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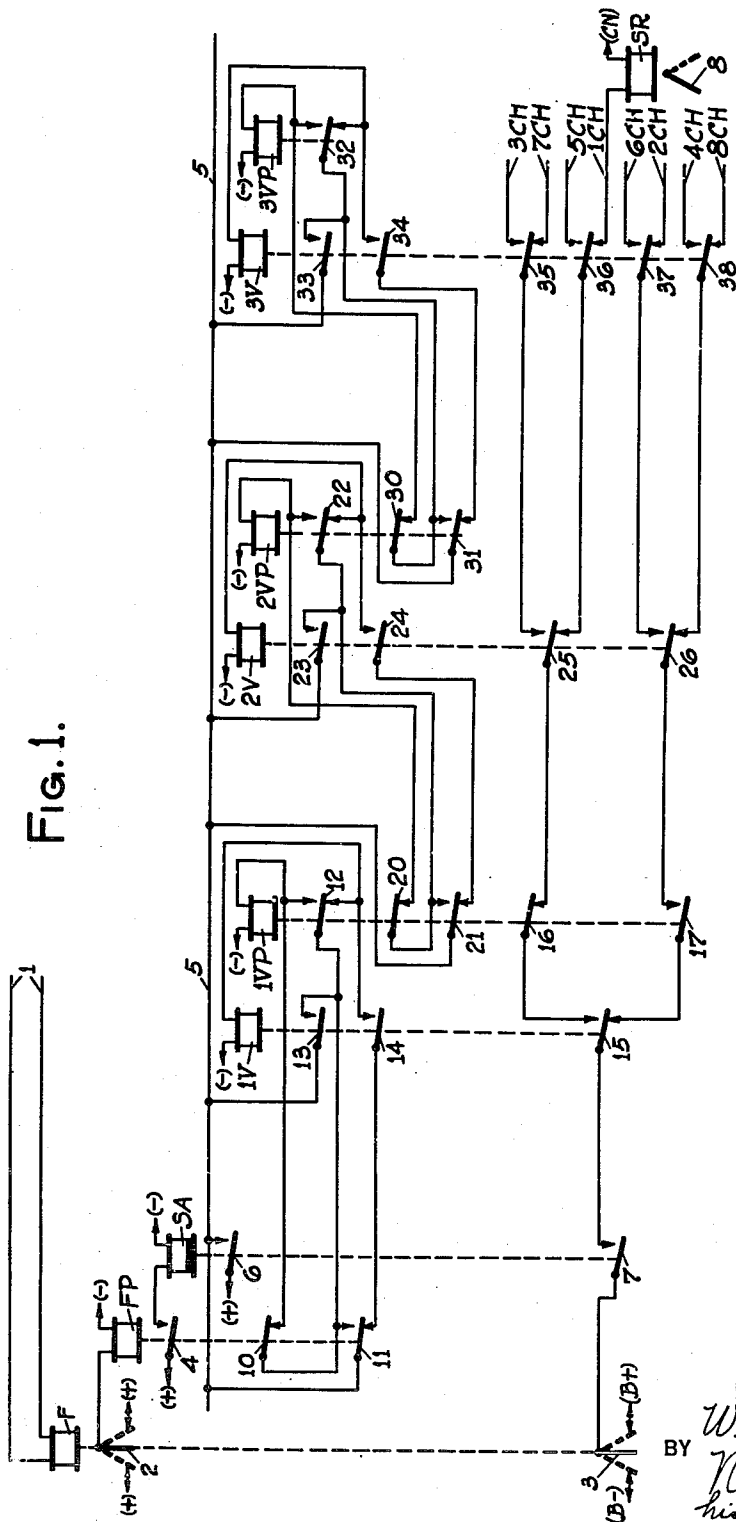
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CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

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2 Sheets-Sheet 1

FIG. 1.



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2 Sheets-Sheet 2

FIG. 2.
TYPICAL OPERATION CHART

No. of Operation	Relay Reference Characters						No. of Channel
	FP	IV	IVP	2V	2VP	3V	3VP
1	PU.	PU.					1CH
2	DA.		PU.	PU.			
3	PU.	DA.					2CH
4	DA.		DA.		PU.	PU.	
5	PU.	PU.					3CH
6	DA.		PU.	DA.			
7	PU.	DA.					4CH
8	DA.		DA.		DA.		PU.
9	PU.	PU.					5CH
10	DA.		PU.	PU.			
11	PU.	DA.					6CH
12	DA.		DA.		PU.	DA.	
13	PU.	PU.					7CH
14	DA.		PU.	DA.			
15	PU.	DA.					8CH
16	DA.		DA.		DA.		DA.

