

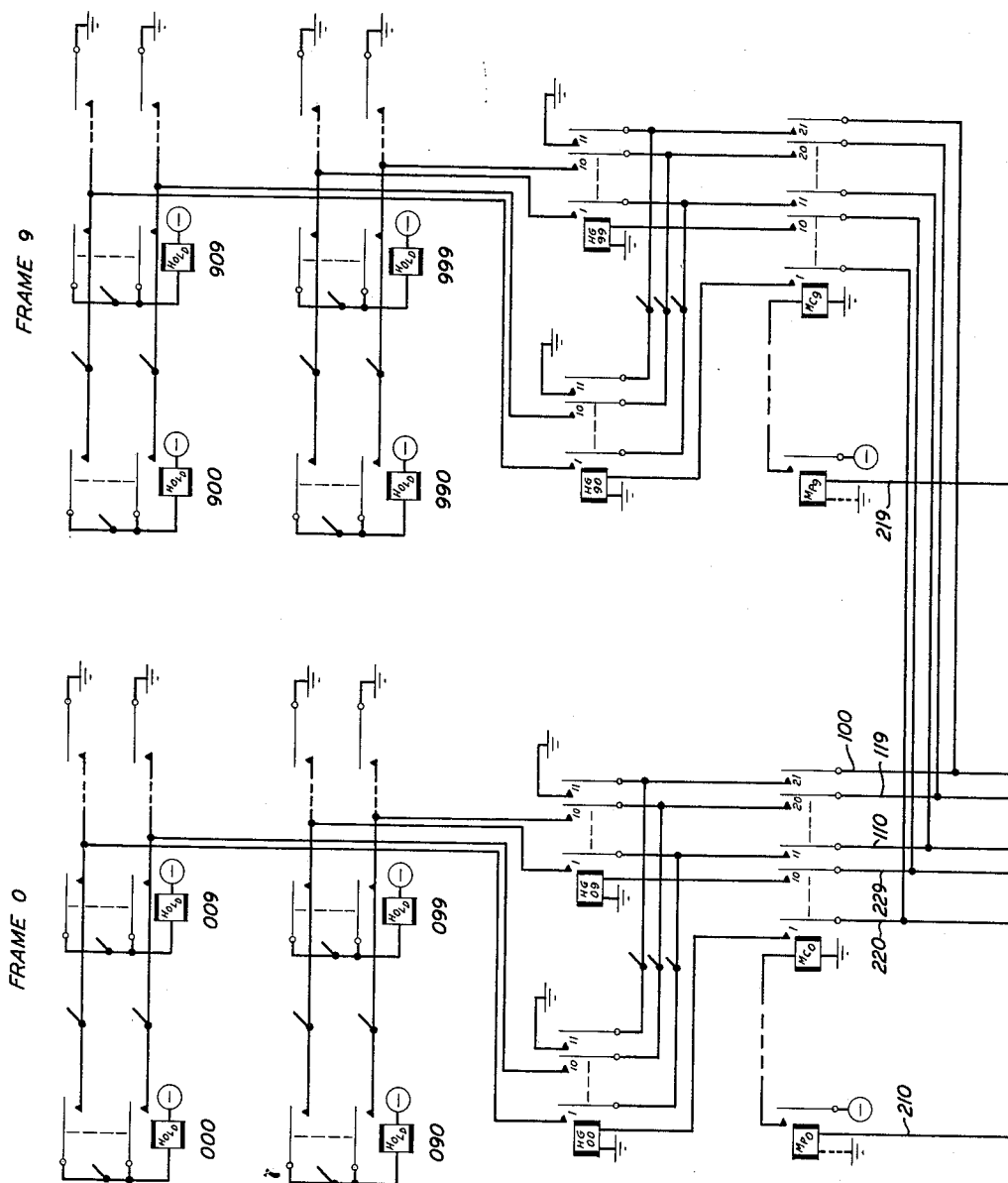
Aug. 23, 1955

R. C. AVERY
COUNTING CIRCUIT

2,715,996

Filed Oct. 22, 1953

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

