

Jan. 5, 1937.

O. H. DICKE

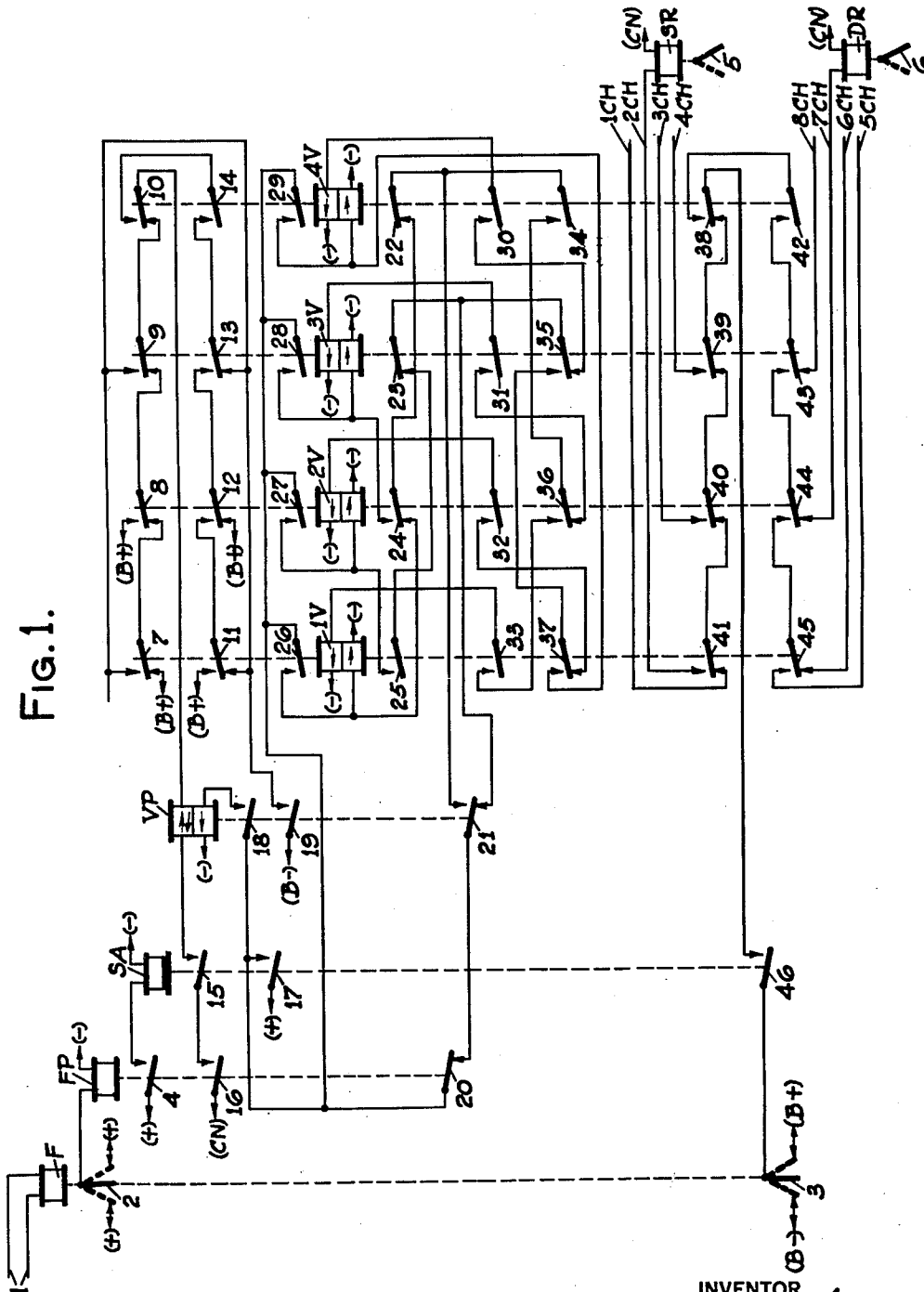
2,067,151

CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

Filed Dec. 30, 1932

4 Sheets-Sheet 1

Fig. 1:



INVENTOR
O. H. Dicke,
BY Neil H. Preston,
his ATTORNEY

Jan. 5, 1937.

O. H. DICKE

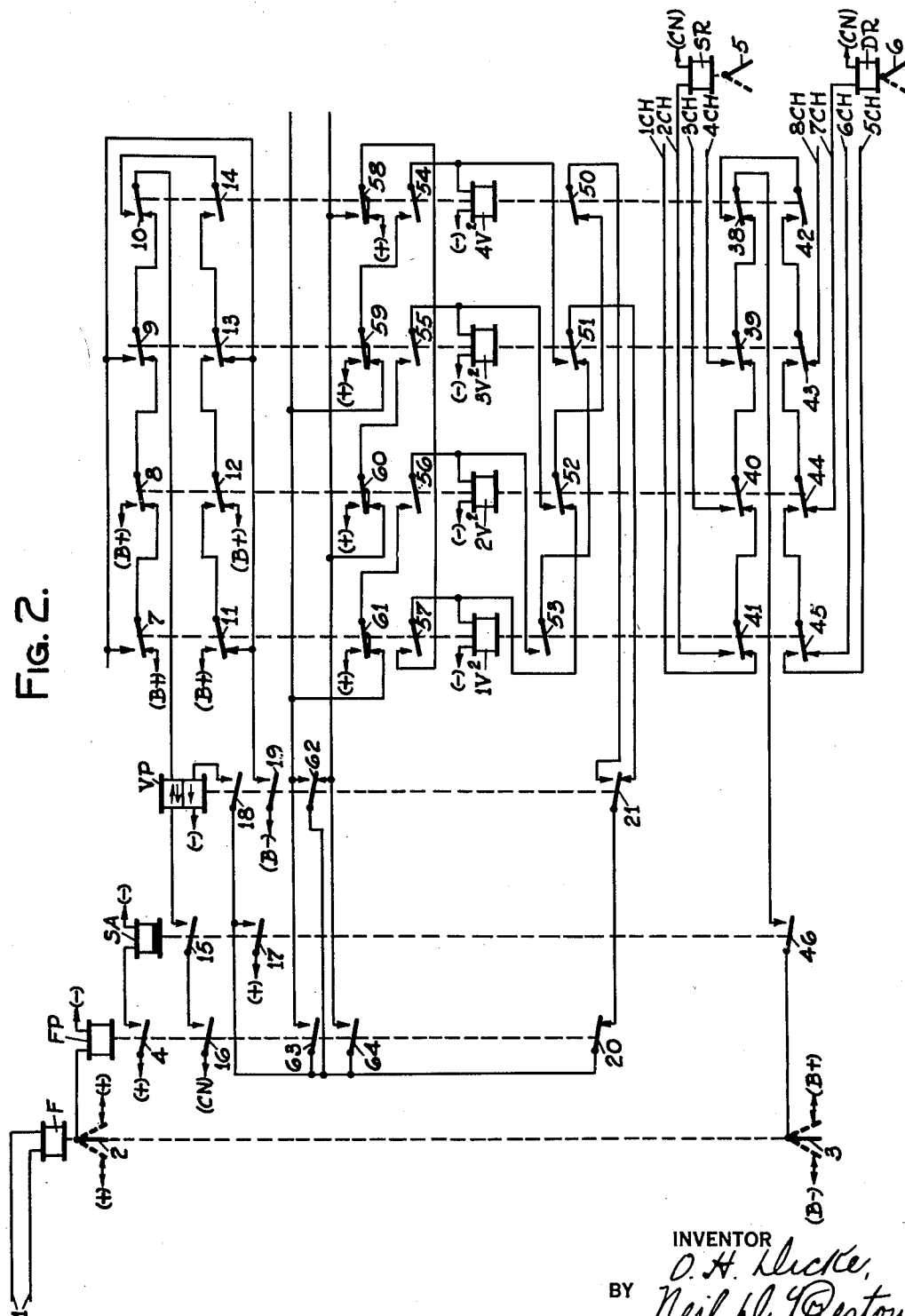
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4 Sheets-Sheet 2

FIG. 2.



