Sept. 9, 1952 T. P. FARKAS 2,610,242

IMPULSE COUNTING RELAY AND SYSTEM THEREFOR

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FIG. 1

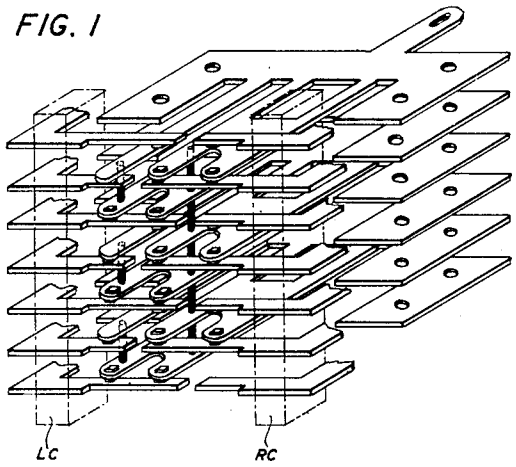


FIG. 2

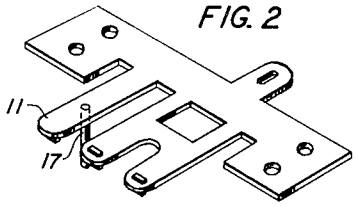


FIG. 3

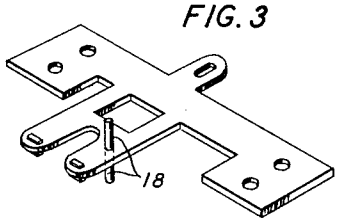


FIG. 4

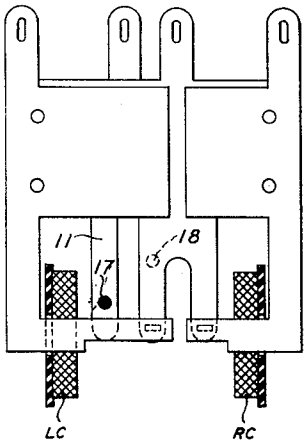


FIG. 5

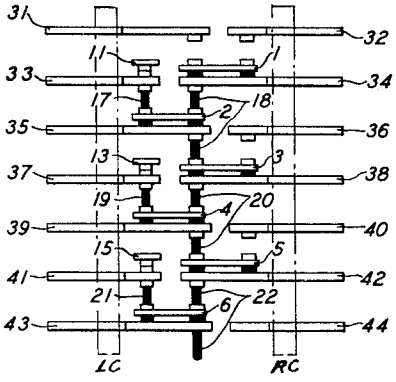
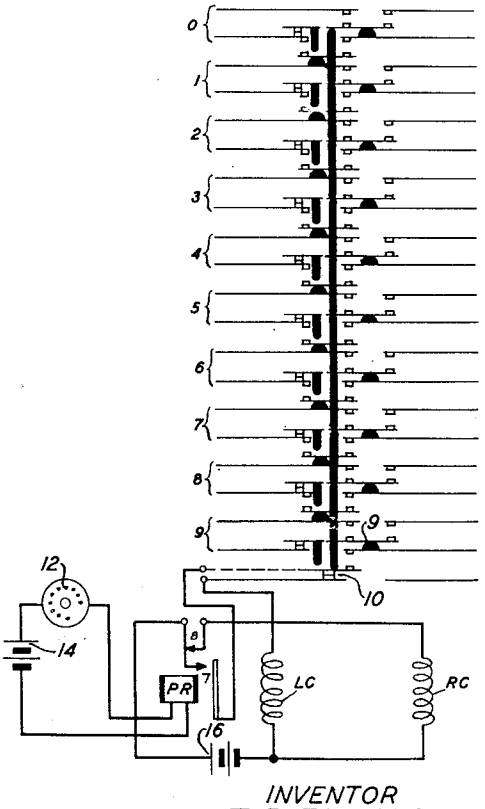