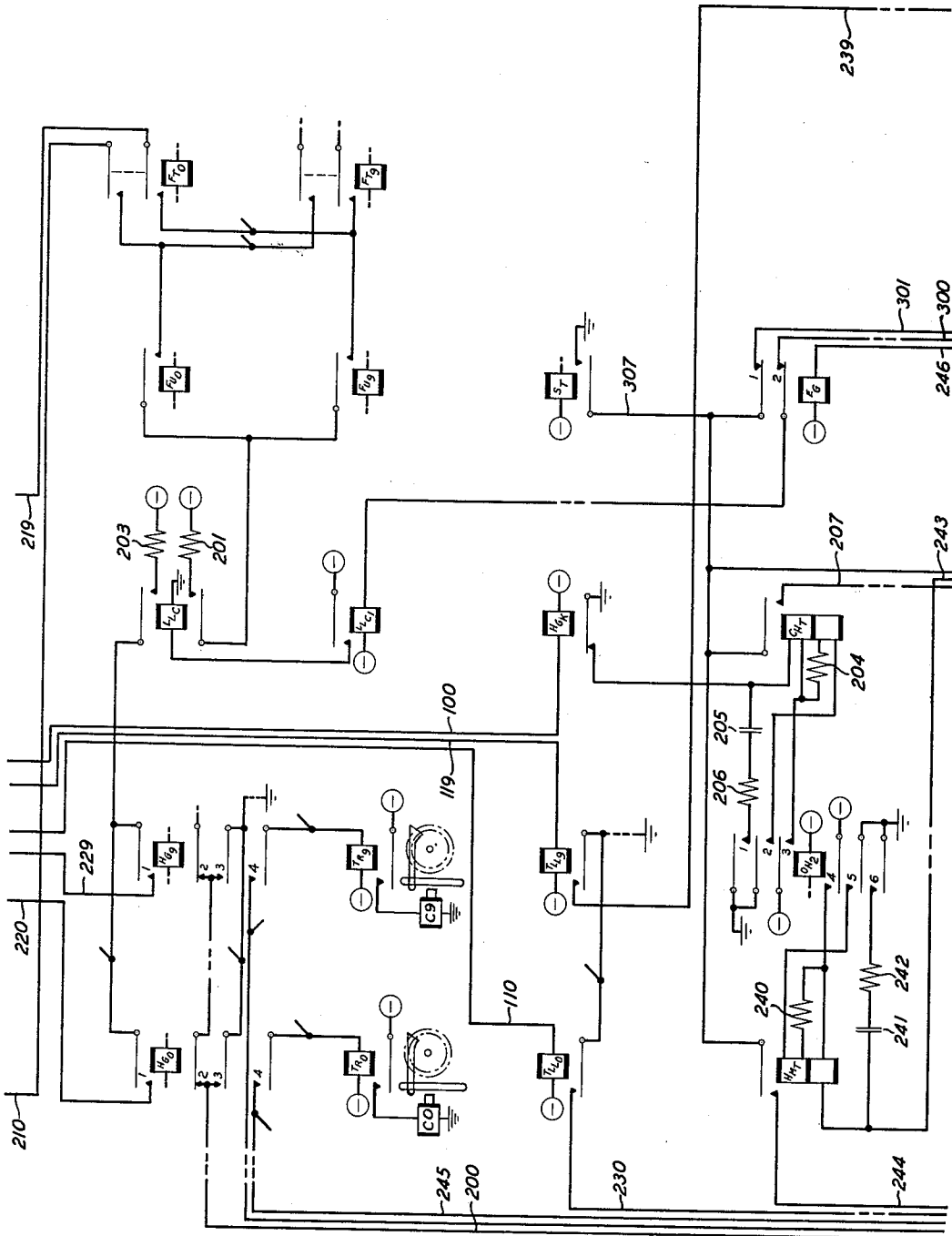


FIG. 2

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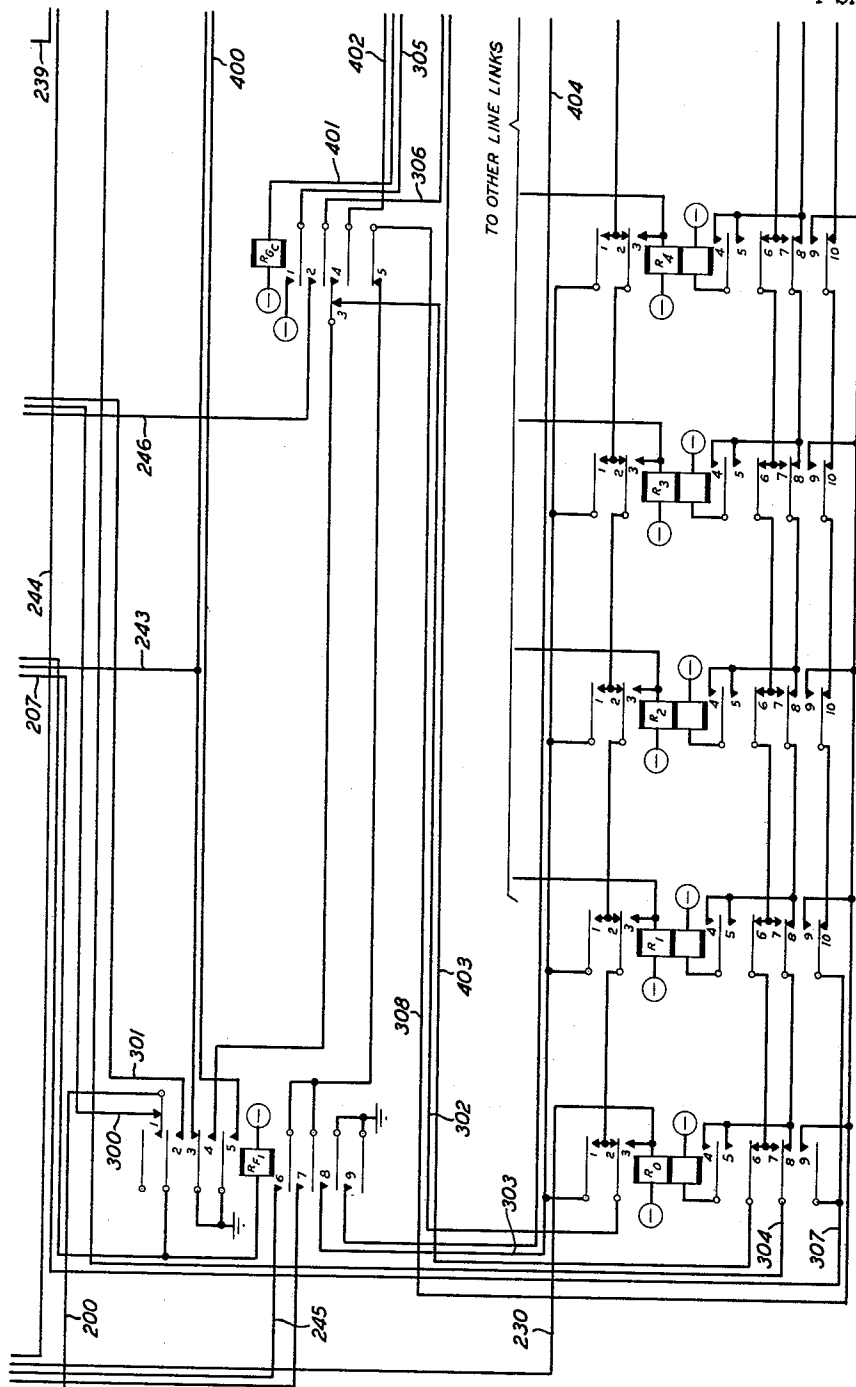
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4 Sheets-Sheet 3