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CENTRALIZED TRAFFIC CONTROLLING
SYSTEM FOR RAILROADSWinfred T. Powell, Rochester, N. Y., assignor to
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13 Claims. (Cl. 177—353)

This invention relates to centralized traffic controlling systems for railroads, and more particularly pertains to the communication apparatus employed in such systems.

In a centralized traffic controlling system employing a coded type of communication system, such as disclosed, for example, in the pending application of Judge and Bushnell, Ser. No. 640,062, filed October 28, 1932, corresponding to British Patent 419,399, it is desirable to employ step-by-step mechanisms which require a minimum amount of apparatus to accomplish the necessary operations.

The present invention proposes a step-by-step mechanism for coded type systems in which a bank of stepping relays makes up a plurality of local channel circuits. This bank of stepping relays includes a plurality of what may be termed "stepping groups," each group comprising a full step relay and a half step relay. Each of these stepping groups are identical and any number may be employed in the stepping relay bank.

The first stepping group of the bank responds with one relay operation for each operation of the control relay. As there are two relays in the group, namely, a full step relay and a half step relay, only half of the operations of the control relay are repeated by the half step relay of the first group, which half step relay in turn controls the second stepping group. Similarly, the half step relay of the second stepping group controls the third stepping group, and so on, each stepping group responding with one half of the operation of its next preceding group.

The number of local channel circuits which is made up by such a stepping relay bank is equal to two raised to the power of the number of stepping groups. Thus, one stepping group provides two local channel circuits; two stepping groups provide four local channel circuits; three stepping groups provide eight stepping channel circuits; four stepping groups provide 16 local channel circuits; and so on, the number of channels being doubled by the addition of each stepping group.

Other objects, purposes and characteristic features of the present invention will be in part obvious from the accompanying drawings and in part pointed out as the description thereof progresses.

In describing the invention in detail, reference will be made to the accompanying drawings in which like characters designate corresponding parts, and in which:—

Fig. 1 illustrates a stepping relay bank arranged in accordance with the present invention; and Fig. 2 illustrates a typical operation chart for a stepping bank arranged as in Fig. 1.

For the purpose of simplifying the illustration and facilitating in its explanation, the various parts and circuits constituting the embodiment of the invention have been shown diagrammatically and certain conventional illustrations have been employed, the drawings having been made more with the purpose of making it easy to understand the principles and mode of operation than with the idea of illustrating the specific construction and arrangement of parts that would be employed in practice. Thus, the various relays and their contacts are illustrated in a conventional manner and symbols are used to indicate connections to the terminals of batteries, or other sources of electric current, instead of showing all of the wiring connections to these terminals.

The symbols (+) and (−) are employed to indicate the positive and negative terminals respectively of suitable batteries, or other sources of direct current; and the circuits with which these symbols are used, always have current flowing in the same direction. The symbols (B+) and (B−) indicate connections to the opposite terminals of a suitable battery, or other direct current source which has a central or intermediate tap designated (CN); and the circuits with which these symbols are used, may have current flowing in one direction or the other depending upon the particular terminal used in combination with the intermediate tap (CN).

While certain features of the invention are applicable to and useable with any type of communication system for centralized traffic control, the specific embodiment of the invention has been shown in a form adapted for use with a selective communication system of the duplex coded type, shown and described in detail in the above mentioned pending application of Judge and Bushnell, Ser. No. 640,062, filed October 28, 1932. Thus, before considering the structure and mode of operation of the parts constituting this invention, it becomes desirable to explain some of the features of this communication system insofar as material to an understanding of the present invention, reference being made to said prior application for other details of the structure and operation of such a communication system not directly related to the features of this invention.

The centralized traffic control system contemplated as embodying the present invention in-

cludes a central control office and a plurality of outlying field stations to which and from which controls and indications respectively are transmitted. The control office and each of the field stations includes a bank of stepping relays which are operated in synchronism through cycles of operation comprising a predetermined number of steps. On each of these steps, the control line circuit connecting the control office with the several field stations, is conditioned in accordance with code calls and controls for the selection of a particular station and the transmission of controls to that station. Similarly, on each of these steps, a field station may be conditioning an indication line circuit interconnecting the control office with the several field stations, whereby that field station is registered in the control office followed by the storing of its indications.