FIG. 6



INVENTOR
T. P. FARKAS

BY

J. W. Schmied

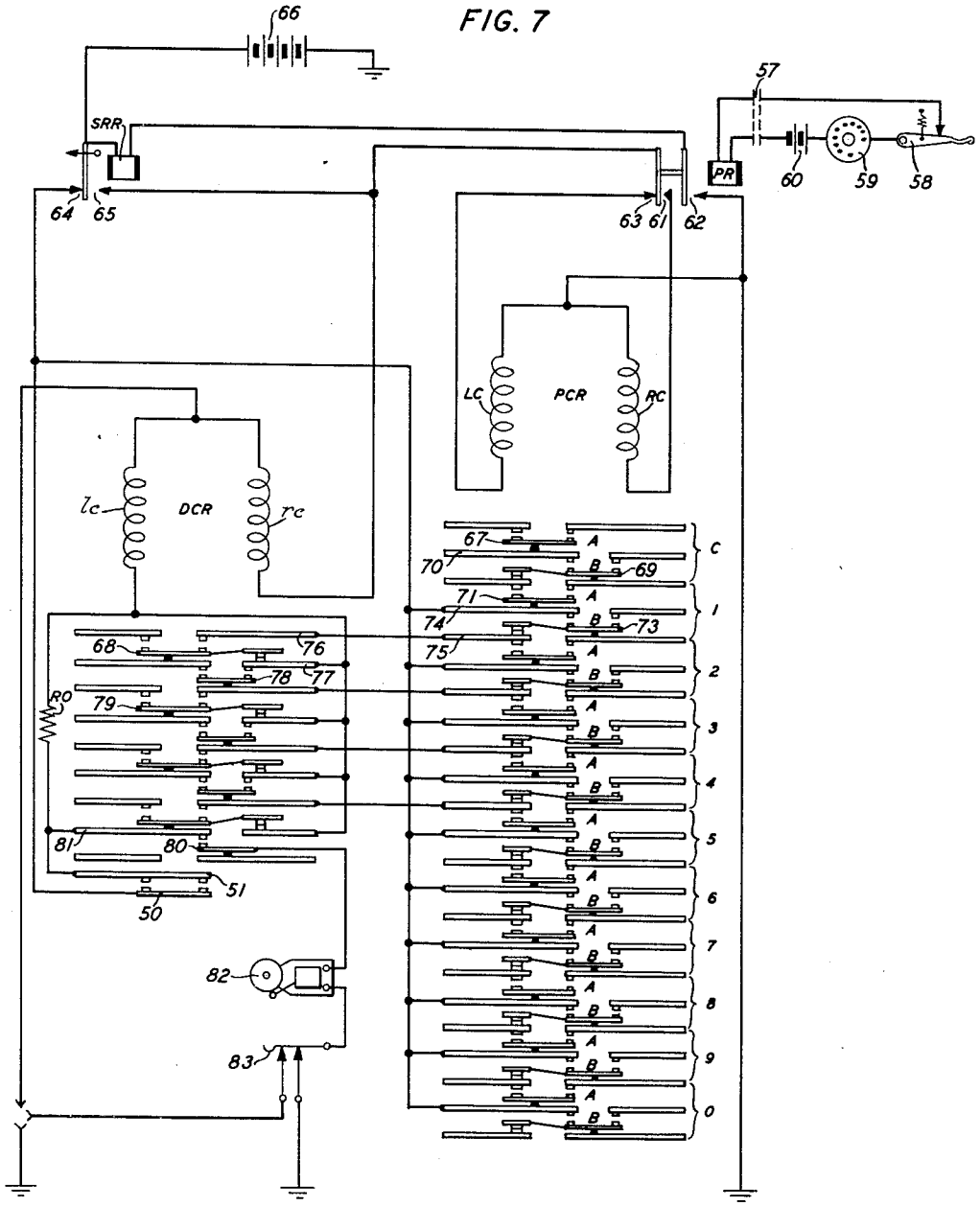
ATTORNEY

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IMPULSE COUNTING RELAY AND SYSTEM THEREFOR

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FIG. 7



INVENTOR
T. P. FARKAS

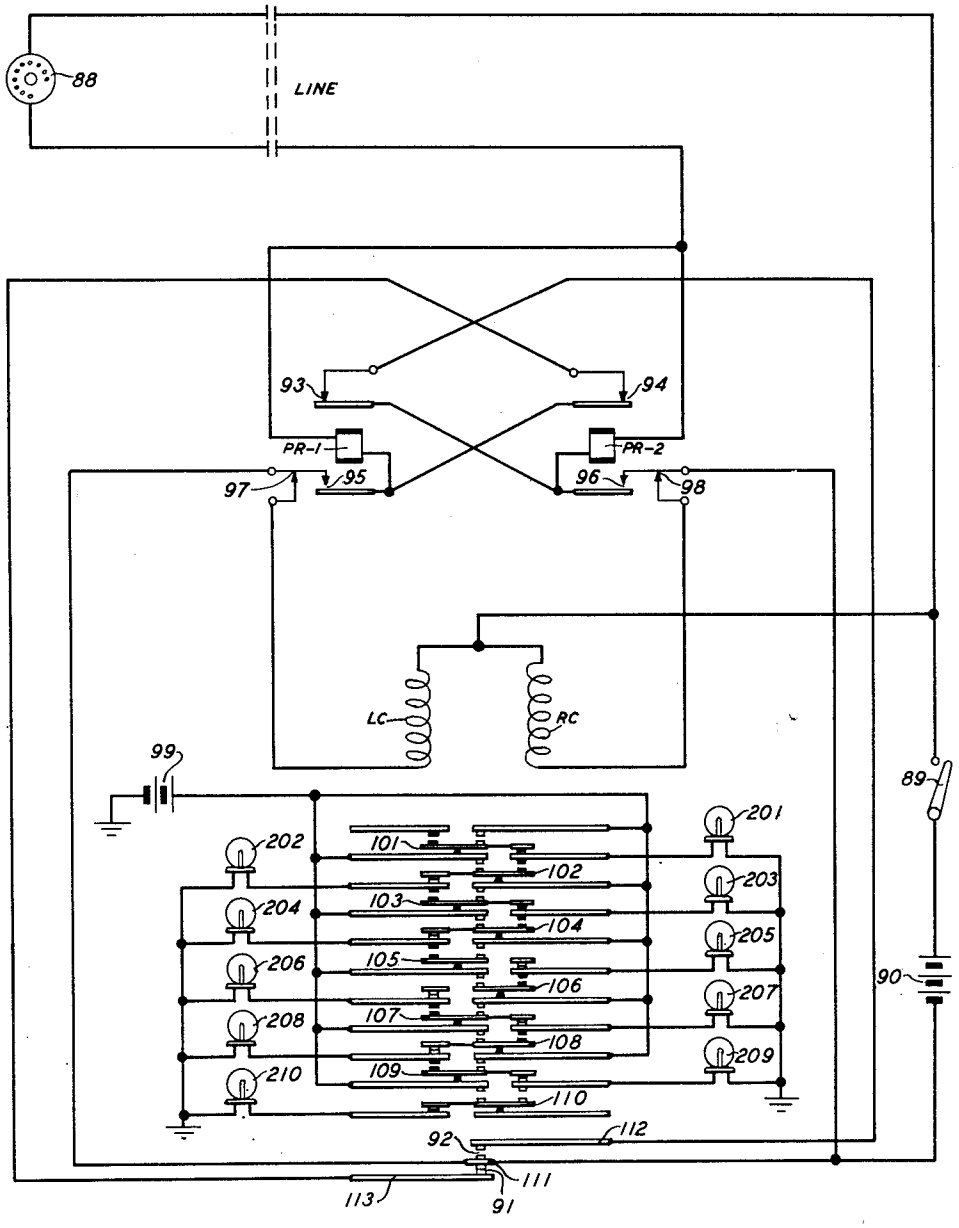
BY J. W. Schmied

ATTORNEY

IMPULSE COUNTING RELAY AND SYSTEM THEREFOR

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FIG. 8



INVENTOR
T. P. FARKAS
BY
J. W. Schmied
ATTORNEY

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IMPULSE COUNTING RELAY AND SYSTEM THEREFOR

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FIG. 9

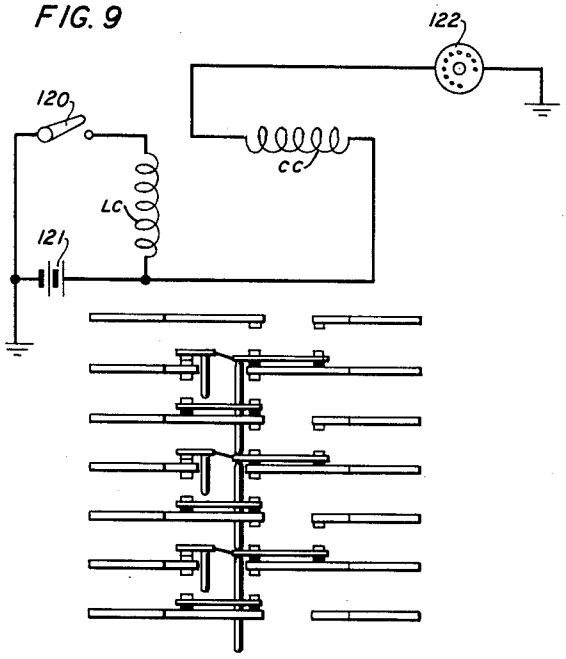


FIG. 10

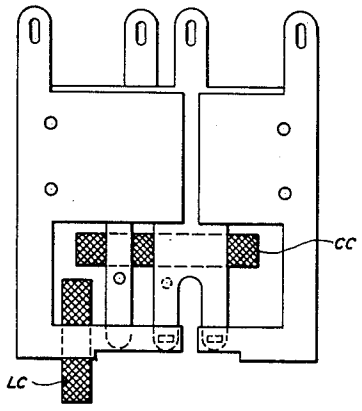


FIG. 11

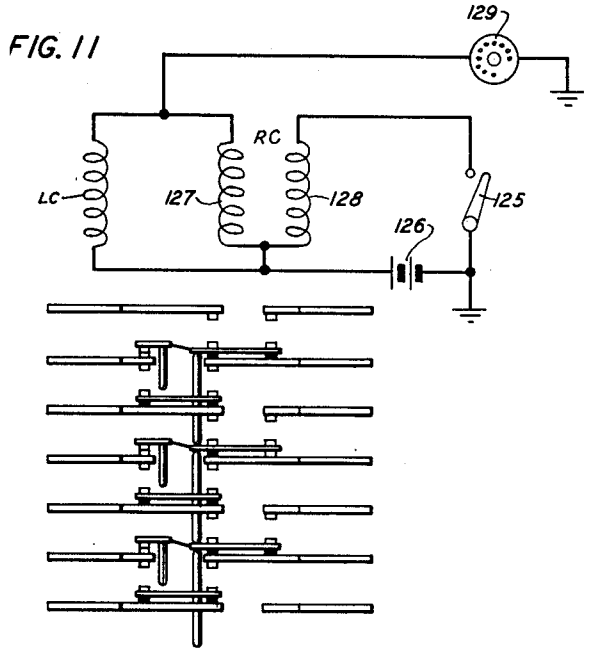
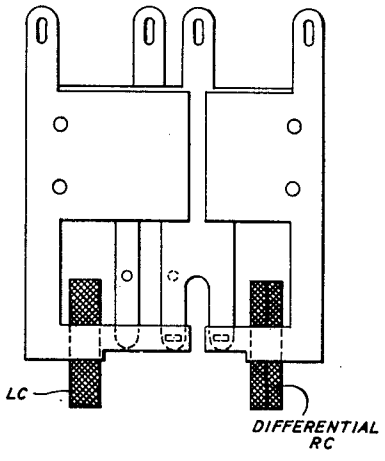


FIG. 12



INVENTOR
T. P. FARKAS

BY J. W. Schmied

ATTORNEY

Patented Sept. 9, 1952

2,610,242

UNITED STATES PATENT OFFICE

2,610,242

IMPULSE COUNTING RELAY AND SYSTEM THEREFOR

Thomas P. Farkas, Jackson Heights, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application March 20, 1948, Serial No. 16,091

11 Claims. (Cl. 177—353)

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This invention relates to electrical impulse signaling systems and more particularly to improvements in magnetic counting relays and circuits for selective calling of telephone or telegraph stations of the type disclosed by C. N. Hickman in copending application Serial 758,904 filed July 3, 1947, now Patent No. 2,589,806.

An object of this invention is to provide an electrical impulse counting system responsive to a continuous train of electrical impulses received in uninterrupted sequence.

Another object of the invention is to eliminate the requirement for a slow-release characteristic in magnetic contact counting relays heretofore employed in a telephone station calling system.

Another object of the invention is to provide an improved magnetic contact relay structure wherein the tendency of such contacts to stick is overcome and wherein a positive break of successive contacts is assured for each impulse cycle.

A further object of the invention is to reduce the space required for selective signaling apparatus of the magnetic contact relay type.

A still further object of this invention is to provide a simplified electrical impulse counting circuit wherein a magnetic contact counting relay is operable directly by such conventional means as a standard telephone dial, without the necessity of an intervening pulsing relay.

