June 6, 1944. G. V. KING ET AL 2,350,466

TELEPHONE SYSTEM TROUBLE RECORDER

Filed Oct. 31, 1942 7 Sheets-Sheet 1

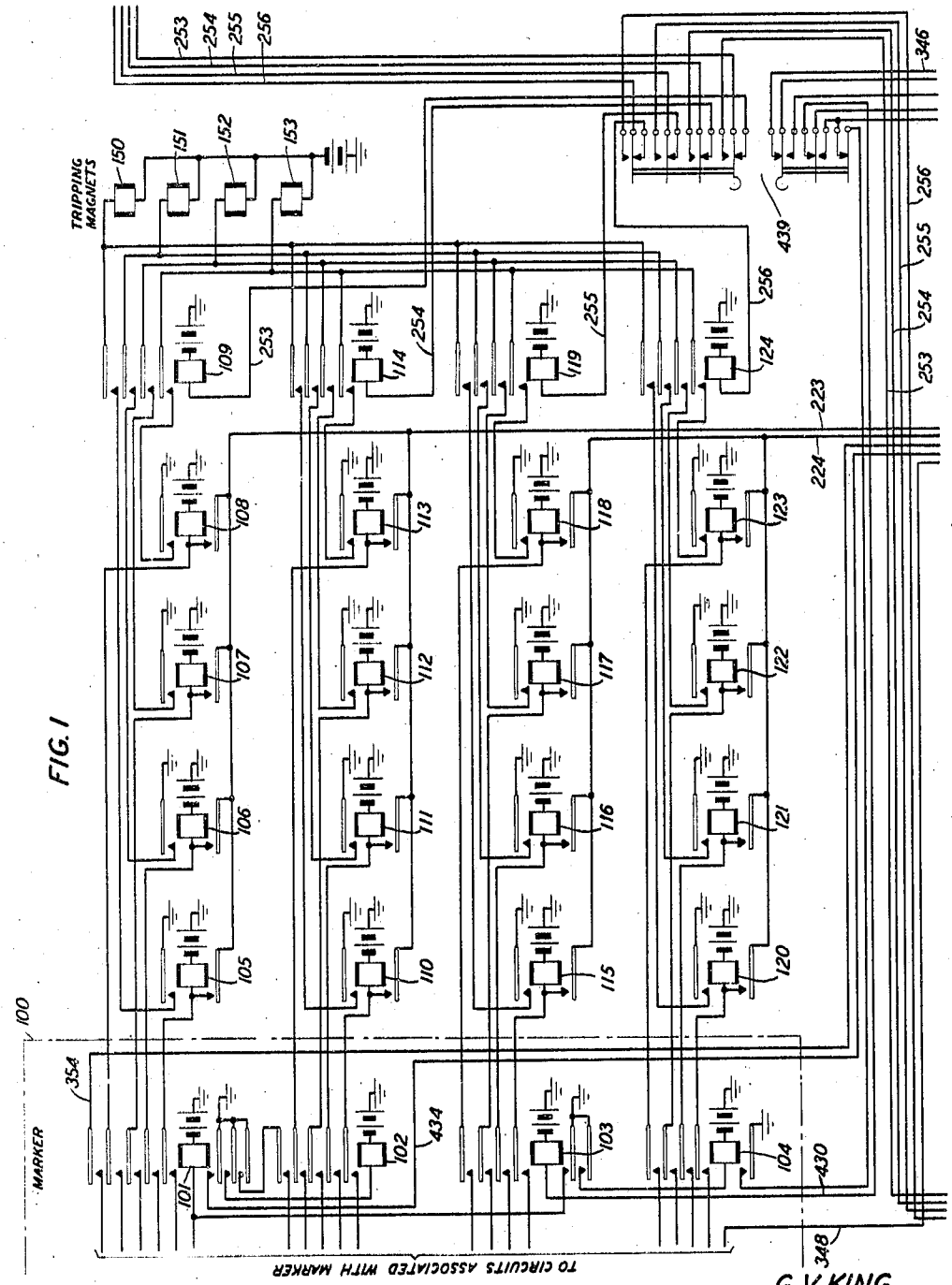

FIG. 1

FIG. 11

FIG. 1	FIG. 2	FIG. 4
FIGS. 3 & 6		FIG. 5

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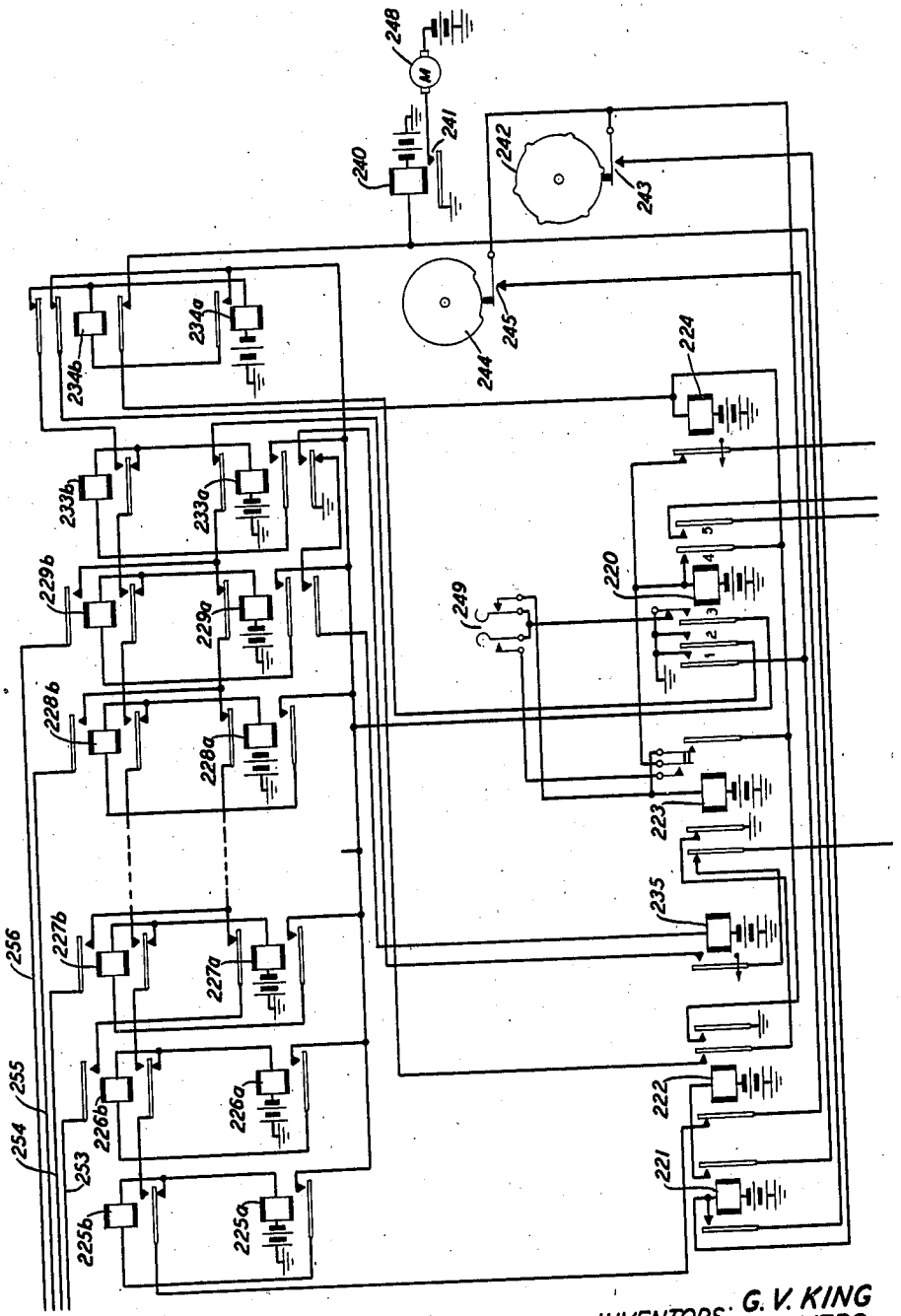
TELEPHONE SYSTEM TROUBLE RECORDER

Filed Oct. 31, 1942 7 Sheets-Sheet 2

FIG. 2



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June 6, 1944. G. V. KING ET AL 2,350,466