The conditioning of the line circuits at the control office and the field stations, as well as the reception of these conditions at the respective locations, is accomplished on each step by the provision of what are conveniently termed local channel circuits.

Although these local channel circuits are employed both for the transmission and reception of controls and for the transmission and reception of indications at the several locations as required in accordance with a communication system of this character, the present invention has been shown as applied to the step-by-step apparatus at a field station for the reception of controls at that station.

Description of apparatus

With reference to Fig. 1 of the accompanying drawings, the step-by-step apparatus at a typical field station is illustrated as controlled over a line circuit which includes a line wire 1, and a three-position biased-to-neutral polarized line relay F. It is assumed that different series of impulses are placed upon this line circuit in a central office for causing the step-by-step operation at the several stations, irrespective of the polarity of the impulses, while the polarity of the impulses of any series forms the code call and controls to be transmitted for that series. The line relay F is provided with contacts 2 and 3 which are operated to right hand positions by a positive impulse over the line circuit and which are operated to the left hand positions by a negative impulse over the line circuit.

A quick acting line repeating relay FP repeats each energization of the line relay F irrespective of the polarity of such energization by reason of the closure of an energizing circuit by the contact 2 of the relay F in either of its energized positions. These circuits will be obvious from the drawings.

A slow acting relay SA is energized each time the quick acting line repeating relay FP is picked up by reason of the closure of front contact 4 of relay FP, through circuits obvious from the drawings. This slow acting relay SA is slow in picking up and is slow in dropping away, although it is to be understood that it is relatively quick in picking up as compared to its drop-away period. This arrangement provides that the relay SA is picked up at the beginning of each series of impulses repeated by the relay FP and remains picked up throughout the series irrespective of the time spaces between successive impulses, but drops at the end of such series when the line circuit has been de-energized for a pre-

determined period of time. Thus, the closure of front contact 5 of relay SA energizes the bus wire 5 throughout any series of impulses applied to the control line 1 and de-energizes the bus wire 5 between the successive application of different series of impulses.

The stepping relay bank includes a plurality of stepping groups. Each group includes a full step relay V and half step relay VP. For example, the first stepping group includes the relays 1V and 1VP; the second group includes the relays 2V and 2VP; and the third group includes the relays 3V and 3VP.

For convenience in the explanation, the contacts on the relays of the first group and their controlling contacts on the relay FP are made distinctive by the use of the integer 1 in the tens place of their reference character; similarly, the contacts on the relays of the second group and their controlling contacts on the relay 1VP are made distinctive by the use of the integer 2 in the tens place of their reference character; and likewise, the contacts on the relays of the third group and their controlling contacts on the relay 2VP are made distinctive by the use of the integer 3 in the tens place of their reference character.

A two-position polarized relay SR of the magnetic stick type is illustrated as controlled on the first local channel circuit, although it is to be understood that any type of relay may be employed on any channel circuit, and that the channel circuits may be used for any purpose that may be desired in a communication system of the type contemplated in accordance with the present invention. This relay SR has a polar contact 8 which is operable to right or left hand positions dependent upon whether the windings of the relay SR are energized with positive or negative potentials respectively.

It is believed that the nature of the invention, its advantages and characteristic features can be best understood with further description being set forth from the standpoint of operation.

Operation

With the system in a normal condition of rest, the relays illustrated in Fig. 1 are in normally de-energized conditions.

Let us assume that a series of time spaced impulses are placed upon the control line 1, which series includes 8 energized periods, the first of which is relatively longer than the rest. Also, the last energized period of the series is followed by a relatively long de-energized period before another series is applied to the control line. The polarity of these impulses may be determined in accordance with the usual means of such a coded type system, but the particular code arrangement is immaterial for an understanding of the present invention, except that it should be understood that each impulse may be either positive or negative in character and such distinctive character is effective to position particular devices in accordance therewith.

Although a particular channel circuit is completed for each full step taken by the stepping relay bank, the channel circuits will be pointed out following a description of the step-by-step operation.

