

June 13, 1939.

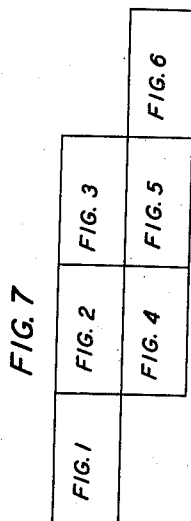
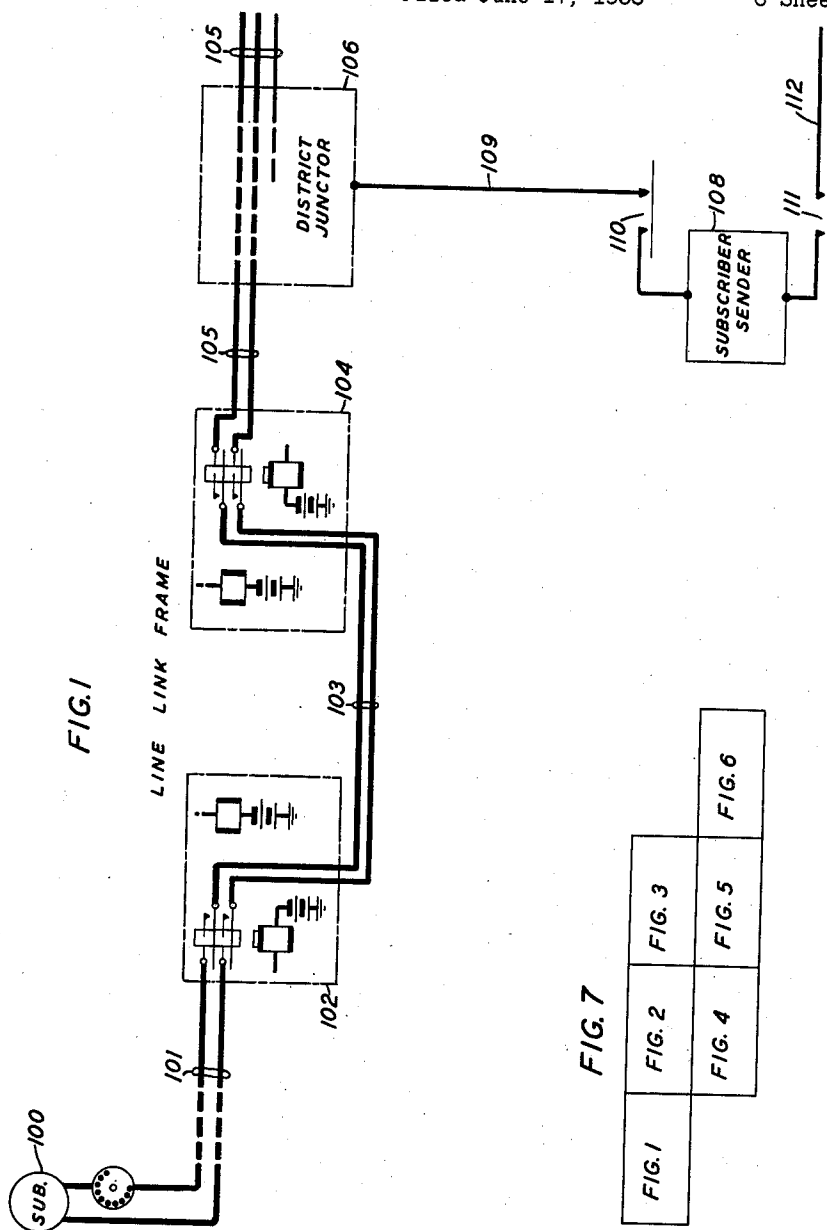
R. E. HERSEY

2,161,864

TELEPHONE SYSTEM

Filed June 17, 1938

6 Sheets-Sheet 1



INVENTOR
R.E.HERSEY

R.E. HERSEY

BY W.T. McFenney
ATTORNEY

ATTORNEY

June 13, 1939.

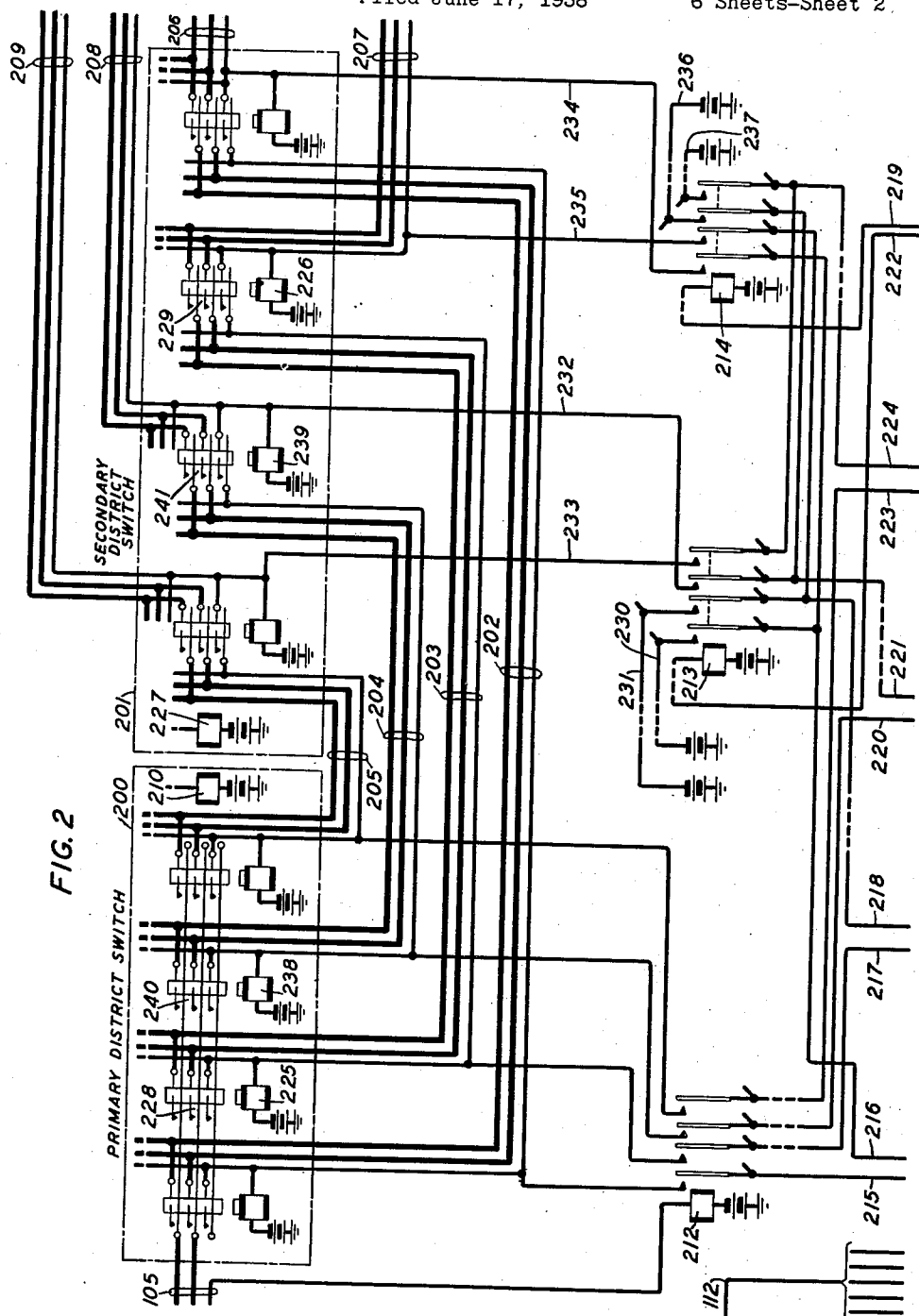
R. E. HERSEY

2,161,864

TELEPHONE SYSTEM

Filed June 17, 1938

6 Sheets-Sheet 2



INVENTOR
R.E. HERSEY

BY *W. J. McNamee*
ATTORNEY

June 13, 1939.

