Dec. 12, 1944. F. A. KORN 2,364,796

TROUBLE INDICATING SYSTEM

Filed March 27, 1942 5 Sheets-Sheet 1

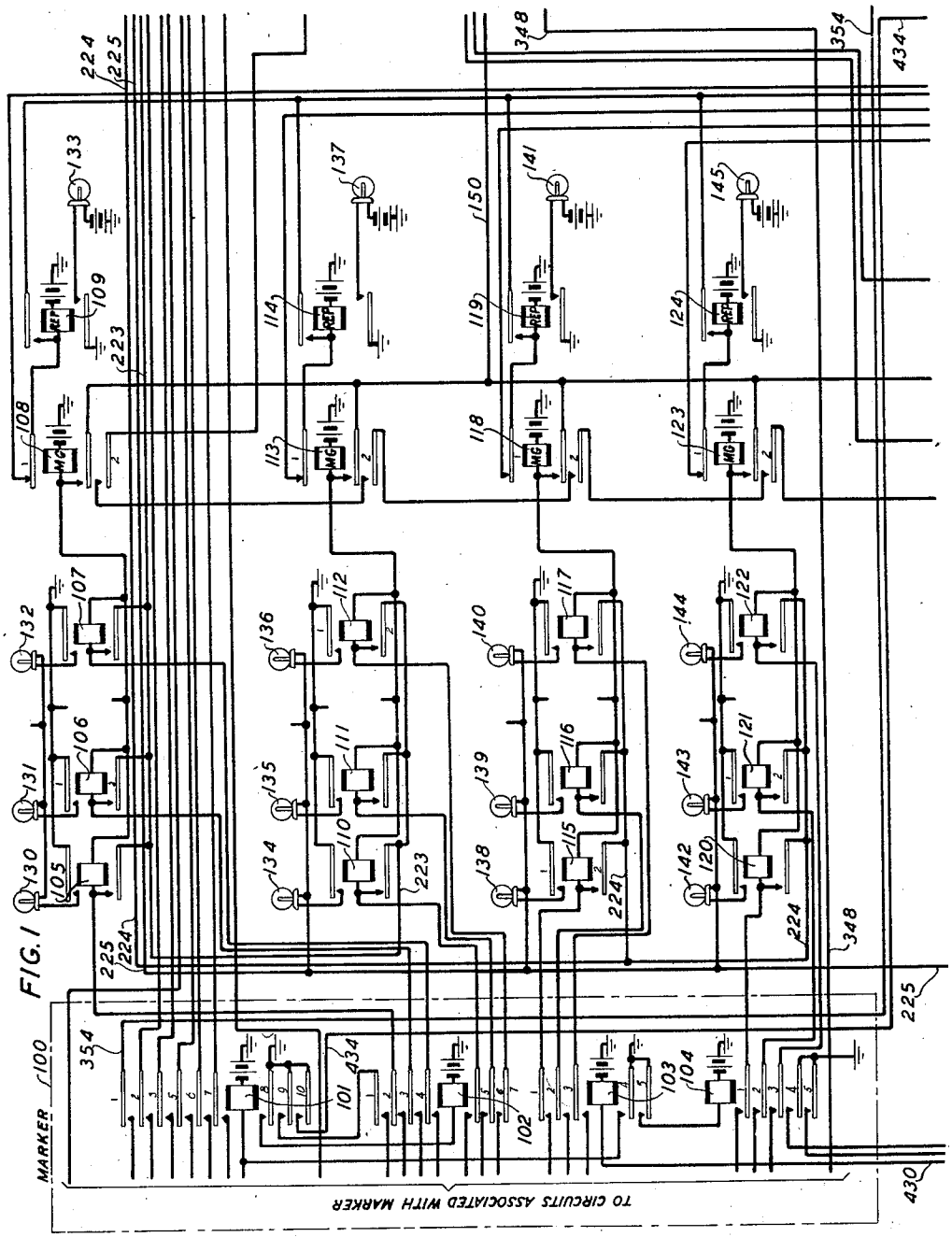

FIG. 1

FIG. 6

FIG. 2	FIG. 4
FIG. 3	FIG. 5
FIG. 1	

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TROUBLE INDICATING SYSTEM

Filed March 27, 1942 5 Sheets-Sheet 2

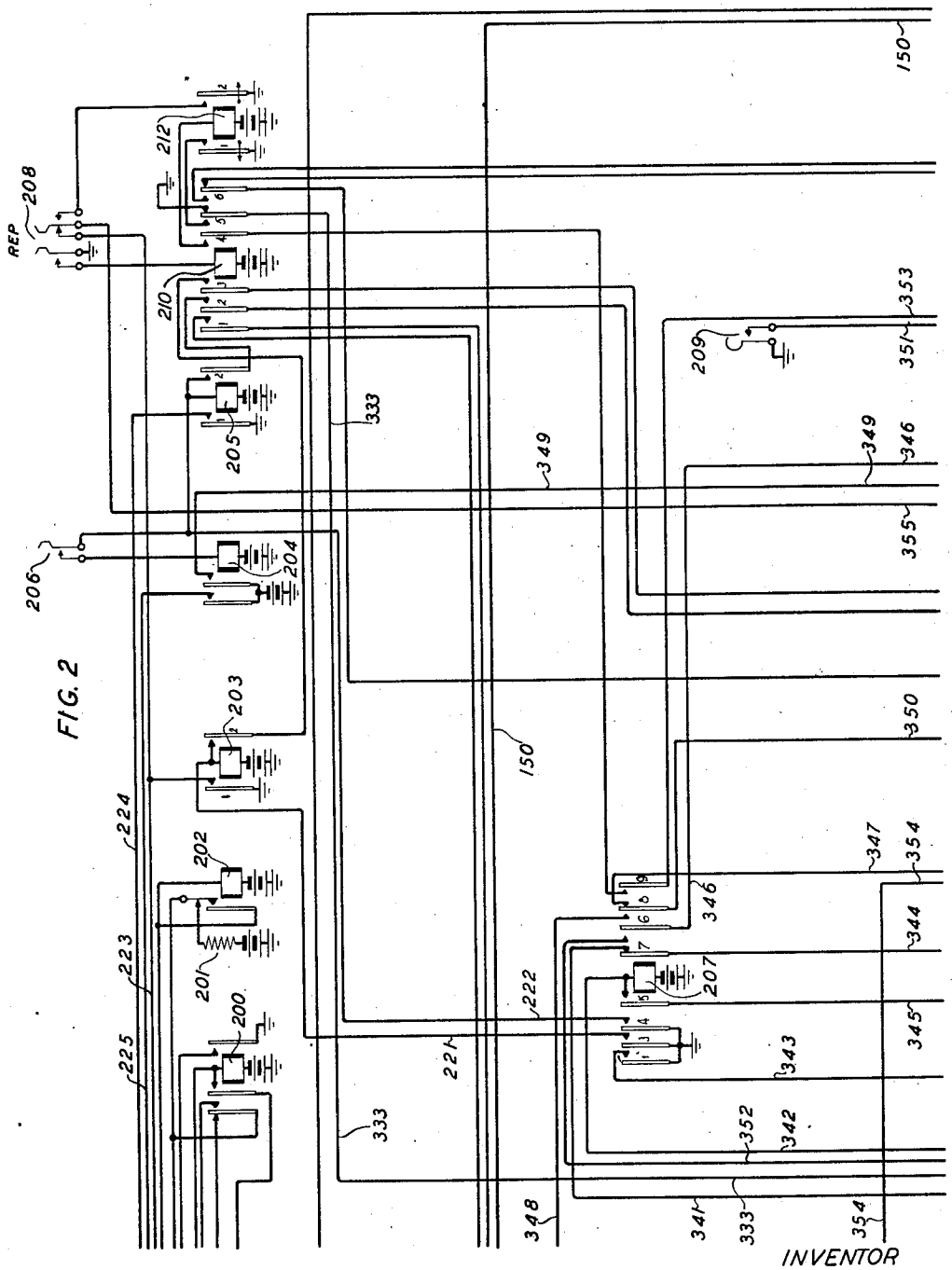

FIG. 2

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TROUBLE INDICATING SYSTEM