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4 Sheets-Sheet 4

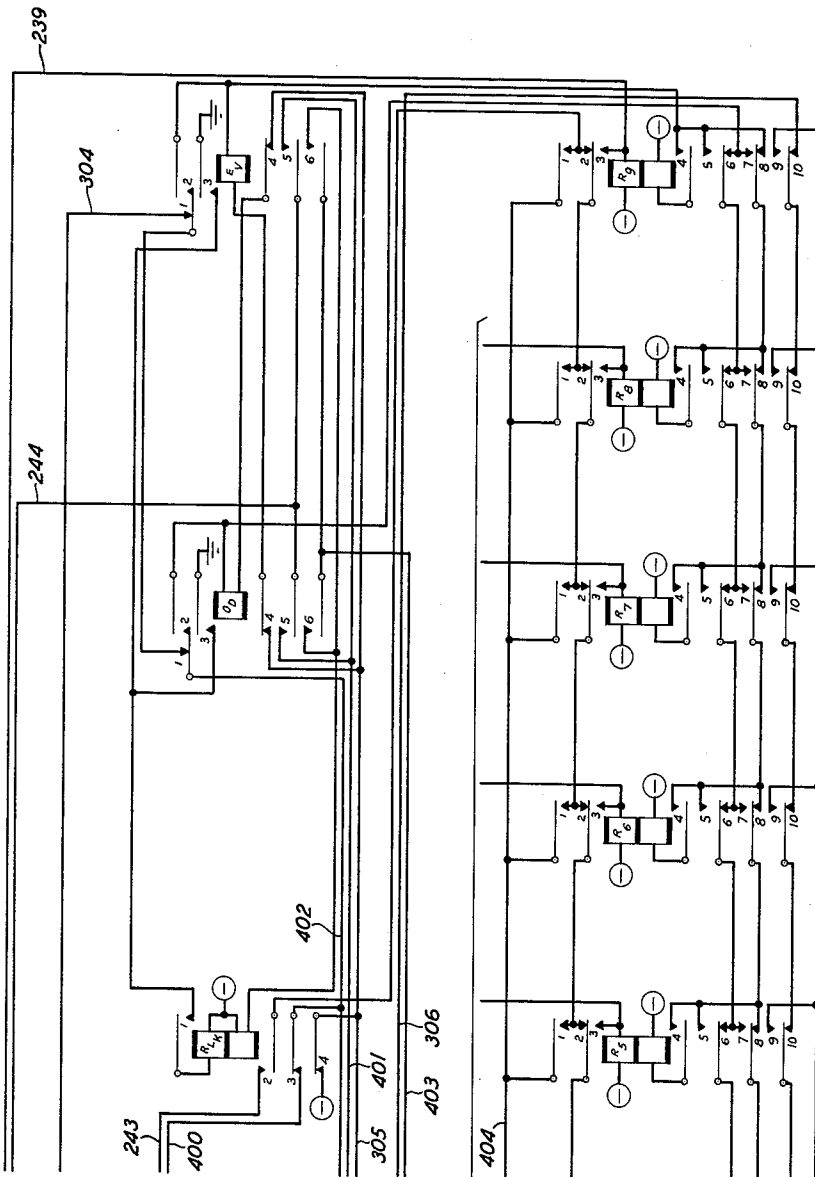


FIG. 4

FIG. 5

FIG. 1	FIG. 2	FIG. 3	FIG. 4
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Application October 22, 1953, Serial No. 387,581

11 Claims. (Cl. 235—61)

This invention relates to observing and recording arrangements and has for its object to facilitate the counting of randomly arranged objects.

Where a large number of objects, for example, pieces of electrical apparatus may be in either one of two conditions and it is desired to observe the number of such objects in one of such conditions at various times, it is convenient to test such objects in groups by means of a group of relays responsive to such one condition and then count the number of relays operated. Since the condition of the objects might change during the counting operation it is advisable to lock the operated relays and disconnect all of them from the objects during the counting operation after which they may be released and connected to other groups of objects to continue the observation.

The present invention relates to means for counting the number of randomly operated relays in such an observing arrangement.

More specifically the invention provides means for counting the number of randomly operated relays by initially locking all of the operated relays and releasing them one by one, counting the number of release operations.

In accordance with one feature of the invention a number of testing relays constitute a serially arranged group having a primary locking circuit initially extended to the first relay of the group and adapted to be extended from relay to relay to hold the first operated relay of the group and a secondary holding circuit extended from the last relay of the group by the intermediate relays to the second operated relay of the group.

Means is provided for intermittently opening the primary locking circuit at the same time operating a counting device. At each opening of the primary locking circuit the first operated relay releases, extending the primary locking circuit to the next operated relay. The secondary locking circuit comprises a pair of chain circuits and at each opening of the primary locking circuit is transferred from one of the chain circuits to the other to continue to hold the second operated relay and place the first operated relay solely under the control of the primary locking circuit.

A holding relay is provided for each chain circuit, the holding relays operating alternately and locking to provide the secondary locking circuit. The operation of either holding relay controls the means for opening the primary locking circuit. The intermittent opening of the primary locking circuit is also under the control of a timing device which is in turn controlled by the holding relays.

The invention is especially adapted for making traffic studies in telephone systems where the various circuit elements such as links and trunks are arranged in groups.

The features of the invention will be more clearly understood from a consideration of the following description read in connection with the attached drawing in which:

Fig. 1 shows in diagrammatic form a number of groups

of line links appearing on crossbar line switches together with a portion of the connector by which access is obtained to the links;

Fig. 2 shows a number of relays for controlling the selection of a group of line links as well as the relays for testing the line links;

Figs. 3 and 4 show the relays for indicating the result of the line link test and the circuits for counting the number of indicating relays operated; and

Fig. 5 is a diagram showing the manner in which Figs. 1 to 4 should be arranged.

The specific embodiment of the present invention is based on the line insulation test control circuit disclosed in applicant's copending application Serial No. 286,266, filed May 6, 1952, and uses the same control relays for successively selecting the groups of circuits to be tested. Reference is made to the above-identified application for a complete description of the selecting operations.

In the crossbar system, for example, of the type disclosed in United States Patent 2,585,904 granted to A. J. Busch February 19, 1952, individual crossbar switches having either one hundred or two hundred crosspoints are coordinately mounted on frames, each frame accommodating ten horizontal levels of switches and each level including a variable number of switches according to the traffic requirements. Each switch has ten or twenty input circuits according to its size and ten output circuits. Where more than one switch is mounted in a horizontal level the output circuits of all of the switches on that level are connected in multiple so that each level has ten output circuits.

The operation of the crossbar switches is controlled by any one of a plurality of common markers. Each frame has an individual frame control circuit to which the marker obtains access by means of its frame connector and which the marker operates selectively to reach a desired group of circuits.

In the line insulation testing circuit of applicant's above-identified application, means is provided for substituting the testing circuit for one of the markers, together with means for operating the line link frame connectors of the various frames and the line link frame control circuits to reach the lines for testing. The testing circuit therefore includes means for progressively selecting each frame, each horizontal group on a frame and each line group in a horizontal group. Ordinarily the testing circuit will be initially conditioned to select the No. 0 frame, the No. 0 horizontal group and the No. 0 line group. In order to interfere as little as possible with service to subscribers, the testing circuit selects and tests only one group of lines on a frame and then progresses to the next frame. When the selected group of lines has been tested on each frame the line group selecting means is advanced to select the next group of lines and this group of lines is tested on each frame. When all of the line groups in the No. 0 horizontal group have been tested, the horizontal group selecting means is advanced to select the next horizontal group, the progression continuing in this manner until all the lines in the office have been tested. It will, of course, be understood that the method of progressing from group to group is unimportant in the present case.

In accordance with the present invention when the line insulation testing circuit is used for making traffic studies, the line insulation testing equipment is by-passed and means is provided for recording the test of the line links outgoing from each horizontal group. While the disclosures of applicant's above-identified application and of the present application are specific to the line link frame, it will be apparent that the same or similar apparatus may be used for making traffic studies on other links and on trunk circuits.

Referring now to Fig. 1 the first and last group of line links on the first and last of a group of ten frames have been indicated. Only the sleeve conductor and contacts have been shown. Each of the hold magnets controls a set of ten crosspoints over one of which the associated line is connected to one of the line links and thence over other switches (not shown) to a trunk circuit which supplies ground for locking the hold magnet and marking the line and the line link busy. In setting up a connection the marker first tests the line links for one not marked by busy ground and operates the select magnet, after which a hold magnet is operated in accordance with the location of the wanted line, the hold magnet locking over its sleeve contact to the ground supplied by the circuit to which the line is connected. The hold magnets have been given designations indicating their location, for example, Hold 000 identifies the hold magnet on frame 0 associated with horizontal level 0 and occupying the 0 position in the switch.