R. E. HERSEY

2,161,864

TELEPHONE SYSTEM

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6 Sheets-Sheet 3

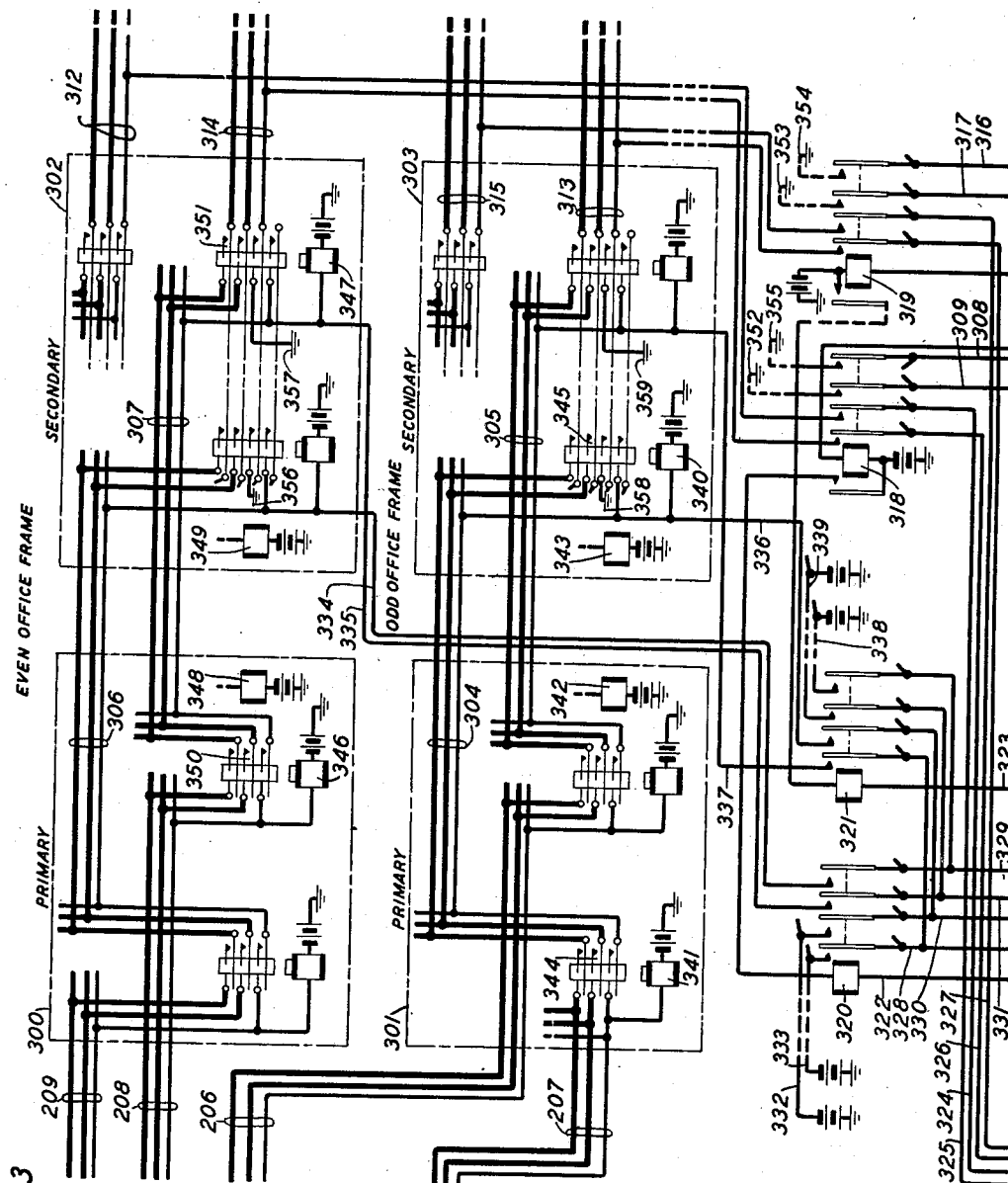


FIG. 3

INVENTOR
R.E. HERSEY

BY *W. M. McFarney*
ATTORNEY

June 13, 1939.