TELEPHONE SYSTEM TROUBLE RECORDER

Filed Oct. 31, 1942 7 Sheets-Sheet 3

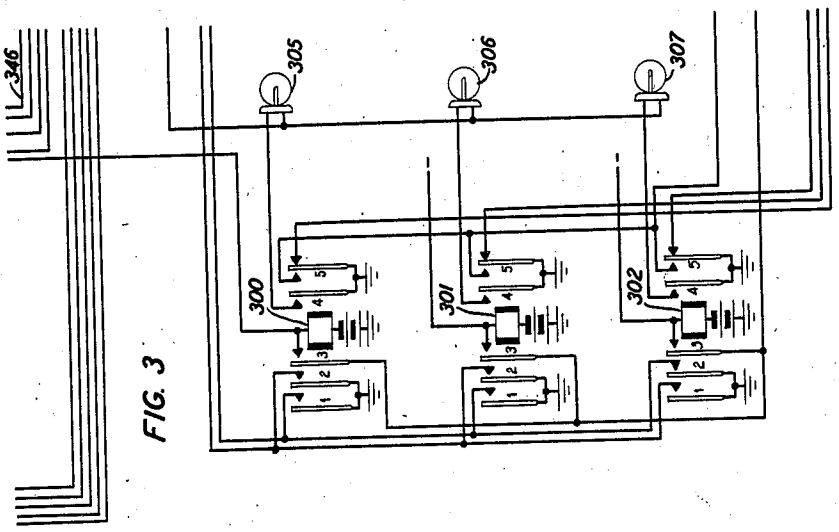

FIG. 3

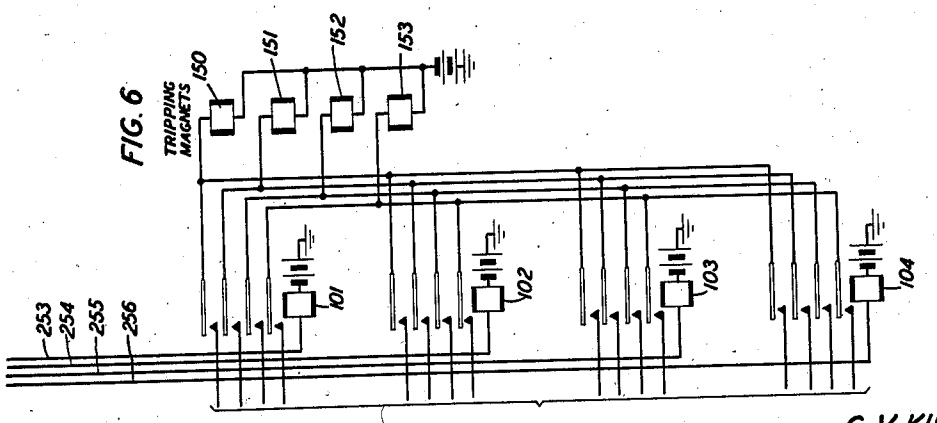

FIG. 6

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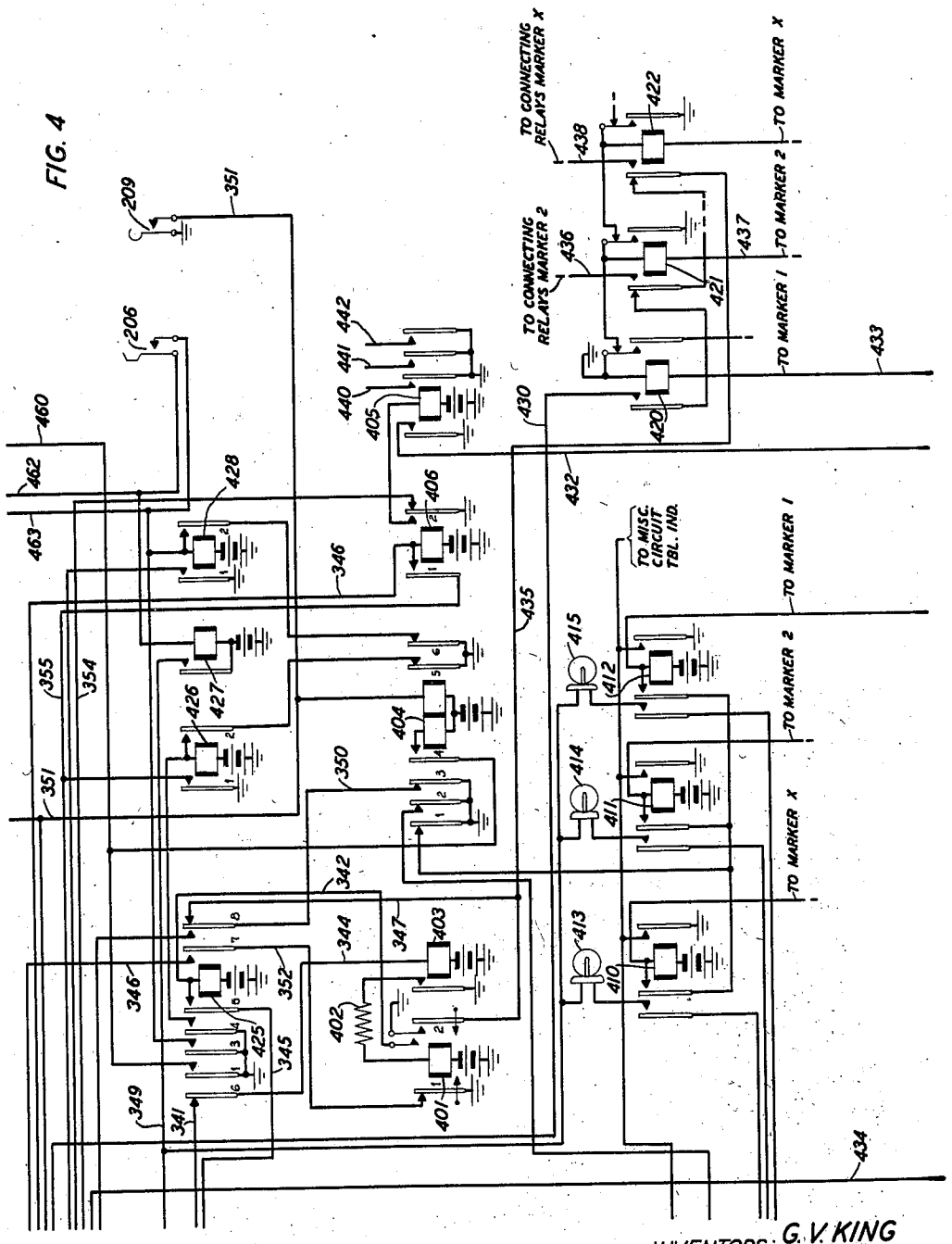
June 6, 1944. G. V. KING ET AL 2,350,466

TELEPHONE SYSTEM TROUBLE RECORDER

Filed Oct. 31, 1942 7 Sheets-Sheet 4

FIG. 4



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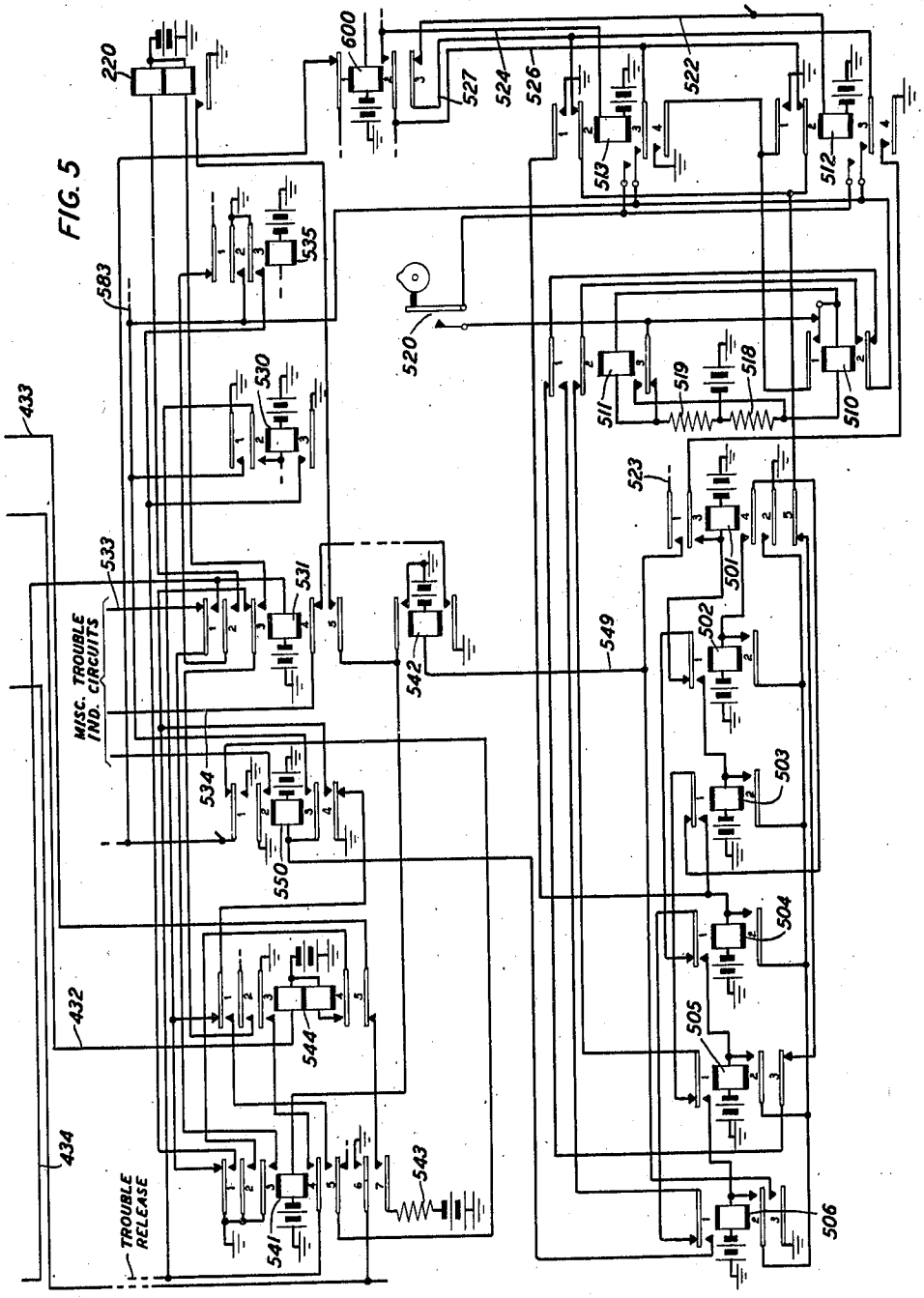
TELEPHONE SYSTEM TROUBLE RECORDER