In the use of magnetic contact counting relays of the type disclosed by G. R. Stibitz in Patent 2,305,450, issued December 15, 1942, for selective signaling purposes, it has been found that the magnetic contacts sometimes display a tendency to stick when they should open, and this tendency has reduced the speed at which such relays could be operated and even, in some cases, has caused faulty or incorrect operation. This tendency for magnetic contacts to stick has been attributed to residual magnetism remaining in the contact members after deenergization of the operating coil, and in part to leakage flux through magnetic members of one side of the structure from the energizing coil associated with members of the opposite side of the relay structure. Heretofore, the effects of residual magnetism and leakage flux which cause this tendency for contacts to stick have been overcome solely by the application of a more powerful magnetic field to operate the relay against these restraining forces. It is apparent that this solution to the problem has required more power for the operation of the relay than would otherwise have been necessary. In the present invention an additional element has been introduced into the relay whereby the effects of these undesirable forces are overcome and the relay is rendered operable by less power.

Another difficulty encountered in the use of magnetic contact counting relays for a selective

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signaling system is the necessity of providing a slow release characteristic for one side of such a relay when used for digit counting, as disclosed by the copending application of C. N. Hickman, Serial No. 758,904 filed July 3, 1947, now Patent No. 2,589,806. Because of the inherent fast operate characteristic of these relays, and because of the relatively low current required for their operation, and the comparatively weak magnetic fields which are set up, as compared with other types of relays, it is more difficult to provide a slow release characteristic for relays of the magnetic contact counting variety than it is for other types. To overcome this difficulty the inventor has devised a new and improved electrical impulse signaling circuit in which magnetic contact counting relays without any slow release characteristic are employed.

In all similar systems for signaling or impulse counting, heretofore disclosed in the art, it has been necessary to employ two relay armatures to count each individual electrical impulse, i. e., one armature would operate at the beginning of each impulse and a second armature would operate at the end of each impulse. Although this arrangement is quite satisfactory for systems employing a short train of impulses for each digit or group, it becomes apparent that if larger groups of impulses are required, as may be the case in many signaling applications, the size of the necessary relay stack with two armatures per pulse may become unwieldy, or even so large as to be inoperable. Therefore, the inventor has devised an improved impulse counting circuit wherein only one armature of the counting relay is operated by each complete pulsing cycle. With this arrangement the over-all height of a relay stack as may be required for any particular impulse counting operation may be reduced to approximately one-half that formerly required. With this reduction in over-all size and its attendant reduction in space requirements and cost of apparatus, there is also gained a greater concentration of magnetic field which results in more efficient operation of the relay, less operating current being required than in the case of the larger structures.

Heretofore, all impulse counting circuits employing magnetic contact counting relays have included a continuity transfer pulsing relay, responsive to dial pulses, by means of which the operating coils of the magnetic contact relay are alternately energized and deenergized. The inventor has discovered that by a rearrangement of the operating coils on the impulse counting relay, the need for a pulsing transfer relay may be eliminated. Thus, in some applications, an additional economy of space and apparatus may be enjoyed by this means.

Still another former limitation of the mag-

netic contact counting relays has been overcome by the present invention. This limitation was the impossibility of recycling former types of such relays. This limitation has been overcome in the present invention by the addition of an extra armature tongue at one end of the counting relay stack. By this means, herein disclosed, a magnetic contact counting relay may be automatically recycled so that it will respond continuously to an uninterrupted train of impulses for an unlimited time. With such an arrangement the inventor's improved magnetic contact counting relay may be used in any application where continuous stepping switches have formerly been employed. Thus the utility of this type of relay may now be extended to many additional operations in telephone plants and systems.

The nature and operation of the present invention may be more clearly understood from a consideration of the detailed description which follows when studied in connection with the related drawings wherein:

Fig. 1 is an exploded and partly cut away isometric drawing showing the essential operating elements of a magnetic contact counting relay of the type embodied in the present invention;

Fig. 2 is a perspective drawing of a single armature lamination of the type employed in the first, third and fifth layers of the relay stacks illustrated by Fig. 1;

Fig. 3 is a perspective drawing of a single armature lamination of the type employed in the second, fourth and sixth layers of the relay stacks illustrated by Fig. 1;

Fig. 4 is a top plan view of the relay stacks of Fig. 1 showing the relationship between operating coils, pole-pieces and armatures;

Fig. 5 is a front view elevation of the relay stacks of Figs. 1 and 4, showing the relationship between pole-pieces and armatures;

Fig. 6 is a schematic diagram of a relay of the type herein disclosed showing an auxiliary armature tongue 10 at one end of the relay stack connected with the operating coil and associated pulsing relay whereby the impulse counting relay may be recycled and thus enabled to respond continuously to impulses as received in sequence;

Fig. 7 is a schematic diagram of two impulse counting relays of the type herein disclosed, interconnected to comprise a complete digital selective signaling system. In this figure may be seen an additional armature tongue 50 in the digit counting relay stack whereby operating coils of this relay are held energized during the interval between transmission of successive digits, thereby eliminating the need for a slow release characteristic to be built into the relay structure. To simplify the appearance of Fig. 7 and reduce the possibility of circuit confusion, the insulated studs which extend between armature tongues are not illustrated in this drawing. Tongue 50, unlike all the other tongues, has no insulated stud associated with it;

Fig. 8 is a schematic diagram showing the manner in which a magnetic contact counting relay of the type embodied in the present invention may be interconnected with two pulsing relays so that only one armature tongue of the counting relay will come up for each complete pulsing cycle. In this arrangement, as illustrated, a relay stack having only ten armature tongues may be employed to count as many as ten impulses, whereas in all arrangements previously disclosed such a relay structure would be limited to counting a maximum of only five impulses.

Here, again, the insulating studs between armatures have been omitted for the sake of clarity in the circuit drawing. It will be noted that all of the armature tongues, with the exception of tongue 111, have associated insulated studs as shown by Figs. 1–6;

Fig. 9 is a schematic diagram showing one arrangement in which a magnetic contact counting relay of the type embodied in the present invention may be operated directly from dial pulses, without the interconnection of a pulsing relay as previously required in all such impulse counting circuits;

Fig. 10 is a top plan view of a relay stack of the type represented schematically in Fig. 9, showing one operating coil positioned around the center armatures, and the other operating coil around the pole-piece leg of one side of the relay structure;

Fig. 11 is a schematic diagram of an alternative circuit by means of which a magnetic counting relay of the type embodied in the present invention may be operated directly from dial impulses;

Fig. 12 is a top plan view of a relay stack of the type represented schematically by Fig. 11, here showing the location of a differentially wound operating coil on one leg of the relay pole-piece arms.

The general principles involved, and the method of operation in magnetic contact counting relays for impulse counting and signaling are described in copending application of C. N. Hickman Serial No. 758,904, and by reference thereto the disclosure and drawings of said application are hereby incorporated into the specification of the present application. In the stepping relays previously disclosed, the advantage of magnetic contacts, which provide a high contact pressure for a relatively low operating current, were offset to a large degree by the disadvantage of residual magnetism and leakage flux which tended to hold the back contacts closed at a time when they should be opening for the stepping operation. Heretofore the problem has been to provide a relay with sufficient contact pressure between the pole-pieces and back contacts of the armature to satisfy the requirement of noise-free telephone circuits, and at the same time assure positive stepping operation of the relay on each energizing cycle of the operating coil. One possible solution to the problem of residual magnetism and leakage flux is the substitution of non-magnetic discs for the magnetic back contacts as disclosed in the prior art. However, this solution limits the use of the stepping relay to those applications where back contacts are not required in the circuit.