In order to control the line link frame, a line link connector is provided having a preference relay MP0 and a set of connector relays indicated by relay MC0 for each market. When the marker has a call for a line on frame No. 0 it operates its associated preference relay MP0. If the frame is idle or as soon as it becomes idle the connector relay MC0 is operated to extend a plurality of circuits to the marker. These circuits include circuits for operating ten horizontal group relays such as relays HG00 to HG09, ten line link test circuits and a check circuit, as well as a large number of other circuits (not shown).

When it is desired to make a traffic check on the line link frames the line insulation testing circuit is substituted for one of the markers as described in applicant's above-identified application. When the test circuit is placed in service frame tens relay FT0, frame units relay FU0 and horizontal group relay HG0 are operated. However, means is provided for operating any desired combination of these relays to select a particular group of line links if desired. In addition, relay ST is operated to prepare the test circuit for functioning and relay ON2 is operated to prepare a pair of timing circuits.

Assuming that relays FT0, FU0 and HG0 are operated, when the test circuit is ready, a circuit is closed from ground over contact 3 of relay HG0, conductor 200, contact 1 of relay RF1, conductor 300, contact 2 of relay EG to battery through the winding of relay LLC1. Relay LLC1 closes an obvious circuit for relay LLC which connects battery through resistance 201, contact of relay FU0, contact of relay FT0, conductor 210 to ground through the winding of preference relay MP0 of frame 0. When the frame is idle, relay MP0 operates relay MC0. With relay MC0 operated a circuit is completed from battery through resistance 203, contact 1 of relay HG0, conductor 220, contact 1 of relay MC0 to ground through the winding of the frame horizontal group relay HG00. Relay HG00 operates, closing a circuit from ground over its contact 11, contact 21 of relay MC0, conductor 100 to battery through the winding of horizontal group check relay HGK. Relay HG00 also connects the sleeve conductors of the line links of horizontal group 0 over its contacts 1 to 10, contacts 11 to 20 of relay MC0, conductors 110 to 119 to the windings of the line link test relays TLL0 to TLL9. If a line link is idle, the corresponding test relay will not be operated, but, if ground is connected to the sleeve conductor of the line link from the circuit to which it has been connected, the corresponding test relay will be operated. The test relay, for example relay TLL0, will close a circuit from ground over its contact, conductor 230 to battery through the upper winding of the corresponding indicating relay R0.

When the horizontal group check relay HGK operates as above described it initiates a timing operation. When relay ON2 operated as above described, it closes a circuit from battery over its contact 3 through resistance

204, lower winding of relay CHT to ground at contact 2 of relay ON2. Relay ON2 also closes a circuit from battery over its contact 3, upper winding of relay CHT, condenser 205, resistance 206 to ground at contact 1 of relay ON2. Initially relay HGK is not operated and ground is connected over the back contact of relay HGK to the upper winding of relay CHT in shunt of condenser 205. With these circuits closed, relay CHT is energized in a direction to hold its contact open. When relay HGK operates, it opens the shunt around condenser 205 and that condenser charges in series with the upper winding of relay CHT, continuing the energization of relay CHT to hold its contact open for an additional measured interval. When the charging current for condenser 205 decreases, the lower winding of relay CHT becomes effective to close the relay contact. When the contact of relay CHT closes, a circuit is completed from ground over the contact of relay ST, conductor 307, contact of relay CHT, conductor 207 to battery through the winding of relay RF1. The time between the operation of relay HGK and the operation of relay CHT is designed to allow sufficient time for any of the relays TLL0 to TLL9 which are connected to busy line links to operate and in turn operate the associated relays R0 to R9.

When relay RF1 operates it locks over its contact 2, conductor 301, contact 1 of relay EG, conductor 307 to ground at the contact of relay ST. At its contact 4, relay RF1 connects ground over contact 3 of relay RGC to conductor 302 to complete the primary locking circuit for the first operated one of relays R0 to R9. At its contacts 8 and 9, relay RF1 connects ground to conductors 303 and 404 to provide supplementary locking grounds for the second and any other operated ones of relays R0 to R9.

After relay RF1 has operated and connected ground to conductors 302, 303 and 404, it opens its contact 1, releasing relay LLC1 which in turn releases relay LLC to remove battery from the frame selecting circuit and the horizontal group selecting circuit to release the line link frame connector and permit the line link frame to serve subscriber calls. With the line link frame connector released, relay HGK is released to reclose the shunt around condenser 205 and reenergize relay CHT in a direction to hold its contact open. The release of the line link frame also releases any operated ones of relays TLL0 to TLL9.

For the purpose of describing the counting operation let it first be assumed that no busy links were found; next that a consecutive group of links were found busy, for example, links 1 to 5, inclusive, and last that a non-consecutive group of links were found busy, for example, links 2, 5, 7 and 8.

To control the operation of the counting devices, timing relay HMT is provided. When off-normal relay ON2 operated as previously mentioned, it closed a circuit from battery over its contact 4 through resistance 240, upper winding of relay HMT to ground at contact 5 of relay ON2. Relay ON2 also closes a circuit from battery over its contact 4 through the lower winding of relay HMT, condenser 241, resistance 242 to ground at contact 6 of relay ON2. Normally condenser 241 and resistance 242 are shunted by a circuit over conductor 243 to ground at the normally closed contact 3 of relay RF1. Under this condition relay HMT holds its contact open. When relay RF1 operates, it opens this shunt circuit and condenser 241 charges in series with the lower winding of relay HMT continuing the energization of relay HMT in a direction to hold its contact open. When the charging current dies down relay HMT closes its contact.

If, as first assumed, none of the relays TLL0 to TLL9 are operated, none of the relays R0 to R9 operates and, as soon as relay RF1 operates, a circuit is closed from battery over contact 4 of relay RLK, conductor 305, contact 4 of relay OD, winding of relay EV, contacts

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8 of relays R9 to R0, conductor 304, contacts 1 of relays EV and OD, conductor 402, contact 3 of relay RLK, conductor 400 to ground at contact 5 of relay RF1. Relay EV operates in this circuit, closing a locking circuit for itself which extends as above traced from battery to the winding of relay EV and thence over contact 2 of relay EV, contact 1 of relay OD, contact 3 of relay RLK, conductor 400 to ground at contact 5 of relay RF1. With relay EV operated, when relay HMT closes its contact, a circuit is completed from ground at the contact of relay ST, conductor 307, contact of relay HMT, conductor 244, contact 5 of relay EV, conductor 401 to battery through the winding of relay RGC. Relay RGC operates in this circuit and closes a substitute holding circuit for relay EV, which may be traced from battery over contact 1 of relay RGC, conductor 305, contact 4 of relay OD, winding and contact 2 of relay EV, contact 1 of relay OD, conductor 402, contact 4 of relay RGC to ground at contact 4 of relay RF1. Relay RGC also closes a circuit from battery through the winding of the end-of-group relay EG, conductor 246, contact 2 of relay RGC, conductor 306, contacts 10 of relays R9 to R1, conductor 307 to ground at the contact of relay ST. Relay EG operates, further opening the operating circuit for relay LLC1 and also opening the locking circuit for relay RF1 causing relay RF1 to release. In addition, relay EG causes the frame selection relays to advance to select the next frame.