INVENTOR
O. H. Dicke,
BY Neil H. Preston,
his ATTORNEY

Jan. 5, 1937.

O. H. DICKE

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4 Sheets-Sheet 3

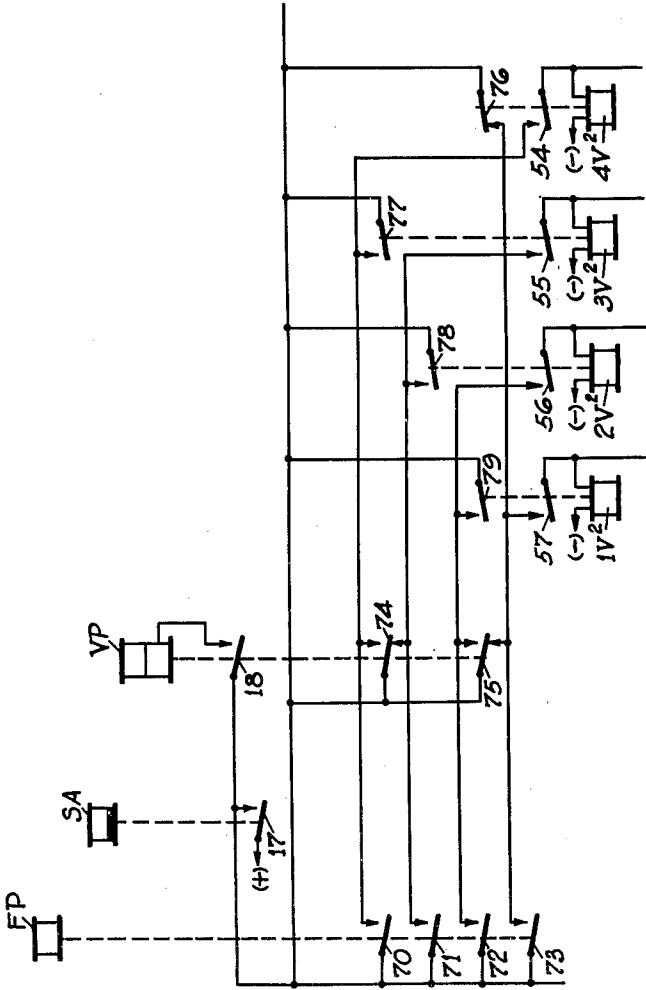


FIG. 3.

INVENTOR
O. H. Dicke,
BY Neil W. Preston,
his ATTORNEY

Jan. 5, 1937.

O. H. DICKE

2,067,151

CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

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4 Sheets-Sheet 4

FIG. 4.

TYPICAL OPERATION CHART

NO. OF OPERATION	RELAY REFERENCE CHARACTERS						NO. OF CHANNEL
	FP	VP	1V	2V	3V	4V	
1	PU.	PU.					1CH.
2	DA.		PU.				2CH.
3	PU.	DA.					
4	DA.			PU.			3CH.
5	PU.	PU.					
6	DA.				PU.		4CH.
7	PU.	DA.					
8	DA.					PU.	5CH.
9	PU.	PU.					
10	DA.		DA.				6CH.
11	PU.	DA.					
12	DA.			DA.			7CH.
13	PU.	PU.					
14	DA.				DA.		8CH.
15	PU.	DA.					
16	DA.					DA.	

INVENTOR
O. H. Dicke,
BY Neil W. Preston,
his ATTORNEY

UNITED STATES PATENT OFFICE

2,067,151

CENTRALIZED TRAFFIC CONTROLLING
SYSTEM FOR RAILROADSOscar H. Dicke, Rochester, N. Y., assignor to
General Railway Signal Company, Rochester,
N. Y.

Application December 30, 1932, Serial No. 649,606

18 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.

5 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
10 British Patent 419,399, it is desirable to employ step-by-step mechanisms which will require a minimum amount of apparatus to accomplish the required operations.

15 The present invention proposes a step-by-step mechanism for coded type communication systems, which mechanism includes a plurality of stepping relays for making up a plurality of local channel circuits. This bank of stepping relays is so organized, that each relay adds two
20 channel circuits to the total capacity of the bank.

The arrangement of the stepping relay bank, in order that each stepping relay may be capable of providing two channel circuits, is such that the stepping relays are picked up sequentially until all of the relays are picked up, and then the relays are deenergized sequentially in the same order that they are picked up. Thus, two stepping relays provide four channel circuits; three stepping relays provide six channel circuits; four stepping relays provide eight channel circuits; and so on, the number of channels being increased by two by the addition of each stepping relay.

25 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.

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

35 Fig. 1 illustrates a stepping relay bank arranged in accordance with the present invention;

40 Fig. 2 illustrates a stepping relay bank arranged in accordance with the present invention and similar to the bank illustrated in Fig. 1 except with modified means for providing the sequential deenergization of the stepping relays;

45 Fig. 3 illustrates a stepping relay bank arranged in accordance with the present invention and similar to the stepping bank illustrated in

50 Fig. 2 but with modified stick circuits for pro-

viding the sequential deenergization of the stepping relays; and

Fig. 4 is a typical operation chart showing the sequence of relay operation during a complete cycle. The abbreviation P. U. refers to the pick- 5
ing up of the associated relay and the abbreviation D. A. refers to the dropping away of the associated relay.

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
15 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
20 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.

25 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
30 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).

35 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
40 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
45 as material to an understanding of the present in-

55

vention, 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.

5 The centralized traffic control system contemplated as embodying the present invention includes 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 mechanism at a typical field station of a centralized traffic controlling system is illustrated as having a three-position biased-to-neutral line relay F included in a line circuit 1. The line relay F is provided with polar contacts 2 and 3 which are operated to right hand positions by a positive impulse on the line circuit 1 and which are operated to left hand positions by a negative impulse on the line circuit 1.

A quick acting line repeating relay FP is associated with the line relay F to repeat each energization of the line relay irrespective of the polarity of such energization. This is accomplished as the polar contact 2 of the line relay F closes the energizing circuit for the relay FP when in either polar position, as will be apparent 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 its front contact 4 included in circuits obvious from the drawings. This slow acting relay SA is provided with such slow acting characteristics that it is slow in picking up and slow in dropping away, although it is to be understood that the drop-away period is much slower than the pick-up period.

The stepping relay bank is of the type having a plurality of full step relays V with a single half step or steering relay VP common to each of the full step relays. For example, the stepping relay bank illustrated includes the full step relays 1V,

2V, 3V, and 4V together with the half step relay VP.

Associated with the stepping relay bank are two polarized relays SR and DR which are of the two-position polarized magnetic stick type to illustrate one manner in which the channel circuits may be utilized. However, it is to be understood that the channel circuits closed by the stepping bank may be employed for any purpose desired in a communication system contemplated in accordance with the present invention. The relay SR has a polar contact 5 which is operable to either right or left hand positions dependent upon the positive or negative energization of its windings; while the relay DR has a contact 6 which is operable to either right or left hand positions dependent upon whether it is energized positively or negatively.

It is believed that the nature of the invention, its advantages and characteristic features can be best understood from the standpoint of operation of the system.

Operation

With the system in a normal condition of rest, each of the relays illustrated in Fig. 1 is in its normal deenergized condition and all of their contacts are dropped away.