Filed Oct. 31, 1942 7 Sheets-Sheet 5

FIG. 5



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June 6, 1944. G. V. KING ET AL 2,350,466

TELEPHONE SYSTEM TROUBLE RECORDER

Filed Oct. 31, 1942 7 Sheets-Sheet 6

FIG. 8

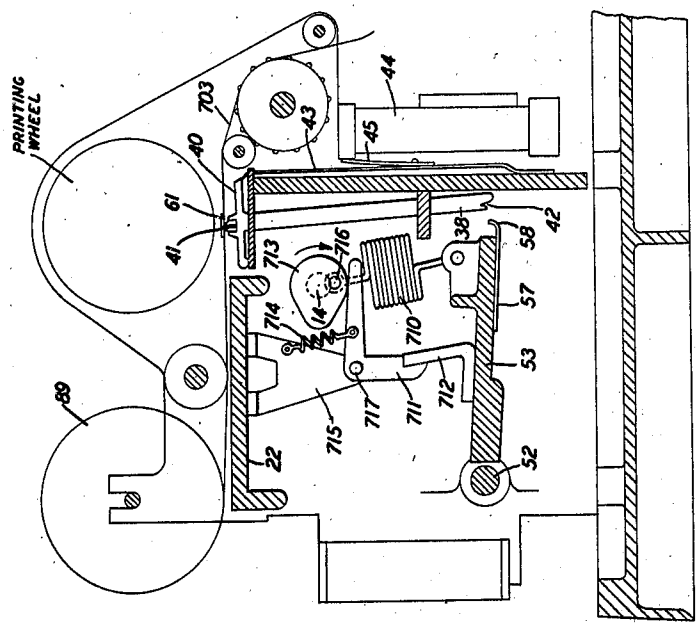
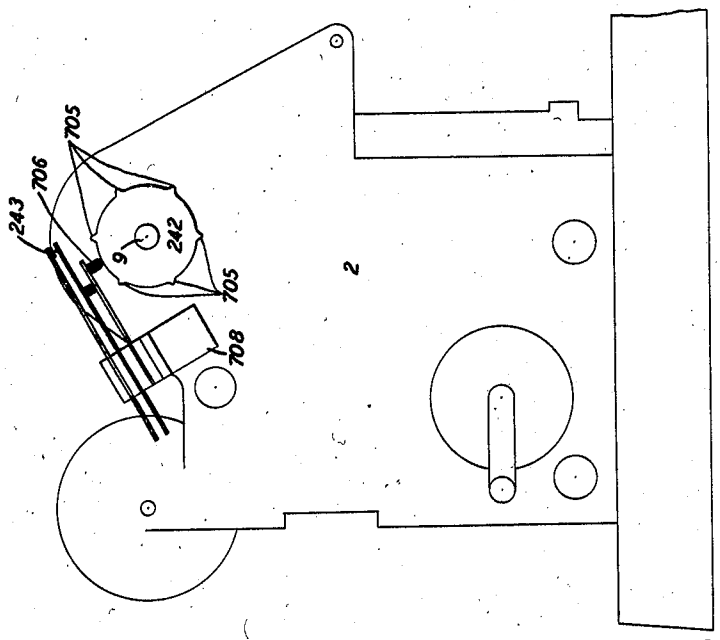


FIG. 7



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June 6, 1944. G. V. KING ET AL 2,350,466

TELEPHONE SYSTEM TROUBLE RECORDER

Filed Oct. 31, 1942 7 Sheets-Sheet 7

FIG. 10

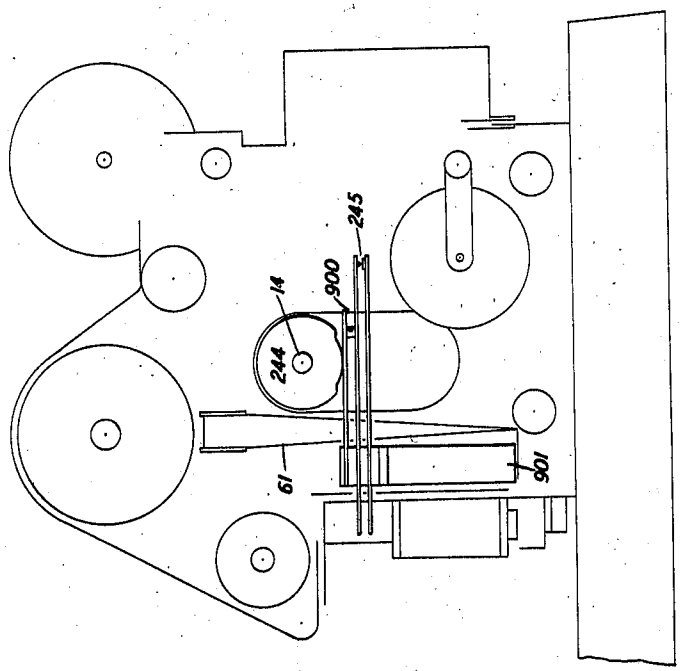
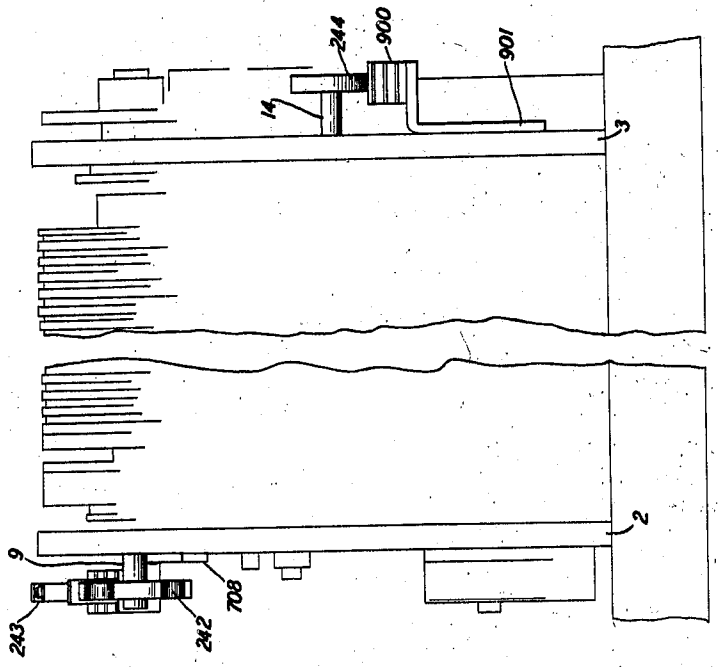


FIG. 9



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Patented June 6, 1944

2,350,466

UNITED STATES PATENT OFFICE

2,350,466

TELEPHONE SYSTEM TROUBLE RECORDER

Gerald V. King, Chatham, N. J., and Oscar Myers, Mount Vernon, N. Y., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application October 31, 1942, Serial No. 464,074

4 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 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 a plurality of equipment units 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.

As shown in the above patent to Powell, the troubles which occur either in a marker or in any of the individual units of equipment combined therewith for making a telephone connection indicate this trouble in the circuit of each unit of equipment by connecting ground with the trouble-indicator leads and with leads which identify the location of the units of equipments so combined. The Powell trouble indicator comprises a plurality of relays which are equivalent in number to the maximum number of leads extending to the trouble indicator from any combination of equipment units and, consequently, any lead which has ground connected thereto operates one of these relays. The relays which are thus operated are locked by the trouble indicator. The marker and associated circuits are thereupon released. Each relay thus operated lights an indicating lamp to indicate the circuit or equipment in trouble and the location of the units of equipment formed into a combination attempting to complete a telephone connection.