Step-by-step operation.—The application of the first impulse to the line is repeated by the line relay F, and irrespective of its particular polarity, the relay FP is energized by the closure of contact 2 in either a right or a left hand posi-

tion. The energization of the relay FP and the resulting closure of its front contact 4 causes the relay SA to be energized. As the first impulse of the series is relatively long as compared to the remaining impulses, sufficient time is provided for the contacts 6 and 7 of the relay SA to pick up. When the relay SA is once picked up, its slow acting characteristics provide that its contacts will remain picked up, although the relay SA is intermittently de-energized upon the opening of front contact 4 of relay FP in response to the time spaces between the impulses of the series.

As soon as the relay SA closes its front contact 6, a pick-up circuit is closed for the relay IV from (+), through a circuit including front contact 6 of relay SA, bus wire 5, front contact 11 of relay FP, back contact 12 of relay IVP, windings of relay IV, to (-).

As soon as the contacts of the relay IV respond, its temporary stick circuit is closed from (+), through a circuit including front contact 6 of relay SA, bus wire 5, front contact 13 of relay IV, back contact 12 of relay IVP, windings of relay IV, to (-). It is apparent that this stick circuit will remain closed until the back contact 12 of relay IVP is opened.

Upon the de-energization of the relay FP for the first time space in the series of impulses, a holding stick circuit is closed for the relay IV, from (+), through a circuit including front contact 6 of relay SA, bus wire 5, back contact 11 of relay FP, front contact 14 of relay IV, windings of relay IV, to (-). This holding stick circuit is closed prior to the opening of the temporary stick circuit of relay IV, as previously traced, in response to the closure of the pick-up circuit of the relay IVP. In other words, the temporary stick circuit is effective only during the change over period, that is, during the change over from the pick-up circuit to the holding stick circuit.

The pick-up circuit for the half step relay IVP is energized immediately upon the closure of back contact 10 of relay FP. This circuit is closed from (+), through a circuit including front contact 6 of relay SA, bus wire 5, front contact 13 of relay IV, back contact 10 of relay FP, windings of relay IVP, to (-).

The response of the relay IVP closes a temporary stick circuit from (+), through a circuit including front contact 6 of relay SA, bus wire 5, front contact 13 of relay IV, front contact 12 of relay IVP, windings of relay IV, to (-).

Upon the next energization of the relay FP in response to the second impulse on the control line 1, a holding stick circuit is closed for the relay IVP from (+), through a circuit including front contact 6 of relay SA, bus wire 5, front contact 11 of relay FP, front contact 12 of relay IVP, windings of relay IVP, to (-). This holding stick circuit for the relay IVP is closed prior to the opening of the temporary stick circuit for the relay IVP at front contact 13, which opens when the relay IV drops away in response to the opening of its holding stick circuit at back contact 11 of relay FP.

The next de-energized period or time space in the series of impulses causes the drop-away of the relay FP which in turn de-energizes the relay IVP and allows its contacts to drop away. This de-energization of the relay IVP is caused by the opening of its holding stick circuit at front contact 11.

In other words, two energized periods and two time space periods on the control line circuit

cause the stepping group comprising relays IV and IVP to complete a cycle of operation, that is, to be picked up successively and to be dropped successively. It is apparent that the relay IVP repeats only half of the operations of the relay FP, and similarly, the relay 2VP repeats half of the operations of the relay IVP while the relay 2V repeats the other half.

Similarly, as the stepping group IV and IVP repeat the operations of the relay FP, the second stepping group comprising relays 2V and 2VP repeat the operations of the half step relay IVP.

Likewise, the stepping group comprising relays 3V and 3VP repeat the operations of the relay 2VP. In brief, each stepping group repeats half of the operations of the preceding stepping group. This principle is provided so that the local channel circuits may be built up exponentially, as presently to be described.

Each stepping group is similar, so that a detailed description of the operation of the second and third groups is deemed unnecessary, although the circuits of each will be pointed out in detail.

The pick-up circuit for the relay 2V is closed from the bus wire 5, through a circuit including front contact 21 of relay IVP, back contact 22 of relay 2VP, windings of relay 2V, to (-).

The temporary stick circuit for the relay 2V is closed from the bus wire 5, through a circuit including front contact 23 of relay 2V, back contact 22 of relay 2VP, windings of relay 2V, to (-).

The holding stick circuit for the relay 2V is closed from the bus wire 5, through a circuit including back contact 21 of relay IVP, front contact 24 of relay 2V, windings of relay 2V, to (-).