In describing the stepping relay bank illustrated in Fig. 1 and the modifications illustrated in Figs. 2 and 3, it is convenient to divide the operating characteristics into three divisions, namely, a description of the operation of the half step relay, a description of the pick-up and stick circuits of the full step relays, and a description of the channel circuits closed by the full step relays. This arrangement is more particularly desirable inasmuch as the modifications illustrated in Figs. 2 and 3 refer more particularly to the pick-up and stick circuits of the full step relays while the half step or steering relay and the channel circuits are in each case identical with Fig. 1.

In considering the operation of the stepping relay bank, it is convenient to assume that the line relay F is included in a line circuit 1 having a plurality of different series of impulses applied thereto with the polarity of the impulses of each series so selected as to provide code combinations and controls for the field stations of a centralized traffic controlling system as disclosed, for example, in the above mentioned application of Judge et al., (Ser. No. 640,062, filed October 28, 1932).

Although each series of impulses applied to the line circuit 1 has the polarity of its impulses arranged in accordance with some code plan, such coded arrangement is immaterial for an understanding of the present invention, except that it should be understood, that each such impulse is of either positive or negative character selectively chosen so as to operate a particular device in accordance therewith, as shown, although other kinds of distinctiveness of currents may be employed if desired. Also, the first impulse of each series of impulses is relatively long as compared to the remaining impulses so as to provide sufficient time for the slow acting relay SA to be picked up at the beginning of each series and the time space between successive impulses of the series is sufficiently short to provide that the relay SA does not drop away during such time spaces. Also, between each different series of impulses is a prolonged time space which is longer than the time spaces between the successive impulses in a

series, so that the relay SA may have sufficient time in which to drop away. In other words, the relay SA is picked up at the beginning of each series and is dropped away at the end of each series.

Operation of half step or steering relay.—The application of the first impulse of a particular series to the line circuit 1 is repeated successively by the relays F, FP, and SA irrespective of the polarity of that impulse, as previously explained.

As the first impulse is relatively long and maintains the energization of the relay FP subsequent to the picking up of the contacts of the relay SA, the first pick-up circuit for the relay VP is closed from (B+), through a circuit including back contacts 7, 8, 9, and 10 of the stepping relays 1V, 2V, 3V, and 4V respectively, upper winding of the relay VP, front contact 15 of the relay SA, front contact 16 of the relay FP, to (CN).

This energization of the relay VP causes its contacts to pick up, thereby closing a stick circuit from (+), through a circuit including front contact 17 of relay SA, front contact 18 of relay VP, lower winding of relay VP, to (—). This stick circuit for the relay VP closed during the first energized period of the line circuit maintains the relay VP energized throughout the succeeding time space or deenergized period of the line circuit.

When the line circuit is deenergized for the first deenergized period, such condition is repeated by the relays F and FP, but the relay SA remains picked up throughout the period. The drop-away of the contacts of the relay FP causes the first stepping relay 1V to be picked up and to be stuck up, the details of which will be pointed out hereinafter.

Assuming that the relay 1V is picked up and stuck up, then upon the application of the second impulse to the line circuit and the response of the contacts of the relay FP, a differential stick circuit for the relay VP is closed from (B—), through a circuit including front contact 19 of relay VP, front contact 7 of relay 1V, back contacts 8, 9, and 10 of stepping relays 2V, 3V and 4V respectively, upper winding of relay VP, front contact 15 of relay SA, front contact 16 of relay FP, to (CN).

It is apparent that current in this circuit flows from left to right in the upper winding of relay VP, while the current in the lower winding of relay VP flows from right to left. As the windings of the relay VP are constructed to have a substantially equal number of ampere turns, the magnetic fluxes produced by these windings buck each other so that the resulting flux is substantially zero, thereby allowing the contacts of the relay VP to drop away.

It is, of course, to be understood that the relay VP may be so designed that the bucking magnetic flux provided in the upper winding is slightly greater than the magnetic flux provided in the lower winding to thereby compensate for any residual which may be in the core structure of the relay. However, it is sufficient for an understanding of the present invention to know that the resultant magnetic flux is reduced to zero, or at least to such a value sufficiently low to allow its contacts to drop away.

The simultaneous opening of front contacts 18 and 19 deenergizes both of the windings of the relay VP. This de-energized condition of the relay VP continues throughout the following time space or de-energized period of the line circuit 1.

The second de-energized period or time space

on the line circuit is repeated by the relay FP causing the stepping relay 2V to be picked up and stuck up, as will be later explained in detail.

Thus, the application of the third impulse to the line circuit and the resulting response of the relay FP causes the relay VP to be again picked up by reason of a circuit closed from (B+), through a circuit including front contact 8 of relay 2V, back contacts 9 and 10 of relays 3V and 4V respectively, upper winding of the relay VP, front contact 15 of relay SA, front contact 16 of relay FP, to (CN). This energization of the relay VP causes its contacts to be picked up, thereby closing its stick circuit including its front contact 18, so that the relay VP remains stuck up throughout the succeeding de-energized period marked off by the absence of current in the line circuit.

The third de-energized period or time space on the line circuit is repeated by the relay FP causing the stepping relay 3V to be picked up and stuck up, as will be later explained in detail.

Thus, the application of the fourth impulse to the line circuit and the resulting response of the relay FP causes the relay VP to again drop away by reason of the closure of its bucking stick circuit. This bucking stick circuit is closed from (B—), through a circuit including front contact 19 of relay VP, front contact 9 of relay 3V, back contact 10 of relay 4V, upper winding of relay VP, front contact 15 of relay SA, front contact 16 of relay FP, to (CN). The direction of current which flows in this circuit is opposite to that which flows in the stick circuit including the lower winding of the relay VP, so that the magnetic flux in the relay VP is reduced to substantially zero, as previously explained, causing the contacts of this relay to drop away. This de-energized condition of the relay VP maintains throughout the next time space marked off on the line circuit.

The fourth de-energized period or time space on the line circuit is repeated by the relay FP causing the stepping relay 4V to be picked up and stuck up, as will be later explained in detail.

Thus, the application of the fifth impulse to the line circuit 1 and the resulting response of the relay FP causes the relay VP to be again picked up by reason of a circuit closed from (B+), through a circuit including front contacts 11, 12, 13, and 14 of stepping relays 1V, 2V, 3V, and 4V respectively, front contact 10 of relay 4V, upper winding of relay VP, front contact 15 of relay SA, front contact 16 of relay FP, to (CN). This energization of the relay VP causes its contacts to be picked up, thereby closing its stick circuit including front contact 18, so that the relay VP remains picked up throughout the succeeding de-energized period of the line circuit.

The fifth de-energized period or time space on the line circuit is repeated by the relay FP, causing the stepping relay 1V to be de-energized in a manner later to be explained in detail.

Thus, the application of the sixth impulse to the line circuit and the resulting response of the relay FP causes the relay VP to again drop away by reason of the closure of its bucking stick circuit. This bucking stick circuit is closed from (B—), through a circuit including front contact 19 of relay VP, back contact 11 of relay 1V, front contacts 12, 13 and 14 of relays 2V, 3V and 4V respectively, front contact 10 of relay 4V, upper winding of relay VP, front contact 15 of relay SA, front contact 16 of relay FP, to (CN). The

direction of current flow in this bucking stick circuit is opposite to the direction of current flow in the lower winding of the relay VP, so that the magnetic flux in the relay VP is reduced to substantially zero causing its contacts to drop away. This de-energized condition of the relay VP remains throughout the following de-energized period of the line circuit 1.

The sixth de-energized period or time space on the line circuit is repeated by the relay FP which causes the stepping relay 2V to be dropped away, as will be later explained in detail.