Filed March 27, 1942 5 Sheets-Sheet 3

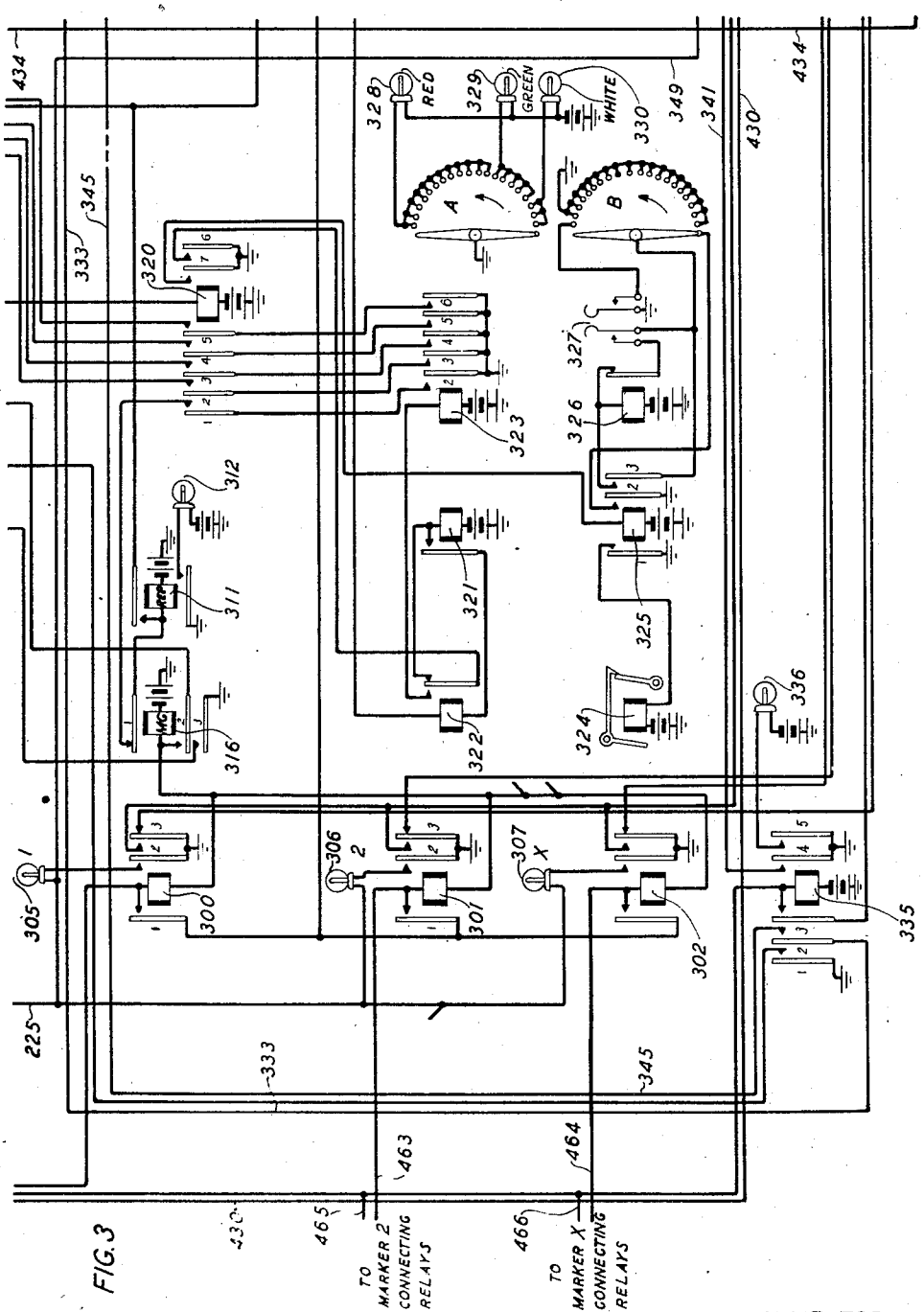

FIG. 3

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TROUBLE INDICATING SYSTEM

Filed March 27, 1942 5 Sheets-Sheet 4

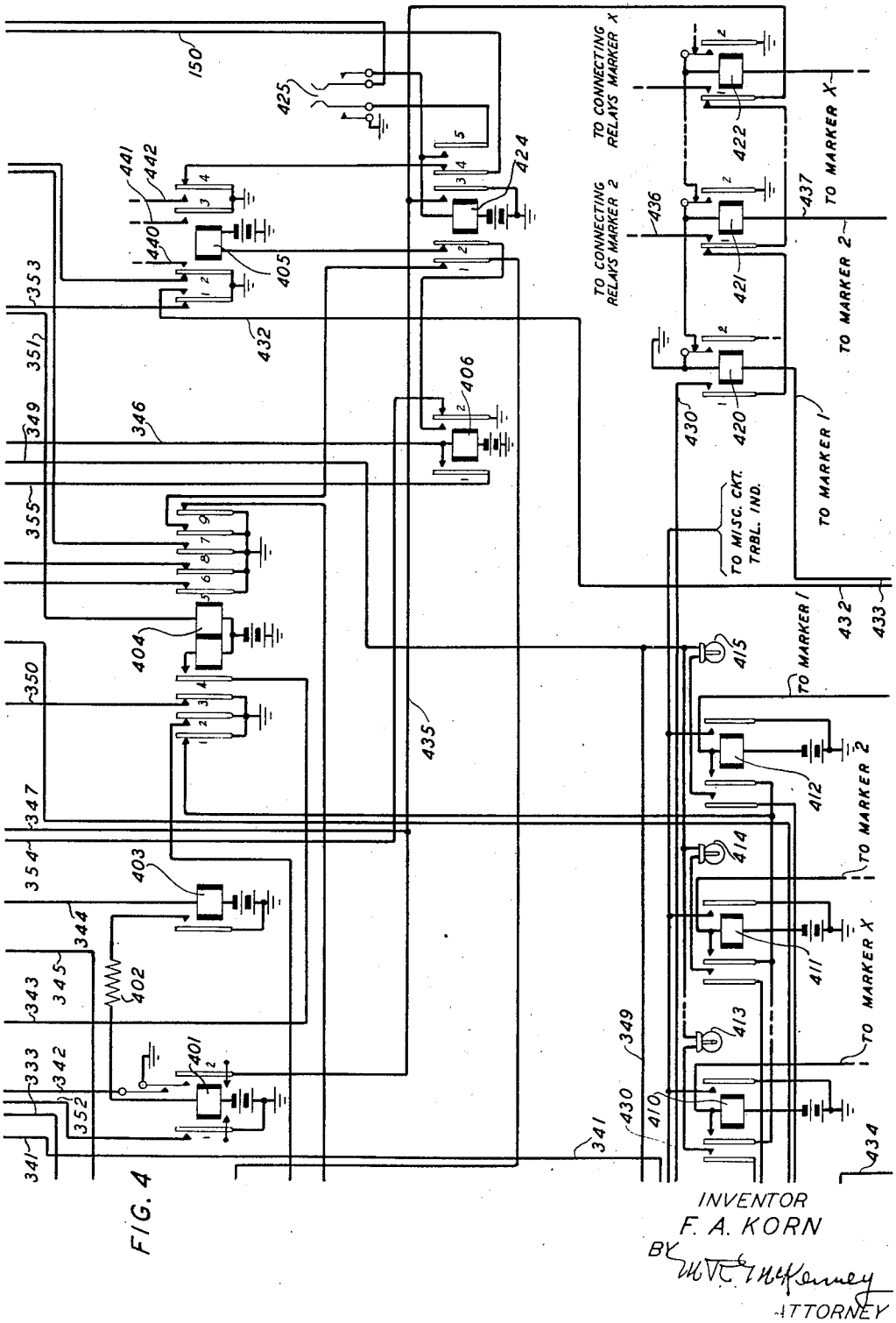

FIG. 4

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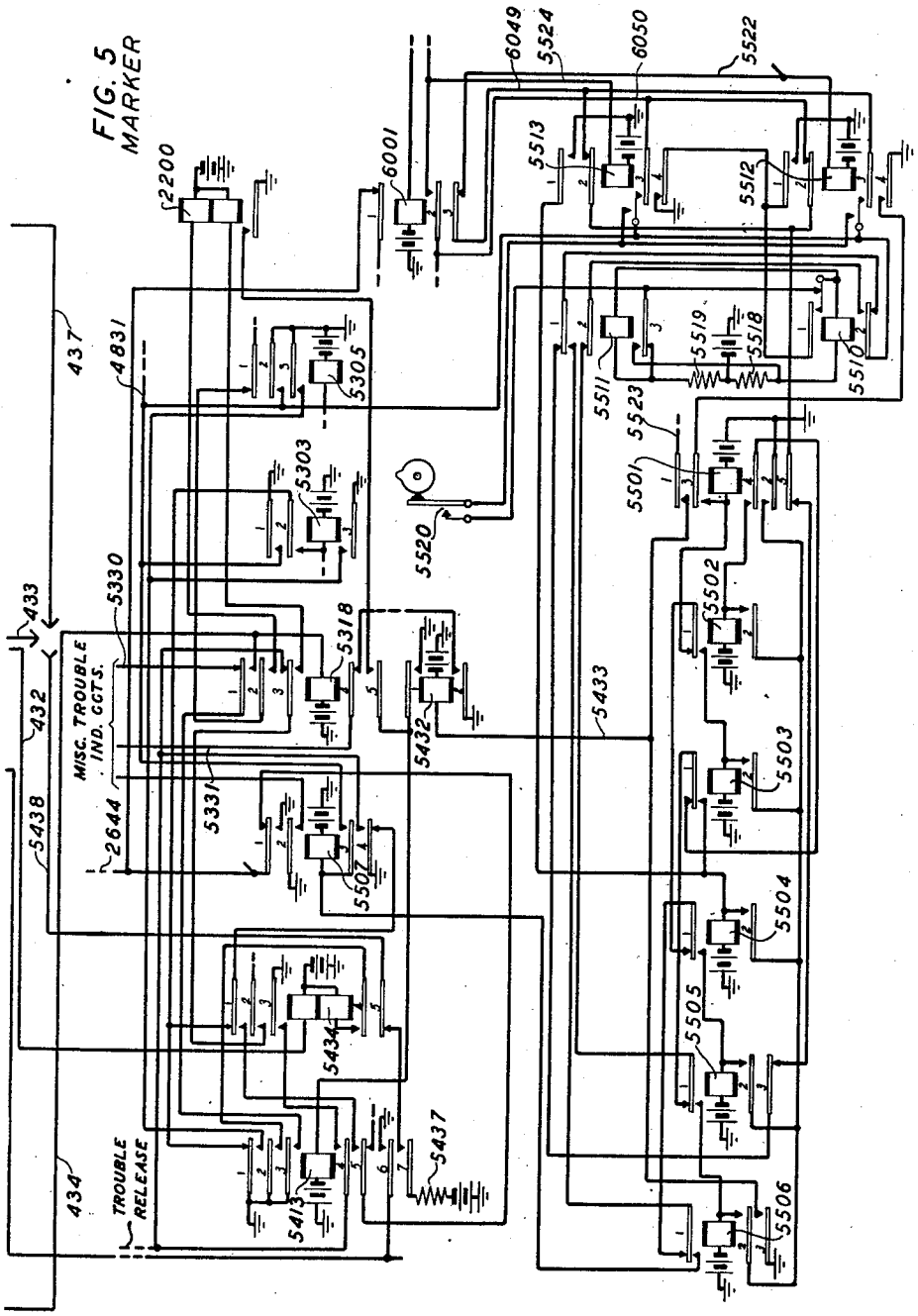
TROUBLE INDICATING SYSTEM