The marker and associated circuits are released but the lamps in the trouble indicator remain lighted until a record is made or the trouble analyzed. During this time the trouble indicator is held busy so that other markers if in trouble cannot be associated with the trouble indicator. Since there are troubles which at times cause repeated failures it is found that the trouble indicator should be free to record these troubles as rapidly as possible. It is therefore proposed that a permanent printed record be made so that the trouble indicator may be restored to normal as well as the other circuits involved as quickly as possible. In the present invention a simple printing machine has been incorporated in the trouble indicator of the type shown in Patent 1,862,200 to H. Sengebusch, June 7, 1932, which has a printing wheel or drum having sixty separate wheels, each having sixty characters around the peripheries which provide sixty horizontal rows of sixty characters per row. This provides characters in each horizontal row for separately printing the location of a particular unit of equipment and the fault or faults incorporated in this unit of equipment. The printing machine has been modified and a circuit used with these modifications for arranging the simultaneous printing of a complete line of characters which can be any or all of the sixty characters in a horizontal row.

This invention is in the nature of an improvement of systems shown and described in Patents 1,614,285 to E. B. Craft et al., January 11, 1927, and L. M. Potts 1,620,286, March 8, 1927, which incorporate telegraph printing devices with a trouble-indicator circuit which is arranged to successively print characters from code combinations.

A feature of this invention resides in providing separate tripping magnets in a printing machine individual to each of a plurality of leads extending from the units of equipment combined with a marker for a telephone connection to a trouble-indicating device, individually and simultaneously operating any of said tripping magnets individual to each lead electrically energized to print a record of the location of and faults in a unit of equipment on a line of a paper strip and in progressively connecting said tripping magnets with said different units of equipment and automatically advancing the paper platen so that each record is simultaneously printed on a separate line on said paper strip.

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

To illustrate the features of the invention ref-

erence may be had to the following drawings in which:

Figs. 1 and 6 illustrate circuit arrangements for operating the tripping magnets individual to each lead extending from the trouble-indicating device to the different units of equipment combined with a marker;

Fig. 2 illustrates a control mechanism for the recording device;

Figs. 3 and 4 show the relay equipment energized by a marker for connecting the marker to the trouble recording device and for releasing the marker;

Fig. 5 shows the marker timing equipment; and

Figs. 7, 8, 9 and 10 illustrate modifications of the recording printer adapted to this trouble-recording circuit.

The seizure of the trouble-recording device by a marker is in general the same as fully described in Patent 2,202,921 to A. C. Powell, June 4, 1940. A timing device connected with the marker allots a time for completing a telephone connection and when not completed in this allotted time seeks the services of a trouble indicator which in this description is more accurately termed "a trouble recorder." Assuming that at this time the trouble recorder is not busy it is actuated by the marker timing circuit for connecting a large plurality of leads from a plurality of different units of equipment assembled together with this marker to the trouble-recording circuit. The trouble-recording circuit has a chain of relays with one relay individual to each marker connected to the timing circuit and has multicontact relays associated therewith individual to each marker of the office. The operation of one of the relays of this chain causes the seizure of the trouble indicator or recording circuit and energizes the relays therein which connect the leads from the units of equipment to the trouble indicator.

In the units of equipment certain leads are connected to ground to indicate the location of the equipment unit and other leads are connected to ground to show faults in circuits and equipment which prevent proper completion of the telephone connection. In one arrangement of the invention the aforementioned multicontact relays are energized by the aforementioned relay of the chain for connecting the leads from the marker and units of equipment combined therewith to relays in the trouble-recording device and the relays which are operated over the aforementioned energized leads are locked in position so that the marker and the multicontact connecting relays may be released before the locations and faults in the circuits and equipment are recorded. The relays which are locked in position connect ground to another set of leads corresponding to the leads which operated these relays and these leads are connected to contact springs of other multicontact relays individual to the marker and to each unit of equipment connected thereto. The sixty recording machine tripping magnets are connected directly to the springs of these relays which make contact with the springs connected to the aforementioned leads when these multicontact relays are operated. From this viewpoint the tripping magnets, in effect, are energized in the same manner as the lamps of the aforementioned Powell patent with the exception that the lamps are simultaneously lighted for all units of equipment while the tripping magnets of the recording machine are simultaneously energized for printing the locations and faults in one unit of equipment. The tripping magnets are successively energized and released for making records of the different units of equipment.

The motor of the recording machine is energized as soon as the foregoing relays have been operated and locked. The type wheels and paper platen are thus rotated step by step and a synchronizing cam starts the recording operations when the printing wheel having the type thereon reaches a particular position. The location and faults in the units of equipment are recorded in a particular order and thus the printed record when started in a particular position on the printing wheel characterizes this order. Another cam is arranged through the agency of relays to successively energize the relays which connect the tripping magnets with leads from the locked relays for printing locations and faults in the different units of equipment. The records are thus printed in lines across the paper strip which is stepped forward one step after a record is simultaneously printed for each unit of equipment until the last record is made. At this time the motor circuit is automatically opened and the trouble recording circuit and equipment is restored to normal.

In a second arrangement of this recording device the leads from each unit of equipment are connected directly from the marker and from each unit of equipment combined therewith to the tripping magnets of the recording machine and no relays are operated by these leads as in the aforementioned arrangement. To carry out this principle of operation the marker is held by the trouble recorder during the printing of the permanent record and the marker connecting relays are successively operated for connecting the leads from each unit of equipment, successively with the tripping magnets of the recording machine. The marker and associated circuits are released and the trouble recorder is restored to normal as soon as the record is completed.

Detail Description

The operation of the marker timing circuit for a marker such as shown by Carpenter in Patent 2,235,803 and the manner in which it connects with the trouble indicator will first be described.

The timing circuit shown in Fig. 5 comprises relays **501** to **507** and **510** to **513**, inclusive, together with the associated interrupter **520**. 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 restored to normal.

The operation of the marker connector circuit in connecting the sender with the marker connects ground to conductor **583**. Assuming that the marker is not engaged on another call in the marker stage, as indicated by the fact that relay **600** is not operated, relay **512** operates in a circuit from battery through its winding, conductor **522**, contact **3** of relay **600**, conductor **527**, back contacts of relays **513**, **501**, **505**, **511** and **510** to the ground on conductor **583**. Relay **512** locks over

its middle contact 3 to grounded conductor 583 and extends this ground over its inner contact 3 to the armature of interrupter 520. When the interrupter closes its contact, relay 510 operates in a circuit from battery through resistance 518, winding and contact 1 of relay 510, to ground over the interrupter 520. Relay 510, in operating, locks over its contact 1 to ground on contact 1 of relay 512, and prepares a circuit for relay 511 from battery through resistance 519, winding of relay 511, contact 1 of relay 510 to ground at contact 1 of relay 512. Relay 511 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 520 subsequently opens its contacts, this shunt is removed and relay 511 operates. Upon the second closure of the contacts of interrupter 520, relay 510 releases, its winding being shunted by the ground over the interrupter contacts and over contact 3 of relay 511. Relay 511, upon the release of relay 510, holds over the closed contacts 1 of relay 510 to the ground supplied through the interrupter contacts. The second opening of the contacts of interrupter 520 opens the holding circuit for relay 511 which releases, thus completing the first cycle of operation and release of relays 510 and 511. This action of relays 510 and 511 continues as long as relay 512 remains operated and maintains ground on the armature of interrupter 520.

Upon the second closure of the contacts of interrupter 520, when relay 510 releases but relay 511 is still held operated, a circuit is closed for operating relay 501, over the back contacts of relays 502, 504, and 506, contact 1 of relay 511, contact 2 of relay 510 to ground on conductor 583. Relay 501, in operating, locks over its contact 3 to ground on contact 4 of relay 512.

Upon the operation of relay 501, indicating the termination of the subsidiary timing interval, a circuit is completed from battery through the winding of relay 542, over conductor 549, and contact of relay 501 to conductor 523. Conductor 523 is grounded as described in the aforementioned 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 501, relay 542 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 501 operates, but, since ground has been removed from conductor 523, relay 542 does not operate. As long as relay 600 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 512 remains operated and relays 510 and 511 continue to function under the control of interrupter 520 and the ground on conductor 583. When relay 510 operates for the second time at the start of the second cycle, relay 502 operates in a circuit from battery through its winding, contact 4 of relay 501, back contacts 1 of relays 503 and 505, contact 2 of relay 511, contact 2 of relay 510, to the ground on conductor 583. Relay 502 locks over its contact 2 to ground supplied over contact 2 of relay 501.