R. E. HERSEY

2,161,864

TELEPHONE SYSTEM

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6 Sheets-Sheet 4

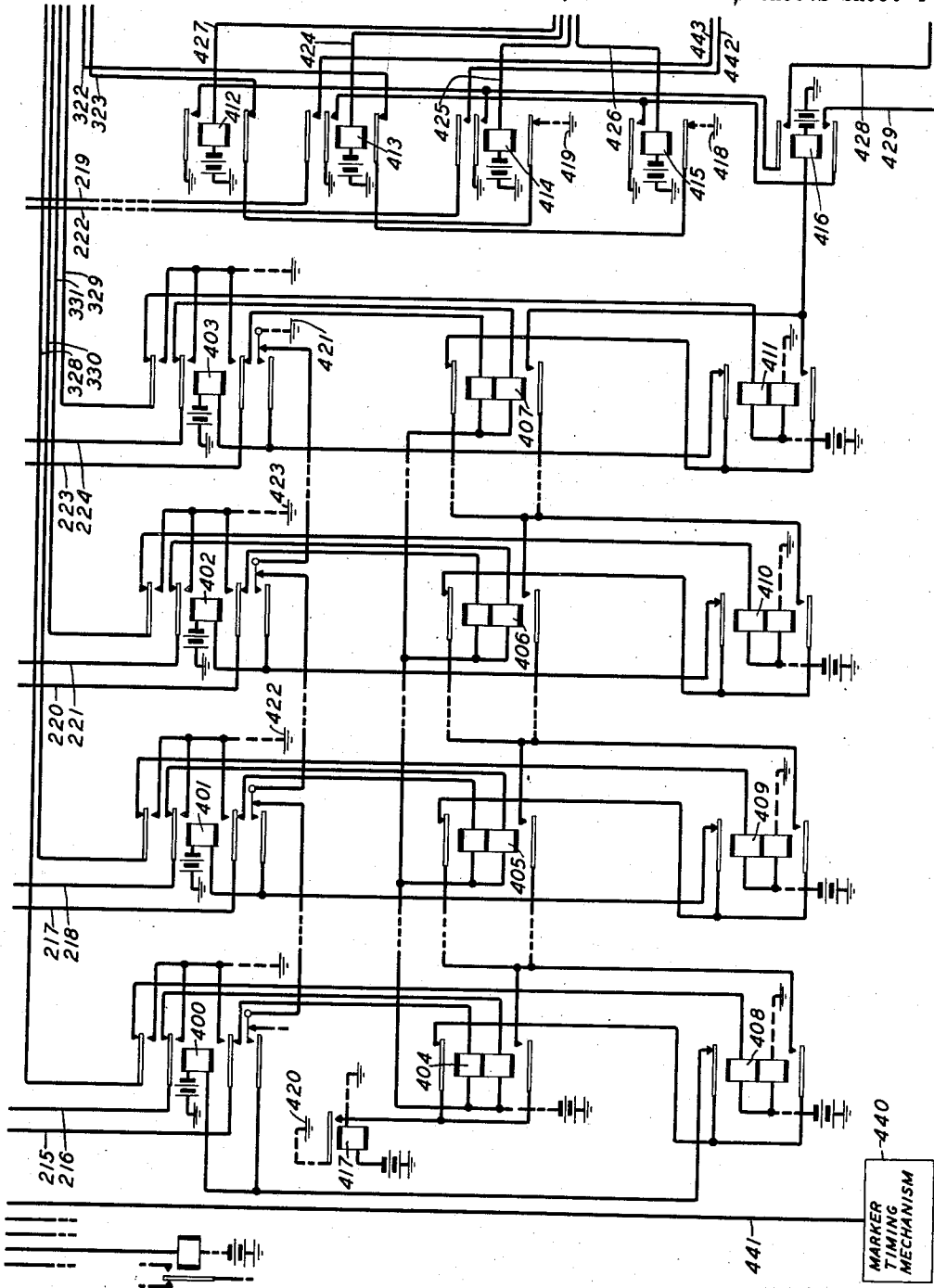


FIG. 4

INVENTOR
R.E. HERSEY

BY *W.T. McKenney*
ATTORNEY

MARKER
TIMING
MECHANISM

June 13, 1939.

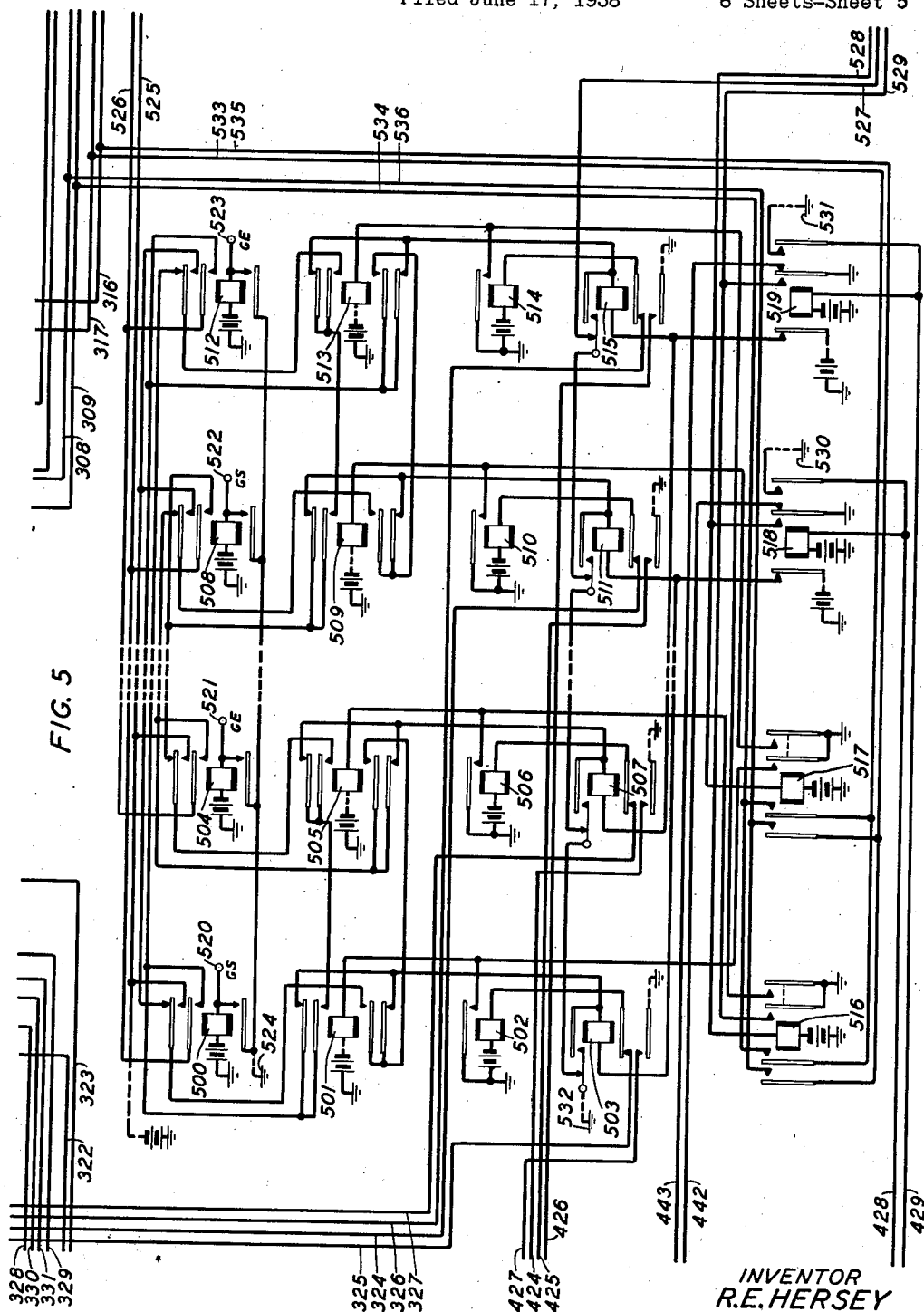
R. E. HERSEY

2,161,864

TELEPHONE SYSTEM

Filed June 17, 1938

6 Sheets-Sheet 5



INVENTOR
R.E. HERSEY

BY *W. T. McKenney*
ATTORNEY

June 13, 1939.