Filed March 27, 1942 5 Sheets-Sheet 5



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Patented Dec. 12, 1944 2,364,796

UNITED STATES PATENT OFFICE

2,364,796

TROUBLE INDICATING SYSTEM

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Application March 27, 1942, Serial No. 436,457

15 Claims. (Cl. 179—175.2)

This invention relates to trouble indicating and recording circuits for telephone switching systems and particularly for such systems under the control of mechanical and electrical devices.

The object of the invention is to simplify the analyzation of recurring troubles in complicated switch controlling devices.

Devices of the character disclosed in the Patent 2,202,921 to A. C. Powell, June 4, 1940, are used for indicating and recording troubles which occur in a telephone switching system as disclosed by W. W. Carpenter in his Patent 2,235,803, March 18, 1941, which employs a plurality of markers for connecting switches between calling incoming lines and outgoing lines selected according to registrations set up in the marker. When a trouble occurs in completing a telephone connection the marker, as shown in the above patent to Carpenter, seizes a trouble-indicating circuit and the trouble is analyzed from the combination of indicators associated with a plurality of circuit units connected with the marker. Upon analyzing the record as indicated in the trouble-indicating circuit, the trouble may be found to exist in any one of numerous circuits which are brought together and associated with the marker for completing a telephone connection. After this trouble is analyzed the unit of equipment which has caused unsatisfactory operation may be at once repaired or may be removed from service while the trouble is remedied.

Troubles have, however, occurred which cause repeated failures before an analysis can be made and which affect groups of equipment, such as switch trains, lines, senders or markers, which give considerable trouble in a very short period of time. For example, a single fault in a line number indicating group to which all markers have access may cause a plurality of markers attempting to select a line in this group to obtain connection with the trouble indicator. In telephone systems of this character the equipment for completing a telephone connection operates so rapidly that in many cases the same trouble is indicated by two or more markers which successively encounter this fault within a very short period of time.

A feature of the present invention resides in a trouble-indicating circuit having means therein for automatically analyzing troubles which cause successive failures in completing telephone connections.

Another and related feature of the invention resides in a trouble-indicating circuit having an auxiliary indicating device associated with each of a plurality of indicating devices which are operatively connectable with an equivalent plurality of circuits of different characters to indicate successive failures in the completion of a telephone connection caused by a fault in the same circuit connected in successive combinations of circuits of different characters for completing said telephone connections.

Another and related feature of the invention resides in a trouble-indicating circuit having a means to automatically release all of a plurality of indicating devices upon successive seizures of said trouble indicating circuit by markers having a plurality of other circuits connected thereto, excepting an indicating device connected with a circuit which indicates a repeat of the same trouble indicated upon a preceding seizure of said trouble indicating circuit.

These and other features will be discussed more fully in the following description.

To illustrate the features of the invention, reference may be made to the following drawings in which:

Fig. 1 illustrates marker connecting relays in the left portion of the drawings and indicating devices in the remainder of the drawings;

Fig. 3 illustrates indicating devices individual to the markers and common equipment associated with repeated troubles indicated in the trouble indicator circuit;

Figs. 2 and 4 illustrate trouble indicator circuit control relays;

Fig. 5 illustrates the equipment in a marker which causes the association of the marker with a trouble indicating circuit.

Each marker has a timing circuit as shown in Fig. 5 for timing the various operations of the marker when it is taken for use for completing a telephone connection. Ground is connected to lead **4831** as the marker starts functioning and energizes the timing circuit. If no trouble is encountered in completing the connection, this ground is removed from lead **4831** by the energization of equipment in the marker. If the functioning of the marker is delayed beyond the time period allotted, a circuit is established for connecting the marker to the trouble indicator. The trouble indicator circuit is energized if it is not already connected to another marker. If the trouble indicator is already connected to a marker, a lamp is lighted to identify the marker which attempted to associate its leads with the trouble indicator but found it engaged.

Certain equipment in the trouble indicator cir-

cuit is provided for each marker served by this indicator circuit. This comprises start relays, such as relay **420**, individual to the marker equipment shown diagrammatically in Figs. 1 and 5, in a chain circuit with other start relays, such as **421** and **422** which are individual to other markers the same as the one shown. Relays, such as **410**, **411** or **412** are also individual to the markers. These and associated lamps are energized to indicate a marker which attempts to seize the trouble indicator circuit when another marker is connected thereto. Only one marker can be connected to the trouble indicator for recording a trouble and normally the trouble indicator is held busy to all markers until a permanent record has been made or the trouble analyzed. Under the repeat trouble recording arrangement disclosed herein, the trouble indicator is not held busy to other markers after the release of the marker which has made the record, thus as soon as this marker is disconnected from the trouble indicator another marker may seize it to make a record of a trouble which has caused a failure to complete a telephone connection. According to the invention the indicating devices in the trouble indicator may remain energized after the marker has been disconnected from the trouble indicator circuit and in certain instances these indicating devices are used to automatically analyze the trouble and locate the circuit causing the failure. The connecting relays, such as **101**, **102**, **103** and **104** are provided in each marker, as shown in the Carpenter Patent 2,235,803, Figs. 79 and 80, for connecting a large plurality of leads from the marker to the trouble indicator circuit to give the trouble indicator a full record of the identification of the marker connected thereto and the other circuits connected to the marker which may have a fault therein and which are of interest in tracing this fault to a particular circuit as fully disclosed in the aforementioned Patent 2,202,921 to A. C. Powell. The marker connecting relays are energized by the trouble indicator start relay, such as **420** after the trouble indicator circuit has been seized by the marker having these connecting relays therein. Relays **300**, **301** and **302** are individual to the markers with relay **300** connected to the winding of the marker connecting relay **102** shown in the operating circuit of relay **420**. These relays and associated lamps are energized to indicate the designation of the marker which has seized the trouble indicator. Relays, such as **115**, **116**, **117**, **120**, **121** and **122** are individual to other units of equipment to which a marker associated with the trouble indicator may be connected. As disclosed in the aforementioned Patent 2,235,083, to Carpenter, the marker is connected with a sender, different connectors, a district and office link frame equipment and trunk selecting equipment. The different stages of operations in this equipment are also indicated by lamps individual thereto which may be energized to indicate the location of trouble in this equipment connected to the marker. Other types of recorders may be used in place of the lamps shown when a permanent record is desired.

It is particularly desirable to locate troubles which may disrupt telephone service which sometimes arise when a single trouble repeatedly asserts itself in a unit of equipment during a busy period in the telephone exchange. According to the invention signaling circuits individual to each character of equipment are arranged to indicate when a trouble in a particular circuit is repeated successively and the trouble indicator is arranged to automatically analyze this trouble to indicate the particular circuit causing the failures. For example, the repeat relays **310** and **311** and repeat lamp **312** are so connected to the individual marker indicating relays **300**, **301** and **302** that when the same marker is connected to the trouble indicator twice successively a circuit is established for repeat lamp **312**. Relays **120**, **121** and **122** may be individual to districts, and repeat relays **123** and **124** and repeat lamp **145** are so connected to the individual district indicating relays that when the same district indicates a trouble successively a circuit is established for repeat lamp **145**. A quick analyzation of the trouble will follow the lighting of a repeat lamp as may be determined from the following. When two different markers are successively associated with the same district which had a fault therein, a registered telephone connection could not be completed because of the fault in this district. In this case the first marker to seize the trouble indicator may operate individual marker relay **300** which lights individual marker lamp **305**. The district having a fault therein may operate individual district relay **120** which lights individual district lamp **142**. The second marker to be associated with the faulty district may operate individual marker relay **301** which lights individual marker lamp **306**, but the district would again attempt to operate the same individual district relay **120**. This, as explained later in detail, would operate the district repeat relay which lights district repeat lamp **145** and both marker lamps would be extinguished. Thus the trouble indicator points directly to the district giving the trouble and eliminates the markers from the investigation. This district may then be taken out of service to prevent further troubles.

The remaining equipment shown in the drawings other than that shown for explaining the operation of the marker is common to the trouble indicating circuit and common to all markers and the circuits associated therewith.

Detail description

The operation of the marker timing circuit and the manner in which it connects with the trouble indicator will first be described.