Relay 511 is operated by the opening of the interrupter contacts and relay 510 is released by the subsequent closure of the interrupter contacts. With relay 511 operated and relay 510 released, relay 503 operates in a circuit from battery through its winding, contact 2 of relay 502, contacts 1 of relays 504 and 506, contact 1 of relay 511, contact 2 of relay 510, to the ground on conductor 583. Relay 503 locks to ground contact 2 of relay 501.

The next operation of relay 510 completes a circuit for relay 504; the next release of relay 510 closes a circuit for relay 505 and the subsequent operation of relay 510 operates relay 506. Relays 504, 505 and 506 all lock under the control of relay 501.

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 600 remains unoperated, to permit relay 506 to operate, a circuit is closed from battery through the winding of relay 542, conductor 549 to ground at the outer lower contact of relay 506. Relay 542 causes the trouble indicator to be called in.

Under normal conditions, when the marker has connected to the frames and district junctor, relay 600 is operated, opening the locking circuit for relay 512. Relay 512 releases, opens the locking circuit for relay 501 and opens the circuit from the grounded control conductor 583 to the armature of interrupter 520, thereby releasing relays 510 or 511, or both, if they are operated at the time. The release of relay 501 in turn releases whichever of the relays 502, 503, 504, 505 and 506 had operated and locked prior to the release of relay 512. When all of these relays have released, a circuit is completed for operating relay 513 in order to shift from the first to the second interval of the timing circuit to cover the selection of a truck and the operation of switches for completing the telephone connection. The operating circuit for relay 513 is traceable from battery through its winding, over conductor 524, contact 2 of relay 600, conductor 526, back contacts of relays 512, 501, 505, 511, and 510 to the ground on the timing control conductor 503. In operating, relay 513 locks through its winding, conductor 524, front contact of relay 600, conductor 526, and over its lower middle front contact to the ground on conductor 583. This ground is also extended to the armature of interrupter 520. Ground over contact 1 of relay 513 operates relay 504 in an obvious circuit. Relay 504, in operating, completes a circuit from contact 1 of relay 511, over contact 1 of relay 506 and its own contact 1 to the winding of relay 505 so that the latter relay will operate, instead of relay 501 as before, upon the subsequent operation of relay 511 under control of interrupter 520.

The next closure of the contacts of interrupter 520 releases relay 510 but holds relay 511. Since relay 504 is now operated, relay 505 is operated by the release of relay 510 while the subsequent reoperation of that relay causes relay 506 to operate and in turn operate relay 542 for seizing the trouble indicator.

Connection of marker to trouble indicator

When relay 542 operates as above described, it closes an obvious circuit for relay 541. This completes a circuit from battery through resistance 543, contact 7 of relay 541, contact 5 of relay 544, conductor 433, winding of relay 420, individual to marker No. 1 in the trouble-indicator circuit to ground. Relays such as 420 are arranged in a preference chain one for each marker

in the office, which allows but one marker to connect to the trouble indicator at any time.

Key 439 is shown to obviate the use of optional wiring to illustrate the circuit wiring associated with the equipment of Fig. 1 with the key normal and associated with the equipment of the modification, Fig. 6 with the key actuated. The operation of the equipment of Fig. 1 will be first described.

Relay 420 operates over the above traced circuit and, assuming that no other relay in the chain is operated, a circuit is completed for operating the connecting relays of marker No. 1. This circuit may be traced from ground on contact 3 of relay 404, contact 8 of relay 425, conductor 347, conductor 435 and contact 1 of relays 422, 421 and 420, conductor 430, to battery through the winding of multicontact connecting relay 103 which operates relay 103. Relay 103 connects ground to the windings of multicontact relays 101 and 104, relay 101 connects ground to the winding of multicontact relay 102 thereby operating the marker multicontact connecting 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 equipment of marker No. 1 is also operated over an obvious circuit to ground on contact 6 of relay 541. The circuit for lamp 415 is opened by the operation of relay 300 also individual to the marker shown. 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 while it is busy with another marker. The circuit for lamp 414 is established through contact 3 of relay 301 which in this case would not be operated. This occurs when any of the markers attempt to seize the trouble indicator when it is busy recording the troubles in circuits connected with another marker.

Operation of trouble indicator

The operation of the marker connecting relays 101, 102, 103, 104 and other marker connecting relays not shown connect a large plurality of trouble indicator circuit leads to the marker and through the marker to units of equipment such as a district, a sender, sender connector, etc. 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. The connecting relays operated are individual to marker No. 1, and therefore, relay 300 is energized from ground on contact 4 of connecting relay 104 which extends through the winding of relay 300, to battery. Relay 300, in operating, locks through its contact 1 to ground on contact 2 of relay 404. Let it be assumed that relays 105, 106, 107, 110, 112, 115 and 120 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 are held operated over the circuits traced until relays in the trouble indicator are operated to establish locking paths for these relays.

The operation of relay 300 establishes a circuit for relay 403 which may be traced from battery through the winding of relay 403, contact 6 of relay 425, contact 4 of relay 300 to ground. Relay 403 operated establishes an obvious circuit for relay 401 through resistance 402. The operation of relay 401 establishes a circuit for operating relay 425 from ground on the inner spring of its contact 2, winding of relay 425 to battery. Relay 425 locks through its contact 5 to ground on contact 1 of relay 300. Returning to the operation of relay 401, this relay associates ground through 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 425 when the latter relay is operated by relay 401 thus holding the connecting relays operated although the original operating circuit for these relays is opened.

The operation of relay 425 connects ground through its contact 3, winding of relay 426 to battery for operating relay 426; and also connects ground through its contact 4, winding of relay 428 to battery for operating the latter relay. Relays 426 and 428 lock to ground on contacts of relay 404. Relay 426 connects ground with lead 223 which establishes a locking circuit for relays 105 to 108 and 110 to 113, any of which could have been operated over circuits connected to the marker. Relay 428 connects ground to lead 224 which establishes a locking circuit for relays 115 to 118 and relays 120 to 123 any of which may have been operated.

Release of marker

The operation of relay 425 opens the energizing circuit for relay 403. The release of relay 403 opens the energizing circuit for slow release relay 401. Since relay 425 remains locked to ground on contact 1 of relay 300, the circuit for the connecting relays 101, 102, 103, and 104 is opened by the disconnection of ground from lead 435 when relay 401 releases. The connecting relays thus release, which disconnects the marker from the trouble indicating leads of the trouble indicating circuit. At this time, however, any of the trouble indicating relays such as 105 to 123 associated with a grounded lead would have been operated and locked to provide a record as later described. The operation of relay 425 and the release of relay 401 establishes an operating circuit for relay 406 from battery through its winding, contact 7 of relay 425, to ground on contact 1 of relay 401. Relay 406, in operating, establishes a locking circuit for itself over lead 355, to ground on contact 1 of relay 426. 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 release the connected marker from the trouble indicator but make the trouble indicator busy to all of the markers until the trouble indications in the trouble-indicating circuit have been recorded. Relay 405 associates ground with lead 432 which extends through the upper winding of relay 544 to battery, operating the latter relay. The operation of relay 544 opens the circuit extending to start relay 420. Relay 544 also causes the re-

lease of the marker and the circuits associated with the marker. Relay 544 locks in a circuit from battery through its lower winding, contact 4 to ground on contact 2 of relay 541. Relay 541 is released by the release of the marker. This causes the release of relay 544 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 544 to prevent seizure of the trouble-indicator circuit.

The foregoing operation of the trouble-indicating circuit thus leaves relays 405, 406, and 425 energized which maintains the ground and battery circuits established for locking the indicating relays so that a record may be made before these trouble-indicator circuit relays are released.

The foregoing operations take place very quickly after seizure of the trouble indicator by a marker to operate certain of the relays 105 to 123 which are locked in position so that the marker may be released for use in completing other telephone connections. At the time that relay 425 is operated, the recording device is started so that there is an overlapping operation in releasing the marker and starting the recording machine at the time that relay 425 is operated.

Recording device

The recording device shown in Patent 1,862,200 to H. Sengebusch, June 7, 1932 has been modified for use with the circuit and equipment of the present invention. The construction of this recording device, other than the modifications described herein, may be assumed as the same as shown in this patent with the exception that the characters on the typewheel 10 may be chosen to represent circuit designations and thus may be different from the numbers 0 to 60 described in the patent as arranged on the periphery of each typewheel 10.

The motor 248 shown in Fig. 2 may be the same as motor 17 shown in Figs. 2 and 4 of the patent. The mechanical lock magnet 240 of Fig. 2 may be the same as magnet 24 with its associated mechanism in Fig. 2 of the patent having an armature 25 pivoted at 26 and secured to end plate 3. The contact 241 of Fig. 2 may be the same as the contact held by spring 35 of the patent. The mechanical lock operated by this magnet designated 240 in the drawings of this application and 24 in the patent is fully described on page 2 of the patent and need not be repeated herein.