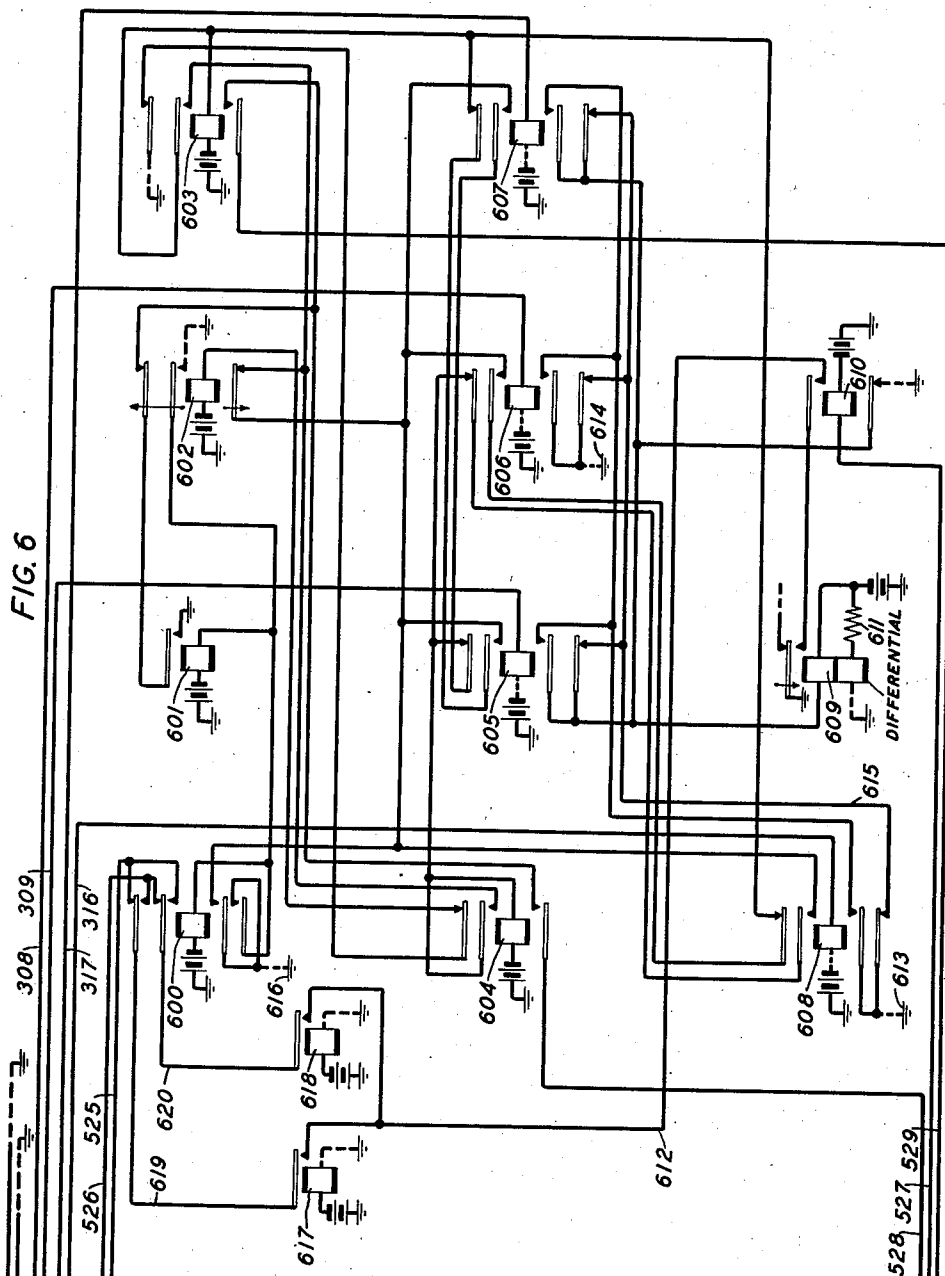
R. E. HERSEY

2,161,864

TELEPHONE SYSTEM

Filed June 17, 1938

6 Sheets-Sheet 6



INVENTOR
R. E. HERSEY

BY *W. T. McJannet*
ATTORNEY

UNITED STATES PATENT OFFICE

2,161,864

TELEPHONE SYSTEM

Ralph E. Hersey, Madison, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application June 17, 1938, Serial No. 214,350

7 Claims. (Cl. 179—25)

This invention relates to telephone systems and particularly to those employing automatic switching equipment for establishing conversational connections.

5 One of the advantages of automatic switching systems employing switches of the cross-bar type and common markers for controlling their selective operations is the facility with which the markers can be arranged to test and retest
10 all available circuit paths in an effort to establish a desired connection. These tests are made in so short a time that it is possible and desirable to make second and even third trials to serve the waiting call. And in some cases a
15 group of trunks, if found busy on a first trial, may be retested a moment later in a second attempt to complete the same call.

Another advantage of the cross-bar system is that the trunks of a group may be divided into
20 two subgroups, one of which is located on one frame of switches and the other on a second frame of switches, the marker being capable of testing both subgroups simultaneously for the purpose of finding an idle one for use. To do this
25 the marker connects itself to the proper pair of switch frames through frame connectors and proceeds to test all trunks of the group, selecting the first idle one for use. Having found an idle trunk on a particular frame, the marker
30 then makes a test of the link paths of that frame and, if an idle one of these paths is located, completes the connection through to the selected idle trunk.

With these facilities a high degree of efficiency is possible in the use of the available
35 equipment for completing calls. In some cases, however, it is possible that a call may fail to be served, due to such causes as faulty test connections, which may persist on subsequent as
40 well as on first trials, or the failure to find at the same time an idle trunk and an idle link path in the frame of switches on which such trunk appears.

The objects of the present invention, therefore, are to increase still further the efficient use
45 of the equipment in these systems; to increase the accessibility of calls to the trunks and connecting circuits that serve them; to reduce the likelihood of failure because of temporary irregularities in the testing mechanism; and in
50 other respects to improve these systems.

In accordance with these objects it is a feature of the invention to provide a testing arrangement in the marker which acts, when the
55 marker is making a first trial to extend a call

over a desired group of trunks, to test the successive trunks in a definite order and to choose the first idle one for use, and which acts, when the marker is engaged in making a subsequent
5 trial to extend the call, to test the successive trunks of said group in the reverse order.

According to another feature of the invention, when a call is received for a given group of trunks, one subgroup of which appears in one switch and a second subgroup in a second switch,
10 each switch being reached over separate groups of link paths, all trunks of the group are tested simultaneously to select an idle one in one or the other of the subgroups, followed by a test of the link paths leading to the selected trunk;
15 and, if all these link paths are found busy, a retest is made of both subgroups, all trunks being rendered artificially busy in the subgroup that could not be reached because all link paths were busy on the first attempt, causing thereby
20 the selection of an idle trunk in the other subgroup if it contains one; and thereupon a test is made to find an idle link path in the group that has access to said other subgroup. With
25 this arrangement a call for a trunk group is not allowed to fail if either of its two subgroups has an idle trunk and an idle link path leading to the idle trunk is available at the time.

A further feature of the invention is a system in which a common switch controlling marker
30 makes repeated trials to extend a call by connecting itself simultaneously to a pair of switch frames and testing the desired trunk group, some of which appear on one frame and some on the other; in which a failure of the marker on a
35 first trial to establish proper connection with the switch frames results in the release of the marker and the reseizure of the same or another marker for a second trial; in which the marker on a subsequent trial, although failing to make
40 proper connection with one frame, proceeds to test the desired trunk group; and in which all trunks on the frame to which the marker failed to connect are rendered artificially busy in order
45 to confine the selection of the idle trunk for use to the second frame, to which the marker succeeded in making an operative connection.

A clearer understanding of the purpose and scope of the invention will be obtained from the following description in connection with the
50 attached drawings in which:

Figs. 1 to 6, when arranged as seen in Fig. 7, show partly in diagrammatic form and partly in detail, a telephone system embodying the features
55 of this invention;

Fig. 1 shows conventionally a subscriber station connected over a line to a district junctor circuit through cross-bar switches of a line link frame. This figure also shows a sender selector, a sender, and a marker connector diagrammatically;

Fig. 2 shows the district selector primary and secondary cross-bar switches. This figure also shows parts of a district frame connector;

Fig. 3 shows parts of two office frames of primary and secondary cross-bar switches, an outgoing trunk group, and parts of the office frame connectors;

Figs. 4, 5 and 6 illustrate one of the switch controlling markers;

Fig. 4 shows the test relays which test for an idle channel extending through district and office link frames to an outgoing trunk;

Fig. 5 shows the relays that test for an idle outgoing trunk; and

Fig. 6 shows controlling relays that cooperate with other apparatus as will be hereinafter described.