The release of relay RF1 now recloses the shunt around condenser 241 causing relay HMT to open its contact, thereby releasing relay RGC to in turn release relay EG. The release of relay RF1 also releases relay EV. With relay EG released, relay LLC1 can reoperate when the test circuit is ready to select another frame and test the corresponding group of line links on that frame.

Assuming that links 0 to 4 were found busy, relay TLL0 and the next four test relays would be operated, in turn operating relays R0 to R4. As soon as relay CHT operates, relay RF1 is operated as above described. With relay RF1 operated, a primary locking circuit is closed for relay R0 which may be traced from battery through the upper winding and contact 3 of relay R0, conductor 302, contact 3 of relay RGC to ground at contact 4 of relay RF1. Ground connected to conductor 303 by relay RF1 also closes auxiliary locking circuits for relays R1 to R4. The locking circuit of relay R1 extends over contact 3 of relay R1 and contact 1 of relay R0; the locking circuit for relay R2 extends over contact 3 of relay R2 and contact 1 of relay R1, while the locking circuits of relays R3 and R4 similarly extend over contact 1 of the next lower numbered relay to conductor 303. Therefore it will be apparent that these auxiliary locking circuits are controlled in a cascade arrangement by the first operated relay of the series.

A preliminary secondary locking circuit is closed for relay R1 which may be traced from battery through the lower winding of relay R1, contacts 4 and 5 of relay R1, contact 7 of relay R0, conductor 304, contacts 1 of relays EV and OD, conductor 402, contact 3 of relay RLK, conductor 400 to ground at contact 5 of relay RF1. With an odd number of relays operated, a branch of this circuit extends from contact 5 of relay R1 over contact 7 of relay R2, contact 5 of relay R3, contact 7 of relay R4, contacts 6 of relays R5 to R9, winding of relay OD, contact 4 of relay EV, conductor 305, contact 4 of relay RLK to battery. Relay OD operates in this circuit and closes a locking circuit for itself over its contact 2, conductor 402, contact 3 of relay RLK, conductor 400 to ground at contact 5 of relay RF1. This locking ground for relay OD extends back over the operating circuit of relay OD to contacts 4 and 5 of relay R1 providing a secondary locking circuit for relay R1 which is independent of relay R0.

When relay HMT operates in the manner above described, a circuit is closed from ground over the contact

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of relay ST, conductor 307, contact of relay HMT, conductor 244, contact 5 of relay OD, conductor 401 to battery through the winding of relay RGC. Relay RGC operates in this circuit, closing a substitute locking circuit for relay OD which may be traced from battery over contact 1 of relay RGC, conductor 305, contact 4 of relay EV, winding and contact 2 of relay OD, conductor 402, contact 4 of relay RGC to ground at contact 4 of relay RF1.

After this holding circuit is closed, relay RGC opens its contact 3, thereby opening the primary locking circuit for relay R0. It will be observed that there is no secondary locking circuit for relay R0, the possible secondary locking circuit for relay R0 being open at contact 4 of relay OD. Therefore relay R0 now releases.

With relay R0 operated, the operation of relay RF1 closed a circuit from ground at the contact of relay ST, conductor 307, contact 9 of relay R0, conductor 308, contact 5 of relay RGC, contact 6 of relay RF1, conductor 245, contact 4 of the operated horizontal group relay HG0 to battery through the winding of relay TR0, relay TR0 being individual to horizontal group 0 and closing a circuit for counting device C0 which may be of any desired type. Counting device C0 is energized in this circuit preparatory to counting. When relay RGC operates, relay TR0 releases to cause counting device C0 to complete its counting operation. There is a separate relay TR0 to TR9 for each horizontal group so that the number of busy links in each horizontal group is counted separately.

As soon as relay R0 releases, a circuit is closed from battery through the lower winding of relay RLK, contact 6 of relay OD, conductor 403, contact 6 of relay R0, contact 5 of relay R1 and thence over the secondary locking circuit of relay R1 to ground at contact 4 of relay RF1. Relay RLK operates in this circuit and closes a locking circuit for itself from battery through its upper winding and over its contact 1 to ground at contact 3 of relay OD.

With relay RLK operated, a circuit is closed from ground at contact 8 of relay RF1, conductor 303, contact 1 of relay R4, contacts 2 of relays R5 to R9, contact 2 of relay RLK, conductor 243 to the lower winding of relay HMT in shunt of condenser 241 causing relay HMT to again open its contact and disconnect ground from conductor 244. The removal of ground from conductor 244 opens the circuit of relay RGC causing that relay to release. As relay RGC releases, it first closes a circuit from ground over contact 4 of relay RF1, contact 3 of relay RGC, conductor 302, contact 2 of relay R0, contact 3 of relay R1 to battery through the upper winding of relay R1 completing the primary holding circuit for relay R1. Having completed this circuit relay RGC then opens the locking circuit for relay OD causing that relay to release and open the secondary holding circuit for relay R1. With relay OD released the operating and locking circuits for relay RLK are opened and that relay in turn releases.

With relays R0 and RGC released, the circuit of relay TR0 is reclosed extending from ground on conductor 307 over contact 9 of relay R1 to conductor 308 and thence as previously traced to the winding of relay TR0.

As soon as relay RLK releases, the preliminary secondary locking circuit for relay R2 is closed which may be traced from battery through the lower winding and over contacts 4 and 5 of relay R2, contact 7 of relay R1, contact 8 of relay R0, conductor 304, contacts 1 of relays EV and OD, conductor 402, contact 3 of relay RLK, conductor 400 to ground at contact 5 of relay RF1. Since an even number of relays remain operated, a branch of the above traced circuit extends over contact 7 of relay R3, contact 5 of relay R4, contacts 8 of relays R5 to R9, winding of relay EV, contact 4 of relay OD, conductor 305 to battery at contact 4 of relay RLK. Relay EV operates and locks over its contact

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2 and contact 1 of relay OD, conductor 402, contact 3 of relay RLK, conductor 400 to ground at contact 5 of relay RF1.

As soon as relay RLK released it disconnected ground from conductor 243 permitting condenser 241 to charge so that relay HMT again closes its contact after an interval. When relay HMT closes its contact a circuit is closed for relay RGC over conductor 401, contact 5 of relay EV, conductor 244, contact of relay HMT to ground on conductor 307.

Relay RGC closes the holding circuit for relay EV which extends from battery over contact 1 of relay RGC, conductor 305, contact 4 of relay OD, winding and contact 2 of relay EV, contact 1 of relay OD, conductor 402, contact 4 of relay RGC to ground at contact 4 of relay RF1 thereby holding relay EV operated independent of relay RLK.