The pick-up circuit for the relay 2VP is closed from the bus wire 5, through a circuit including front contact 23 of relay 2V, back contact 20 of relay IVP, windings of relay 2VP, to (-).

The temporary stick circuit for the relay 2VP is closed from the bus wire 5, through a circuit including front contact 23 of relay 2V, front contact 22 of relay 2VP, windings of relay 2VP, to (-).

The holding stick circuit for the relay 2VP, is closed from the bus wire 5, through a circuit including front contact 21 of relay IVP, front contact 22 of relay 2VP, windings of relay 2VP, to (-).

The pick-up circuit for the relay 3V is closed from the bus wire 5, through a circuit including front contact 31 of relay 2VP, back contact 32 of relay 3VP, windings of relay 3V, to (-).

The temporary stick circuit for the relay 3V is closed from the bus wire 5, through a circuit including front contact 33 of relay 3V, back contact 32 of relay 3VP, windings of relay 3V, to (-).

The holding stick circuit for the relay 3V is closed from the bus wire 5, through a circuit including back contact 31 of relay 2VP, front contact 34 of relay 3V, windings of relay 3V, to (-).

The pick-up circuit for the relay 3VP is closed from the bus wire 5, through a circuit including front contact 33 of relay 3V, back contact 30 of relay 2VP, windings of relay 3VP, to (-).

The temporary stick circuit for the relay 3VP is closed from the bus wire 5, through a circuit including front contact 33 of relay 3V, front contact 32 of relay 3VP, windings of relay 3VP, to (-).

The holding stick circuit for the relay 3VP, is closed from the bus wire 5, through a circuit in-

cluding front contact 31 of relay 2VP, front contact 32 of relay 3VP, windings of relay 3VP, to (—).

It is to be understood, that any number of stepping groups may be provided, all of which operate in the manner above described. Also, the length of each impulse period and each time space between successive impulses is sufficient to allow all the operations in the stepping bank. In other words, the periods of impulse and time space must be long enough to permit the response of a relay in each of the stepping groups at certain points in each complete cycle of the stepping bank. Thus, the greater the number of stepping groups, the larger the periods of impulse and time space must be.

At the end of a series of impulses, the last de-energization of the control line causes the de-energization of the relay FP and returns all of the relays to normally dropped away positions in the particular embodiment illustrated. However, if a different number of groups were provided, or in the event that the stepping did not continue for the full number of usual steps, the occurrence of the long de-energized period at the end of a series of impulses would cause the de-energization of the relay SA and thereby return all relays to normally de-energized positions by reason of the de-energization of the bus wire 5 from which the whole stepping bank is controlled.

Channel circuits.—With reference to Fig. 2 of the accompanying drawings, a typical operation chart has been illustrated.

In this chart, only the operations of the relays have been given rather than to point out the particular condition of each relay for each condition of the relay FP, to thereby eliminate many repetitions. In other words, each time the relays FP, IV, IVP, 2V, 2VP, 3V and 3VP change positions, such a change is noted in the chart by the abbreviations P. U. for pick-up and D. A. for drop away.

For example, the first energized period causes the relay FP to pick-up, as indicated, which results in the picking up of the relay IV, as indicated. In the last column of the chart, the particular channel circuit which is made up is named, which for the first energized period is the channel circuit 1CH. For another example, the sixth energized period causes the relay FP to pick up, which results in only the drop-away of the relay IV, to thereby complete the sixth channel circuit 6CH. Likewise, the fourth time space in the series causes the drop-away of the relay FP, which in turn causes the drop-away of the relay IVP, the drop-away of the relay 2VP, and the pick-up of the relay 3VP but there is no channel circuit made up at this time.

By referring to this chart of Fig. 2 and to the circuits of Fig. 1, it is believed that the making up of the channel circuits will be readily apparent.

For example, the first channel circuit during the first energized period following the picking up of the relay SA is closed from (B+) or (B—), through the polar contact 3 of relay F in either a right or a left hand position respectively, through a circuit including front contact 7 of relay SA, front contact 15 of relay IV, back contact 16 of relay IVP, back contact 25 of relay 2V, back contact 36 of relay 3V, through windings of relay SR, to (CN). Depending upon whether the impulse is of positive or negative potential, the relay SR is energized positively or negatively causing its

contact 8 to be actuated to either a right hand or left hand position respectively.