Before describing circuit operations in detail, it is advantageous to consider the general features of the system.

A subscriber station 100 is connected over line 101 with the primary switch 102 of the line link frame and thence over the link 103 with the secondary switch 104, both of which switches are indicated in abbreviated diagrammatic form. The connection from the line link frame is extended over the district junctor 105, the control equipment of which is illustrated at 106, to the horizontal conductors of primary district switch 200. These horizontal conductors have access as shown, to any one of a plurality of vertical district links 202, 203, 204, 205, which extend to the secondary district switch 201, and connect thereon with horizontals. These horizontals, although shown connected to the same switch, may also be connected to several different switches. From the secondary switch 201, district links 202, 203, 204, 205 are extended over office junctors 206, 207, 208, 209, respectively, to switches of a pair of office link frames, which frames, for purposes of identification, are in practice consecutively numbered. Accordingly one of the frames will be identified by an even number, and the other by an odd number. Junctors 208 and 209 are shown extending to primary switch 300 of the even numbered frame and junctors 206 and 207 to primary switch 301 of the odd numbered frame. The four junctors aforesaid connect respectively to verticals on the two frames. Junctors 206 and 207, which have access to horizontals of switch 301, are extended over office links 304 and 305 to verticals of secondary switch 303, and junctors 208 and 209, which have access to horizontals of switch 300, are extended over office links 306 and 307 to verticals of secondary switch 302. Links 304, 305, 306 and 307 have access to horizontals of the two switches which are connected with outgoing trunks 314 and 313.

Trunk 312 on the even frame, and trunk 315 on the odd frame, without connections, are also shown. These trunks may be connected to other horizontals, not shown, to which the vertical links 306 and 307, and 304 and 305 may also have access.

When the subscriber of station 100 originates a call the connection is first extended over line 101, through line link switches 102 and 104, connected by link 103, thence over district junctor 105 to the connecting horizontal of district switch 200. The calling line is also extended over con-

ductors 109 through sender selector 110 to an idle sender 108. After the office code of the designation has been received in sender 108 from the calling subscriber's dial, the sender connects to an idle marker, such as the one shown in part by Figs. 4, 5 and 6, through marker connector 111 and over a plurality of conductors 112. The marker now proceeds to select an idle trunk. When this trunk has been selected, an idle channel extending from the district junctor 105 to the selected trunk must be determined. A channel consists of three serially connected elements, that is, a district link between primary and secondary district switches, an office junctor between secondary district and primary office switches, and an office link between primary and secondary office switches. Assuming that an idle channel is found, the marker now operates the proper switch magnets and effects the closure of four sets of switch contacts which thereby complete the connection to the selected outgoing trunk.

Let it be assumed that the trunks are grouped for testing purposes in the order 312-313-314-315. The marker tests the trunks in this order. If, for any reason, after the idle trunk has been selected, the marker cannot complete the connection which thereby necessitates a second trial, the trunk test is made in the reverse order, that is, 315-314-313-312.

If all channels leading to the selected trunk are found busy, then a retest of the group of trunks is made after all trunks on the frame that could not be reached the first time are made artificially busy. For instance, let it be assumed that trunk 314 on the even office frame has been selected on the first test. When a test is then made to select an idle channel it is found that the channels which have access to this trunk, and which terminate in office links 306 and 307 are busy. In a working installation consisting, for instance, of ten district frames and five pairs of mated office frames there would be a maximum of twenty possible channels from each district junctor to each trunk, when only one trunk is assigned to a single horizontal on the office frame. The two channels aforesaid are sufficient, however, to illustrate the operation, and when these are found busy as hereinbefore stated, then all trunks on the even numbered frame are made artificially busy. Accordingly trunks 312 and 314 are made to appear busy to the trunk testing relays which are shown in Fig. 5. One of the trunks 313 or 315 on the odd numbered office frame is then selected on the second test. Assuming that trunk 313 is selected, then a test for an idle channel extending to this trunk is made. A plurality of these channels is represented by the channels terminating in office links 304 and 305.

If the marker is making a first trial and a failure occurs due to an open test conductor extending to one of the pair of office frames upon which pair of frames is located the trunk extending to the called office, then the marker will time out and send a trouble release signal to the sender. One of these test conductors is represented, for instance, by conductor 308. If the connecting relay should fail to operate properly and conductor 308 should not be connected to ground 355, then the marker will time out as hereinbefore stated, provided it is functioning on a first trial. If the marker is engaged on a second or third trial, however, and it encounters a failure of this nature, it does not time out but makes trunks 312 and 314 of the even numbered

frame appear busy to the trunk testing relays, since these trunks are located on the frame on which the assumed trouble in connection with the test conductor 308 was encountered. The marker then proceeds to test the trunks 313 and 315 on the odd numbered frame. If trunk 313 should be found not busy, then the channels terminating in links 304 and 305, which have access to trunk 313, are tested, and, if one of these is found idle, the connection is established to trunk 313.

While the system disclosed is not limited to the use of cross-bar switches of any particular type, reference may be had to the patent to Reynolds 2,021,329 of November 19, 1935, for an understanding of the construction and operation of a switch suitable for use in such systems. Because of the complicated nature of these systems, and since it is not necessary to an understanding of the invention that the system in all of its details be disclosed, much of the circuits and equipment has been eliminated in the present disclosure for the sake of simplicity. And in the following descriptions reference will be made to numerous operations which are not fully disclosed in all of their details. Wherever such references occur it will be understood that the circuits and equipment so referred to are already known, and in particular reference is here made to the following for a detailed disclosure of all operations and equipment referred to herein but not specifically disclosed: Carpenter Patent 2,093,117 of September 14, 1937; and Carpenter application Serial No. 214,356, filed June 17, 1938.

The operation of the system will now be described in detail. When the subscriber of station 100 originates a call over line 101, cross-bar switches 102 and 104 of the line link frame function, extending line 101 through link 103 to the district junctor 105. Junctor 105 is then connected to sender 108 over a plurality of conductors 109 by means of a sender selector mechanism 110, represented by a conventional abbreviation. The connection from station 100 is also further extended over the district junctor to a horizontal of primary district switch 200. At this time select magnet 210 corresponding to this horizontal is caused to operate over a circuit, not shown, extending from junctor control circuits 106. When the subscriber of station 100 has dialed the code of the office to which the call is to be extended, sender 108, having received and registered this code, is connected to an idle marker by a conventionally represented connecting device 111, over a plurality of conductors represented by the line 112. The sender in response to the recorded office code then selectively operates certain relays, not shown, in the marker and causes thereby the selective operation of relay 318 of the office frame connector associated with the even frame, and of relay 319 of the office frame connector of the odd frame. These relays are selectively operated because they are associated with frames on which are located the trunks 312, 313, 314 and 315 extending to the called office. Relays 318 and 319 in operating operate, with their left contacts, associated relays 320 and 321, through circuits not completely shown. Relays 318 and 319 effect the closure of trunk testing conductors 324 and 325, and 326 and 327. Relays 320 and 321 connect to the marker the testing conductors for office links 304, 305, 306 and 307. As will be hereinafter explained, when the particular office frame, even or odd, upon which the selected trunk is located, has been determined, then the relay 320 or 321 cor-

responding to the frame which is not to be used for the call, is released, to avoid interference. Consequently the test conductors are used for both frames, but for only one frame at a time.