The operation of relay RGC opens the primary locking circuit of relay R1 and opens the circuit of relay TR0 to permit the traffic register C0 to complete its second count. The secondary locking circuit previously traced for relay R1 is now open at contact 2 of relay OD and contact 4 of relay EV so that relay R1 now releases. With relay R1 released, relay RLK operates over contact 6 of relay EV, conductor 403, contact 6 of relay R0, contact 6 of relay R1, contact 5 of relay R2 and thence over the secondary locking circuit for relay R2. Relay RLK locks through its upper winding and over its contact 1 to ground at contact 3 of relay EV. As previously described relay RLK causes relay HMT to open its contact, releasing relay RGC to in turn release relay EV and relay RLK.

Relay RGC, in releasing, recloses the primary locking circuit which now extends over contacts 2 of relays R0 and R1 to contact 3 and the upper winding of relay R2. Relays R3 and R4 are held over the circuits previously traced.

In the manner previously described a preliminary locking circuit for relay R3 extends from battery through the lower winding and over contacts 4 and 5 of relay R3, contact 7 of relay R2, contacts 8 of relays R1 and R0, conductor 304 and thence as previously traced to ground at contact 5 of relay RF1. With only three of the indicating relays left operated a branch of this circuit is closed from contact 5 of relay R3, contact 7 of relay R4, contacts 6 of relays R5 to R9, winding of relay OD, contact 4 of relay EV, conductor 305 to battery at contact 4 of relay RLK. Relay OD operates and locks as previously described, the locking circuit of relay OD extending back over its operating circuit to contact 5 of relay R3 and thence over contact 4 and through the lower winding of relay R3 to battery to provide the secondary locking circuit for relay R3. Since relay R2 is now the first relay operated, conductors 307 and 308 are connected together over contact 10 of relay R1 and contact 9 of relay R2 to provide an energizing circuit for relay TR0. The release of relays R2 to R4 and the counting of three additional busy line links take place in the manner described for relays R0 and R1.

It will be seen from the foregoing description that the counting of the number of relays of the series which have been operated as a result of testing a group of line links is controlled by the successive closing and opening of a plurality of locking circuits, namely a primary locking circuit, auxiliary locking circuits, a preliminary locking circuit and a secondary locking circuit. The primary locking circuit for the first relay operated, the auxiliary locking circuits for the second and other operated relays and the preliminary locking circuit for the second operated relay are all closed as soon as relay RF1 operates to initiate the counting operation, followed as soon as relays OD or EV operates by the completion of the secondary locking circuit. At the end of the time interval measured by the slow operation of relay HMT the primary locking circuit is opened, releasing the first oper-

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ated relay to in turn open the auxiliary locking circuit and the preliminary locking circuit for the second operated relay. The release of the first operated relay also initiates a series of operations which result in the reclosure of the primary locking circuit which now extends to the second operated relay and the opening of the secondary locking circuit for the second operated relay. The opening of the secondary locking circuit for the second operated relay permits the reclosure of the preliminary locking circuit which now extends to the third operated relay followed by the closure of the secondary locking circuit for the third operated relay.

It will also be seen that the secondary locking circuit involves a double transfer chain, one branch of the chain extending from the winding of relay OD to contacts 6 and 7 of relay R9, and the other branch extending from the winding of relay EV to contacts 5 and 8 to relay R9. At the other end of the chains, the armature of relay R0 controlling contacts 5 and 6 is connected over conductor 403 to front contacts of relays OD and EV to provide an operating circuit for relay RLK, while the armature of relay R0 controlling contacts 7 and 8 is connected over conductor 304, normally closed contacts 1 of relays EV and OD, contact 3 of relay RLK, conductor 400 to ground at contact 5 of relay RF1. Contacts 5 to 8 of relays R0 to R9 are so arranged that, with none of the relays operated, ground is extended to the winding of relay EV and at each operated relay the double transfer chain is reversed so that, with one or any odd number of relays operated, relay OD is operated while with any even number of relays operated relay EV is operated. Contacts 4 and 5 of each relay are connected in multiple so that when either relay OD or relay EV operates and locks, the locking circuit for this relay provides a secondary locking circuit for the second operated one of the indicating relays. When the first operated relay releases with relay OD or relay EV operated, the secondary locking circuit extends back over the contacts of the now released first operated relay to operate relay RLK.

This reversal of the secondary locking circuits will be more clearly apparent if the operation for a non-consecutive group is considered. Assume, as above, that relays R2, R5, R7 and R8 are operated. The primary locking circuit for relay R2 may be traced from battery through its upper winding and over its contact 3, contacts 2 of relays R1 and R0, conductor 302, contact 3 of relay RGC to ground at contact 4 of relay RF1. Relays R5, R7 and R8 are held operated by means of auxiliary locking circuits, that for relay R5 extending over contact 3 of relay R5, contacts 2 of relays R4 and R3, contact 1 of relay R2 to conductor 303. The auxiliary locking circuit for relay R7 extends over contact 3 of relay R7, contact 2 of relay R6 and contact 1 of relay R5, conductor 404, to ground at contact 9 of relay RF1. The auxiliary locking circuit for relay R8 extends over contact 3 of relay R8, contact 1 of relay R7 to ground on conductor 404.

The preliminary locking circuit for relay R5 may be traced from battery through the lower winding and over contacts 4 and 5 of relay R5, contacts 6 of relays R4 and R3, contact 7 of relay R2, contacts 8 of relays R1 and R0, conductor 304, normally closed contacts 1 of relays EV and OD, conductor 402, contact 3 of relay RLK, conductor 400 to ground at contact 5 of relay RF1. A branch of this circuit extends over contact 8 of relay R6, contact 7 of relay R7, contact 5 of relay R8, contact 8 of relay R9, winding of relay EV, contact 4 of relay OD, conductor 305 to battery over contact 4 of relay RLK. Relay EV operates in this circuit and locks over its contact 2, contact 1 of relay OD, conductor 402 to ground as above traced. This locking ground extends back to contacts 4 and 5 of relay R5 providing the secondary locking circuit for relay R5. After closing this secondary locking circuit at its contact 2, relay EV at its contact 1 opens the pre-

liminary locking circuit for relay R5 leaving relay R5 held over the locking circuit of relay EV. It may be noted that, since this circuit extends over contact 5 of relay R8, which is connected in multiple to contact 4 of that relay, the secondary locking circuit is also closed to relay R8 but has no function at this time.

With relay EV operated, the operation of the timing relay HMT operates relay RGC as previously described. Relay RGC supplies substitute battery to conductor 305 and ground to conductor 402 to hold relay EV operated and opens the metering circuit to permit the meter to advance. It also opens the primary locking circuit for relay R2 causing that relay to release. As soon as relay R2 releases, ground on the secondary locking circuit for relay R5 is extended over contact 5 of relay R5, contacts 6 of relays R4 to R0, conductor 403, contact 6 of relay EV to battery through the lower winding of relay RLK. Relay RLK locks under the control of relay EV and closes a circuit from ground on conductor 404 over contact 1 of relay R8 and contact 2 of relay R9, contact 2 of relay RLK, conductor 243 to the winding of relay HMT to cause that relay to open its contact and release relay RGC.