Cam 242 having six raised segments thereon has been added and mounted as shown on the shaft designated with the numeral 9 in the patent to close the contact 243, also added to the recording device of the patent. The contact springs are mounted in member 708 securely fastened to end plate 2 as shown in Figs. 7 and 9. The numbers shown in parentheses in Figs. 7, 8, 9 and 10 are the same as the numerical designations in the patent and in all cases may be assumed as constructed in the same manner as shown in the patent.

As stated in the patent, the typewheels 10 each have sixty characters thereon, one character on each wheel may be printed upon each step of the recording device if the associated printing lever is released by its tripping magnet. In the circuit and equipment of the invention only ten printing operations are required for a cycle of operations to record the faults which may be found in the marker and equipment units associated therewith which have been connected to the trouble indicator. Cam 242, therefore, provides six positions where cycles of records may be started to arrange the recording device and circuit operations so that ten printing operations take place between each raised segment 705. As later explained in the circuit description, the closure of contact 243 by cam 242 energizes a relay which starts a cycle of printing operations. Cam 242 makes one complete rotation for each complete rotation of the printing wheel. Since each printing wheel has sixty characters around its periphery, this printing wheel with cam 242 will comprise six complete cycles of recording operations of the troubles encountered by six markers in attempting to complete telephone connections.

Cam 244 has been added as shown in Fig. 10 mounted on shaft 14 which makes one revolution for each printing operation or ten revolutions for the ten printing operations between the raised segments 705 of cam 242. This cam, 244, therefore, closes and opens contact 245 to energize as many tripping magnets for each printing operation as there are faulty circuits encountered upon each step of the recording device printing mechanism, including the printing wheel. Cam 244 operates in synchronous relation with the printing mechanism including the positioning of the print levers 38. The springs 900 are mounted on bracket 901 which is rigidly fastened to the frame of the recording device.

As shown in Fig. 8, the principle of operating the printing mechanism has been slightly modified to provide a spring for operating the lifting member 53. This requires the provision of cam 713, latch 711 and detent 712. Cam 713 is mounted on shaft 14 and this cam and spring 710 do the work of the piston 55 shown in the patent. Release latch 711 is pivoted in bracket 715 which is rigidly fastened to frame 22 and serves to hold the lifting member 53 in position until maximum tension is obtained in the spring 710 for quickly operating the lifting member 53 in the following manner. For this description it may be assumed that a plurality of tripping magnets 44 have been energized which attracted their respective armatures 43 causing the associated printing levers 38 to swing by gravity to a position with their notches 42 directly above the upturned portion 58 of spring 57. As described in the patent, when armature 43 is attracted by the energization of a tripping magnet, the upper end of the armature 43 removes its support from end 40 of the printing lever 38, thus permitting this printing lever to rotate into position where it may be moved upward by the lifting member 53. This occurs during the rotation of cam 713 when the spring 710 is approximately in the position shown or shortly thereafter. In this position no tension is placed upon the spring. The latch 711 at this time is in engagement with the detent 712 which is rigidly fastened to the lifting member 53. As cam 713 rotates in the direction indicated by the arrow, the tension of the spring increases until maximum tension is obtained when pivot 716 is rotating through its highest arc. At this time the protruding portion of cam 713 forces the latch 711 downward causing it to rotate on pivot 717 and move away from detent 712. The lift member 53 is now quickly drawn upward by spring 710. The lift member 53 extends the entire length of the machine and, therefore, the upturned part 58 of spring 57 engages all of the printing levers 38

which were released by their respective tripping magnets. The lifting member 53 thus drives the printing mallets 41 of the printing lever 38 upward to press the paper and inked tape 61 against the characters presented by the printing wheel, thus printing a plurality of characters in a row across the paper ribbon. As cam 713 continues to rotate, the release latch 711 is drawn upward by spring 714 and since the tension is removed from spring 710 the lifting lever 53 is lowered until the latch 711 is again brought into the position shown in Fig. 8 for holding the lifting lever 53 until maximum spring tension is again obtained on the next rotation of cam 713.

The cam 244 which rotates once per printing operation is so shaped as to close and open contact 245 for controlling relay operations in the circuit of Fig. 2 to cause the deenergization of the tripping magnets in synchronous relation to the release of the printing levers 38. Therefore, after the printing levers have been moved upward by lifting member 53 the armatures 43 of the tripping magnets are pressed forward by spring tension to place the upper end of the armature 43 in position as shown under the end 40 of the printing lever 38 to hold the lever away from the lifting member 53 when it is lowered after the printing operation.

Printing operations

The operation of relay 425 energizes relay 220 which is a start relay for the recording machine and a start relay for the progressive control of printing operations. The circuit for relay 220 may be traced from ground on contact 1 of relay 425, thence over lead 460, contact of relay 224, winding of start relay 220 to battery. Relay 220 establishes a circuit for relay 427 which may be traced from battery, through the winding of the latter relay, contact 5 of relay 220 to ground on contact 4 of relay 425. Relay 427 connects battery through lamps 305 to 307 and lamps 413 and 415, so that the marker number is indicated and markers which attempt to seize the trouble indicator while it is busy are also indicated. A circuit is established by relay 220 for the motor control and mechanical lock magnet 240 which may be traced from ground through contact 2 of relay 220, contact 3 of relay 234b, winding of the magnet 240 to battery. This establishes a circuit for motor 248 through contacts 241 to start the rotation of the recording machine and establishes the mechanical lock as set forth in the aforementioned Patent 1,862,200 to Segenbusch.

A circuit is established for counting relay 225a from battery, through its winding, contact of relay 225b, contact 3 of relay 222, contact 1 of relay 220 to ground. Relay 225b is not energized following the operation of relay 225a, since the winding of relay 225b is shunted at this time by ground on each conductor of the winding. Cam 242 is a synchronizing cam or it may be known as a start recording cam which closes contact 243 after the motor has moved the printing wheel to a particular position which is the No. 1 position in a series of ten records or ten rows of records. This establishes a circuit from ground, through contact 1 of relay 220, contact 243, winding of relay 221 to battery, operating the latter relay, which brings relay 222 into a circuit established by cam 244. Relay 221 in operating establishes a locking circuit for itself to ground on contact 2 of start relay 220. As previously stated cam 244 rotates once for each record made by the printing machine. The closure of contact 245 by cam 244 associates ground through contact 1 of relay 220, contact 245, contact 2 of relay 221, winding of relay 222 to battery, operating relay 222.

The operation of relay 222 removes ground from the armature and winding of relay 225b, causing relay 225b to operate in series with relay 225a, through the contact of relay 225a to ground on contact 3 of relay 220. The further rotation of cam 244 opens the contact 245, which releases relay 222. The release of relay 222 establishes an operating circuit for relay 226a from ground on contact 1 of relay 220, lower contact of relay 222, contact of relay 225b, contact of relay 226b, winding of relay 226a to battery. Contact 245 is again opened and relay 222 is again released, removing the shunt from relay 226b, which causes the latter relay to operate from battery in series with relay 226a, contact of relay 226a to ground on contact 3 of relay 220.

The operation of relay 226b establishes a circuit which controls the printing of the first record. This circuit extends from battery, through multicontact relay 109, contact 1 of relay 226b, lower contacts of the lower counting relays, contact 2 of relay 222, when this relay is operated to ground on contact 1 of relay 223. The operation of relay 109 establishes circuits for as many trip magnets as there are relays 105 to 108 operated. This may include a large plurality of relays since the relays shown are only part of the relays which may be used to operate any of the 60-trip magnets of the recording machine. As shown in Patent 1,862,200 to H. Sengebusch, the energization of any trip magnet causes the associated printing lever 38 to be placed in the path of the lifting member 53. The lifting member is raised by spring tension, as previously described, causing the characters on the printing wheel to be printed on tape 703 from pressure of the mallet 41 against the character on the printing wheel with the strip 703 and inked ribbon 61 therebetween. The printing machine continues in operation as driven by the motor 248 and consequently the counting relays continue in operation. The next successive release of relay 222 causes the energization of counting relay 227a which opens the circuit for multicontact relay 109 and the tripping magnets energized through the contact of this relay. The printing levers 38 are thus released and restore to their normal position.