In the present invention the problems discussed above are solved by the addition of an auxiliary branch leg 11 in Fig. 2, to the armature laminations in alternate layers of the relay stack. Auxiliary branch 11 may also be seen in Fig. 4, and auxiliary branches 11, 13 and 15 may be clearly seen in Fig. 5. Each of these auxiliary branches carries a magnetic contact on the lower face of its forward extremity, which engages a corresponding magnetic contact on the upper face of the left-hand pole-piece to which the auxiliary leg is adjacent. In the entire relay structure, when completely assembled, these auxiliary branch legs may normally be biased downwardly by the spring tension of the leg itself, although such spring tension is not essential inasmuch as an ample contact pressure may be assured by the passage of magnetic flux through this auxiliary branch member and its associated magnetic con-

tacts with the adjacent magnetic pole-piece. By reference to Fig. 5, it will be observed that the main armature tongues in each layer of the relay stacks, as represented by 1, 2, 3, 4, 5, and 6 in this view, all carry magnetic contacts on the upper faces of their forward extremities in a position to engage corresponding magnetic contacts on the lower faces of the pole-pieces adjacent to and next above each of the main armature tongues. However, these armature tongues differ from those previously disclosed in that they are provided with non-magnetic spacers on the under-faces of their forward extremities. These main armature tongues are normally biased in a downward direction so that even when the relay is completely deenergized, the non-magnetic spacers are held against the pole-piece below the armature tongue by means of the spring tension in the tongue. The high reluctance introduced into the magnetic circuit between each of the main armature tongues and the magnetic pole-piece immediately below by means of the non-magnetic spacers eliminates the undesirable effects of residual magnetism and leakage flux as heretofore encountered. Thus the main armatures are freed from the retarding magnetic influences formerly exerted through magnetic back contacts and thereby are enabled to come up quickly in succession in response to pulsations of the operating coils.

As in previous magnetic stepping relays, successive operation of the armature tongues is assured by non-magnetic insulating studs which are interposed between armatures in adjacent layers of the relay stack and by means of which all armatures except one are disabled from operating at any time, and operation of the one free armature lifts a restraining stud from the next adjacent armature thereby enabling it to operate on the next pulsing cycle. Referring now to Figs. 1, 2, 3, 4 and 5, the insulating studs may be seen at 17, 18, 19, 20, 21 and 22. It will be seen that insulating studs are provided for each auxiliary branch leg, as by 17, 19 and 21 in Fig. 5, and that these studs are separate from those provided for the main armature tongues as shown by 18, 20 and 22 in Fig. 5. The studs affixed to the auxiliary branch arms are somewhat shorter than the corresponding portion of insulating studs which are fixed to the main armatures. Although this slight difference in length of studs is not clearly apparent in Fig. 5 because the ends of each stud are hidden from view behind magnetic contacts on the armatures, the spacing referred to is clearly illustrated by Figs. 9 and 11 wherein the studs are not drawn in their true lineal relationship but are shown out from behind the concealing magnetic contacts. Thus it is that the stud 17 which is affixed to auxiliary branch leg 11 in Fig. 5 has a gap between its lower extremity and the upper face of main armature 2, which gap may be of the order of ten one thousandths of an inch to provide lost motion coupling between the adjacent main armature 2 and auxiliary armature 11. Similarly the stud 19 which is affixed to auxiliary branch leg 13 has a corresponding gap between its lower extremity and the upper surface of main armature 4, and in like manner stud 21 affixed to auxiliary branch leg 15 has a gap between its lower end and the top face of main armature 6. The gaps thus provided aid in opening the magnetic contacts of the auxiliary branch leg against the forces of residual magnetism and leakage flux through the auxiliary branch. The manner in which these forces are overcome may be better understood from a detailed analysis of the operation of this relay.

Referring now to Fig. 5, we shall trace in detail the process of operation involved in this relay. If we start by energizing left coil LC it is apparent that the first armature tongue 1 will be attracted upward into magnetic contact with upper left-hand pole-piece 31. At the same time, auxiliary branch leg 11 is held down by the magnetic attraction of left-hand pole-piece 33, and armature 2 is similarly held down by the combined forces of its spring tension bias and the magnetic flux flowing through left-hand pole-piece 35. The third armature tongue 3 is also attracted by the magnetic field of left-hand pole-piece 35 but this armature is prevented from rising by the downward force exerted from armature 2 through its protruding insulating stud 18, the force between armature 2 and pole-piece 35 being much greater than the force exerted by pole 35 on armature 3 because of the difference in spacing. In like manner, armature 5 is restrained from moving upward by the downward force of insulating stud 20 protruding from armature 4 which in turn is held down by the magnetic pull of left-hand pole piece 39. In this initial condition with only the left coil LC energized, all of the auxiliary branch legs are held in magnetic contact with their adjacent left-hand pole-pieces. Now if the right coil RC is energized, all of the main tongues except one will be attracted downwardly so that no movement occurs. The first tongue 1 which is already up now experiences a pull against upper right-hand pole-piece 32 whereby armature 1 is held in its upward position. Now if left coil LC is deenergized, the second tongue 2 is no longer held down by a magnetic pull from pole-piece 35 but is instead attracted upward by the magnetic pull of right-hand pole-piece 34. At the same time, contact between auxiliary branch leg 11 and pole-piece 33 is opened by action of the insulated stud 17 which is struck by armature tongue 2 in its upward traverse. At this time, armature tongue 4 is attracted upward through the magnetic pull of right-hand pole-piece 38 but is prevented from coming up by the restraining force of stud 20 affixed to armature tongue 3 which is held downward by the greater magnetic pull of right-hand pole-piece 38. As we have seen before all main tongues below are similarly restrained by the interposed insulating studs. Now if the left coil LC is again energized, all armature tongues which are up will remain up, while all armatures which are down remain down. If the right coil RC is now deenergized, tongues 1 and 2 which are already up will be held up by magnetic contact with pole-pieces 31 and 33 respectively. Armature 3 having been enabled to move by the previous lifting of insulated stud 18 now comes up into contact with pole-pieces 35 and 36, being held in this position by the magnetic attraction of pole-piece 35. The auxiliary branch 13 remains in intimate magnetic contact with pole-piece 37, and a circuit is now closed between pole-pieces 35 and 37. As we have seen previously, none of the remaining armature tongues comes up. However, when RC is once again energized and LC subsequently deenergized, the fourth armature tongue 4 will then rise under the magnetic attraction exerted by right-hand pole-piece 38, and in coming up armature 4 strikes insulated stud 19 thereby opening the magnetic contact between auxiliary branch 13 and pole-piece 37. In like manner, upon successive energization and

deenergization of the left and right coils alternately, the remaining armature tongues in the relay stack will step up successively. Thus it is readily seen that in each complete pulsing cycle, one circuit between adjacent pairs of left-hand pole-pieces is closed and a previous such circuit is opened. This stepping operation may be continued for as many impulses as there are pairs of armature tongues in the relay stack.

In reference to Fig. 5 it will be observed that although back magnetic contacts have been eliminated from the underside of the main armature tongues, the non-magnetic spacing provided between these members and the pole-pieces adjacent to their underside is much less than the normal air-gap between the upper magnetic contacts of the armature tongues and the next pole-pieces adjacent above the armature. It is by means of these non-magnetic back spacers that the undesirable effects of residual magnetism and leakage flux, which in previous relays have occasioned unreliable operation due to armatures sticking when they should have stepped, are eliminated in the present invention. It will be observed that in the idle relay condition as illustrated by Fig. 5, armature 1 is in closer proximity to right-hand pole-piece 34 than it is to either of the upper pole-pieces 31 and 32. It will be apparent that if the right coil RC is first energized, armature 1 will be subjected to a magnetic force from upper right-hand pole-piece 32, but that due to the greater air-gap between these two members as compared with the spacing between armature 1 and right-hand pole-piece 34, the armature will not be attracted upward but instead will remain in its lower position held there under the combined influence of its downward spring tension and the downward magnetic force exerted by the attraction of pole-piece 34. It is only when the left coil LC is energized and the right coil RC deenergized, that armature 1 yields to the upward attraction of magnetic force from upper left-hand pole-piece 31 as was seen in the detailed analysis of the relay operation. Similarly when only left coil LC is energized, armature 1 now being up in intimate magnetic contact with pole-piece 31, armature 2 is subjected to a slight lifting force due to the magnetic attraction of left-hand pole-piece 33 but this force is much less than the downward pull of left-hand pole-piece 35, so that armature 2 remains down until the next cycle of pulsing whereupon right coil RC is energized and left coil LC deenergized at which time armature 2 comes up under the magnetic influence of upper right-hand pole-piece 34. In like manner the spacing and spring tension bias of all remaining armatures is such that they remain in their downward position until they are first enabled to come up by the lifting of an insulated restraining stud and then are brought up by the magnetic attraction of an opposite upper pole-piece. In the present invention therefore, not only are the undesirable effects of residual magnetism and leakage flux eliminated from the main armature tongues by means of non-magnetic back spacers, but the contact to be broken on each successive stepping operation has been transferred to an auxiliary arm wherein positive contact closure is assured through the intimate adhesion of magnetic contacts, yet the positive interruption of this contact is also assured, when desired, through the action of the next succeeding main armature on an insulated stud attached to the auxiliary arm. By means of the slight gap provided between the auxiliary arm's insulated stud and the next adjacent large armature which operates upon it, the main armature on every operation is allowed to start its upward traverse and by means of this lost motion coupling thus acquires sufficient kinetic energy to always insure opening the auxiliary contact upon striking the insulated stud. The undesirable effects of residual magnetism and leakage flux in the present invention are minimized in the contacts to be broken by virtue of the thin magnetic member which carries this contact, and the resulting increase in reluctance through this portion of the magnetic circuit. The small size of the auxiliary branch arm also reduces the spring tension to be overcome in breaking this magnetic contact, thereby further facilitating the positive interruption of this circuit as the relay steps in response to sequential impulses. Inasmuch as the auxiliary branch arm may be stamped from the lamination which carries the main armature tongue as illustrated by Fig. 2, no additional operation is required to form this member and no added cost is thereby incurred. Although the auxiliary branch armature could be formed of a separate piece of metal without departing from the spirit or principle of the present invention, another advantage of the arrangement illustrated by Fig. 2 is that internal strapping between the make contact and the break contact members is eliminated, thereby reducing materially the cost of assembly and wiring of such stepping relays. Another advantage afforded by the relay of the present invention is that independent and isolated circuits may be successfully controlled by the device herein disclosed, whereas all previously disclosed magnetic stepping relays were limited to the operation of connecting any one of a given number of lines to a common line unless another pole face piece was added for each pulse as in the Stibitz patent. As was seen in the detailed analysis of the relay operation in reference to Fig. 5, a circuit is first closed between pole-pieces 31 and 33, then on the next pulsing cycle this circuit is opened and another circuit is closed between pole-pieces 35 and 37. In like manner the next impulse cycle opens the circuit previously completed between pole-pieces 35 and 37 and then closes another circuit between pole-pieces 39 and 41. Thus it may be seen that a plurality of isolated circuits, each separate and insulated from the other, may be controlled by the stepping relay of the present invention.