With relay R2 released, as soon as relay RGC releases, the primary locking circuit for relay R5 becomes effective. This circuit extends from battery through the upper winding and over contact 3 of relay R5, contacts 2 of relays R4 to R0, conductor 302, contact 3 of relay RGC to ground at contact 4 of relay RF1.

With relay RLK operated and relay RGC released, relay EV releases, opening the secondary holding circuit for relay R5 but that relay is now held over the primary locking circuit, while relays R7 and R8 are held over their auxiliary locking circuits. As soon as relay EV releases, relay RLK also releases, removing ground from the winding of relay HMT so that the latter relay may operate to control the counting of the next busy line link.

The preliminary holding circuit for relay R7 may now be traced from battery through the lower winding of that relay and over its contacts 4 and 5, contact 6 of relay R6, contact 7 of relay R5, contacts 8 of relays R4 to R0, conductor 304, contacts 1 of relays EV and OD, conductor 402, contact 3 of relay RLK, conductor 400 to ground at contact 5 of relay RF1. A branch of this circuit extends over contact 7 of relay R8, contact 6 of relay R9, winding of relay OD, contact 4 of relay EV to battery at contact 4 of relay RLK. Relay OD now operates and locks over its contact 2 to ground on conductor 402 and this locking circuit extends back to complete the secondary locking circuit for relay R7. With relay R5 operated the previously traced circuit for the counter is closed.

When relay HMT operates, relay RGC is operated to cause the counter to advance and to open the primary locking circuit so that relay R5 releases. With relay R5 released, relay RLK operates over the locking circuit of relay R7 and causes relays HMT, RGC and OD to release after which relay RLK releases. With relays R5 and RGC released, relay R7 is held over the primary locking circuit extending over contact 3 of relay R7 and contacts 2 of relays R6 to R0. As soon as relays OD and RLK release, a circuit is closed as previously traced from ground on conductor 304 and over contacts 8 of relays R0 to R6, contact 7 of relay R7, contacts 4 and 5 of relay R8 to battery through the lower winding of relay R8 and over contact 8 of relay R9, winding of relay EV and thence to battery as previously traced. Relay EV operates and locks extending its locking circuit back to contacts 4 and 5 of relay R8 to complete the secondary locking circuit for that relay.

With relay EV operated, when relay HMT operates, relay RGC operates to open the primary locking circuit

for relay R7 and complete the counting of the third busy link. As soon as relay R7 releases, relay RLK operates, releasing relays HMT, RGC and EV. As above, relay RGC in releasing closes the primary locking circuit for relay R8 before opening the locking circuit of relay EV. With only relay R8 left operated, a circuit is closed from ground on conductor 402, contacts 1 of relays OD and EV, conductor 304, contacts 8 of relays R0 to R7, contact 7 of relay R8, contact 6 of relay R9, winding of relay OD, contact 4 of relay EV to battery over conductor 305. Relay OD operates and locks, but with only a single relay operated no secondary locking circuit is closed. With relay R8 operated, the circuit of the counter is again closed and when relay RGC operates under the control of relay HMT this circuit, as well as the primary holding circuit for relay R8, is opened to count the fourth busy link and release relay R8. As soon as relay R8 releases, a circuit is closed from ground on conductor 307 over contacts 10 of relays R1 to R9, conductor 306, contact 2 of relay RGC, conductor 246, to battery through the winding of relay EG. Relay EG opens the locking circuit for relay RF1 to prepare for a new count, opens the circuit for relay LLC1 and initiates the advance of the selecting equipment of the line insulation test circuit to another group of line links.

What is claimed is:

1. An arrangement for counting the number of a group of objects on which a predetermined condition may exist at random comprising a corresponding group of relays responsive to said predetermined condition, means for simultaneously connecting said relays to said objects to operate the relays corresponding to the objects on which said predetermined condition exists, contacts controlled by said relays and chain circuits interconnecting all of said relays in a series arrangement, a primary locking circuit for the serially first one of said operated relays, a secondary locking circuit for the serially second one of said operated relays, said locking circuits including portions of said chain circuits, means under the control of said connecting means to close said locking circuits and disconnect said relays from said objects, timing means, means under the control of said timing means to alternately open and close said primary locking circuit and said secondary locking circuit to release the operated ones of said relays one at a time, counting means, and means responsive to the release of each operated relay to operate said counting means.

2. An arrangement for counting the number of a group of objects on which a predetermined condition may exist at random comprising a corresponding group of relays responsive to said predetermined condition, means for simultaneously connecting said relays to said objects to operate the relays corresponding to the objects on which said predetermined condition exists, contacts controlled by said relays and chain circuits interconnecting all of said relays in a series arrangement, a primary locking circuit for the serially first one of said operated relays, a secondary locking circuit for the serially second one of said operated relays, said locking circuits including portions of said chain circuits, means under the control of said connecting means to close said locking circuits and disconnect said relays from said objects, timing means, means under the control of said timing means to alternately open and close said primary locking circuit and said secondary locking circuit to release the operated ones of said relays one at a time, said chain circuits effective responsive to the release of each operated relay to extend said primary locking circuit and said secondary locking circuit to the next two operated relays of said series, counting means, and means responsive to the release of each operated relay to operate said counting means.

3. An arrangement for counting the number of a group of objects on which a predetermined condition may exist at random comprising a corresponding group of relays responsive to said predetermined condition, means for

simultaneously connecting said relays to said objects to operate the relays corresponding to the objects on which said predetermined condition exists, contacts controlled by said relays and chain circuits interconnecting all of said relays in a series arrangement, a primary locking circuit for the serially first one of said operated relays, a secondary locking circuit for the serially second one of said operated relays, said locking circuits including portions of said chain circuits, means under the control of said connecting means to close said locking circuits and disconnect said relays from said objects, timing means, means under the control of said timing means to alternately open and close said primary locking circuit and said secondary locking circuit to release the operated ones of said relays one at a time, said chain circuits effective responsive to the release of each operated relay to extend said primary locking circuit and said secondary locking circuit to the next two operated relays of said series, counting means, means responsive to the release of each operated relay to operate said counting means, and means responsive to the release of the serially last one of said operated relays to reoperate said connecting means.

4. An arrangement for counting the number of a group of objects on which a predetermined condition may exist at random comprising a corresponding group of relays responsive to said predetermined condition, means for simultaneously connecting said relays to said objects to operate the relays corresponding to the objects on which said predetermined condition exists, contacts controlled by said relays and chain circuits interconnecting all of said relays in a series arrangement, a primary locking circuit for the serially first one of said operated relays, a secondary locking circuit for the serially second one of said operated relays, said locking circuits including portions of said chain circuits, auxiliary locking circuits for other operated relays, means under the control of said connecting means to close said locking circuits and disconnect said relays from said objects, timing means, means under the control of said timing means to alternately open and close said primary locking circuit and said secondary locking circuit to release the operated ones of said relays one at a time, counting means, means responsive to the release of each operated relay to operate said counting means, and means responsive to the release of each operated relay to open the auxiliary locking circuit for the next operated relay.