The timing circuit shown in Fig. 5 comprises relays **5501** to **5507** and **5510** to **5513**, inclusive, together with the associated interrupter **5520**. The timing cycle, measured under the control of these relays and interrupter, is divided into two intervals which correspond to the decoding and marking stages of operation in the marker. The first interval covers the operation of the marker from its seizure until it has connected with the district and office frame and the particular district junctor involved in the call, while the second interval covers the operation of the marker from the end of the first interval until the marker has been restored to normal.

The operation of the marker connector circuit in connecting the sender with the marker connects ground to conductor **4831**. Assuming that the marker is not engaged on another call in the marker stage, as indicated by the fact that relay **6001** is not operated, relay **5512** operates in a circuit from battery through its winding, conductor **5522**, contact 3 of relay **6001**, conductor **6049**, back contacts of relays **5513**, **5501**, **5505**, **5511** and **5510** to the ground on conductor **4831**. Relay **5512** locks over its middle contact 3 to grounded conductor **4831** and extends this ground

over its inner contact 3 to the armature of interrupter 5520. When the interrupter closes its contact, relay 5510 operates in a circuit from battery through resistance 5518, winding and contact 1 of relay 5510, to ground over the interrupter 5520. Relay 5510, in operating, locks over its contact 1 to ground on contact 1 of relay 5512, and prepares a circuit for relay 5511 from battery through resistance 5519, winding of relay 5511, contact 1 of relay 5510 to ground at contact 1 of relay 5512. Relay 5511 does not operate at this time since its winding is shunted, over its own back contact 3 by the ground supplied under control of the interrupter contacts. When interrupter 5520 subsequently opens its contacts, this shunt is removed and relay 5511 operates. Upon the second closure of the contacts of interrupter 5520, relay 5510 releases, its winding being shunted by the ground over the interrupter contacts and over contact 3 of relay 5511. Relay 5511, upon the release of relay 5510, holds over the closed contact 1 of relay 5510 to the ground supplied through the interrupter contacts. The second opening of the contacts of interrupter 5520 opens the holding circuit for relay 5511 which releases, thus completing the first cycle of operation and release of relays 5510 and 5511. This action of relays 5510 and 5511 continues as long as relay 5512 remains operated and maintains ground on the armature of interrupter 5520.

Upon the second closure of the contacts of interrupter 5520, when relay 5510 releases but relay 5511 is still held operated, a circuit is closed for operating relay 5501, over the back contacts of relays 5502, 5504, and 5506, contact 1 of relay 5511, contact 2 of relay 5510 to ground on conductor 4831. Relay 5501, in operating, locks over its contact 3 to ground on contact 4 of relay 5512.

Upon the operation of relay 5501, indicating the termination of the subsidiary timing interval, a circuit is completed from battery through the winding of relay 5432, over conductor 5433, and contact of relay 5501 to conductor 5523. Conductor 5523 is grounded as described in the Carpenter patent, until the transfer of the incoming information to the decoder has been completed. If this transfer is unduly delayed until after the operation of relay 5501, relay 5432 is operated and causes the trouble indicator to be called in, as will be set forth hereinafter.

Assuming that no such delay was encountered, relay 5501 operates, but, since ground has been removed from conductor 5523, relay 5432 does not operate. As long as relay 6001 remains released and thereby indicates that the marker has not yet established connections to the office and district frames and to the district junctor, relay 5512 remains operated and relays 5510 and 5511 continue to function under the control of interrupter 5520 and the ground on conductor 4831. When relay 5510 operates for the second time at the start of the second cycle, relay 5502 operates in a circuit from battery through its winding, contact 4 of relay 5501, back contacts 1 of relays 5503 and 5505, contact 2 of relay 5511, contact 2 of relay 5510, to the ground on conductor 4831. Relay 5502 locks over its contact 2 to ground supplied over contact 2 of relay 5501.

Relay 5511 is operated by the opening of the interrupter contacts and relay 5510 is released by the subsequent closure of the interrupter contacts. With relay 5511 operated and relay 5510 released, relay 5503 operates in a circuit from battery through its winding, contact 2 of relay 5502, contacts 1 of relays 5504 and 5506, contact 1 of relay 5511, contact 2 of relay 5510, to the ground on conductor 4831. Relay 5503 locks to ground contact 2 of relay 5501.

The next operation of relay 5510 completes a circuit for relay 5504; the next release of relay 5510 closes a circuit for relay 5505 and the subsequent operation of relay 5510 operates relay 5506. Relays 5504, 5505 and 5506 all lock under the control of relay 5501.

Within this interval the marker should complete the reception and translation of the office code and establish connections with the office and district frames and district junctor. If it fails to do so and relay 6001 remains unoperated, to permit relay 5506 to operate, a circuit is closed from battery through the winding of relay 5432, conductor 5433 to ground at the outer lower contact of relay 5506. Relay 5432 causes the trouble indicator to be called in.

Under normal conditions, when the marker has connected to the frames and district junctor, relay 6001 is operated, opening the locking circuit for relay 5512. Relay 5512 releases, opens the locking circuit for relay 5501 and opens the circuit from the grounded control conductor 4831 to the armature of interrupter 5520, thereby releasing relays 5510 or 5511, or both, if they are operated at the time. The release of relay 5501 in turn releases which ever of the relays 5502, 5503, 5504, 5505 and 5506 had operated and locked prior to the release of relay 5512. When all of these relays have released, a circuit is completed for operating relay 5513 in order to shift from the first to the second interval of the timing circuit to cover the selection of a trunk and the operation of switches for completing the telephone connection. The operating circuit for relay 5513 is traceable from battery through its winding, over conductor 5524, contact 2 of relay 6001, conductor 6050, back contacts of relays 5512, 5501, 5505, 5511, and 5510 to the ground on the timing control conductor 4831. In operating, relay 5513 locks through its winding, conductor 5524, front contact of relay 6001, conductor 6050, and over its lower middle front contact to the ground on conductor 4831. This ground is also extended to the armature of interrupter 5520. Ground over contact 1 of relay 5513 operates relay 5504 in an obvious circuit. Relay 5504, in operating, completes a circuit from contact 1 of relay 5511, over contact 1 of relay 5506 and its own contact 1 to the winding of relay 5505 so that the latter relay will operate, instead of relay 5501 as before, upon the subsequent operation of relay 5511 under control of interrupter 5520.

The next closure of the contacts of interrupter 5520 releases relay 5510 but holds relay 5511. Since relay 5504 is now operated, relay 5505 is operated by the release of relay 5510 while the subsequent reoperation of that relay causes relay 5506 to operate and in turn operate relay 5432 for seizing the trouble indicator.

Connection of marker to trouble indicator

When relay 5432 operates as above described, it closes an obvious circuit for relay 5413. This completes a circuit from battery through resistance 5437, contact 7 of relay 5413, contact 5 of relay 5434, conductor 5438, winding of start relay 420 of the trouble indicator circuit to ground. These start relays are arranged in a

preference chain which allows but one marker to connect to the trouble indicator at any time.

Relay 420 operates over the above-traced circuit and, assuming that no other start relay in the chain is operated, a circuit is completed for operating the marker connecting relays. This circuit may be traced from ground on contact 3 of relay 1800, contact 8 of relay 207, conductor 347, contact 1 of relays 422, 421 and 420, conductor 430, to battery through the winding of multicontact connecting relay 103 which operates relay 103 and connects ground to the windings of multicontact relays 101, 102 and 104 thereby operating the latter multicontact relays. When the connecting relays of the marker have all operated, a chain circuit is closed through numerous conductors extending from various points in the marker to the recording equipment of the trouble indicator as fully explained in the aforementioned Carpenter patent.

Relay 412 individual to the marker equipment shown is also operated over an obvious circuit to ground on contact 6 of relay 5413. As hereinafter described, the circuit for lamp 415 is opened by the operation of relay 300. If, however, marker No. 2 attempts to seize the trouble indicator while it is busy with marker No. 1, a circuit is established for relay 411 to light lamp 414 which gives the designation of the marker attempting to seize the trouble indicator. The circuit for lamp 414 is established through contact 3 of relay 301 which in this case would not be operated.

Operation of trouble indicator

The operation of the connecting relays 101, 102, 103, and 104 as herein stated connect a large plurality of trouble indicator circuit leads to the marker and through the marker to units of equipment which have been associated therewith for completing a telephone connection. These units of equipment energize relays in the trouble indicator circuit to identify the individual units of equipment associated with the marker which has failed to complete the telephone connection because of a trouble in itself or a trouble in one of these units of equipment. Let it, therefore, be assumed that marker No. 1 is connected to the trouble indicator which operates relay 300. The connecting relays are individual to this marker, and therefore, this relay is energized from ground on contact 4 of connecting relay 104 which extends through the winding of relay 300, winding of relay 310 to battery. Relay 310 is marginal and does not operate at this time. Relay 300, in operating, locks through its contact 1 to ground on contact 2 of relay 404. Let it also be assumed that relays 121, 115, 112, and 106 are energized over similar circuits from ground extended thereto from different units of equipment such as a district, sender, link, etc., associated with the marker. These relays are energized from the above-mentioned ground circuits through their individual windings and through the windings of marginal relays 123, 118, 113, and 108 to battery. None of the above marginal relays are energized at this time. Relays 121, 115, 112 and 106 are held operated over the circuits traced and the trouble indicator is operated to later establish locking paths for the relays and energizing circuits for the indicating lamps. Relay 335 is common to all markers and operates from ground on contact 5 of marker connecting relay 104 or a like relay when any marker seizes the trouble-indicating circuit for displaying a fault. Relay 335 locks through its contact 3, contact 6 of repeat control relay 210, contact 8 of relay 404 to ground.