Each of the remaining channel circuits are similarly completed during their respective periods marked off by the energization of the relays F and FP for the corresponding impulses applied to the line circuit.

In this connection, it may be noted that the front contact 7 of relay SA is not essential to provide for the operableness of the present embodiment, but is rather provided so that the local channel circuits may be protected from a temporary energization due to a surge on the line circuit. This is accomplished with the present arrangement, as such a surge would be of insufficient duration to provide for the pick-up period of the relay SA.

These channel circuits may be extended for any number of stepping groups in a similar manner as illustrated, thereby doubling the number of channel circuits by the addition of each group.

The only unsymmetrical part of the channel circuits is the provision of back and front contacts 16 and 17 respectively of the relay IVP which provide that there is no overlap between channel circuits. In other words, the response of each of the devices required for any one period is required before the channel circuit for that period is closed, and in the interim between the first response for that period and the last, there is no channel circuit closed.

It is to be understood that channel circuits illustrated in the present embodiment may be employed for other purposes than for the reception of controls from the line circuit as illustrated, but may be used in various purposes, such as, for example, the control of a pulsing relay to govern an indication line circuit, or for various purposes such as found, for example, in the above mentioned pending application of Judge et al. Ser. No. 640,062, filed October 28, 1932.

Having described a stepping relay bank as particularly adaptable for selective type communication systems in centralized traffic control systems as one specific embodiment of the present invention, it is desired to be understood that this form is selected to facilitate in the disclosure of the invention rather than to limit the number of forms which it may assume; and, it is to be further understood that various modifications, adaptations and alterations may be applied to the specific form shown to meet the requirements of practice, without in any manner departing from the spirit or scope of the present invention except as limited by the appended claims.

What I claim is:—

1. In combination, a control relay having front and back contacts, a series of stepping relays capable of taking a plurality of steps and including a full step relay and a half step relay, a pick-up circuit for said full step relay including a front contact of said control relay and a back contact of said half step relay, a temporary stick circuit for said full step relay including its own front contact and a back contact of said half step relay, a holding stick circuit for said full step relay including its own front contact and a back contact of said control relay, a pick-up circuit for said half step relay including a front contact of said full step relay and a back contact of said control relay, a temporary stick circuit for said half step relay including its own front contact and a front contact of said full step relay, a holding stick circuit for said half step relay including its own front contact and a front contact of said control

relay, and electro-responsive means controlled by said full step and half step relays.

2. In combination; a control relay; a plurality of stepping groups of relays comprising a chain of counting relays capable of going through a plurality of steps, each group of which comprises a full step relay and a half step relay; means for causing the first of said relay groups to respond to only half of the operations of said control relay, and each remaining group of relays to respond to only half of the operations of its preceding relay group; a number of channel circuits made up by said groups of relays, said number being equal to two raised to the power of the number of said groups of relays; and means effective to prevent the closure of any of said channel circuits during the operations of said groups of relays in changing from one of said channel circuits to another of said channel circuits.

3. In combination; a control relay; a plurality of stepping groups of relays capable of taking a plurality of steps, each group of which comprises a full step relay and a half step relay; means causing said full step and said half step relays of each group to operate alternately in response to control impulses; control circuits for the first of said groups of relays arranged to provide control impulses for said first group for each operation of said control relay; control circuits for said remaining groups of relays so arranged that each group receives a control impulse for each operation of the half step relay of the preceding group; and a plurality of channel circuits, each of said circuits including a contact of the full step relay of each group and a contact of the half step relay of the first group.

4. In combination; a control relay; means for successively picking up and dropping said control relay; a plurality of stepping groups of relays, each group of which comprises a single wound full step relay and a single wound half step relay; means for energizing and de-energizing the single windings of the relays of the first of said groups to cause them to respond to only one half of the pick up operations of said control relay, means for energizing and de-energizing the single windings of the relays of each remaining group to cause them to respond to only one half of the pick up operations of its preceding relay group; a number of channel circuits made up by said groups of relays, said number being equal to two raised to the power of the number of said groups of relays; means for distinctively energizing said channel circuits; and relay means distinctively controlled in accordance with the distinctive energization of said channel circuits.