5. An arrangement for counting the number of a group of objects on which a predetermined condition may exist at random comprising a corresponding group of relays responsive to said predetermined condition, means for simultaneously connecting said relays to said objects to operate the relays corresponding to the objects on which said predetermined condition exists, contacts controlled by said relays and chain circuits interconnecting all of said relays in a series arrangement, a primary locking circuit for the serially first one of said operated relays, a secondary locking circuit for the serially second one of said operated relays, said locking circuits including portions of said chain circuits, auxiliary locking circuits for other operated relays, means under the control of said connecting means to close said locking circuits and disconnect said relays from said objects, timing means, means under the control of said timing means to alternately open and close said primary locking circuit and said secondary locking circuit to release the operated ones of said relays one at a time, said chain circuits effective responsive to the release of each operated relay to extend said primary locking circuit and said secondary locking circuit to the next two operated relays of said series, counting means, means responsive to the release of each operated relay to operate said counting means, and means responsive to the release of each operated relay to open the auxiliary locking circuit for the next operated relay.

6. An arrangement for counting the number of a group of objects on which a predetermined condition may exist

at random comprising a corresponding group of relays responsive to said predetermined condition, means for simultaneously connecting said relays to said objects to operate the relays corresponding to the objects on which said predetermined condition exists, contacts controlled by said relays and chain circuits interconnecting all of said relays in a series arrangement, a primary locking circuit for the serially first one of said operated relays, a secondary locking circuit for the serially second one of said operated relays, said locking circuits including portions of said chain circuits, auxiliary locking circuits for other operated relays, means under the control of said connecting means to close said locking circuits and disconnect said relays from said objects, timing means, means under the control of said timing means to alternately open and close said primary locking circuit and said secondary locking circuit to release the operated ones of said relays one at a time, said chain circuits effective responsive to the release of each operated relay to extend said primary locking circuit and said secondary locking circuit to the next two operated relays of said series, means responsive to the release of each operated relay to open the auxiliary locking circuit for the next operated relay, counting means, means responsive to the release of each operated relay to operate said counting means, and means responsive to the release of the serially last one of said operated relays to reoperate said connecting means.

7. A counting arrangement for counting the number of simultaneously random operated relays of a serially arranged group of relays, means to simultaneously operate random ones of said relays, a primary locking circuit for the serially first one of said operated relays, a secondary locking circuit for the serially second one of said operated relays, a holding relay included in said secondary locking circuit, a counting device, means under the control of said holding relay to operate said counting device and to open said primary locking circuit to release said first operated relay, and means responsive to the release of said first operated relay to transfer said primary locking circuit to said second operated one of said relays and said secondary locking circuit to the serially third one of said operated relays.

8. A counting arrangement for counting the number of simultaneously random operated relays of a serially arranged group of relays, means to simultaneously operate random ones of said relays, a primary locking circuit for the serially first one of said operated relays, means under the control of said first operated relay for holding the other operated ones of said relays, a pair of chain circuits controlled by each of said relays, a holding relay connected to each chain circuit, means under the control of said first operated relay to energize one of said chain circuits, means controlled by each operated relay for reversing said chain circuits whereby one of said hold relays is operated if an even number of relays is operated and the other one of said hold relays is operated if an odd number of relays is operated, means responsive to the operation of either hold relay for holding the serially second one of said operated relays over said chain circuits, a counting device, means under the control of the operated hold relay to operate said counting device and to open said primary locking circuit to release said first operated relay, and means responsive to the release of said first operated relay to transfer said primary locking circuit to said second operated relay and to energize the other one of said chain circuits.

9. A counting arrangement for counting the number of simultaneously random operated relays of a serially arranged group of relays, means to simultaneously operate random ones of said relays, a primary locking circuit for the serially first one of said operated relays, auxiliary locking circuits for all of said operated relays except the first, each of said auxiliary locking circuits controlled by a serially prior operated relay, a pair of chain circuits controlled by each of said relays, a hold-

ing relay connected to each chain circuit, means under the control of said first operated relay to energize one of said chain circuits, means controlled by each operated relay for reversing said chain circuits whereby one of said hold relays is operated if an even number of relays is operated and the other one of said hold relays is operated if an odd number of relays is operated, means responsive to the operation of either hold relay for holding the serially second one of said operated relays over said chain circuits, a counting device, means under the control of the operated hold relay to operate said counting device and to open said primary locking circuit to release said first operated relay, and means responsive to the release of said first operated relay to substitute said primary locking circuit for the auxiliary locking circuit of said second operated relay and to energize the other one of said chain circuits.

10. A counting arrangement for counting the number of simultaneously random operated relays of a serially arranged group of relays, means to simultaneously operate random ones of said relays, a primary locking circuit for the serially first one of said operated relays, means under the control of said first operated relay for holding the other operated ones of said relays, a pair of chain circuits controlled by each of said relays, a holding relay connected to each chain circuit, means under the control of said first operated relay to energize one of said chain circuits, means controlled by each operated relay for reversing said chain circuits whereby one of said hold relays is operated if an even number of relays is operated and the other one of said hold relays is operated if an odd number of relays is operated, means responsive to the operation of either hold relay for holding the serially second one of said operated relays over said chain circuits, a counting device, timing means, means under the joint control of the operated hold relay and said timing means to operate said counting device and to open said primary locking circuit to release said first operated relay, means responsive to the release of said first operated relay to release said timing means, to transfer said primary locking circuit to said second operated relay and to energize the other one of said chain circuits,

means responsive to the release of said timing means to reclose said primary locking circuit and release the operated hold relay, and means responsive to the release of said operated hold relay to reoperate said timing means.

11. A counting arrangement for counting the number of simultaneously random operated relays of a serially arranged group of relays, means to simultaneously operate random ones of said relays, a primary locking circuit for the serially first one of said operated relays, auxiliary locking circuits for all of said operated relays except the first, each of said auxiliary locking circuits controlled by a serially prior operated relay, a pair of chain circuits controlled by each of said relays, a holding relay connected to each chain circuit, means under the control of said first operated relay to energize one of said chain circuits, means controlled by each operated relay for reversing said chain circuits whereby one of said hold relays is operated if an even number of relays is operated and the other one of said hold relays is operated if an odd number of relays is operated, means responsive to the operation of either hold relay for holding the serially second one of said operated relays over said chain circuits, a counting device, timing means, means under the joint control of the operated hold relay and said timing means to operate said counting device and to open said primary locking circuit to release said first operated relay, means responsive to the release of said first operated relay to substitute said primary locking circuit for the auxiliary locking circuit of said second operated relay, to release said timing means and to energize the other one of said chain circuits, means responsive to the release of said timing means to reclose said primary locking circuit and release the operated hold relay, and means responsive to the release of said operated hold relay to reoperate said timing means.

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