Thus, the application of the seventh impulse to the line circuit, and the resulting response of the relay FP, causes the relay VP to be again picked up by reason of a circuit closed from (B+), through a circuit including back contact 12 of relay 2V, front contacts 13 and 14 of relays 3V and 4V respectively, front contact 10 of relay 4V, upper winding of relay VP, front contact 15 of relay SA, front contact 16 of relay FP, to (CN). This energization of the relay VP causes its contacts to be picked up thereby closing its stick circuit including its front contact 18, so that the relay VP remains picked up throughout the succeeding de-energized period of the line circuit.

The seventh de-energized period or time space marked off on the line circuit is repeated by the relay FP causing the stepping relay 3V to be dropped away in a manner to be later explained in detail.

Thus, the application of the eighth impulse to the line circuit and the resulting response of the relay FP causes the relay VP to be again dropped away by reason of the closure of its bucking stick circuit. This bucking stick circuit is closed from (B-), through a circuit including front contact 19 of relay VP, back contact 13 of relay 3V, front contacts 14 and 10 of relay 4V, upper winding of relay VP, front contact 15 of relay SA, front contact 16 of relay FP, to (CN). The direction of current flow in this bucking stick circuit is opposite to the direction of current flow in the lower winding of relay VP, so that the magnetic flux in its core structure is reduced to substantially zero causing its contacts to drop away. This deenergized condition of the relay VP remains throughout the following deenergized period of the line circuit 1.

The eighth deenergized period of the line circuit is repeated by the relay VP causing the relay 4V to be dropped away in a manner to be later explained in detail.

As the series of impulses assumed for the embodiment of the present invention is considered to comprise eight impulses and eight time spaces, it is apparent that the completion of the series of impulses has returned the half step relay to its normal position, as well as all of the full step relays. This last time space or deenergized period on the line circuit is, of course, prolonged for a definite period (providing another series of impulses is immediately following) in which period the relay SA drops away. However, if another series of impulses is not immediately following, this eighth deenergized period is prolonged indefinitely until such time as the system is again initiated into operation.

It should be noted here that if the stepping relay bank included an odd number of full step relays V instead of an even number as illustrated, the relay VP would still be picked up at the end of the last impulse, but in such a case the relay VP is restored to normal at the end of the

deenergized period for that series by reason of the opening of front contacts 15 and 17 of the relay SA which drop at the end of each series of impulses.

From the above description, it is apparent that the relay VP is operated to picked up and dropped away positions alternately upon the picking up of the contacts of the relay FP throughout the cycle of operation comprising the sequential picking up of the relays 2V, 3V, and 4V and their sequential deenergization.

Although the relay VP has been illustrated as being of the differential type for this specific embodiment of the present invention, it is to be understood that any other type of VP relay may be employed, such as a two-position polar magnetic stick relay shown in the application of Preston and Hitchcock, Ser. No. 455,304 filed May 24, 1930, corresponding to Australian Patent 1501 of 1931, or just a neutral stick relay with proper pick-up and stick circuits to provide the required operation as shown in the Patent to Brixner, 1,995,272 dated March 19, 1935.

Operation of stepping relays.—The manner in which stepping relays 1V, 2V, 3V, and 4V are caused to be picked up successively and then to be dropped away successively will now be explained.

The application of the first impulse to the line circuit results in the picking up of the relay VP which is stuck up until the application of the second impulse. Thus, when the first deenergized period or time space on the line circuit is repeated by the relay FP, the pick-up circuit for the stepping relay 1V is closed from (+), through a circuit including front contact 17 of relay SA, back contact 20 of relay FP, front contact 21 of relay VP, back contacts 22 and 24 of relays 4V and 2V respectively, lower winding of relay 1V, to (-). The response of the contacts of the relay 1V closes its stick circuit from (+), through a circuit including front contact 17 of relay SA, front contact 26 of relay 1V, lower winding of relay 1V, to (-).

With the stepping relay 1V picked up during the first deenergized period of the line circuit 1, the application of the second impulse causes the relay VP to drop away, as previously described.

Thus, when the second deenergized period of the line circuit is repeated by the relay FP, the pick-up circuit for the relay 2V is closed from (+), through a circuit including front contact 17 of relay SA, back contact 20 of relay FP, back contact 21 of relay VP, back contact 23 of relay 3V, front contact 25 of relay 1V, lower winding of relay 2V, to (-). The response of the contacts of the relay 2V closes its stick circuit from (+), through a circuit including front contact 17 of relay SA, front contact 27 of relay 2V, lower winding of relay 2V, to (-).

With the stepping relay 2V picked up during the second deenergized period of the line circuit 1, the application of the third impulse causes the relay VP to be picked up, as previously described.

Thus, when the third deenergized period or time space marked off on the line circuit is repeated by the relay FP, the pick-up circuit for the relay 3V is closed from (+), through a circuit including front contact 17 of relay SA, back contact 20 of relay FP, front contact 21 of relay VP, back contact 22 of relay 4V, front contact 24 of relay 2V, lower winding of relay 3V, to (-). The response of the contacts of the relay 3V closes its stick circuit from (+), through a cir-

cuit including front contact 17 of relay SA, front contact 28 of relay 3V, lower winding of relay 3V, to (—).

With the stepping relay 3V picked up during the third deenergized period marked off on the line circuit, the application of the fourth impulse causes the relay VP to drop away, as previously described.

Thus, when the fourth deenergized period of the line circuit is repeated by the relay FP, the pick-up circuit for the relay 4V is closed from (+), through a circuit including front contact 17 of relay SA, back contact 20 of relay FP, back contact 21 of relay VP, front contact 35 of relay 3V, front contact 37 of relay 1V, lower winding of relay 4V, to (—). The response of the contacts of the relay 4V closes its stick circuit from (+), through a circuit including front contact 17 of relay SA, front contact 29 of relay 4V, lower winding of relay 4V, to (—).

With the stepping relay 4V picked up during the fourth deenergized period marked off on the line circuit, the application of the fifth impulse causes the relay VP to be picked up, as previously described.

Thus, when the fifth deenergized period or time space marked off on the line circuit is repeated by the relay FP, a differential energizing stick circuit for the relay 1V is closed from (+), through a circuit including front contact 17 of relay SA, back contact 20 of relay FP, front contact 21 of relay VP, front contact 34 of relay 4V, front contact 36 of relay 2V, front contact 33 of relay 1V, upper winding of relay 1V, to (—).

It is readily apparent, that the direction of current flow in this differential stick circuit is opposite to the direction of current flow in the stick circuit of relay 1V including its lower winding. Thus, the magnetic fluxes produced by the upper and lower windings buck each other, so that the resulting magnetic flux in the core structure of the relay is substantially zero, which allows the contacts of the relay 1V to drop away. The simultaneous opening of stick contacts 33 and 26 opens both of the energizing circuits of the relay 1V, so that it remains deenergized throughout the remainder of the cycle of operation.

With the stepping relay 1V dropped away during the fifth deenergized period and with the remaining stepping relays still picked up, the application of the sixth impulse causes the relay VP to drop away, as previously described.

Thus, when the sixth deenergized period of the line circuit is repeated by the relay FP, a differential energizing stick circuit for the relay 2V is closed from (+), through a circuit including front contact 17 of relay SA, back contact 20 of relay FP, back contact 21 of relay VP, front contact 35 of relay 3V, back contact 37 of relay 1V, front contact 32 of relay 2V, upper winding of relay 2V, to (—). The direction of current flow in the upper winding of relay 2V is opposite to the direction of current flow in the lower winding of the relay 2V, so that the resultant flux in the relay is reduced to substantially zero, and its contacts drop away. This deenergized condition of the relay 2V maintains throughout the remainder of the cycle of operation.

With the stepping relay 2V dropped away during the sixth deenergized period marked off on the line circuit, the application of the seventh impulse causes the relay VP to be picked up, as previously described.