5. In combination; a control relay; a series of stepping relays; means for causing said stepping relays to take a plurality of steps at least one for each pick up or drop away operation of said control relay; a channel circuit prepared by said series of stepping relays for each pick up operation of said control relay; means controlling the preparation of said channel circuits so that the stepping operations of said series of relays between said pick up operations positively opens all of said channel circuits until the stepping operation of said series of relays for said next pick up operation of said control relay; and means controlling the energization of said prepared channel circuits.

6. In combination; a control relay having contacts operated to opposite positions alternately; a plurality of series of stepping relays capable

of taking a plurality of steps, each of said series including a single wound full-step relay and a single wound half-step relay; means for alternately picking up and dropping the full-step relay of a first series upon successive operation of said contacts to one of their positions; means for alternately picking up and dropping said half-step relay of said first series upon successive operation of said contacts to the other of their positions; and circuit means controlled jointly by said full-step and said half-step relays of said first series for controlling the operation of the full-step and the half-step relays of a second series.

7. In combination, an impulse relay for repeating a plurality of impulses, a first stepping relay and a second stepping relay, means including a front contact of said impulse relay and a back contact of said second stepping relay for operating said first stepping relay in response to the operation of said impulse relay, means for operating said second stepping relay in response to the release of said impulse relay, and means including a back contact of said impulse relay for completing a stick circuit for said first stepping relay before its operating circuit is interrupted by the operation of said second stepping relay.

8. In combination; a stepping line circuit having a plurality of series of time spaced impulses impressed thereon; an impulse relay; means responsive to said impulses for operating said impulse relay; a step-by-step mechanism operable through a separate cycle for each of said series of impulses, said mechanism comprising a plurality of groups of relays and each group comprising a pair of relays picked up and dropped only by the closing and opening respectively of their energizing circuits; means controlled by said mechanism for selecting a number of channel circuits which equals two raised to the power of the number of said groups; and means responsive to the operation of said impulse relay for operating said mechanism into a separate distinctive condition for each of said impulses and the time spaces between said impulses.

9. In combination, a plurality of single wound relays, means for applying a series of time spaced impulses of current to said relays, means responsive to a first impulse for energizing the single winding of one of said relays whereby said one relay is picked up, means responsive to the succeeding time space for energizing the single winding of another of said relays whereby said another relay is picked up, means responsive to a second impulse and succeeding time space for opening the circuits of said one relay and said another relay respectively whereby they are released.

10. In combination, a plurality of single wound relays, means for applying a first series of time spaced impulses of current to said relays, means responsive to a first impulse for energizing the single winding of one of said relays whereby said one relay is picked up, means responsive to the succeeding time space for energizing the single winding of another of said relays whereby said another relay is picked up, means responsive to a second impulse and succeeding time space for opening the circuits of said one relay and said another relay respectively whereby they are released, and means controlled by one of said relays for generating a second series of time spaced impulses which equal one-half the number of impulses in said first series.

11. In combination, a first plurality of single wound relays, means for applying a first series of time spaced impulses of current to said relays, means responsive to a first impulse for energizing the single winding of one of said relays whereby said one relay is picked up, means responsive to the succeeding time space for energizing the single winding of another of said relays whereby said another relay is picked up, means responsive to a second impulse and succeeding time space for opening the circuits of said one relay and said another relay respectively whereby they are released, means controlled by one of said relays for generating a second series of time spaced impulses which equal one-half the number of impulses in said first series, and means controlled by the impulses and time spaces of said second series for controlling a second plurality of relays in the same manner said first plurality of relays is controlled by said first plurality of impulses and time spaces.

12. In combination, an impulse relay capable of being picked up and dropped to comprise a cycle of operations, a pair of counting relays capable of counting the cycles of operations of

said impulse relay, means including a front contact of said impulse relay for picking up one of said counting relays, means including a back contact of said impulse relay for sticking said one counting relay, means including a back contact of said impulse relay for picking up the other of said counting relays, and means including a front contact of said impulse relay for sticking said other counting relay.

13. In combination, an impulse relay capable of being picked up and dropped to comprise a cycle of operations, a pair of counting relays capable of counting the cycles of operations of said impulse relay, means including a front contact of said impulse relay for picking up one of said counting relays, means including a back contact of said impulse relay for sticking said one counting relay, means including a back contact of said impulse relay for picking up the other of said counting relays, means including a front contact of said impulse relay for sticking said other counting relay, and means including a front contact of said one counting relay for sticking both of said counting relays.

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