Referring now to Fig. 6, we see a schematic circuit diagram in which the stepping relay of the present invention is connected in a manner to recycle, or in other words continuously respond to sequential electrical impulses as received, without limit to the number of such impulses which may be received. Here it will be observed that the circuit for operating the left coil LC is completed through the last contacts in the relay stack, 10, in such manner that when a series of impulses has been received which operates all of the armature tongues in sequence to and including the last armature tongue, the automatic opening of the contacts 10, in response to the tenth impulse received, will open the battery circuit through left coil LC thereby allowing all armatures of the relay stack to fall off into their normal position as biased downward when the both coils of the relay are deenergized. This then automatically resets the relay, thus conditioning it to start stepping from the top all over

again in response to the next or eleventh impulse which may be received in sequence without interruption. The recycling contact 10 may be carried on one of the auxiliary branch arms, in which case it is opened indirectly by operation upon an insulated stud, or it may be of the type illustrated in Fig. 6 which is opened directly by movement of the magnetic armature tongue. We will now trace the sequence of operation in the circuit of Fig. 6. Pulsing relay PR is operated by electrical impulses received from battery 14 in the circuit controlled by operator's dial 12, or this pulsing relay may be operated by any sequential series of electrical impulses as employed in telephone signaling. Operation of the stepping relay is identical with that described in reference to Fig. 5 until we come to the last armature tongue 10. Here on the operation of pulsing relay PR for the ninth time, contact 7 closes completing a circuit from battery 16 through contacts 10 to energize the left coil LC. Subsequently contact 8 opens, thereby deenergizing coil RC and allowing the next to the last tongue 9 to come up. A circuit is now closed through the ninth pair of pole-pieces on the left side, and all other such circuits are opened. On the release of pulsing relay PR contact 8 closes, coil RC is energized, and contact 7 is opened, thereby deenergizing left coil LC and allowing the last armature tongue 10 to come up. The auxiliary branch arm of the previous tongue is opened by operation of armature 10 upon the insulated stud associated with this auxiliary branch, and circuit 9 between the left-hand pole-pieces of the relay stack is thereby opened. Contact 10 connected in series with left coil LC is also opened by this operation. Now upon operation of pulsing relay PR for the tenth time, contact 7 closes but coil LC cannot now be energized since contact 10 is opened. Then when contact 8 of pulsing relay PR subsequently opens right coil RC is deenergized, thus creating a condition in which both operating coils of the stepping relay are deenergized and all of the armature tongues of the relay stack fall off into their normally idle positions. But, in returning to its normal downward biased position the last armature again closes contact 10 thereby energizing left coil LC through contact 7 of the pulsing relay PR which is still operated. This energization of coil LC now brings up the first armature tongue and closes a circuit between the first pair of left-hand pole-pieces, O. The stepping relay has now started its second cycle and succeeding armature tongues will respond to successive impulses as before. This recycling feature is considered highly desirable in many applications within the communication industry. Of course, it is to be understood that this recycling arrangement is not limited to a stepping relay having ten external control circuits as illustrated in Fig. 6, but may be employed with any size of stepping relay having either more or less than ten control circuits.

Referring now to Fig. 7 we see a schematic circuit diagram of a complete selective signaling system employing two magnetic contact counting relays of the type comprehended in the present invention. A significant advantage which this circuit offers over all previous circuits for digital signaling systems employing magnetic contact stepping relays is the elimination of the former requirement for a slow release characteristic in the digit counting relay. Experience has indicated that because of the inherent fast operate characteristic of relays of this type it is quite difficult to build a satisfactory magnetic counting relay of sizeable proportions with an adequate slow release feature.

In the circuit of Fig. 7 the slow release sleeve formerly required on one operating coil of the digit counting relay has been replaced by an auxiliary armature tongue 50 which engages an additional magnetic pole-piece 51 whenever the left coil LC of digit counting relay DCR is energized, thereby providing a positive means for locking up this side of the relay during the interval of pause between digits. The manner in which this functions will be better understood from a study of the detailed circuit analysis following.

Another advantage which the arrangement of Fig. 7 offers over all previous circuits for selective signaling by means of magnetic contact stepping relays is in the elimination of chains of series contacts through the magnetic contact members of the relays. As described in reference to Fig. 5, the auxiliary armature legs afford a means for controlling a plurality of separate isolated and insulated circuits in succession without the necessity of carrying the control circuits through more than one pair of magnetic contacts, as heretofore was required in all previous circuits. By thus reducing the number of contacts in series, the relay device of the present invention reduces the probability of circuit failure due to noisy or open contact conditions developing between the magnetic contacts. Still another improvement offered by the arrangement of Fig. 7 is a reduction in the over-all power drain required for operation of this selective signaling system. The manner in which these advantages are obtained will be more apparent from a detailed analysis of the sequence of operation involved when considered in reference to Fig. 7.

In general, the operation of this circuit is similar to that of the circuit disclosed in the Hickman application previously referred to. In the latter circuit, if the pulse counting relay is energized the correct number of times an alternate path is established through the contacts of the pulse counting relay and the digit counting relay in such a manner that the left coil of the digit counting relay holds up when the slow release relay falls off during the brief pause at the end of each digit. Since this holding circuit passes through the contacts of the pulse counting relay, it is necessary also to hold up one of the coils, as shown, the right coil, of this pulse counting relay. Then at the start of the next digit, it is necessary to release the pulse counting relay so that it may return to its initial idle position, and this release is accomplished by momentarily opening the holding circuit. Consequently, the left coil of the digit counting relay in that circuit is also opened, and the armatures which have already counted digits will fall off unless a slow release characteristic has been built into this coil of the digit counting relay. Because of the inherent fast operation of relays of this type, it has been found difficult to design suitable relays having a sufficient slow release holdup characteristic. However, in the present invention, by means of the arrangement illustrated in Fig. 7, this problem is solved through the operation of the auxiliary armature 50 in cooperation with this contacting pole-piece 51. The sequence of operation in the circuit of Fig. 7 when the pulsing of a digit is completed and the slow release relay SRR falls off is as follows: First, assuming

that the correct number of impulses had been received, the left coil LC of digit counting relay DCR will be energized through one pair of contacts on the digit counting relay and another pair of contacts on the pulse counting relay. Simultaneously, the armature 50 comes up into intimate magnetic contact with the adjacent pole-piece 51 to provide an alternate path for current through left coil LC, thereby locking up the relay DCR. Next the complete release of the slow release relay SRR opens the battery circuit to the operating coil of the pulse counting relay PCR, thereby restoring that relay to its normal idle position. Since the pulse counting relay is thus restored to normal at the end of each digit, there is no power drain holding up this relay during the interval between digits, and no need to restore this relay to normal at the start of the next succeeding digit, as has heretofore been required. Thus it is clear that with the circuit of Fig. 7 the left coil of the digit counting relay can now be deenergized after the right coil is energized at the start of the succeeding digit, so that there is no need for a slow release feature to be incorporated in the left coil of this relay. Since only the coil on the digit counting relay is here energized at the end of a correct digit, and there is no energizing of the left coil on the digit counting relay during the pulsing of a digit as previously, the power drain required by this circuit is considerably less than that required by all previous selective signaling systems employing magnetic contact stepping relays. The addition of the resistance RO in series with the holding circuit of digit counting relay DCR operates to reduce the current through the left coil LC to a minimum hold value, thereby further reducing the power drain.