Thus, when the seventh deenergized period of

the line circuit is repeated by the relay FP, a differential stick circuit for the relay 3V is closed from (+), through a circuit including front contact 17 of relay SA, back contact 20 of relay FP, front contact 21 of relay VP, front contact 34 of relay 4V, back contact 36 of relay 2V, front contact 31 of relay 3V, upper winding of relay 3V, to (—). The direction of current flow in the upper winding of relay 3V is opposite to the direction of current flow in the lower winding of relay 3V, so that the resultant flux in the relay is reduced to substantially zero, and its contacts drop away. This deenergized condition of the relay 3V maintains throughout the remainder of the cycle of operation.

With the stepping relay 3V dropped away during the seventh deenergized period of the line circuit, the application of the eighth impulse causes the relay VP to drop away, as previously described.

Thus, when the eighth deenergized period of the line circuit is repeated by the relay FP, a differential stick circuit for the relay 4V is closed from (+), through a circuit including front contact 17 of relay SA, back contact 20 of relay FP, back contact 21 of relay VP, back contact 35 of relay 3V, front contact 30 of relay 4V, upper winding of relay 4V, to (—). The direction of current flow in the upper winding of the relay 4V is opposite to the direction of current flow in the lower winding of relay 4V, so that the resultant flux in the relay is reduced to substantially zero, and its contacts drop away.

As this eighth deenergized period marks the end of the series of impulses, the relay SA drops away after a predetermined time opening front contact 17 thereby insuring that all of the stepping relays have been dropped away. Although only four stepping relays have been illustrated, it is to be understood that any number of relays may be provided.

Having thus described the stepping operation, it is convenient to now point out the closure of the channel circuits.

Channel circuits.—As explained above, the half step relay VP operates during the energized periods of the line circuit; while the full step relays V assume their new positions during the deenergized periods. Thus, the shift from one channel circuit to another, by the relays V is accomplished while the channel circuits are not in use.

The channel circuits are indicated as energized with positive or negative potential in accordance with right or left hand positions of the polar contact 3 of line relay F, and as terminating at the reference characters having letter characters CH with preceding numerals designating the order in which these channel circuits are made up. For example, the first channel circuit is designated by 1CH and is completed during the first energized period following the response of the relay SA to close its front contact 46 and prior to the response of any of the stepping relays, thereby including the back contacts 38, 39, 40 and 41 of the stepping relays 4V, 3V, 2V, and 1V respectively.

During the first deenergized period after the first impulse on the line circuit, the polar contact 3 assumes a neutral deenergized position and the relay FP operates to a deenergized position causing the response of the stepping relay 1V. This prepares the channel circuit 2CH by closure of front contact 41 of relay 1V. Thus, upon the application of the second impulse, the second channel circuit 2CH is energized with positive or nega-

tive potential from (B+) or (B-) depending upon the position of contact 3 of the relay F, through a circuit including front contact 46 of relay SA, back contacts 38, 39, and 40 of relays 4V, 3V, and 2V respectively, front contact 41 of relay 1V, windings of relay SR to (CN). The polar contact 5 of relay SR is operated to a right or a left hand position depending upon whether the relay SR is energized with positive or negative potential respectively.

The channel circuits are thus completed sequentially as the stepping relays are picked up. Similarly, upon the sequential deenergization of the stepping relays, channel circuits are also completed. For example, upon the application of the seventh impulse following the sixth time space, during which the stepping relay 2V is dropped away as previously described, the relay DR receives positive or negative potential depending upon the character of that impulse as repeated by the polar contact 3 of line relay F. More specifically, this channel circuit is closed from (B+) or (B-) with the polar contact 3 of the relay F in a right or a left hand position respectively, through a circuit including front contact 46 of relay SA, front contacts 38 and 42 of relay 4V, front contact 43 of relay 3V, back contact 44 of relay 2V, windings of relay DR, to (CN). The polar contact 6 of relay DR is actuated to a right or a left hand position depending upon whether positive or negative potential is applied to the windings of this relay.

It is of course to be understood that the channel circuits completed by the relays 1V, 2V, 3V, and 4V may be employed for other purposes than for the reception of code impulses, as illustrated. It is also to be noted, that the front contact 46 of the relay SA is not essential to the usual operation of the disclosure, but is provided to prevent the momentary energization of a channel circuit due to a surge on the line circuit, which surge would usually be of insufficient duration to allow for the pick-up of a relay SA.

Modified form of Fig. 2.—The relays F, FP, SA, VP, SR, and DR are the same relays in Fig. 2 as in Fig. 1 and therefore have been given the same reference characters. The relay FP of Fig. 2 has two extra contacts 63 and 64, and the relay VP has an extra contact 62. The stepping relays V of Fig. 2 operate similar to the stepping relays of Fig. 1 and thus have been given corresponding reference characters with distinctive exponents. These stepping relays 1V², 2V², 3V², and 4V² have only single windings, while the stepping relays of Fig. 1 are provided with double windings.

As the control of the relay VP is the same in Figs. 1 and 2, and as the description of the operation for Fig. 1 will read directly upon the associated circuits, the contacts on the stepping relays 1V², 2V², 3V², and 4V², which control the relay VP have been given the same reference characters as in Fig. 1. Similarly, the contacts on the stepping relays of Fig. 2 which are included in the channel circuits have been given the same reference characters as in Fig. 1. However, those contacts which are employed on the stepping relays to control their pick-up and stick circuits have been given distinctive reference characters, as the circuit arrangement is somewhat different and as certain of these contacts are of the make-before-break type.

As previously mentioned, the operation of the half step relay upon the reception of a series of impulses to comprise a cycle of operations is identical with the operation already described in con-

nection with Fig. 1. Also, the channel circuits are closed in the same way and are identical with the channel circuits of Fig. 1. Thus, the description of Fig. 2 will be directed more particularly to the pick-up and drop-away features of the stepping relays.

One of the objects of this modification shown in Fig. 2 is to provide stepping relays which are controlled positively without differential circuits. This is accomplished in accordance with the invention by opening the stick circuits of the stepping relays at the right times instead of forcing them down, as disclosed in Fig. 1. This arrangement will be best understood by considering the operation of the stepping relays.

The application of the first impulse to the line circuit is repeated by the relays F, FP, and SA sequentially, as previously described. The picking up of the relay FP causes the picking up of the relay VP during the first impulse.

Thus, when the first deenergized period after the first impulse on the line circuit is repeated by the relay FP, a pick-up circuit for the relay 1V² is closed from (+), through a circuit including front contact 17 of relay SA, back contact 20 of relay FP, front contact 21 of relay VP, back contacts 50 and 52 of relays 4V² and 2V² respectively, windings of relay 1V², to (-). The response of the contacts of the relay 1V² to this energization closes a stick circuit completed from (+), through a circuit including back contact 58 of relay 4V², front contact 57 of relay 1V², windings of relay 1V², to (-).

With the stepping relay 1V picked up during the first deenergized period of the line circuit, the application of the second impulse causes the relay VP to drop away, as previously described.

Thus, when the second deenergized period of the line circuit is repeated by the relay FP, a pick-up circuit for the relay 2V² is closed from (+), through a circuit including front contact 17 of relay SA, back contact 20 of relay FP, back contact 21 of relay VP, back contact 51 of relay 3V², front contact 53 of relay 1V², windings of relay 2V², to (-). The response of the contacts of relay 2V² closes a stick circuit from (+), through a circuit including front contact 61 of relay 1V², front contact 56 of relay 2V², windings of relay 2V², to (-).

With the stepping relay 2V² picked up during the second deenergized period marked off on the line circuit, the application of the third impulse on the line circuit causes the relay VP to be picked up, as previously described.