With the operation of relays 318 and 319 which closed the trunk testing conductors as hereinbefore described, the marker proceeds to test for an idle trunk in the group of trunks

312—313—314—315.

Referring to Fig. 5, it will be observed that there are shown four files of testing relays, each file corresponding to a trunk. Relays 500, 501, 502 and 503 are used for trunk 312 on the even frame, relays 504 to 507 for trunk 313 on the odd frame, relays 508 to 511 for trunk 314 on the even frame and relays 512 to 515 for trunk 315 on the odd frame. For a working installation provision is made to test trunk groups containing a maximum of forty trunks, twenty trunks being assigned to the even numbered and twenty to the odd numbered frame of a pair of frames. Accordingly it is to be understood that between relay files, 504—507 and 508—511 there should be, on the basis of forty trunks maximum, thirty-six additional relay files—eighteen assigned to even numbered frames and eighteen to odd numbered frames. Although a maximum of forty trunks in a group may be provided, any smaller number may be used. In general, groups containing an even number of trunks are used, the even numbered trunks being assigned to the even numbered frames and the odd numbered trunks to the odd numbered frames.

In the case of groups containing an odd number of trunks, one additional trunk terminal on one of the switches is grounded artificially to maintain the symmetry of the testing chain.

Returning now to the test of the trunks

312—313—314—315,

the marker must indicate before starting the test the beginning and end of the group of trunks extending to the called office. This result is obtained by grounding two of the winding terminals 520, 521, 522, 523, one of the terminals grounded corresponding to a relay test file assigned to the even frame and the other to a file assigned to the odd frame. With this arrangement any even number of trunks from two to forty in a test group may be provided for, and the beginning and end of the group may be located at any point as required by the location of the trunk group on the office frames. Let it be assumed now, for the purpose of this description that the marker grounds terminal 520 of relay 500, and terminal 523 of relay 512, marking thereby the group start and group end points respectively, that trunks 312 and 315 are busy due to ground being connected to their sleeve terminals, and that trunks 313 and 314 are idle. The aforesaid grounding of the sleeve conductors is effected by the closing of their associated switch contacts and is illustrated for trunks 313 and 314, when grounds 353, 359 and 356, 357, respectively, are thus connected to the associated sleeve conductors. The operation of the system whereby an idle trunk is selected will now be discussed.

The grounding of terminals 520 and 523 causes the operation of relays 500 and 512, which lock through their lower contacts and a circuit, not shown in full, to ground 524. Ground connected to the sleeve terminal of trunk 312 is extended through next to innermost contacts of relay 318 over conductor 325, through lower inner contacts

of relay 503 and winding of relay 502 to battery. Relay 502 operates and closes an obvious circuit for relay 501, which operates and disconnects with its upper and lower break contacts the winding of relay 503, preventing the subsequent operation of this relay. In like manner, relay 319 in operating connects the sleeve conductor of trunk 513, with its innermost contacts, to conductor 327 and thence through lower break contacts of relay 507 to the winding of relay 506. Since by assumption, trunk 313 is not busy, there is no ground on its sleeve terminal and consequently relay 506 and, in turn, relay 505 do not operate. Relay 507, however, does operate now from battery through a circuit path left break contacts of relay 519, winding of relay 507, upper break contacts of relay 505, operated upper make contacts of relay 501, upper inner operated make contacts of relay 500, over conductor 525, through upper, outer break contacts of relay 600 and over conductor 619, through operated contacts of relay 617, over conductor 612 and through upper operated contacts of relay 610 to the contacts of relay 609. Relay 617 or 618 operate when even or odd numbered district frames, respectively, are engaged and are used so as to reverse the direction of testing through the trunk testing circuit. When conductor 526 is connected to conductor 612, then the direction of testing is in the opposite direction to that used when conductor 525 is connected. This arrangement evens the wear on the trunk testing relays.

Relay 610 operated, when the marker was first engaged, over conductor 527 and through upper normally closed contacts of relays 515, 511, 507 and 503 to ground 532. Relay 609 is slow to operate, so as to give ample time for the operation of any of the relays, 502, 506, 510, 514, before their operating circuits are opened by relays 503, 507, 511, 515, respectively. When the marker is engaged for the call, the upper and lower windings are energized, but relay 609 does not operate because of the differential connection of the windings. The circuit of the upper winding extends from battery through the winding of relay 609, lower break contacts of relays 605 and 607 in multiple, to ground through the lower multiplied break contacts of relays 606 and 608. The lower winding of relay 609 is energized from battery through resistance 611 to ground. The group of trunks represented by trunks 312-313-314-315 may be arranged on either a split or non-split basis. If arranged on a split basis then the horizontals of the switches are cut in the middle and one half of the trunks are connected to the left horizontals and the other half to the right horizontals. Assuming that the split arrangement is used, then relay 318 of the even frame in operating connects ground 355 with its outermost contacts to conductor 308, operating thereby relay 606 which in operating disconnects ground 614. In like manner relay 319 of the odd frame connects ground 354 to conductor 316, operating relay 608 which disconnects ground 613. The circuit of the upper winding of relay 609 is now open and relay 609 operates slowly, being energized by the current in the lower winding. Should the trunks be arranged on a non-split basis, then the horizontal switch conductors are not cut and each trunk of the group uses an entire switch horizontal. With this non-split arrangement relay 318 in operating connects ground 352 to conductor 309, operating thereby relay 605. Relay 319 connects ground 353 to conductor 317, operating relay 607. The circuit of the upper winding of relay 609 is also thus opened by the

operation of relays 605 and 607. It must be explained that circuits not shown here are provided so that the pairs of relays 606 and 608, and 605 and 607 are operated regularly only when their respective split and non-split arrangements are used.

Relay 609, when it finally operates, connects ground to the winding of relay 507 over the circuit hereinbefore traced. Relay 507 in operating locks through its upper make contacts to ground 532 through normally closed contacts of relay 503. This disconnects ground from the winding of relay 610, which releases, thereby opening the operating circuit of relay 507, which remains locked through the circuit before described. The release of relay 610 also connects ground, with its lower break contacts, to the upper winding of relay 609, thereby reestablishing the original differential condition of the two windings of relay 609, which accordingly releases.