Non-repeat of indications

The operation of relay 335 establishes a circuit for relay 403 which may be traced from battery through the winding of relay 403, contact 7 of relay 207, lead 341, contact 4 of relay 335 to ground. Relay 403 establishes an obvious circuit for relay 401 through resistance 402. The operation of relay 401 establishes a circuit for operating relay 207 from ground on the inner spring of its contact 2, lead 342, winding of relay 207 to battery. Relay 207 locks through its contact 5, lead 345, contact 2 of relay 335, lead 333 to ground on contact 5 of repeat control relay 210. The latter relay, 210, may be either normal or may be operated by key 208 when it is desired that the trouble indicator show repeat connections for self-analyzing failures. It may be assumed for this first connection of a marker to the trouble-indicating circuit that key 208 and relay 210 are normal. Returning to the operation of relay 401, this relay associates ground with its right-hand armature, lead 435, over the chain circuit through the start relays 422, 421, and 420 which extends over conductor 430 through the winding of connecting relay 103 to battery before the ground for this chain circuit is opened through contact 8 of relay 207 when the latter relay is operated by relay 401.

The operation of relay 207 connects ground through its contact 3, winding of relay 203 to battery for operating relay 203; to ground through its contact 4, winding of relay 205 to battery; and assuming key 206 is operated, this ground extends through the winding of relay 204 to battery. Key 206 is energized and locked when it is desired to immediately have the indicating lamps energized. Relay 203 connects ground with lead 223 which establishes a locking circuit for relays 106 and 112 which were assumed to have been operated. Relay 205 connects ground to lead 224 which establishes a locking circuit for relay 115 and relay 121 which were assumed to have been operated. Relay 204 supplies battery to lead 225 which extends to the indicating lamps for lighting the lamps associated with the operated indicating relays. This battery circuit will thus extend through the filaments of lamp 131, contact 1 of relay 106 to ground, lamp 136, contact 1 of relay 112 to ground, lamp 138, through contact 1 of relay 115 to ground, lamp 143 through contact 1 of relay 121 to ground, and lamp 305 to ground on contact 2 of relay 300. A large plurality of indicating lamps are lighted in this manner to indicate the marker connected to the trouble indicator and also to indicate all of the various circuits which are associated with this marker.

The operation of relay 207 opens the energizing circuit for relay 403 which is a slow-release relay. The release of relay 403 opens the energizing circuit for relay 401 which releases. Since relay 207 remains locked to ground on contact 5 of relay 210, the circuit for the connecting relays 101, 102, 103, and 104 is opened by the disconnection of ground from lead 435 causing their release which disconnects the marker from the indicating leads of the trouble indicating circuit. The operation of relay 207 and the release of relay 401 establishes an operating circuit for relay 406 from battery through its winding, lead 346, contact 6 of relay 207, lead 352 to ground on contact 1 of relay 401. Relay 406, in oper-

ating, establishes a locking circuit for itself over lead 355, key 208, to ground on contact 1 of relay 203. Relay 406 establishes an obvious operating circuit for relay 405. The contacts of the latter relay are connected to all of the markers in the office to make the trouble indicator busy to all of the markers until the trouble indications in the trouble-indicating circuit have been analyzed. It also releases the marker connected to the trouble indicating circuit by associating ground with lead 432 which extends through the upper winding of relay 5434 to battery, operating the latter relay. The operation of relay 5434 opens the circuit extending to start relay 420. Relay 5434 also causes the release of the marker and the circuits associated with the marker. Relay 5434 locks in a circuit from battery through its lower winding, contact 4 to ground on contact 2 of relay 5413. Relay 5413 is released by the release of the marker. This causes the release of relay 5434 if at this time the trouble indicator is not held busy against seizure by any marker. As long as relay 405 remains operated ground over leads such as 440, 441 and 442 is connected to marker relays the same as relay 5434 to prevent seizure of the trouble-indicator circuit.

The foregoing operation of the trouble-indicating circuit thus leaves relays 405, 406, and 207 energized which maintains the ground and battery circuits established for the indicating relays and lamps so that this record may be analyzed before the trouble-indicator circuit is released.

The release of the trouble-indicating circuit is brought about by the energization of release key 209 which establishes an energizing circuit for relay 404. Relay 404 locks through its contact 4, lead 343 to ground on contact 1 of relay 207 and opens the locking circuits for relays 300, 335 and 412. The release of relay 335 opens the locking circuit for relay 207 which releases to open the energizing circuits for relays 203, 204, and 205. The release of relay 203 opens the locking circuit for relay 406 which releases and causes the release of relay 405. The release of these relays extinguishes all lamps that were lighted and removes the busy ground from all markers placed thereon by relay 405 and the trouble indicator may again be seized by a marker which has failed to complete a telephone connection.

Repeat indication

The trouble indicator attendant recognizes normal operation in the telephone exchange and unusual operation which causes rapid and repeated failures. On such occasions the repeat key 208 is operated for quickly analyzing failures which may be caused by trouble in a single unit of equipment or a single circuit. The operation of repeat key 208 energizes relay 210 which remains operated under the control of the locking key 208. Relay 210 associates ground from contacts 5 and 6 of release relay 404 through contacts 2 and 3 of relay 210 to contact 2 of relay 205 and contact 2 of relay 203 to establish locking circuits for these relays. This locking circuit is also used for relay 204. Relay 320 is connected in the repeat circuit through contact 1 of relay 210 and slow-release relay 212 is associated with the trouble-indicating circuit through contact 4 of relay 210. Contact 6 of relay 210 transfers the locking circuit for relay 335 from 404 to relay 405. For the sake of simplicity in the description, it may be assumed that marker No. 1 is the first marker to seize the trouble indicator after repeat key 208 is operated and that start relay 420 is again operated by this marker. The operation of relay 420 establishes an operating circuit for the connecting relays 101, 102, 103 and 104 which associates this marker with the trouble-indicating circuit and associates a plurality of other circuits with the trouble-indicating circuit which were joined together for completing the telephone connection. The operation of the connecting relay 104 establishes a circuit for relay 300 which locks to ground on contact 2 of relay 404 as previously explained. The marginal relay 310 does not operate at this time. The connecting relay 104 also establishes an operating circuit for relay 335 which in this case locks to ground on contact 2 of relay 405 instead of contact 8 of relay 404. Relay 335 establishes an operating circuit for relay 320 which may be traced from battery through its winding, contact 1 of relay 210 to ground on contact 1 of relay 335. The operation of relay 320 establishes a circuit for relay 321 which may be traced from battery through the winding of relay 321, contact of relay 322 to ground on contact 6 of relay 320. Relay 320 establishes a locking circuit for itself and an operating circuit for relay 322 which is made effective when this marker disconnects from the trouble-indicating circuit, as will be explained at the time that the marker is disconnected. At this time relay 322 is shunted by the operating ground on relay 321. The operation of relay 320 also energizes relay 325 over an obvious circuit. Relay 325 energizes message register 324 over an obvious circuit and energizes switch magnet 326 to step this switch forward one step as fully explained later. This switch steps forward upon each operation and release of relay 320.

The operation proceeds as previously described and for this first connection of a marker to the trouble-indicating circuit it may be assumed that relays 106, 112, 115, and 121 are operated, which are the same relays as operated in the previous description. Since this is assumed as the first connection to the trouble-indicator circuit after the repeat key is operated, none of the marginal relays 108, 113, 118 or 123 are operated at this time. The operation of relay 335 establishes a circuit for relay 403, as previously traced, through contact 7 of relay 207, contact 4 of relay 335 to ground. Relay 401 now operates for connecting ground over lead 342 to operate relay 207 and for connecting ground to lead 435 through the contacts of relays 422, 421, and 420 for maintaining the connecting relays operated. Relay 212 is energized from battery through its winding, contact 4 of relay 210, contact 9 of relay 207 to ground on contact 1 of relay 405. The locking circuit for relay 207 is different from the one previously traced and extends through its contact 5 over lead 345, contact 2 of relay 335, lead 333, contact 5 of relay 210 to ground on the contact of relay 212. Relay 207 establishes operating circuits for relays 203, 204, and 205, as previously traced, from ground on contacts 3 and 4 of relay 207. Locking circuits are established for relays 203, 204, and 205 through contacts 2 and 3 of the repeat relay 210 to ground on contacts 5 and 6 of relay 404. Relays 203, 204, and 205 establish ground circuits for locking the indicating relays and battery circuits for the indicating lamps.