Thus, when the third deenergized period of the line circuit is repeated by the relay FP, a pick-up circuit for the relay 3V² is closed from (+), through a circuit including front contact 17 of relay SA, back contact 20 of relay FP, front contact 21 of relay VP, back contact 50 of relay 4V², front contact 52 of relay 2V², windings of relay 3V², to (-). The response of the contacts of the relay 3V² closes its stick circuit from (+), through a circuit including front contact 60 of relay 2V², stick contact 55 of relay 3V², windings of relay 3V², to (-).

With the stepping relay 3V² picked up during the third deenergized period of the line circuit, the application of the fourth impulse causes the relay VP to drop away, as previously described.

Thus, when the fourth deenergized period of the line circuit is repeated by the relay FP, a pick-up circuit for the stepping relay 4V² is closed from (+), through a circuit including front contact 17 of relay SA, back contact 20 of

relay FP, back contact 21 of relay VP, front contact 51 of relay 3V², windings of relay 4V², to (-). The response of the contacts of the relay 4V² closes its stick circuit from (+), through a circuit including front contact 59 of relay 3V², front contact 54 of relay 4V², windings of relay 4V², to (-).

The picking up of the stepping relay 4V² during the fourth deenergized period of the line circuit transfers the stick circuit of relay 1V² from back point 58 to front point 58. This transfer then completes a stick circuit for the relay 1V², from (+), through a circuit including front contact 17 of relay SA, back contact 62 of relay VP, front contact 58 of relay 4V² and stick contact 57 of relay 1V², windings of relay 1V², to (-). This transfer is accomplished without an interruption as the contact 58 is of the make-before-break type, as conventionally indicated in the drawings.

With the stepping relay 4V² picked up during the fourth deenergized period of the line circuit, the application of the fifth impulse causes the relay VP to be picked up, as previously described.

The picking up of the contact 62 of relay VP would open the stick circuit for the relay 1V² if it were not for the fact that the front contact 64 of relay FP was closed prior to the response of the relay VP during this fifth impulse period. In other words, during the fifth impulse period, after the response of the relay VP, the relay 1V² is maintained energized through a stick circuit closed from (+), through a circuit including front contact 17 of relay SA, front contact 64 of relay FP, front contact 58 of relay 4V², front contact 57 of relay 1V², windings of relay 1V², to (-).

Thus, when the fifth deenergized period of the line circuit is repeated by the relay FP, the front contact 64 opens, thereby breaking the stick circuit of the relay 1V².

This dropping away of the relay 1V² transfers the stick circuit of relay 2V² from front contact 61 to back contact 61 which maintains relay 2V² energized by a circuit closed from (+), through a circuit including front contact 17 of relay SA, front contact 62 of relay VP, back contact 61 of relay 1V², front contact 56 of relay 2V², windings of relay 2V², to (-). This transfer is completed without an interruption of the energization of the relay 2V² as the contact 61 is of the make-before-break type.

With this stepping relay 1V² dropped away during the fifth deenergized period of the line circuit, the application of the sixth impulse causes the relay VP to be dropped away, as previously described.

The dropping away of the relay VP opening front contact 62 would open the stick circuit for the stepping relay 2V², if it were not for the closure of front contact 63 of relay FP during this sixth energized period. There is no interruption in the stick circuit for the relay 2V² as the relay FP closes front contact 63 prior to the opening of front contact 62 of relay VP.

Thus, when the sixth deenergized period of the line circuit is repeated by the relay FP, the front contact 63 of relay FP opens, thereby deenergizing the stepping relay 2V² allowing its contacts to drop away. The dropping away of the contacts of the relay 2V² transfers the stick circuit of the stepping relay 3V² from front contact 60 to back contact 60 which then completes the stick circuit for the relay 3V² from (+), through a circuit including front contact 17 of relay SA,

back contact 62 of relay VP, back contact 60 of relay 2V², front contact 55 of relay 3V², windings of relay 3V², to (-).

With the stepping relay 2V² dropped away during the sixth deenergized period of the line circuit, the application of the seventh impulse causes the relay VP to be picked up, as previously described. The opening of back contact 62 of relay VP would open the stick circuit for relay 3V², if it were not for the closure of front contact 64 of relay FP prior to the response of relay VP to the seventh impulse period.

Thus, when the seventh deenergized period of the line circuit is repeated by the relay FP, its front contact 64 opens, thereby deenergizing the stick circuit of the relay 3V² allowing its contacts to drop away. The dropping away of the contacts of the relay 3V² transfers the stick circuit of the relay 4V² from front contact 59 to back contact 59, thereby completing a stick circuit for the relay 4V² from (+), through a circuit including front contact 17 of relay SA, front contact 62 of relay VP, back contact 59 of relay 3V², stick contact 54 of relay 4V², windings of relay 4V², to (-).

With the stepping relay 3V² dropped away during the seventh deenergized period of the line circuit, the application of the eighth impulse causes the relay VP to drop away, as previously described, thus opening the front contact 62 of relay VP which would open the stick circuit of the relay 4V² if it were not for the fact that the front contact 63 of relay FP was closed prior to the response of the relay VP.

Thus, when the eighth deenergized period of the line circuit is repeated by the relay FP, its front contact 63 opens, thereby deenergizing the stick circuit for the relay 4V² allowing its contacts to drop away.

As the eighth deenergized period marks the end of the series of impulses applied to the line circuit for one cycle of operations, the relay SA drops away after a predetermined time. Thus, the stepping relays have been returned to their normal positions and all of the channel circuits have been completed in the same order and in the same manner, as described in connection with Fig. 1.

Modified form of Fig. 3.—With reference to Fig. 3, a modified arrangement of the stick circuits of the stepping relays 1V², 2V², 3V², and 4V² of Fig. 2 has been illustrated. In place of the contacts 63 and 64 of relay FP in Fig. 2, new contacts 70, 71, 72, and 73 are provided. Similarly, in place of contact 62 of relay VP in Fig. 2, new contacts 74 and 75 are employed. The make-before-break contacts 58, 59, 60, and 61 of the stepping relays in Fig. 2 are replaced by the contacts 76, 77, 78, and 79 respectively.

The pick-up circuits for the relays 1V², 2V², 3V², and 4V² are identical with the pick-up circuits illustrated in Fig. 2, and thus have not been shown in connection with Fig. 3.

Thus, it will be assumed that each of the stepping relays is suitably picked up on its respective period in the cycle of operation, and the stick circuits completed for each of these relays, when thus picked up, will now be pointed out.

When relay 1V² is picked up on the first deenergized period or time space in the series of impulses of the line circuit, a stick circuit is closed from (+), through a circuit including front contact 17 of relay SA, back contact 76 of relay 4V², stick contact 57 of relay 1V², windings of relay 1V², to (-).

When relay $2V^2$ is picked up on the second deenergized period of the line circuit, a stick circuit is closed from (+), through a circuit including front contact 17 of relay SA, front contact 79 of relay $1V^2$, stick contact 56 of relay $2V^2$, windings of relay $2V^2$, to (-).

When relay $3V^2$ is picked up on the third deenergized period of the line circuit, a stick circuit is closed from (+), through a circuit including front contact 17 of relay SA, front contact 78 of relay $2V^2$, stick contact 55 of relay $3V^2$, windings of relay $3V^2$, to (-).

When relay $4V^2$ is picked up on the fourth deenergized period of the line circuit, a stick circuit is closed from (+), through a circuit including front contact 17 of relay SA, front contact 77 of relay $3V^2$, stick contact 54 of relay $4V^2$, windings of relay $4V^2$, to (-).