When relay 507 operated as before described, it was an indication that the corresponding trunk 313 on the even office frame was idle. Relay 507 in operating opens, with its lower break contacts, the circuit of relay 506. Let it be assumed now that the marker, because of some trouble condition cannot complete the call. After the timing mechanism 440 has measured an interval of time, the sender 103 receives a trouble release signal, the marker is released, and immediately a second trial is made, with either the same or another marker. The trunks are again tested by the second-trial marker. Assuming, as before, that trunks 312 and 315 are busy and trunks 313 and 314 idle, test relays 502 and 514 operate, and test relays 506 and 510 remain deenergized. For this second trial condition a circuit is closed for operating relay 602, which extends from battery through the winding of relay 602, break contacts of relays 604 and 603 and a circuit path to ground. Relay 602 in operating closes, with its make contacts, a circuit for operating relays 600 and 601. Relay 600 in operating transfers with its upper contacts conductor 619 from its normal connection with conductor 525 to conductor 526. Ground on conductor 526 is connected through the upper, inner operated make contacts of relay 512, lower operated make contacts of relay 513, (which is operated because trunk 315 is assumed to be busy), lower break contacts of relay 509, winding of relay 511 and left break contacts of relay 513 to battery. Relay 511 operates and locks to ground 532 through its upper make contacts and a series circuit through normally closed upper contacts of relays 507 and 503, and of relays, not shown, intervening between relays 511 and 507. Relay 511 in operating opens the circuit of relay 510. Accordingly, it appears from the before-given discussion that, under this second trial condition, the trunk selection process is in the reverse order 315-314-313-312, and that the selected trunk 314 is the one nearest the end trunk 315, and not nearest to end trunk 312, as in the first selection.

It will be noted that this reversal in the order of testing the trunks is accomplished by the operation of relay 600 in the marker when it is seized for a second trial. On a first trial the trunks are all tested simultaneously, as above explained, by the test relays shown in Fig. 5. After the test relays have had time to operate, the chain test circuit, grounded by the relay 609, as described, is extended over conductor 525 through the contacts of the successive test relays, beginning at the left, representing busy trunks until the first

idle trunk is reached. This chain test circuit in effect examines each successive trunk in the group, beginning at one end, until it finds an idle one. And this idle trunk is the one that is taken for use. When a second trial is made, however, the relay 600 is operated as explained, and, after the simultaneous test of all trunks has been completed, the chain test circuit now extends over conductor 526 which proceeds through the contacts of the test relays, beginning at the right in Fig. 5, until the first idle trunk is reached. Thus the successive trunks of the tested group on a second trial are examined in the opposite direction, until an idle one is found.

If, instead of grounding terminal 520 of relay 500 of the extreme left file of test relays shown in Fig. 5, terminal 522 of relay 508 is grounded so that the group start point corresponds to the relay file, consisting of relays 508, 509, 510 and 511, then all relay files to the left of this last-mentioned file are rendered ineffective. If any of the trunks beyond the limit of the test group should be busy then their relays 502, 506, etc. will be operated, causing associated relays 501, 505, etc. to operate. None of the selecting relays 503, 507, etc. can, however, find a path to operate through either operated or non-operated contacts of the relays 501, 505, etc. due to the non-operated condition of the upper inner make contacts of the relays 500, 504, etc.

Having thus described the trunk selection feature it is now in order to discuss the means whereby an idle channel extending between district junctor 105 and the selected trunk is selected and established. Fig. 4 has four files of channel testing relays, each file arranged to test a corresponding channel. Usually, however, provision is made to test a maximum of twenty channels. To facilitate this description the files of relays in Fig. 4 between the ends and two middle files are omitted and the omission is indicated by broken lines. Relays 404, 405, 406 and 407 test the district link and office junctor, and relays 408, 409, 410 and 411 the office link of each channel. In order to provide for installations where there are fewer than twenty channels, lower windings are furnished for relays 408, 409, 410 and 411. These relays are then operated by circuit arrangements not shown, through these lower windings, whenever the corresponding channel is not available, which has the effect of blanking out the missing channel as if it were busy. The selection of a particular channel is indicated by the operation and locking up of the corresponding relay 400, 401, 402 or 403. The relays of Fig. 4 are used to test channels extending to either the even or odd office frames. When relays 213 and 320 associated respectively with the district and office frame connectors, are selectively operated, the test conductors are connected to channels extending to the even frame. Relays 214 and 321 are selectively operated when it is desired to test channels extending to the odd frame. Since there are shown only two complete channels extending to each of the two frames, battery connections to conductors 230 and 231, 236 and 237, 332 and 333, 338 and 339, associated with relays 213, 214, 320 and 321 are shown in order to indicate a complete working arrangement for each file of channel testing relays of Fig. 4.

Let it be assumed that trunk 313 connected to the odd office frame has been found idle as before described. It is now a function of the marker to test the channels extending to this

trunk, and select an idle one over which a connection from the district junctor 105 may be extended. When trunk 313 was selected, relay 507 operated and locked as before described, and connected ground through its lower outer contacts over conductor 424 to the winding of relay 413, which operated. Relay 413 is identified with the odd office frame and in operating opens a circuit extending from ground 418 through break contacts of relays 415 and 413 over conductor 322 and through the winding of relay 320 to battery on the left operated contacts of relay 318. Relay 413 also in operating, effects the operation of relay 214 in a circuit over conductor 219, contacts of relay 413, conductor 443, to ground through the contacts of relay 519, and relay 214 closes the test conductors for junctors extending to the odd office frame. Relays 320 and 321, were previously selectively operated when, in response to information received from sender 108, certain relays, in the marker were operated indicating that the outgoing trunks to the called destination would be found on a pair of even and odd office frames with which relays 320 and 321 were identified. Relay 320 is identified with the even office frame and when it releases due to the opening of its operating circuit as before described, test conductors 332, 333, 334 and 335 are disconnected in order to avoid interference with test conductors 336, 337, 338 and 339 extending to the odd office frame on which is located the selected trunk 313 and to which an idle channel is to be selected.

When the channel test conductors are connected through to their respective test points, relays 404, 405, 406 and 407 operate, through break contacts on relays 400, 401, 402 and 403, respectively, if the connected district links or office junctors, either or both, are busy as evidenced by the presence of ground on their respective sleeve conductors. Similarly, relays 408, 409, 410 and 411 operate if their respective office links are busy. Let it be assumed now, as a basis for description, that the channel consisting of district link 203, office junctor 207 and office link 304 is idle and that all other channels are busy. After the test conductors have been connected for a short interval, which interval is sufficiently long to insure the operation of all test relays that are going to operate, relay 417 operates, through a circuit not shown in full, connecting ground 420 to the armatures of relay 404. With either or both of the relays 404 and 408 operated, the circuit for relay 400 is kept open at either or both of the break contacts of these relays, and ground 420 is further extended to the armatures of relay 405 through a series path consisting either of the make contacts of relay 404 or break and make contacts of relays 404 and 408 and contacts of intervening relays, not shown. By previous assumption the channel corresponding to relays 401, 405 and 409 is idle and consequently the ground on the armatures of relay 405 is extended through break contacts of relays 405 and 409 to the winding of relay 401, which operates and locks through its lower, outer make contacts and a series circuit including lower, outer normally closed contacts of relay 402, intervening relays and relay 403 to ground 421. Since neither relay 405 nor 409 is operated there can be no further extension of ground 420 to the armatures of the next relay, 406. Consequently, starting from the left it is evident that the first idle channel is selected, and that relays 402 and 403 cannot operate whether their corresponding chan-

nels are busy or not. Relay 401 in operating transfers to ground 422, with its inner transfer contacts, conductors 217 and 218 from the windings of relay 405, and with its uppermost transfer contacts conductor 330 from the winding of relay 409. Ground 422 on these three conductors effects the operation of the holding magnets 225 and 226 on the district frame, and 341 and 340 on the odd office frame. Since select magnets 210, 227, 342 and 343 were all previously operated, through circuits not shown, the four cross-points 228, 229, 344 and 345 are accordingly closed, establishing the connection between district junctor 105 and the outgoing trunk 313.