The operation of relay 207 opens the energizing circuit for relay 403 and the release of relay 403 causes the release of relay 401. The release of relay 401 opens the circuit over con-

ductor 435 for energizing the connecting relays 101, 102, 103, and 104 which now release. Relay 207 remains locked and consequently the release of relay 401 establishes an energizing circuit for relay 406 from battery through the winding of relay 406, lead 346, contact 6 of relay 207 to ground on contact 1 of relay 401. The locking circuit for relay 406 under this condition extends over lead 355, right contact of key 208 to ground on contact 2 of relay 212. Relay 406 energizes relay 405 over an obvious circuit, as previously described. Relay 405 energizes the marker relay 5434 in the associated marker for releasing this marker and also energizes relays the same as relay 5434 in all other markers to momentarily hold these markers busy until further release of the trouble-indicating circuit. The operation of relay 405 opens the locking circuit for relay 335 causing its release and opens the energizing circuit for relay 212. Relay 212 is slow in releasing in order to permit time for the release of the associated marker. The release of relay 335 opens the locking circuit for relay 207 causing its release. When relay 212 releases, the locking circuit for relay 406 is opened causing its release. The release of relay 406 opens the energizing circuit for relay 405 permitting its release which will allow another marker or the same marker to seize the trouble-indicating circuit.

Successive seizures of trouble indicator for automatically analyzing repeated failures

With the repeat key and repeat relay operated, the indicating relays and lamps are, therefore, locked in position after the marker connecting relays have been released and after the marker has been released from the trouble indicator. When the marker No. 1 was released, the circuit for relay 320 was opened which causes the release of this relay. This removes the shunt from relay 322 which now energizes in series with relay 321 over a circuit which may be traced from battery through the winding of relay 321, contact of relay 321, winding of relay 322, to ground on contact 9 of relay 404. Therefore, when the first marker to seize the trouble-indicating circuit after the repeat relay 210 is operated, has been disconnected from the trouble indicating circuit, the following relays remain operated; relays 321, 322, 300, 121, 115, 112, 106, 203, 204, 205 and 210. The remaining relays were released. It will be noted that in the repeat manner of operating the trouble indicating circuit it is unnecessary to operate relay 404 in order to permit other markers to seize the trouble indicating circuit, since relays 335, 207, 406 and 405 are released independently of relay 404.

Let it now be assumed that under this condition a second marker seizes the trouble indicator while the indicating lamps are displayed. Let it further be assumed for the sake of simplicity in description that the timing circuit shown in Fig. 5 is in marker No. 2 and that marker No. 2 seizes the trouble indicator instead of marker No. 1. As previously described, relay 5432 is operated in the marker to cause the seizure of the trouble indicating circuit. Relay 5432 establishes an operating circuit for relay 5413 which connects battery through resistance 5457, contact 7 of relay 5413, contact 5 of relay 5434, to conductor 5438. Now assuming that this conductor is connected with conductor 437 through the windings of start relay 421 to ground on the contact of relay 420 and the start circuit is energized for the trouble-indicator circuit which has been seized by marker No. 2. It will, therefore, be assumed that lead 436 extends to the winding of a marker connecting relay the same as relay 103 and that this relay is energized over lead 436 instead of lead 430. The circuit for the connecting relay in marker No. 2 will, therefore, extend from battery through the winding of a connecting relay the same as connecting relay 103 over lead 436, contact 1 of relay 421 operated, contact 1 of relay 422 normal, conductor 435, conductor 437, contact 8 of relay 207, conductor 350, contact 3 of relay 404 to ground. The operation of the connecting relays in marker No. 2 such as 101, 102, 103 and 104 establishes connection with the same trouble-indicating relays which are shown in Fig. 1, and the operation of these relays will depend upon the circuits from units of equipment which are connected to marker No. 2 for attempting to complete a telephone connection. The connecting relay for marker No. 2 has ground associated with contact 4 of a relay the same as relay 104 extending through the winding of marker indicating relay 301 which is individual to marker No. 2 and ground from contact 5 for operating relay 335 which is common to all markers. The circuit for relay 301 may be traced from ground over lead 463, winding of relay 301, through the winding of marginal relay 310 to battery.

At this time marginal relay 310 operates since ground is also extended through the winding of relay 300 and the winding of relay 310 to battery, relay 300 having remained locked to ground on contact 2 of relay 404. Relay 310 establishes a locking circuit for itself over lead 150 to ground on contact 4 of relay 405 and in so doing connects ground to both the winding of relay 300 and the winding of relay 301 which shunts both these relays causing their release and extinguishing lamps 305 and 306.

It may now be assumed that one of the circuits from the same unit of equipment which was connected to marker No. 1 is found also to be connected with marker No. 2. This may be assumed to be a district and is thus connected to indicating relay 121 which is one of the same relays as connected to marker No. 1. The other indicating relays operated may be assumed as relays 117, 110 and 107. Relay 115 operated by marker No. 1 remains locked and relay 117 is operated through marker No. 2. With both relays 115 and 117 energized a circuit is established for marginal relay 118 since the resistance in series with relay 118 is reduced sufficiently to cause this relay to operate. The operation of marginal relay 118 establishes a locking circuit for itself over lead 150 to ground on contact 4 of relay 405. This ground shunts both relays 115 and 117 causing them to release and extinguish lamps 138 and 140. The same is true with relays 110 and 112, both having been operated to cause the operation of marginal relay 113. Relay 113 locks over lead 150 to ground on contact 4 of relay 405 and shunts both relays 110 and 112 causing their release which extinguishes lamps 134 and 136. This is also true of relays 106 and 107 which cause the energization of relay 108 and the energization of relay 108 shunts relays 106 and 107 to extinguish lamps 131 and 132.

Returning now to relay 121 associated with the same circuit through each of markers No. 1 and No. 2, ground connected with the winding of this relay maintains the relay operated to battery through the winding of marginal relay 123, but

marginal relay 123 does not operate and lamp 143 is maintained lighted.

Returning to the operation of relay 320 which took place upon the operation of relay 335 when marker No. 2 connected to this relay. This establishes a circuit for relay 323 which can only be established with relays 321 and 322 energized by the first marker connected to the trouble indicator after the repeat relay 210 is operated. The circuit for relay 323 may be traced from battery through the winding of relay 323, contact of relay 322 to ground on contact 6 of relay 320. Relay 323 establishes circuits for all of the repeat relays of which 109, 114, 119, 124 and 311 are shown. Since a different marker established connection and operated relay 310, the circuit for repeat relay 311 is opened at the contact of relay 310. This is true of the circuits in Fig. 1, in which the marginal relays 108, 113 and 118 were operated. Marginal relay 123, however, was not operated, since relay 121 is the only district relay operated. Repeat relay 124 is, therefore, energized over a circuit from battery through its winding, contact 1 of marginal relay 123, contact 2 of relay 320 to ground on contact 3 of relay 323. Relay 124 is locked through its contact, contact 1 of relay 424, to ground on contact 7 of relay 404. In consequence of this operation only lamp 143 and lamp 145 remain lighted which indicates that this one unit of equipment was associated with both markers and in all probability caused a failure in the telephone connections in which these markers were involved.

Release of marker No. 2

The operation of relay 335 establishes a circuit over lead 341 similar to the one previously described for energizing relay 403. Relay 403 energizes relay 401 which now establishes an obvious operating circuit over lead 342 for relay 207 and connects ground to lead 435 through the contacts of relays 422 and 421 extending over lead 436 to keep the connecting relays of marker No. 2 operated. Relay 212 is energized over a circuit from battery through its winding, contact 4 of relay 210, contact 9 of relay 207 to ground on contact 1 of relay 405. Relay 207 establishes a locking circuit for itself through its contact 5, lead 345, contact 4 of relay 335, conductor 333, contact 5 of relay 210, contact 1 of relay 212 to ground. The operation of relay 207 opens the operating circuit for relay 403 which is a slow-release relay. The release of relay 403 releases relay 401. The release of relay 401 opens ground extending over conductor 435 which opens the circuit for the marker connecting relays causing their release. A circuit is established through contact 1 of relay 401 for operating relay 406 which may be traced from ground through contact 1 of relay 401, conductor 352, contact 6 of relay 207, conductor 346, winding of relay 406 to battery. Relay 406 locks through its inner contact over lead 355, key 208 to ground on contact 2 of relay 212. Relay 406 disassociates ground from the marker and connects ground through its contact 2, contact 2 of relay 424, winding of relay 405 to battery for operating the latter relay. The operation of relay 405 connects ground to conductor 432 for energizing marker relay 5434 which as herein described causes the release of the marker and associated circuit units but hold the trouble indicator busy against reseizure by this marker until the release of the relay 5434. Relay 405 also connects ground through leads 440, 441, 442 and other like conductors to all of the markers to prevent the seizure of the trouble indicator during the time that this relay is operating. The locking circuit for relay 335 is opened through contact 2 of relay 405 and the operating circuit for relay 212 is opened through contact 1 of relay 405. The locking circuit for the marginal relays 108, 113, 118, 123 and 310 is opened through contact 4 of relay 405 so that all the marginal relays are released. The release of relay 335 opens the locking circuit for relay 207. The release of relay 212 opens the locking circuit for relay 406 which releases relay 405.

The release of relay 335 also released relay 320 which opened the operating circuit for relay 323 and also opened the operating circuit for relay 325. Release of relay 325 disassociates ground from the circuit of register 324 and from the switch magnet 326. Each release of relay 320 causes the switch to make one step forward. A certain number of successive operations maintain lamp 330 lighted. After that, lamp 329 is lighted and if there are sufficient successive operations of the trouble indicator, lamp 328 is lighted. Each lamp is of a different color to indicate its significance and the attendant can see quickly the approximate number of recurring troubles encountered.