As cam 244 continues to rotate contact 245 is again established, which again energizes relay 222. This removes the shunt from relay 227b which now operates in series with relay 227a to ground on contact 3 of relay 220. The operation of relay 227b establishes a circuit for multicontact relay 114, from battery, through its winding, conductor 254, contact 1 of relay 227b, lower contacts of counting relays, contact 2 of relay 222, contact 1 of relay 223 to ground. The operation of relay 114 connects ground through its contacts from any of the relays 110 to 113 which were operated through the windings of the respectively associated tripping magnets to battery. It will be remembered that these relays were operated and locked when the marker connector relays were operated. Only four of these relays have been shown, but it is indicated that there may be a large plurality of such relays which are operated by circuits connected with the marker and locked by the trouble indicator after having been operated. A second plurality of characters are now printed on the second row

of the recording machine paper tape. As previously explained the tape moves the space of one row of characters after each printing operation. For this second row of characters a number of trip magnets may have been operated, depending upon whether trouble was found in this circuit associated with the marker and connected through the multicontact relay 102. One of the characters printed indicates the location of the particular circuit and equipment unit which is used with the marker in an unsuccessful attempt to complete the telephone connection. Other characters indicate faults in the circuit or equipment. As previously stated, each trip magnet energized releases the associated printing lever 38 in order that these printing levers may be elevated by the lifting member 53 for printing a character on the paper tape 703.

As the motor continues to rotate cam 244, the counting relays are successively energized as previously described, which successively energizes relays 119 and 124 and as many like relays as necessary to make a record of the circuits associated with the marker which encountered trouble in completing the telephone connection. As previously stated each relay, such as 109, 114, 119 and 124 connects leads grounded by the operation of relays such as 105 to 123 for operating tripping magnets and the grounded leads extending through the contacts of each relay 109, etc. indicate a trouble in a particular unit of equipment. In the present embodiment ten rows of characters are used for successive operations in recording the different circuits and the troubles in these circuits which are connected to the trouble indicator through the marker. To terminate the recording of these troubles, counting relays 234*a* and 234*b* are used as end counting relays for operation after the recording has taken effect. Therefore, after the record has been completed the subsequent release of relay 222, associates ground on contact 1 of relay 220, through contact 3 of relay 222, contacts of the counting relays 225*b* to 233*b* in series, winding of the end counting relay 234*a*, to battery, operating the latter relay. At this time the winding of relay 234*b* is shunted but operates as soon as relay 222 operates because of continued rotation of the cam 244. Relay 234*b* is energized in series with relay 234*a*, contact of relay 234*a* to ground on contact 3 of relay 220. The operation of relay 234*b* opens the ground circuit from contact 2 of relay 220 to the winding of mechanical lock 240, which opens the circuit for motor 243 to arrest the operation of the recording machine. This ground also extended through the winding of relay 221 to lock the relay and consequently this relay is released at this time since the contact 243 is open. The operation of relay 234 opens the locking circuit for relay 220 which extended through contact 4 of relay 220, contact 2 of relay 234 to ground on contact 3 of relay 220. The start relay therefore releases, which releases all of the counting relays. This contact of relay 234 also opens the circuit for slow-release relay 224, which causes its release after a short period.

Returning to the operation of the last two counting relays, it will be apparent that the operation of relay 232*a* establishes a circuit for operating the slow-release relay 235. The subsequent operation of counting relay 233*a* opens the circuit for relay 235 and establishes a circuit through the contact of relay 235, which is effective before relay 235 releases. This circuit is established for releasing the relays of the trouble indicator and extends from ground, through contact 1 of relay 233*a*, contact of relay 235, contact 4 of relay 223, over lead 461, through the winding of relay 404 to battery, operating the latter relay. Relay 404 locks to ground on contact 1 of relay 425, so that the relays of the trouble indicator will all be released before relay 404 is released. It is apparent from the preceding description that the operating circuit for relay 404 is opened as soon as the slow-release relay 235 releases and that relay 404 thereafter depends upon its locking circuit.

The operation of relay 404 opens the locking circuit for relays 300, 426, 427 and 428; the release of relay 300 opens the locking circuit for relay 425; the release of relay 425 opens the locking circuit for relay 406; the release of relay 425 opens the locking circuit for relay 404; and the release of relay 406 opens the locking circuit for relay 405. As previously set forth, relay 405 holds the trouble indicator busy to all markers during the period when it was recording the faults indicated by the operation of relays such as 105 to 123 and the release of relay 405 removes this busy condition and permits other markers to seize the trouble indicator circuit to record faults which have prevented the completion of a telephone connection.

It should be noted that successive operations take place in releasing the equipment of the trouble indicating circuit in Figs. 1, 2 and 4 and the release of the recording equipment in Fig. 2. The release of the relays of Figs. 1, 3 and 4 took place when counting relay 233*a* associated ground with relay 404 for operating the latter relay. At this time the slow-to-release relay 224 is energized to ground on contact 3 of relay 220. The circuit for relay 224 is opened by the end relay 234*b* which occurs after the operation of relay 404. Since relay 224 is slow in releasing, it holds the energizing circuit for start relay 220 opened until after relay 425 has been released and thus the start relay 220 cannot be again operated until the trouble indicator is subsequently seized by another marker.

Key 249 is used for advancing the paper over the print roll to a particular point if the machine has been moved by hand for some reason, dislocating the starting point on the print roll and it may be used for removing a length of paper strip having a record thereon from this recording machine. The operation of key 249 energizes relay 223 from ground on contact 3 of relay 220. This key is only used when the start relay 220 is in its normal position. The energization of relay 223 establishes an operating circuit for the start relay 220 from battery, through the winding of the latter relay, contact 5 of relay 223, key 249 to ground on contact 3 of relay 220. Relay 220 in operating locks through its contact 4, contact 2 of relay 234*b* to ground on the make contact of the transfer springs shown as contact 3 of relay 220. Relay 223 locks to ground on this contact over the circuit traced through contact 2 of relay 234*b*. The paper advance key 249 may now be released. The motor 248 is started by the mechanical lock which energizes over a circuit from battery, through its winding, contact 3 of relay 234*b* to ground on contact 2 of start relay 220.

The paper is now drawn forward by the devices of the recording machine. The circuit for counting relay 225*a* is closed as soon as the start relay 220 is operated but no further operations take place until cam 242 is rotated to a raised

portion 705 which closes contact 243. A circuit is thus established for relay 221 which locks to ground on contact 2 of relay 220. When cam 233 subsequently closes contact 245 a circuit is established for operating relay 222 which removes the shunt from the winding of relay 225b to bring about the operation of the latter relay. The motor rotates cam 244 to repeatedly close and open contact 245. Each revolution this cam progressively operates the counting relays as previously described. In this case, however, the multicontact relays, such as 109, are not operated since the circuit for these relays is opened by contact 1 of relay 223 which is locked in an operated position. Relay 235 is operated over a circuit previously traced but the circuit established through its contact is open at contact 4 of relay 223 and therefore relay 235 is released after the operation of counting relay 233a without having established an operating circuit through its contact. The operation of the end counting relay 234b, as previously traced, opens the motor circuit and thus causes the recording machine to stop at the next start position. The operation of relay 234b also opens the locking circuit for relay 220 and extends through contact 2 of relay 234b. This restores all equipment of the trouble recorder to normal, including the counting relays and relay 223.

A modification of the invention is shown in Fig. 6 in which the tripping magnets of the recording machine are connected through the contacts of the marker connecting multicontact relays 101 to 104 directly to the units of equipment which have been combined with a marker in an attempt to complete a telephone connection. As in all cases where the marker is connected to the trouble indicator the telephone connection is not completed because of a fault in the marker or in one of these equipment units and the associated circuits. In this modification the trouble indicating relays 105 to 123 and the multicontact relays 109, 114, 119 and 124 are eliminated and the trouble indicator equipment which controls these relays is eliminated which will be recognized from the following description.