For a better understanding of the operation of the selective signaling system illustrated by Fig. 7, we will now trace the sequence of operation step-by-step. Upon operation of the operator's dial 59, which may be located at a remote central office, with the switchhook 58 closed as illustrated, a series of electrical impulses are transmitted from battery 60 through loop 57 to pulsing relay PR. When the pulsing relay PR is energized by the first received electrical impulse, contact 61 closes, contact 63 opens, and contact 62 closes to complete a circuit from battery 66 through slow release relay SRR. Upon operation of SRR, contact 65 closes thereupon energizing the right-hand coils of digit counting relay DCR and pulse counting relay PCR, respectively. Now in response to the magnetic attraction of the upper right-hand pole-pieces in both stepping relays, the first tongue 67 of PCR and 68 of DCR come up. Contact 64 of slow release relay SRR opens but no action now occurs as the circuit through armature 50 and pole-piece 51 of digit counting relay DCR is open. Now at the end of the first impulse, pulsing relay PR is deenergized, contact 62 opens and deenergizes slow release relay SRR, but this relay does not open due to its slow release characteristic. Contact 63 closes thereby energizing left coil LC of pulse counting relay PCR. Contact 61 opens, thereby deenergizing right coil RC of pulse counting relay PCR and allowing the second armature tongue 69 of the pulse counting relay to come up under the magnetic attraction of the left-hand pole-piece 70.

At the start of the second impulse, pulsing relay PR is again energized, contact 61 again closes to energize coil RC of pulse counting relay PCR, contact 63 now opens, thereby deenergizing coil LC of pulse counting relay PCR and allowing the third armature tongue 71 of PCR to come up. Contact 62 closes, completing the operating circuit through slow release relay SRR, but no further operation of this relay now occurs because SRR had not previously released due to its slow release characteristic. When the pulsing relay PR is deenergized at the end of the second impulse, contact 62 opens thereby deenergizing slow release relay SRR but yet this relay holds up due to its slow release characteristic, contact 63 closes thereby energizing coil LC of pulse counting relay PCR, and contact 61 opens thereby deenergizing coil RC and allowing the fourth armature tongue 73 of PCR to come up. Thus it is seen that for every complete pulse received by this system, two armature tongues of the pulse counting relay come up. On the last impulse received in a train, the interval between digits is sufficient to allow the slow release relay SRR to fall off, and at this time there are two possible occurrences, depending on whether the number which was dialed is correct or not.

If an incorrect number has been dialed, the following sequence results. When the slow release relay SRR finally falls off, contact 64 closes but coil LC of digit counting relay DCR cannot thereby be energized since there is no path established through the contacts of the pulse counting relay and the digit counting relay. Contact 65 opens and deenergizes coils RC of DCR and LC of PCR, thereby allowing all armature tongues of both stepping relays to fall off. Thus it is seen that reception of an incorrect digit operates to reset the entire selective signaling circuit to its normal idle condition.

If, however, the correct digit has been dialed, the following sequence occurs. When slow release relay SRR finally releases, contact 64 closes thereby completing a circuit from battery 66 through the fourth armature tongue 73 of pulse counting relay PCR which has closed a circuit between left-hand pole-pieces 74 and 75 of PCR, thence through the first armature tongue 68 of digit counting relay DCR which has completed a circuit between the right-hand pole-pieces 76 and 77 of DCR, thence through left coil LC of DCR to ground. Thus LC is energized, the first armature tongue 68 of DCR is held up, the auxiliary contact armature 50 closes contact with pole-piece 51 thereby locking up left coil LC of DCR, and the second armature tongue 78 of DCR is enabled to operate. Contact 65 of SRR opens, thereby deenergizing coils RC of DCR and LC of PCR, thus allowing all the armature tongues of the pulse counting relay to release and at the same time bringing up the second armature tongue 78 of digit counting relay DCR. Thus it is seen that a correct digit brings up two armature tongues of the digit counting relay and resets the pulse counting relay to normal.

At the start of the next train of impulses, representing the second digit, pulsing relay PR is energized on the first impulse, contact 61 closes, contact 63 opens, and contact 62 closes thereby energizing slow release relay SRR. Contact 65 of SRR closes thereby energizing the right-hand coils of both DCR and PCR whereupon the first armature tongue 67 of PCR comes up. Contact 64 opens thereby deenergizing the left coil LC of digit counting relay DCR whereupon the third armature tongue 79 of DCR comes up, and the auxiliary armature tongue 50 falls off disengaging contact with pole-piece 51. The circuit is now in exactly the same condition as that fol-

lowing the first impulse of the first series except for the fact that now the first three armature tongues of digit counting relay DCR are up instead of just the first tongue being up. Thus the path necessary through digit counting relay DCR has now been changed and the correct number of pulses required for the second digit may be either the same as or different from the number required for the first digit depending upon the manner of interconnection between PCR and DCR. If four correct digits are dialed in sequence, all eight armature tongues of the digit counting relay will come up, and a circuit will be closed between the fourth armature tongue 80 and left-hand pole-piece 81 whereby the signal indicator 82 will be operated. The signal may then be interrupted by the subscriber's operation of switchhook 83. The operation of this switchhook can also be used to clear the entire system. If the signal is not answered, the entire system may be restored to normal by the transmission of a single clearing pulse from the Central Office.

Referring now to Fig. 8 we see still another circuit employing a magnetic contact stepping relay of the type comprehended in the present invention. The subject matter of Fig. 8 is shown and claimed in divisional Patent 2,561,730. This circuit differs from all previous pulse counting circuits employing magnetic stepping relays in that the counting relay of Fig. 8 requires only one main armature tongue for each complete pulse to be counted. That is to say, the ten armature tongues in the relay stack of Fig. 8 will count ten impulses, one tongue responding to each impulse as received, whereas as we have seen in the circuits of Figs. 6 and 7, all previous arrangements of magnetic stepping relays have required the operation of two armature tongues for each complete pulse. An obvious advantage of the arrangement of Fig. 8 is the reduction of one-half of the number of armature tongues required to count any given number of impulses. A further advantage is that by operating only one tongue per impulse, the circuit of Fig. 8 may inherently require less time per pulse for counting, thus it is apparent that with the arrangement disclosed in Fig. 8 not only may the size and cost of a magnetic contact stepping relay be reduced but also the speed of operation may be increased.

In Fig. 8, as in Fig. 7, the insulated studs which extend between armature tongues in adjacent layers of the relay stack have been omitted from the drawings for the sake of clarity and to avoid confusion in tracing the schematic circuit. However, it is to be understood that insulating studs of the type disclosed in Figs. 1, 2, 3, 4, 5 and 6 are also incorporated in the magnetic stepping relay of Fig. 8. It is also to be understood that the left and right operating coils, designated schematically as LC and RC respectively in Fig. 8, are wound around the laminated pole-pieces of the left- and right-hand sides of the relay stack respectively, in a manner similar to the arrangement disclosed by the structure of Figs. 1 and 4. The stepping relay structure of Fig. 8 differs from those previously disclosed in that it includes an auxiliary armature tongue 111 interposed between an auxiliary right-hand pole-piece 112 and left-hand pole-piece 113. This auxiliary armature and its associated pole-pieces may be placed either at the bottom of the stepping relay stack as illustrated in Fig. 8, or it may be placed at the top of said stack, or it may be situated anywhere else in the stepping relay structure, provided only that it must not interfere with the stepping operation of the relay. The function of this auxiliary armature tongue 111 is to indicate at all times which of the two operating coils, LC and RC, was the first to be energized whenever both are operating. By reference to Fig. 8, it will be seen that if the left coil LC is first energized, the auxiliary armature tongue 111 will be moved down into conductive engagement with left-hand pole-piece 113, thereby closing contact 91. If the right coil RC is next energized, tongue 111 will not move since the magnetic force due to the closed contact 91 is much greater than the magnetic force through the open contact 92. However, if the left coil LC is then deenergized, armature tongue 111 will come up into intimate contact with right-hand pole-piece 112 thereby closing contact 92. In this situation if the left coil LC is then reenergized, the armature tongue 111 will not again move until such time as right coil RC is deenergized. Thus it is seen that armature 111 always indicates which of the two coils LC and RC was the first to be energized. By means of the two contacts 91 and 92 associated with the auxiliary armature 111, the two pulsing relays PR1 and PR2 are alternately operated on each successive impulse. When starting from idle condition, operation of the correct pulsing relay initially is assured by providing armature 111 with a slight pretension in one direction, in the circuit illustrated by Fig. 8 this pretension being downwardly, to insure that contact 91 is always closed when the circuit is idle.