The trouble indicator has now been prepared for another seizure by a marker since relay 405 has released and no longer holds the trouble indicator busy to the markers. From the foregoing, however, it is apparent that one relay, 121 remains locked to ground on the contact of relay 205 and one lamp, 143 remains lighted to indicate that the circuit connected to relay 121 was connected to both markers No. 1 and No. 2, both having failed to complete telephone connections. The repeat relay 124 also remains locked in position so that repeat lamp 145 is lighted. This automatically analyzes the circuit connections of markers having failures and assuming that relay 121 is connected to a particular district, this district is immediately made busy so that it can no longer be seized for operations in completing telephone connections. The trouble indicator repeat control relay is, however, allowed to remain operated to permit the seizure of the trouble indicator by the same or other markers successively to make sure that the difficulty has been found. Under some conditions the above-described repeat signal may be lighted upon the third, fourth, fifth or subsequent successive seizures of the trouble-indicator circuit and does not necessarily occur upon the second successive seizure.

It should be apparent from the foregoing that after a repeat trouble has been encountered and the repeat control relay 210 remains operated, all of the trouble-indicating relays have been released with the exception of the trouble-indicating relays which show repeat indications such as relays 121 and 124.

The operation of two indicating relays connected with the same type of circuits such as relays 115 and 117 or relays 300 and 301 cause both relays to be shunted and thus released. The battery and ground relays 203, 204 and 205 remain operated. Relays 321 and 322 remain operated and the other relays of the trouble-indicating circuit are released.

The subsequent seizure of the trouble indicator by a marker energizes a start relay such as 420, 421 or 422 the same as previously described which establishes a circuit for the marker connecting relays associated with the third marker to seize

the trouble indicator after the repeat control relay 210 was operated. After the operation of the marker connecting relays the trouble-indicating relays are operated as previously described and the trouble indicator is again released as previously described. This continues as long as desired by the attendant observing the lamp indications lighted in the trouble indicator. Each operation of the trouble indicator as previously stated operates relay 335 from ground on the marker connecting relay. This lights lamp 336 to definitely indicate that the trouble indicator has been seized by a marker. Each successive seizure of the trouble indicator operates relay 320 which advances the A and B brushes of switch 326 as previously described and operates relay 323 to connect ground with circuits which may be established for repeat relays such as relays 109, 114, 119, 124 or 311.

During the operation of the trouble-indicator circuit on a repeat basis the attendant may at any time operate key 425 so that if successive calls do not show a repeat circuit indication, the lamp designations associated with all of the indicating relays connected to the last circuit combination associated with the trouble indicator may be lighted until this key is restored to normal. For example, let it be assumed that lamp 336 is lighted showing that a marker has seized the trouble indicator but that during this seizure no repeat lamp was lighted. Under this condition, all of the marginal relays would be operated when this connection to the trouble-indicator circuit followed a previous connection to the trouble-indicator circuit with repeat control relay 210 operated. It will be remembered that when two relays such as relays 115 and 117 are both operated one being locked by a previous connection of a marker to the trouble-indicator circuit, the resistance in series with the marginal relay is reduced causing the operation of the marginal relay. The operation of the marginal relay 118 would shunt both windings of relays 115 and 117 causing their release. In like manner all indicating relays would be released if no repeat trouble was indicated. Consequently, if no repeat is recorded all of the indicating relays would be released upon the second connection of a marker to the trouble indicator. However, as long as the marker connecting relays remain operated from the last seizure, the circuits for certain indicating relays would remain established but not effective while the marginal relays 108, 113, 118 and 123 and 310 are operated to place a shunt on the trouble indicator relays and prevent them from operating. Under this condition with all of the marginal relays operated and key 425 operated, a circuit is established from ground on contact 3 of marginal relay 310, contact 2 of marginal relay 123, contact 2 of marginal relay 118, contact 2 of marginal relay 113, contact 2 of marginal relay 108, contact of key 425, winding of relay 424 to battery. The operation of relay 424 opens the locking circuit for these marginal relays since it will be noted that contact 4 of relay 424 removes ground from lead 150 which provides this locking circuit for the marginal relays. Relay 424 also opens the circuit for the marker relay 405 so that the marker cannot be released. It also places ground through its contact 3 and through the contacts of the start relays to maintain the marker connecting relays energized. Relay 424 also opens the locking circuit for the repeat relays 311, 124, 119, 114 and 109 since a previous repeat indication may have been recorded. The release of the marginal relays removes the shunt from the individual indicating relays and now permits these relays to be energized so that a complete record of indications can be obtained where no repeat trouble is indicated. After a record of the indicating lamps has been made, key 425 may be released which removes the locking circuit for relay 424 causing its release. This restores the trouble-indicating circuit so that it may function as herein described for releasing the associated marker and make records of repeat troubles successively associated by markers with the trouble-indicating circuit.

What is claimed is:

1. In a telephone switching system, lines, a plurality of groups of circuits, each group having a plurality of the same character of individual circuits, the circuits of the different groups being dissimilar in character, means to combine circuits from a plurality of said groups by automatic selection for completing telephone switching connections between lines, a trouble indicator having connecting means available to the individual circuits of all of said groups, means in any of said combinations of circuits which is unable to complete a telephone switching connection because of a fault in a circuit in said combination for connecting said combinations of circuits with said trouble indicator, means operable in said trouble indicator to identify each individual circuit in a combination connected thereto, means to retain said identifying means operated, means to release the circuits of said combination and enable the connection of another combination to said trouble indicator connecting means available to the individual circuits of all said groups, and an automatic fault analyzer comprising means automatically responsive to successive connections of different circuit combinations with said trouble indicator to identify a circuit of a particular character successively connected to different circuit combinations unable to complete telephone switching connections.

2. In a telephone switching system, lines, a plurality of groups of circuits, each group having a plurality of the same character of individual circuits, the circuits of the different groups being dissimilar in character, means to combine circuits from a plurality of said groups by automatic selection for completing telephone switching connections between lines, a trouble indicator having connecting means available to the individual circuits of all of said groups, means in any of said combinations of circuits which is unable to complete a telephone switching connection because of a fault in a circuit in said combination for connecting said combinations of circuits with said trouble indicator, means in said trouble indicator for indicating all of the individual circuits in said combination, means to release said circuits and enable the connection of another circuit combination to said trouble indicator connecting means available to the individual circuits of all said groups, other signals, and an automatic fault analyzer in said trouble indicator responsive to its successful connection with different circuit combinations having the same individual circuit in each combination comprising means to actuate one of said other designals to distinguish a circuit of a particular character as one successively connected to different circuit combinations unable to complete telephone switching connections.

3. In a telephone switching system, lines, a

plurality of groups of circuits, each group having a plurality of the same character of individual circuits, the circuits of the different groups being dissimilar in character, means to combine circuits from a plurality of said groups by automatic selection for completing telephone switching connections between lines, a trouble indicator having connecting means available to the individual circuits of all of said groups, means in any of said combinations of circuits which is unable to complete a telephone switching connection because of a fault in a circuit in said combination for connecting said combinations of circuits with said trouble indicator, means operable in said trouble indicator for indicating all of the individual circuits in said combination and for releasing said circuits, and means in said trouble indicator responsive to its successive connection with different circuit combinations having the same individual circuit in each combination to indicate only the one individual circuit which was successively connected to the trouble indicator in different circuit combinations and release all said other individual indicating means operated unable to complete telephone switching connections.

4. In a telephone switching system, lines, a plurality of groups of circuits, each group having a plurality of the same character of individual circuits, the circuits of the different groups being dissimilar in character, means to combine circuits from a plurality of said groups by automatic selection for completing telephone switching connections between lines, a trouble indicator having connecting means available to the individual circuits of all of said groups, means in any of said combinations of circuits which is unable to complete a telephone switching connection because of a fault in a circuit in said combination for connecting said combinations of circuits with said trouble indicator, electrically operable signals in said trouble indicator, means to operate certain of said electrically operable signals to identify each individual circuit in a combination connected to said trouble indicator, means to retain said identifying signals and release the circuits of said combination and an automatic fault analyzer in said trouble indicator responsive to its successive connection with different circuit combinations having the same individual circuit in each combination comprising means including another electrically operable signal to distinguish a circuit of a particular character successively connected to different circuit combinations unable to complete telephone switching connections.

5. In a telephone switching system, lines, a plurality of groups of circuits, each group having a plurality of the same character of individual circuits, the circuits of the different groups being dissimilar in character, means to combine circuits from a plurality of said groups by automatic selection for completing telephone switching connections between lines, a trouble indicator having connecting means available to the individual circuits of all of said groups, means in any of said combinations of circuits which is unable to complete a telephone switching connection because of a fault in a circuit in said combination for connecting said combinations of circuits with said trouble indicator, automatically operable signals in said trouble indicator, means to operate certain of said signals to identify each individual circuit in a combination connected to said trouble indicator, means to retain said identifying signals operated, means to release the circuits of said combination and enable the connection of another circuit combination to said trouble indicator connecting means available to the individual circuits of all said groups, and means responsive to successive connections of said trouble indicator with different circuit combinations for automatically releasing said electrically operated signals when the same individual circuit is not included in said successive circuit combinations and for operating different electrically operable signals corresponding to the individual circuits in each combination successively connected with said trouble indicator.