With all of the stepping relays picked up and stuck up, as above considered, the response of the relay $4V^2$ would open the stick circuit of the relay $1V^2$ were it not for the closed condition of another branch of the stick circuit by reason of the position of the relay VP, which is now down. This stick circuit for the relay $1V^2$ during the fourth deenergized period of the line circuit is closed from (+), through a circuit including front contact 17 of relay SA, back contact 75 of relay VP, front contact 57 of relay $1V^2$, windings of relay $1V^2$, to (-).

Then upon the application of the fifth impulse which is repeated by the relay FP, another stick circuit including the front contact 73 of relay FP is closed for the relay $1V^2$, and the relay VP is picked up during this period opening back contact 75. Thus, upon the fifth deenergized period of the line circuit, relay FP is deenergized opening front contact 73, thus allowing relay $1V^2$ to drop away.

The drop-away of the relay $1V^2$ opens its front contact 79 thereby making the relay $2V^2$ dependent on the front contact 75 of relay VP which is now closed, so that the relay $2V^2$ is maintained energized during the fifth deenergized period.

During the sixth impulse period, the relay VP is dropped away opening front contact 75, but, before this occurs, the front contact 72 of relay FP is closed, so that the relay $2V^2$ is maintained energized until the sixth deenergized period or time space at which time the front contact 72 of relay FP opens.

The drop-away of relay $2V^2$ opens its front contact 78, which would deenergize relay $3V^2$, but the back contact 74 of relay VP is closed during the sixth deenergized period maintaining the relay $2V^2$ stuck up. Then upon the seventh impulse period the back contact 74 is opened a short time after the front contact 71 of relay FP is closed, so that relay $3V^2$ is maintained stuck up until the seventh deenergized period at which time it is dropped away upon the opening of front contact 71.

Likewise, the drop-away of the relay $3V^2$ opens its front contact 77 which would allow the relay $4V^2$ to drop away if it were not for the closed condition of front contact 74 of relay VP during the seventh deenergized period. Then upon the eighth impulse period just before the relay VP drops away, the front contact 70 of relay FP is closed, thereby maintaining relay $4V^2$ energized until the opening of front contact 70 upon the reception of the eighth deenergized period by the relay FP.

The front contact 17 of relay SA controls the stick circuit of the relay VP, as already explained in connection with Figs. 1 and 2.

From the above description it is readily apparent that the make-before-break contacts on the stepping relays have been eliminated by providing contacts on the relays FP and VP in such relationship that the stick circuits for the stepping relays are maintained closed during transition periods until it is proper for the stepping relays to be dropped out.

Thus, a stepping relay bank has been shown and described which employs each stepping relay to close two channel circuits by reason of the sequential picking up of the stepping relays in the series which are all held up until the sequential dropping away of these relays in the same order that they were picked up. This provides the increased number of channel circuits by a type of repeat, which requires no additional relays as has been the case in certain prior systems.

Having thus described a stepping relay bank for use in selector type communication systems, as embodiments of the present invention, it is desired to be understood that the forms were selected to facilitate 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 forms 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 line relay for repeating a series of time spaced impulses; a series of stepping relays; means for sequentially picking up said stepping relays, one for each time space repeated by said line relay until all of said stepping relays are picked up; means for sticking up said stepping relays, the first stepping relay of said series being stuck up by a circuit including a back contact of the last stepping relay of said series, and the remaining stepping relays of said series being stuck up by a circuit including a front contact of its immediately preceding stepping relay of the series; means effective upon the picking up of the last stepping relay of the series to maintain said first stepping relay of the series stuck up only until the next time space in said series of impulses occurs; means effective upon the dropping away of each stepping relay during its respective time space to maintain the next succeeding stepping relay stuck up only until the next succeeding time space occurs in said series of impulses; and means including said stepping relays for closing a plurality of channel circuits, one upon the picking up of each stepping relay and one upon the dropping of each stepping relay.

2. In combination; a line relay for repeating a series of time spaced impulses; a series of stepping relays; means for sequentially picking up said stepping relays, one for each time space repeated by said line relay until all of said stepping relays are picked up; means for sticking up said stepping relays, the first stepping relay of said series being stuck up by a circuit including a back contact of the last stepping relay of said series, and the remaining stepping relays of said series being stuck up by a circuit including a front contact of its immediately preceding stepping relay of the series, means effective upon the picking up of the last stepping relay of the series to maintain said first stepping relay of the series stuck up only until the next time space in said

series of impulses occurs; means effective upon the dropping away of each stepping relay during its respective time space to maintain the next succeeding stepping relay stuck up only until the next succeeding time space occurs in said series of impulses; and means including said stepping relays for closing a plurality of channel circuits, one upon each picking up or upon each dropping of said stepping relays during the following impulse in said series of impulses.

3. In combination; a line relay for repeating a series of time spaced impulses; a series of stepping relays; means for sequentially picking up said stepping relays, one for each time space repeated by said line relay until all of said stepping relays are picked up; means for sticking up said stepping relays, the first stepping relay of said series being stuck up by a circuit including a back contact of the last stepping relay of said series, and the remaining stepping relays of said series being stuck up by a circuit including a front contact of its immediately preceding stepping relay of the series; means effective to shunt said back contact of the last stepping relay of said series prior to its picking up, whereby said first stepping relay is maintained stuck up, said means being effective only until the next time space in said series of impulses occurs, means effective to shunt said front contact of each stepping relay prior to its dropping away during its respective time space of said series of impulses, whereby the next succeeding stepping relay is maintained stuck up, said means being effective only until the next succeeding time space in said series of impulses occurs; and means including said stepping relays for closing a plurality of channel circuits, one upon the picking up of each stepping relay and one upon the dropping of each stepping relay.

4. In combination; a line relay for repeating a series of time spaced impulses; a series of stepping relays; means for sequentially picking up said stepping relays, one for each time space repeated by said line relay until all of said stepping relays are picked up; means for sticking up said stepping relays, the first stepping relay of said series being stuck up by a circuit including a back contact of the last stepping relay of said series, and the remaining stepping relays of said series being stuck up by a circuit including a front contact of its immediately preceding stepping relay of the series; means effective upon the picking up of the last stepping relay of the series to transfer the stick circuit of said first stepping relay through a front contact of said last relay to render said stick circuit of said first relay deenergized upon the occurrence of the next time space in said series of impulses; means effective upon the dropping away of each stepping relay during its respective time space to transfer the stick circuit of the next succeeding stepping relay through a back contact of said particular stepping relay to render said stick circuit of said next succeeding stepping relay deenergized upon the occurrence of the next succeeding time space in said series of impulses; and means including said stepping relays for closing a plurality of channel circuits, one upon the picking up of each stepping relay and one upon the dropping of each stepping relay.

5. In combination, a series of stepping relays, a contact closed intermittently, a pick-up circuit for each of said stepping relays, said pick-up circuits being in part controlled by said stepping relays and in part by said contact and closed sequentially until all of said stepping relays have

been energized, a preliminary holding circuit for each stepping relay controlled by said stepping relays and closed until a final holding circuit for such relay is closed, a final holding circuit for each of said stepping relays controlled by a contact operating synchronously with said first mentioned contact but opened when said first mentioned contact is closed, means for opening said final holding circuits for said stepping relays in the same order that their respective pick-up circuits are closed, and means controlled by said preliminary and said final holding circuits for causing the sequential operation of said stepping relays in response to the intermittent closure of said contact.

6. In combination, a series of stepping relays, a contact closed intermittently, a pick-up circuit for each of said stepping relays, said pick-up circuits being in part controlled by said stepping relays and closed sequentially until all of said stepping relays have been energized, a preliminary holding circuit for each stepping relay controlled by said stepping relays, a final holding circuit for each stepping relay, means including a contact opened when said first mentioned contact is closed for controlling said final holding circuit, an intermediate holding circuit for each stepping relay, means including said intermediate holding circuit for holding such relay energized during the time between the opening of the preliminary and the closing of the final holding circuit for such relay, and means controlled by said preliminary, said final and said intermediate holding circuits for causing the sequential operation of said stepping relays in response to the intermittent closure of said contact.