Upon the seizure of the trouble indicator by the marker one of the chain relays, such as 420, 421 or 422 is operated depending upon the marker which seizes the trouble indicator. Assuming again that marker No. 1 has seized the trouble indicator a circuit is established for operating relay 420. In the previous description the operation of relay 420 energized the marker connecting relays 101 to 104 inclusive but as will be shown later in the description of this modification these marker connector relays are operated progressively by the counting relays 226 to 232 and relay 420 when operated establishes a circuit for relay 300 which locks to relay 404. In order to illustrate the operation of the modified form of the invention shown in Fig. 6 a key 439 has been used to obviate the use of optional wiring. This key normal or operated clearly illustrates the differences between the circuit previously described and the modified circuit. Key 439 when operated thus establishes a circuit for relay 300 when relay 420 is energized. This circuit may be traced from ground on contact 3 of relay 404, contact 8 of relay 425 thence over chain circuit through the contacts of relay 422 to 421 normal with a relay 420 operated, contact of key 439, winding of relay 300 to battery. Relay 300 when operated establishes a locking circuit for itself to ground on contact 2 of relay 404 and establishes an operating circuit for relay 403 which may be traced from ground on contact 2 of relay 300, contact 6 of relay 425, winding of relay 403 to battery. Relay 403 energizes relay 401 which establishes an operating circuit for relay 425. Relay 425 in operating establishes a locking circuit for itself to ground on contact 1 of relay 300 and opens the circuit for relay 403 which releases and subsequently releases the slow release relay 401. In the previous description the release of relay 401 established an operated circuit for relay 406 in order to release the marker. In the modified arrangement this lead is opened by key 439 so that relay 406 is not operated at this time and the marker is held connected with the trouble indicator. Relays 426 and 428 serve no purpose in the modified circuit and therefore may be eliminated. The operation of relay 425 establishes a circuit for the start relay 220 over a circuit from ground on contact 1 of relay 425, conductor 460, contact of relay 224, winding of relay 220 to battery. Relay 220 in operating establishes a locking circuit for itself through its contact 4, contact 2 of relay 234b to ground on contact 3 of relay 220. This places the start relay 220 under the control of the end counting relay 234b so that a complete cycle of records is made before this relay is released. Contact 5 of relay 220 closes a circuit for the operation of relay 427 from battery through its winding to ground on contact 4 of relay 425. This provides the battery circuit for marker lamp 305 and for lamps 413 to 415 which may be employed if another marker attempts to seize the trouble indicator while it is busy. A circuit for the mechanical lock 240 is established from battery through its winding, contact 3 of relay 234 to ground on contact 2 of relay 220. This establishes an obvious circuit for motor 243 to ground through contact 241. A circuit for relay 225d is established from ground through contact 1 of relay 220, contact 3 of relay 222, contact of relay 225b, winding of relay 225d to battery.

In the operation of this circuit, the recording machine cam 242 closes contact 243 shortly after the motor is started by moving one of the raised portions 705 forward to close the contact 243. A circuit is thus established for relay 221 from battery through its winding contact 243 to ground on contact 1 of relay 220. Relay 221 in operating establishes a locking circuit for itself through contact 3 of relay 234b to ground on contact 2 of relay 220. Cam 244 continuously rotates one cycle for each record that is made and a counting relay is operated responsive to each cycle of this cam. The first closure of contact 245 by cam 244 establishes an operating circuit for relay 222 from battery through its winding, contact 2 of relay 221, contact 245 to ground on contact 1 of relay 220. Relay 222 establishes a circuit for relay 224 which is slow release and therefore remains operated during each release of relay 222. Relay 224 retains the operating circuit for relay 220 open as previously described so that it is maintained opened during the release of relay 425. The operation of relay 222 also removes the shunt around the winding of relay 225b and thus the latter relay is energized in series with relay 225d, contacts of relay 225d to ground on contact 3 of relay 220. The subsequent release of relay 222 therefore establishes an energizing circuit for relay 226d and the subsequent operation of relay 222 removes the shunt from relay 226b causing its operation in series with relay 226d to ground on contact 3 of relay 220. In this

modified form of the invention a circuit is now established for the marker connector relay 101 from battery through its winding conductor 253, contact 1 of relay 226b lower contacts of relays 227d to 233d inclusive, contact 2 of relay 222, contact 1 of relay 223 to ground. The circuits connected to the contacts of relay 101 which have ground connected thereto energize corresponding tripping magnets for printing a particular character upon paper 703 of the recording machine. Each tripping magnet energized releases its associated printing lever 38 thus bringing a number of printing levers in position to be elevated by the lifting member 53. As previously stated this lifting member is under the control of spring 710 which causes a rapid action in elevating the printing levers 38 to press the paper against the characters on the wheels 10. In this manner the successive rotations of cam 244 successively operate the counting relays which successively operate the marker connecting relays 101, 102, 103 and 104 for associating the indicating leads with the trip magnets 150 to 153. It will be noted that each succeeding operation of the counting relays opens the circuit established for the preceding marker connecting relay and therefore only one marker connector relay is energized at any one time for recording faults in a particular equipment unit. When counting relay 232b is reached in the progressive operation of the circuit, the last printing operation is made and a circuit is established for relay 235 from ground on contact 1 of relay 233d, contact 1 of relay 232d, winding of the slow release relay 235 to battery. The subsequent operation of relay 233d associates ground through the contact of relay 235, contact 4 of relay 223, conductor 461 to battery through the winding of relay 404 and through key 439, winding of relay 406 to battery which operates both relays 406 and 404. Relay 406 locks to contact 1 of relay 426 and operates the marker release relay 405. Relay 405 maintains the trouble indicator busy by associating ground with all markers over leads 432, 440, 441 and 442. As previously described the association of ground with relay 544 in the marker establishes a release circuit for the marker which in this case was marker 1 associated with the trouble indicator. Relay 404 disconnects the locking ground from relay 300 which releases. It also disconnects the locking ground for relay 426 which releases relays 426 and 406 which is locked to relay 426. Relay 405 is released by the release of relay 406. Relay 404 awaits the release of relay 425 since it is locked to contact 1 of relay 425. The release of relay 300 opens the locking circuit for relay 425 which releases, opening the locking circuit for relay 404. At this time relay 224 remains operated and therefore operating ground can not be again associated with relay 220. The end counting relay 234d is energized after the operation of relay 233b and upon subsequent rotation of cam 244 causing the operation of relay 222 the shunt is removed from relay 224b which energizes in series with relay 224d. This opens the locking circuit for the start relay 220 and the circuit for relay 224. Relay 220 immediately releases causing the release of the counting relays and relay 221. Relay 224 releases after the release of relay 220 to reestablish the circuit connection with relay 425 which now is normal. This makes the recording machine circuit in readiness for a subsequent operation of relay 225.

What is claimed is:

1. In an automatic telephone switching system, incoming lines, outgoing lines, means responsive to a call over an incoming line for selectively combining a plurality of different units of equipment one of which is a marker, for completing a telephone connection to an outgoing line, a trouble-recording device, means in said marker operative when trouble is encountered in the operation of any unit of equipment so combined for connecting leads from all of said units of equipment with said trouble-recording device, a motor-driven printer in said trouble-recording device having a plurality of tripping magnets, electrically operable devices for connecting the leads from successive units of equipment to said tripping magnets, means to simultaneously operate any or all of said plurality of tripping magnets by the association of said tripping magnets with leads to any one unit of equipment to simultaneously print a record of the location of and faults in said equipment unit, and means to successively operate said electrically operable devices for successively connecting the leads of each unit of equipment to said tripping magnets to print an individual record of the electrical condition in each unit of equipment.

2. In an automatic telephone switching system, incoming lines, outgoing lines, means responsive to call over an incoming line for selectively combining a plurality of different units of equipment one of which is a marker for completing a telephone connection to an outgoing line, a trouble-recording device, means in said marker operative when trouble is encountered in the operation of any unit of equipment so combined for connecting leads from all of said units of equipment with said trouble-recording device, a motor-driven printer in said trouble-recording device having a printing wheel with type thereon, a paper strip associated therewith, printing devices and a plurality of tripping magnets for positioning said printing devices, means in said trouble-recording device for successively connecting the leads from each unit of equipment to said tripping magnets to cause the simultaneous printing of a record of the location of and faults in each equipment units, and means in said motor-driven printer to advance said printing wheel and paper strip step by step after each record is printed.

3. In an automatic telephone switching system, incoming lines, outgoing lines, means responsive to a call over an incoming line for selectively combining a plurality of different electrically energized units of equipment, one of which is a marker, for completing a telephone connection to an outgoing line, a trouble-recording device, means in said marker operative when trouble is encountered in the operation of any of said units of equipment so combined for connecting leads from all of said units of equipment with said trouble-recording device, a source of electrical potential, means in said units of equipment for connecting an electric potential source to certain of said leads, a motor-driven printer in said trouble-recording device having rotary stepping mechanism and a plurality of printing magnets simultaneously operable to print a row of characters upon each step of the printer, means to successively connect the leads from each of said units of equipment with said tripping magnets, and means to simultaneously energize all magnets of said printer connected to leads in a unit of equipment which are connected to a potential source upon each step of said printer to succes-

sively print individual records of the location and faults in said units of equipment.

4. In an automatic telephone switching system, incoming lines, outgoing lines, means responsive to a call over an incoming line for selectively combining a plurality of different electrical energized units of equipment, one of which is a marker, for completing a telephone connection to an outgoing line, a trouble-recording device, means in said marker operative when trouble is encountered in the operation of any unit of equipment so combined for connecting leads from all of said units of equipment with said trouble-recording device, a source of electrical potential, means in said units of equipment for connecting said electrical potential source to certain of said leads, a motor-driven printer in said trouble-recording device having rotary stepping mechanism and a plurality of printing magnets simultaneously operable to print a row of characters upon each step of the printer, a plurality of relays, means in said printer for operating said relays upon each step for connecting the leads from successive units of equipment to said tripping magnets, and means to simultaneously energize all magnets of said printer connected to the leads in a unit of equipment which are connected to a potential source upon each step of said printer to successively print individual records of the location and faults in each of said units of equipment.

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