The detailed operation of the circuit of Fig. 8 will now be traced through a step-by-step analysis. The circuit is first conditioned for operation by closing a switch 89 which completes a circuit through coils LC and RC and the battery 90. Armature tongue 111 remains in intimate contact with left-hand pole-piece 113 toward which it was initially biased by spring tension. Now if the operator's dial 88, which may be located at a remote office is operated, a circuit will be closed through the dial at the start of the first dial pulse, and pulsing relay PR1 will now be energized through contact 91. Upon operation of PR1 contact 93 first opens, then contact 95 closes to lock up PR1 to battery 90, and then contact 97 opens, thereby deenergizing coil LC, which in turn causes armature 101 to be attracted upwardly into intimate contact with the upper right-hand pole-piece. With LC now deenergized, auxiliary armature tongue 111 is attracted upwardly into intimate contact with right-hand pole-piece 112 thereby closing contact 92. However, this opening of contact 91 has no effect on pulsing relay PR1 which as we have just seen has already locked up through contact 95. At this instant, the closing of contact 92 has no effect on pulsing relay PR2 since contact 93 of PR1 is open, thereby introducing a discontinuity in the circuit through the operating coil of PR2.

Now, at the end of the first dial pulse, the circuit through dial 88 will open, whereupon pulsing relay PR1 is deenergized, contact 97 closes and energizes coil LC, contact 95 opens, and contact 93 closes, but pulsing relay PR2 cannot yet operate because the dial contact 88 is still open. The energizing of LC at this moment has no effect on the auxiliary armature tongue 111 since RC is still energized. However, with the start of the second dial pulse, a circuit is closed through the dial contacts at 88 whereupon pulsing relay PR2 is operated through contact 92.

Upon operation of PR2 contact 94 opens, contact 96 closes thereby locking up PR2, and contact 98 opens to deenergize coil RC. Upon deenergization of coil RC the auxiliary armature tongue 111 comes down into engagement with the left-hand pole-piece 113 to close contact 91 and the armature 102 is attracted upwardly into intimate contact with the left-hand pole-piece. Contact 92 is thereby opened but this has no effect on pulsing relay PR2 since, as we have seen above, this relay has already locked up through its contact 96. The closing of contact 91 at this moment has no effect on the operation of pulsing relay PR1, since contact 94 of PR2 is now open thus introducing a discontinuity in the circuit of the operating coil of PR1. As we have seen above, at the end of this dial pulse the circuit through dial 88 is momentarily opened whereupon pulsing relay PR2 is deenergized, contact 98 closes and energizes coil RC, contact 96 opens, and contact 94 closes but cannot operate pulsing relay PR1 because at this moment the dial contact 88 is open. Similarly, at this instant the energizing of coil RC has no effect on the auxiliary armature 111 since coil LC is still energized and armature 111 is thereby held in intimate magnetic contact with left-hand pole-piece 113. We have now completed one cycle of two dial pulses, and at this time the first two armature tongues 101 and 102 are up and a circuit is completed from battery 99 through armature tongue 102 and lamp 202 to ground, thereby indicating that two pulses have been received and counted. On reception of successive impulses the same sequence of operation will follow. This sequence may be tabulated as follows:

Step	Left Coil (LC)	Right Coil (RC)	Pulse
1	energized	energized	start (SW 89 closed).
2	deenergized	do	1st pulse-dial contact closed.
3	energized	do	1st pulse-dial contact opened.
4	do	deenergized	2nd pulse-dial contact closed.
5	do	energized	2nd pulse-dial contact opened.

This sequence results in only one armature tongue of the counting relay coming up for each complete pulse, thereby reducing the number of tongues necessary to count a given number of pulses, and at the same time increasing the speed at which such pulses may be counted. This arrangement may be of considerable advantage in applications where large numbers of pulses must be counted or where the saving in space and cost of the smaller sized counting relay may more than offset the addition of a second pulsing relay. Referring to Fig. 8, the dark magnetic contacts represent magnetic contacts covered by a thin insulating material for the purpose of circuit isolation.

Referring now to Figs. 9 and 10 we see an alternative arrangement of the operating coils for a magnetic contact counting relay of the type comprehended in the present invention. It may be seen from the plan view of Fig. 10 that a coil, here designated CC, is placed around the armature tongue in lieu of a right-hand operating coil as shown in Fig. 4. The left-hand operating coil LC remains unchanged in this arrangement. The advantage of this arrangement is that it enables the stepping relay to be operated directly from dial pulses without the need for an intervening pulsing relay as heretofore required in all pulse

counting circuits employing magnetic contact stepping relays. The simplicity of this operating circuit is shown by the schematic drawing of Fig. 9. Upon closing switch 120 the left coil LC is energized by current flowing from battery 121, and this coil remains so energized throughout the entire pulsing period. The center coil CC is intermittently energized as the operator's dial 122 alternately closes and opens a circuit through this coil and battery 121. The current direction through both coils is such that the magnetic flux set up in the two coils oppose each other. When the dial contacts 122 are open, only the left coil LC is energized, but when the dial contacts are closed, both the left coil and the center coil are energized, and since the flux in the center magnetic tongue is opposed by the flux in the left coil, the former flux returns along the right leg of the magnetic relay structure. Thus the resulting flux throughout the structure under this condition is the same as if the left coil were deenergized and the relay structure were provided with a right coil which was energized as shown by Fig. 4. Thus it may be seen that the overlapping effect of continuity in sequential energization of the two coils, as provided by the continuity transfer pulse relay in the circuits of Figs. 6, 7 and 8 is automatically performed by the arrangement of operating coils illustrated in Figs. 9 and 10, since in this circuit one coil is always energized. A comparison between the operating sequences of the previous circuit and the circuit of Fig. 9 may be tabulated as follows:

Dial Contacts	Previous Circuits	Curcuit of Fig. 9
closed	Pulsing Relay and RC energized.	Left Coil and Center Coil energized.
open	Left Coil energized	Left Coil energized.

The advantages of this simplified circuit of Fig. 9 are that a continuity transfer pulsing relay is not required, thus saving the space formerly required for this relay and also reducing the cost of the apparatus. Also, the circuit may count pulses more rapidly than previous arrangements, since only one coil must be operated. Furthermore, the operation of the circuit of Fig. 9 is more reliable than the previous circuit since the back contact of the pulsing relays, which may have a tendency to chatter, are hereby eliminated.

Referring now to Figs. 11 and 12 we see an alternative arrangement of the relay structure and circuit Figs. 9 and 10 wherein no center coil is provided around the armature tongue and in lieu thereof a differentially wound right coil is placed around the right-hand pole-piece member. The principle of operation involved in the circuit of Fig. 11 is essentially the same as that of Fig. 9, but only the means employed to accomplish this end are modified. It will be seen that when switch 125 is closed, one-half of the right coil 128 is continuously energized by current flowing from battery 126. The other half of this right coil 127 and left coil LC is intermittently energized by interruption of the dial contacts upon operation of dial 129. Since the current flows through coils 127 and 128 in opposite directions the magnetic field of these coils neutralize each other whenever both coils are energized. Thus it will be seen that when the dial contacts of 129 are closed current will flow through left coil LC thereby setting up a magnetic flux through the pole-piece members on the left side of the relay structure. Under this condition current will also flow through coil 127 of RC, but

since current is already flowing through coil 128 of RC and the two coils are differentially wound, the magnetic fields oppose each other and no flux will flow through the right-hand pole-piece members. However, when the contacts of dial 129 are opened no current will flow through LC or through 127 of RC, so that the magnetic field created by current flowing through coil 128 of RC is unopposed under this condition and therefore magnetic flux will flow through the right-hand members of the relay structure. It is apparent then that the sequence of operations for the circuit of Fig. 11 is the same as that previously examined in reference to Fig. 9.

