlled by said armatures and corresponding respectively to successive impulses of a received series, each select finger having a normal position, a select position, and a post-select position, each said select finger being so con-

trolled as to move from normal position into select position incidental to receipt of its corresponding impulse of the series, and to move into post-select position incidental to receipt of the next succeeding impulse of the series, a series of contact sets associated respectively with said select fingers, and means responsive to the energization of said operate magnet after a series of impulses has been received by the device for operating any of said contact sets depending on its associated select finger being then in select position.

8. In an electromagnetic counting device, electromagnetic means for receiving series of impulses including a plurality of armature-controlling pole members disposed in a plurality of laterally displaced rows, a row of counting armatures each disposed along a line extending to one side of said pole members, each armature having an offset portion extending in overlapping relationship to a pole member in one of said rows, such offset portions of any pair of adjacent armatures extending into association with pole portions lying in different rows, coupling means between adjacent armatures, and means controlled by said electromagnetic receiving means through said pole portions and coupling means for causing said armatures to move in a counting succession responsive to the receipt of the series of impulses.

9. In an electromagnetic counting device, electromagnetic means for receiving series of impulses including a plurality of armature-controlling pole members disposed in three laterally displaced rows, counting armatures each extending in overlapping relationship to a pole member in a single one of said rows, alternate armatures extending into association with pole members in a first row, alternate ones of the remaining armatures extending into association with pole members in a second row, the remaining armatures extending into association with pole members in the third row, coupling means between adjacent armatures, and means controlled by said electromagnetic receiving means through said pole members and coupling means for causing said armatures to move in a counting succession responsive to the receipt of a series of impulses.

10. In a system for receiving and counting impulses, a series of members and means for operating alternate ones thereof in succession responsive respectively to the beginning of successive impulses of a series to be counted, means for operating the other members of the series in succession responsive respectively to the termination of successive impulses of such series, a series of select members corresponding repectively to the impulses of a received series, and means for operating each said select finger under the joint control of the said member which operates responsive to the termination of its corresponding impulse and the next succeeding member, a series of contact sets, and means initially effective following the termination of the received series of impulses for controlling said contact sets through said select fingers.

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