7. In a registering system, an impulse relay operated by a series of impulses, a series of stepping relays, a steering relay, an energizing circuit for said stepping relays including a contact of said steering relay, means responsive to a first operation of said impulse relay for completing said energizing circuit through said contact in one position whereby one of said stepping relays is operated, means responsive to a second operation of said impulse relay for completing said energizing circuit through said contact in another position whereby another of said stepping relays is operated, means responsive to said first and second operations of said impulse relay for alternately operating and releasing said steering relay, whereby its contact is alternately shifted from one position to another, and means responsive to further operations of said impulse relay and the operation and release of said steering relay for sequentially releasing said stepping relays in the same sequence in which they are operated.

8. In combination; a line relay intermittently operated in response to a series of impulses comprising a code; a series of stepping relays which assume operated or released positions depending upon whether or not their windings are energized; a steering relay common to said stepping relays; means controlled by the impulses repeated by said impulse relay for operating said steering relay; pick-up circuits for sequentially operating said stepping relays in a certain order, one for each of a first part of the impulses repeated by said line relay; stick circuits for holding said stepping relays operated; releasing circuits including a differential winding on each relay for effecting the sequential release of said relays, one for each of a second part of the impulses repeated by said line relay; and means con-

trolled by said steering relay for steering the first and second parts of said impulses to said stepping relays.

9. In combination; a line relay intermittently
5 operated in response to a series of impulses comprising a code; a series of stepping relays which assume operated or released positions depending upon whether or not their windings are energized; a steering relay common to said stepping relays;
10 means controlled by the impulses repeated by said impulse relay for operating said steering relay; pick-up circuits for sequentially operating said stepping relays in a certain order, one for each impulse repeated by said line relay; stick
15 circuits for holding said stepping relays operated; releasing circuits including a differential winding on each relay for effecting sequential release of said relays in the same order as they were operated, one for each impulse repeated by said
20 line relay; and means controlled by said steering relay for steering said impulses to said stepping relays.

10. In combination; a line relay intermittently
25 operated in response to a series of impulses comprising a code; a series of stepping relays which assume operated or released positions depending upon whether or not their windings are energized; a single half-step relay; means for operating said half-step relay in response to said impulses; pick-
30 up circuits for sequentially operating said stepping relays in a certain order, one for each impulse repeated by said line relay; stick circuits for holding said stepping relays operated; means for sequentially breaking said stick circuits;
35 means responsive to breaking the stick circuits of said stepping relays for releasing said stepping relays in the same order as they were operated, one for each impulse impressed on said line circuit; and means controlled by said half-step relay for steering said impulses to said stepping
40 relays for controlling their operation and release.

11. In combination; an intermittently operating contact; a series of stepping relays which assume
45 operated or released positions depending upon whether or not their windings are energized; a single half-step relay; means controlled by the operation of said contact for operating said half-step relay; operating circuits for sequentially operating said stepping relays in a certain order,
50 one for each closure of said contact; means including said contact for selectively energizing said circuits; stick circuits for holding said stepping relays operated; means for energizing said stick
55 circuits; means for sequentially breaking said stick circuits; means responsive to the sequential breaking of said stick circuits for effecting sequential release of said relays; and means controlled by said half-step relay for steering
60 the impulses produced by said intermittently operating contact to the circuits of said stepping relays for controlling their operation and release.

12. In combination; an intermittently operating contact; a series of stepping relays which
65 assume operated or released positions depending upon whether or not their windings are energized; a single half-step relay operated in response to the operation of said contact; circuits for sequentially operating said stepping relays
70 in a certain order, one for each closure of said contact; stick circuits for holding said stepping relays operated; means for sequentially breaking said stick circuits; means responsive to the breaking of said stick circuits for effecting sequential
75 release of said relays in the same order as they

were operated, one for each closure of said contact; and means controlled by said half-step relay for steering the impulses produced by said intermittently operating contact to said stepping relays for controlling their operation and release.

13. In combination; a contact; a series of stepping relays which assume operated or released positions depending upon whether or not their windings are energized; a single half-step relay
10 operated in response to the operation of said contact; circuits for sequentially operating said stepping relays in a certain order, one for each closure of said contact; stick circuits each including the winding of only a single relay for
15 holding said stepping relays operated; means for breaking the stick circuits for said stepping relays in the same order as said relays were energized, one for each closure of said contact; and means controlled by said half-step relay for steering
20 the impulses produced by said intermittently operating contact to said stepping relays for controlling their operation and release.

14. In combination, a plurality of stepping relays, a half-step relay having contacts capable
25 of being shifted from one position to another, means for applying a series of impulses to the circuits of said stepping and half-step relays, means controlled by the contacts of said half-step relay in each position for steering certain
30 ones of said impulses to certain circuits of said stepping relays whereby said stepping relays are sequentially operated in response to said series of impulses, means for sticking the operated stepping relays, means controlled by the contacts of
35 said half-step relay in each position for steering certain others of said impulses to certain other circuits of said stepping relays whereby said stepping relays are sequentially released, and means controlled by each impulse of said series for shifting
40 the contacts of said half-step relay from one position to another.

15. In combination, a plurality of stepping relays, a half-step relay having contacts capable
45 of being shifted from one position to another, means for applying a series of impulses to the circuits of said stepping and half-step relays, means controlled by the contacts of said half-step relay in each position for steering certain
50 ones of said impulses to certain circuits of said stepping relays whereby said stepping relays are sequentially operated in response to a first portion of said series of impulses, means for sticking the operated stepping relays, means controlled by the contacts of said half-step relay in
55 each position for steering certain others of said impulses to certain other circuits of said stepping relays whereby said stepping relays are sequentially released in response to a second portion of said series of impulses, and means controlled
60 by each impulse of said series for shifting the contacts of said half-step relay from one position to another.

16. In combination; a plurality of stepping relays; a half-step relay common to said stepping
65 relays; circuits for said stepping relays and said half-step relay; means for selectively applying a series of impulses to said circuits; means responsive to the selective application of said impulses to said circuits for operating and releasing said
70 half-step relay; operating means responsive to the selective application of certain ones of said impulses to said circuits for sequentially operating said stepping relays; means for sticking the operated stepping relays; and releasing means re-
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sponsive to the selective application of certain others of said impulses to said circuits for sequentially releasing the operated stepping relays, said releasing means including differential circuits of
5 said stepping relays selected by said half-step relay in its operated and released positions.

17. In combination; a plurality of double wound relays; circuits for said relays; means for selecting and applying a series of impulses to said
10 circuits; operating means responsive to the application of certain ones of said impulses to said circuits for successively operating said relays, said operating means including a pick-up winding of
15 each relay; means for sticking each operated relay over a circuit including its pick-up winding; and releasing means responsive to the application of certain others of said impulses to said circuits for releasing each operated relay, said releasing
20 means comprising a circuit selected by a first one of said relays which is operated before the operation of a second one of said relays and by a third

one of said relays which is operated after the operation of said second relay and including a differential winding on said second relay.

18. In combination; an impulse relay intermittently operated to produce a series of impulses;
5 a plurality of stepping relays which assume operated or released positions depending upon whether or not their windings are energized; means including said impulse relay for operating
10 said stepping relays in sequence, one for each impulse produced by said impulse relay; means including stick circuits for holding said stepping
15 relays operated; a single steering relay; means including said impulse relay for operating and releasing said steering relay; steering means controlled by said steering relay for selectively steering
20 said impulses to said stepping relays; and means controlled by said impulses and including said steering means for sequentially releasing said stepping relays.

OSCAR H. DICKE.