It is to be understood that the scope of the present invention is not limited to the particular arrangement illustrated by the accompanying drawings, but that numerous modifications may be made, both in the design of the relay structure and in the arrangement of the operating circuit, without departing from the spirit of the present invention as defined by the specification and the appended claims.

What is claimed is:

1. A relay comprising two groups of fixed laminations of magnetic material, principal spring tongues of magnetic material attractable into conductive engagement with fixed laminations in both groups, subordinate spring tongues attractable into conductive engagement with the fixed laminations of one group, laminations of insulating material interposed between said fixed laminations and said spring tongues, energizing coils surrounding said groups of laminations respectively, and lost motion mechanical coupling means interposed between said principal spring tongues and said subordinate spring tongues whereby upon alternate energization and deenergization of said coils respectively, said principal tongues are sequentially attracted into conductive engagement with adjacent fixed laminations, and said subordinate tongues are sequentially disengaged from adjacent fixed laminations by said mechanical coupling means of both groups and said subordinate tongues are sequentially disengaged from adjacent laminations of one group by operation of said lost motion coupling means.

2. A relay comprising two stacks of rigid laminations of magnetic material, a first set of flexible spring tongues of magnetic material interposed between adjacent layers of said rigid laminations and separated therefrom by laminations of insulating material, a second set of flexible spring tongues each in the plane of one tongue of said first set, mechanical coupling means interposed between flexible spring tongues of said first set whereby said springs are normally restrained from conductive engagement with adjacent rigid laminations of both stacks, further mechanical means including lost motion links between tongues of said first and second sets in adjacent layers, energizing coils surrounding each stack of said rigid laminations whereby upon energization and deenergization of said coils alternately said first set of springs are sequentially attracted into conductive engagement with adjacent rigid laminations, and said second set of springs are sequentially disengaged by operation of said lost motion links from contact with adjacent rigid laminations.

3. In a relay structure two adjacent stacks of fixed laminations of magnetic material, laminations of both stacks insulated from each other and from laminations of said adjacent stack by layers of insulating material interposed between the laminations of said stacks, a plurality of primary and secondary spring tongues of magnetic material in adjoining layers interposed between adjacent layers of said insulating material in proximity to said fixed laminations, mechanical coupling studs interposed between primary spring tongues in adjoining layers whereby said primary tongues are normally restrained from conductive engagement with adjacent fixed laminations of both stacks, further mechanical studs interposed between primary spring tongues of alternate layers and secondary spring tongues of an adjoining layer in a manner to include an air-gap between said further studs and said spring tongues of an adjoining layer, magnetic contacts on one side of said primary spring tongues adjacent to and in substantial alignment with corresponding magnetic contacts on facing sides of adjacent fixed laminations in both groups, non-magnetic spacers on the opposite side of said primary spring tongues from said magnetic contacts, further magnetic contacts on each of said secondary spring tongues normally in conductive engagement with a like magnetic contact on an adjacent fixed lamination, and energizing coils surrounding each of said stacks of fixed laminations whereby, upon sequential energization and deenergization of said coils respectively, said primary spring tongues are sequentially attracted into conductive engagement with adjacent fixed laminations of both groups and said secondary spring tongues are successively disengaged from contact with adjacent fixed laminations by said further mechanical studs.

4. An impulse counting system comprising in combination a continuity transfer relay, a source of electrical energy, and a magnetic contact counting relay comprising two adjoining stacks of fixed laminations of magnetic material, laminations of insulating material interposed between adjacent laminations of said magnetic material, a plurality of primary and secondary armatures of magnetic material interposed between adjacent layers of said stacked fixed laminations and insulated therefrom, a tertiary armature of magnetic material, mechanical coupling means interposed between adjacent armatures, energizing coils surrounding each of said stacks of fixed laminations, one of said coils connected to said energy source through one contact of said continuity transfer relay, the other of said coils connected to said energy source through said tertiary armature and another contact of said continuity transfer relay whereby upon successive operation of said continuity transfer relay potential is applied from said source of electrical energy to alternately energize and deenergize said coils and successively establish contact between said primary armatures and adjacent fixed laminations.

5. A magnetic contact counting relay comprising a plurality of rigid laminations of magnetic material arranged in two adjacent stacks, laminations of each stack insulated from the opposite stack, each stack comprising layers of magnetic members having alternate long and short pole-pieces in alternate layers, the long pole-pieces in alternate layers of each stack abutting opposite short pole-pieces in alternate layers of the other stack in a manner to provide substantially uniform air gaps between opposing pole-pieces of the two stacks, insulation between adjacent laminations, further laminations of magnetic material in the form of flexible spring tongues inter-

posed between adjacent layers of said rigid laminations and isolated therefrom by said insulation, one of each such further laminations interleaved between each two adjacent layers of said rigid laminations, each of said further laminations comprising a main spring tongue, alternate layers of said further laminations comprising a narrow auxiliary spring tongue in addition to said main spring tongue, magnetic contact surfaces on the upper face of each of said main spring tongues and non-magnetic spacers on the opposite face of each of said tongues, further magnetic contact surfaces on the lower face of each of said auxiliary spring tongues, magnetic contact surfaces on the faces of said magnetic pole-pieces aligned with and adjacent to said contact surfaces on said tongues, said spring tongues being normally biased downwardly into engagement with the pole-pieces of the next adjacent layer of said rigid laminations, an insulated stud associated with each of said auxiliary spring tongues and adapted to be engaged by the main tongue lamination of the next adjacent layer below said auxiliary tongue when said next adjacent main spring tongue moves into operated position, further insulated studs associated with said main spring tongues in each layer in a manner to bear upon and restrain all main tongues below said layer into their normally downward biased positions, and a pair of operating coils, one of said coils wound around each of said stacks of rigid laminations, whereby upon alternate energization and deenergization of said coils said spring tongues are sequentially moved one at a time into conductive engagement with the next adjacent pair of magnetic pole-pieces, and said auxiliary spring tongues are successively disengaged one at a time from their conductive contacts.

6. A magnetic contact counting relay according to claim 5 comprising an additional armature operable only upon operation of the last sequentially operated spring tongues of said relay to open circuits of both operating coils and condition said relay for recycling.

7. A magnetic contact counting relay according to claim 5 in combination with a continuity transfer relay, a source of electrical potential, and means for generating a series of electrical impulses sequentially.

8. A magnetic contact counting relay according to claim 5 in combination with means for generating sequential electrical impulses, and recycling means comprising an additional auxiliary armature tongue operable at the end of each counting cycle to restore said counting relay to normal.

9. In a magnetic contact counting relay according to claim 5 an armature lamination comprising a plurality of magnetic armatures each bearing magnetic contacts at their outer extremities.

10. In a relay structure two groups of fixed laminations of magnetic material, a first set of magnetic armatures attractable into conductive engagement with laminations of both groups but normally disengaged therefrom, a second set of magnetic armatures each of which is normally in conductive engagement with a fixed lamination of one group, energizing coils surrounding each of said groups of laminations respectively for attracting successive armatures of said first set into conductive engagement with adjacent laminations of both groups upon alternate energization of said coils, mechanical coupling means between armatures of said first set whereby all but one of said armatures are normally restrained from being attracted into conductive engagement with fixed laminations of both groups upon energization of said coils, further mechanical means including a lost motion coupling between armatures of said first and second sets for disengaging said second armatures from said laminations successively as adjoining armatures of said first set are sequentially attracted into operative engagement.

11. An impulse counting relay comprising a plurality of layers of magnetic laminations in adjacent stacks, each of said laminations insulated from the others and each bearing an electrically conductive magnetic surface on one face thereof, a plurality of layers of magnetic spring armatures interposed between layers of said magnetic laminations and insulated therefrom and from each other, alternate layers of armatures comprising a main armature and an auxiliary armature, said main armatures having electrically conductive magnetic surfaces on one face thereof and a non-magnetic surface on the opposite face thereof, electrically conductive magnetic surfaces on one face of said auxiliary armatures, energizing coils surrounding each stack of magnetic laminations, mechanical coupling means extending between main armatures in adjoining layers, means including said mechanical coupling normally holding the electrically conductive magnetic surfaces of said main armatures disengaged from adjacent conductive surfaces of said magnetic laminations, means normally holding the electrically conductive surfaces of said auxiliary armatures in conductive engagement with corresponding surfaces of adjacent magnetic laminations, and further mechanical means including lost motion coupling between said main armatures and auxiliary armatures in adjoining layers whereby upon alternate energization and deenergization of said coils said main armatures are sequentially attracted into conductive engagement with adjacent magnetic laminations and said auxiliary armatures are successively disengaged from electrical contact with said laminations.

THOMAS P. FARKAS.

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