6. In a telephone switching system, lines, a plurality of groups of circuits, each group having a plurality of the same character of individual circuits, the circuits of the different groups being dissimilar in character, means to combine circuits from a plurality of said groups by automatic selection for completing telephone switching connections between lines, a trouble indicator having connecting means available to the individual circuits of all of said groups, means in any of said combinations of circuits which is unable to complete a telephone switching connection because of a fault in a circuit in said combination for connecting said combinations of circuits with said trouble indicator, electrically operable signals in said trouble indicator, means to operate certain of said signals to identify each individual circuit in a combination connected to said trouble indicator, means to retain said identifying signals operated, means to release the circuits of said combination and enable the connection of other circuit combinations to said trouble indicator connecting means available to the individual circuits of all said groups, and means responsive to successive connections of different circuit combinations to said trouble indicator to indicate that these circuit combinations do not include any of the same individual circuits.

7. In a telephone switching system, lines, a plurality of marker circuits, a plurality of groups of other circuits, means automatically responsive to an incoming call over a line for assembling together a marker circuit and a plurality of said other circuits selected from a plurality of said groups, into a combination of circuits for completing a switching connection to a called line, a trouble indicator, means in each marker circuit for seizing said trouble indicator upon failure to complete a telephone connection because of a fault in any circuit of said combination, means responsive to the connection of a marker circuit with said trouble indicator for connecting leads from the circuits in said combination including the marker circuit to said trouble indicator, electrically operable indicators in said trouble indicator individual to each circuit in any circuit combination, means automatically responsive to the connection of said leads from a circuit combination to said trouble indicator for operating indicators individual to the circuits in said combination for identifying said circuits, means in said trouble indicator to enable successive connections to markers and circuits combined therewith and successive disconnections, each operating the indicating means individual to the marker circuits and circuits combined therewith and means automatically operable upon the successive connection to said trouble indicator of circuit combinations having the same circuit connected in each com-

bination, for releasing all said individual circuit indicating means except the one operated by said same circuit in said circuit combinations.

8. In a telephone switching system, lines, a plurality of marker circuits, a plurality of groups of other circuits, means automatically responsive to an incoming call over a line for assembling together a marker circuit and a plurality of said other circuits selected from a plurality of said groups, into a combination of circuits for completing a switching connection to a called line, a trouble indicator, means in each marker circuit for seizing said trouble indicator upon failure to complete a telephone connection because of a fault in any circuit of said combination, means responsive to the connection of a marker circuit with said trouble indicator for connecting leads from the circuits in said combination including the marker circuit to said trouble indicator, electrically operable indicators in said trouble indicator individual to each circuit in any circuit combination, means automatically responsive to the connection of said leads from a circuit combination to said trouble indicator for operating indicators individual to the circuits in said combination for identifying said circuits, means in said trouble indicator to enable successive connections to marker circuits and circuits combined therewith and successive disconnections, each operating the indicating means individual to the marker circuits and circuits combined therewith, means automatically operable upon the successive connection to said trouble indicator of circuit combinations having the same circuit connected in each combination, for releasing all said individual circuit indicating means except the one operated by said same circuit in said circuit combinations, repeat indicators in said trouble indicator, and means to operate a repeat indicator to identify the group of circuits having a circuit therein connected to more than one of said circuit combinations successively connected with said trouble indicator.

9. In a telephone switching system, lines, a plurality of groups of circuits, each group having a plurality of the same character of individual circuits, the circuits of the different groups being dissimilar in character, means to combine circuits from a plurality of said groups by automatic selection for completing telephone switching connections between lines, a trouble indicator having connecting means available to the individual circuits of all of said groups, means in any of said combinations of circuits which is unable to complete a telephone switching connection because of a fault in a circuit in said combination for connecting said combination of circuits with said trouble indicator, electrically operable indicating devices in said trouble indicator individual to the circuits in all of said plurality of groups of circuits, said individual indicating devices being divided into groups corresponding to the groups of circuits of the same character, an auxiliary indicating device associated with each group of individual indicating devices, means to operate individual indicating devices in different groups responsive to the connection of a circuit combination thereto to indicate the circuits in said combination, means to retain said individual indicating devices operated, disconnect the circuits of said combination from the trouble indicator and enable the connection of another circuit combination to said trouble indicator connecting means available to the individual circuits of all said groups, and means automatically responsive to the successive connection of different circuit combinations with said trouble indicator to cause the operation of an auxiliary indicating device connected with an individual indicating device successively energized by a circuit in more than one circuit combination.

10. In a telephone switching system, lines, a plurality of groups of circuits, each group having a plurality of the same character of individual circuits, the circuits of the different groups being dissimilar in character, means to combine circuits from a plurality of said groups by automatic selection for completing telephone switching connections between lines, a trouble indicator having connecting means available to the individual circuits of all of said groups, means in any of said combinations of circuits which is unable to complete a telephone switching connection because of a fault in a circuit in said combination for connecting said combination of circuits with said trouble indicator, electrically operable indicating devices in said trouble indicatod individual to the circuits in all of said plurality of groups of circuits, said individual indicating devices being divided into groups corresponding to the groups of circuits of the same character, an auxiliary indicating device associated with each group of individual indicating devices, means to operate individual indicating devices in different groups responsive to the connection of a circuit combination thereto to indicate the circuits in said combination, means to retain said individual indicating devices operated, disconnect the circuits of said combination from the trouble indicator and enable the connection of another circuit combination to said trouble indicator connecting means available to the individual circuits of all of said groups, and means automatically responsive to the successive connection of different circuit combinations with said trouble indicator for operatively connecting said auxiliary indicating device with said individual indicating devices to cause the operation of an auxiliary indicating device connected with an individual indicating device successively energized by a circuit in more than one circuit combination.

11. In a telephone switching system, lines, a plurality of groups of circuits, each group having a plurality of the same character of individual circuits, the circuits of the different groups being dissimilar in character, means to combine circuits from a plurality of said groups by automatic selection for completing telephone switching connections between lines, a trouble indicator having connecting means available to the individual circuits of all of said groups, means in any of said combinations of circuits which is unable to complete a telephone switching connection because of a fault in a circuit in said combination for connecting said combination of circuits with said trouble indicator, electrically operable indicating devices in said trouble indicator individual to the circuits in all of said plurality of groups of circuits, said individual indicating devices being divided into groups corresponding to the groups of circuits of the same character, an auxiliary indicating device associated with each group of individual indicating devices, means to operate individual indicating devices in different groups responsive to the connection of a circuit combination thereto to indicate the circuits in said combination, means to retain said individual indicating devices operated, disconnect the circuits of said combination from the trouble indicator and enable the connection of another circuit combina-

tion to said trouble indicator connecting means available to the individual circuits of all said groups, means automatically responsive to the successive connection of different circuit combinations with said trouble indicator to cause the operation of an auxiliary indicating device connected with an individual indicating device successively energized by a circuit in more than one circuit combination, means to release the individual indicating devices not connected with an operated auxiliary indicating device, and means to retain operated an individual indicating device successively energized by a circuit in more than one circuit combination.

12. In a telephone switching system, a plurality of switch controlling circuits, a trouble indicator, indicating devices in said trouble indicator individual to said controlling circuits, means in said switch controlling circuits responsive to a failure for causing the seizure of said trouble indicator and the operation of certain of said indicating devices to identify the individual controlling circuits connected thereto, means responsive to the operation of said indicating devices to disconnect said controlling circuits from said trouble indicator, and other means in said trouble indicator operably responsive to successive connections of the same controlling circuit with said trouble indicator to specifically identify said latter controlling circuit.

13. In a telephone switching system, a plurality of switch controlling circuits, a trouble indicator, indicating devices in said trouble indicator individual to said controlling circuits, means in said switch controlling circuits responsive to a failure for causing the seizure of said trouble indicator and the operation of certain of said indicating devices to identify the individual controlling circuits connected thereto, means responsive to the operation of said indicating devices to disconnect said controlling circuits from said trouble indicator, other indicating devices in said trouble indicator to identify controlling circuits repeatedly connected to said trouble indicator, and means to operate said other indicating devices responsive to successive connections of the same controlling circuit with said trouble indicator.

14. In a telephone switching system, a plurality of switch controlling circuits, a trouble indicator, indicating devices in said trouble indicator individual to said controlling circuits, means in said switch controlling circuits responsive to a failure for causing the seizure of said trouble indicator and the operation of certain of said indicating devices to identify the individual controlling circuits connected thereto, means responsive to the operation of said indicating devices to disconnect said controlling circuits from said trouble indicator and retain said indicating devices operated, other indicating devices in said trouble indicator to identify controlling circuits repeatedly connected to said trouble indicator, and means responsive to a subsequent seizure of said trouble indicator to release all operated indicating devices individual to controlling circuits excepting the indicating device individual to a control circuit repeating its connection to said trouble indicator and to operate said other indicating device.

15. In a telephone switching system, a plurality of switch controlling circuits, a trouble indicator, indicating devices in said trouble indicator individual to said controlling circuits, means in said switch controlling circuits responsive to a failure for causing the seizure of said trouble indicator and the operation of certain of said indicating devices to identify the individual controlling circuits connected thereto, means responsive to the operation of said indicating devices to disconnect said controlling circuits from said trouble indicator and retain said indicating devices operated, and means responsive to a subsequent seizure of said trouble indicator by different controlling circuits to release all operated indicating devices and to operate indicating devices individual to the controlling circuits connected to the trouble indicator by said subsequent seizure.

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