In the hereinbefore given description, the selected trunk was assumed to be on the odd office frame. If trunk 314 on the even frame is assumed to be the idle trunk and an idle channel extending to this trunk is to be selected, then the corresponding relay 511 is operated. This relay connects ground with its lowermost contacts to conductor 425, operating relay 414, which disconnects ground 419 from the contacts of relay 412 and conductor 323, releasing relay 321, which disconnects test conductors 336, 337, 338 and 339 extending to the odd office frame, thereby avoiding interference with corresponding test conductors, 332, 333, 334 and 335, connecting with the even frame.

Relay 213, which connects the test conductors for office junctors extending to the even frame on which is located the selected trunk 314, is selectively operated, through a circuit extending over conductor 222, contacts of relay 414, conductor 442, to ground at the contacts of relay 518. Let it be assumed now that the channel consisting of district link 204, office junctor 208, and office link 307 is available, and that channels corresponding to relays 400, 404 and 408, to intervening relays omitted, and to relays 401, 405 and 409 are busy, channel testing relays 402, 406 and 410 now function to select the aforementioned channel in the manner before described in connection with the selection of a channel extending to trunk 313 on the odd frame.

In the description heretofore given it was assumed that an idle channel leading to the selected trunk could be found. If, however, following the selection of the idle trunk, it happens that no idle channel extending to the selected trunk can be found, then the marker retests the trunk group, first causing the test relays of Fig. 5 to function as if all trunks on the frame to which no idle channel could be found, were busy. Having again found an idle trunk this time, on the other frame of the pair, the marker then repeats the channel test to select if possible an idle channel extending to this second trunk. This feature will now be described in detail.

Let it be assumed now that trunk 313 on the odd office frame was selected as before described, and that the channel testing relays of Fig. 4 functioned to indicate that all channels were busy. With all channels busy, relay 416 is operated in a circuit extending from battery through the winding of relay 416, and thence through a series chain of contacts to ground 420. This series circuit extends through the lower make contacts of each operated relay 407, 406, 405 and 404. When one of these relays is not operated, its associated relay 411, 410, 409 or 408 must be operated because the channel is busy, and then the circuit is completed by way of the lower make contacts of the operated relay and the upper break con-

tacts of the associated non-operated relay to ground 420 through contacts of relay 417.

When trunk 313 was selected relay 507 operated and locked and effected the operation of relay 413 which operates when the selected trunk is on the odd office frame. Relay 413 connects ground to conductor 429 through the lower make contacts of relay 416, thereby operating relay 519, which disconnects battery with its left contacts, from the windings of relays 507 and 515 associated with the odd frame, with its right inner make contacts relay 516 and with its right inner break contacts disconnects ground from conductor 443, thereby releasing relay 214, which disconnects conductors 234, 235, 236 and 237, which test the junctors extending to the odd office frame. Relay 519 also locks to ground 531 through its right outer contacts and a circuit not shown in full. Ground 531 is connected in response to the satisfactory operation of the connecting relays 318 and 319. The operation of relay 516 connects ground, with its right make contacts to the windings of relays 505 and 513, associated with the odd office frame and in like manner to the windings of all other similar relays, not shown, which are associated with the odd frame. Each of these relays now operates, if not already operated, due to the busy condition of their associated trunks. This has the effect of making each trunk of the subgroup located on the odd office frame test busy on the subsequent retest.

When battery was disconnected from the winding of relay 507, this relay released and in turn released relay 413. The release of relay 413 connected ground 418 through break contacts of relays 415 and 413 to conductor 322, thereby reoperating relay 320 of the even office frame, which relay was released when the trunk 313 of the odd office frame was previously selected. Relay 320 in operating connects test conductors 332, 333, 334 and 335 to the channel testing circuit of Fig. 4. These conductors test the office links of the even frame. In response to the release of relay 214 heretofore described, relay 417 releases, disconnecting ground from 420 from the channel testing circuit.

With all trunks on the odd office frame responding as busy to the test circuit of Fig. 5 and assuming that trunk 314 of the even frame is idle, relay 511 operates through left break contacts of relay 518 as hereinbefore described in discussing the trunk testing feature. Relay 511 locks to ground 532 through its upper contacts and the series chain consisting of the normally closed contacts of other similar relays. With its lower make contacts, it connects ground to conductor 425, thereby operating relay 414 associated with the even frame. Relay 414, with its break contacts disconnects ground 419 from the break contacts of relay 412 and conductor 323, thereby releasing relay 321 which disconnects the conductors 336, 337, 338 and 339 which test the office links of the odd frames, thereby preventing interference when subsequently testing the corresponding links of the even frame. Relay 414 in operating also effects the operation of relay 213, which connects the conductors for testing the junctors extending to the even office frame. After an interval sufficient to insure the satisfactory closing of all the channel test conductors, relay 417 operates and connects ground to the series contact chain of relays 404, 405, 406 and 407. Assuming now that the channel consisting of district link 204, office junctor 208, and office link 307 is idle and that channels corre-

sponding to relays 400, 404, 408 to intervening relays and to relays 401, 405, 409 are busy, then relay 402 will operate through the series contact circuit terminating in ground 420, as before described. Relay 402 in operating locks to ground 421 and transfers conductors 220 and 221 from the windings of relay 406, and conductor 331 from the winding of relay 410, to ground 423, thereby effecting the operation of holding magnets 230, 239, 345 and 347. Since select magnets 210, 227, 348 and 349 are already operated, cross-points 240, 241, 350 and 351 are closed, thereby completing the connection from district junctor 106 to the outgoing trunk 314.

In the foregoing the operation involving the testing of a group of trunks, the selection of an idle trunk, the testing of the idle channels extending to the selected trunk and the selection of an idle channel were described. There is still another feature whereby the marker is arranged to determine whether it has been connected to the office frames and, if on the first trial there is a failure to connect to one of the frames, to time out and send a trouble release signal to the sender. However, if the aforesaid failure to connect to one of the frames occurs on a second or third trial of the marker, the marker instead of timing out as on a first trial now causes the trunk testing circuit to consider busy all trunks connected to the frame in trouble, and to test the trunks on the other frame. This feature will now be described in detail.

Referring now to Fig. 6, relays 605 and 606 are connected over conductors 309 and 308 respectively with contacts of the connecting relay 318 of the even office frame and relays 607 and 608 are connected over conductors 317 and 316 with contacts of connecting relay 319 of the odd office frame. The horizontal conductors of each office frame may be cut in the middle providing so-called split horizontals with this arrangement: one trunk may be connected to the left half, and another trunk to the right half horizontal, there being accordingly two trunks for each split horizontal level. Where the horizontals are not split there will, of course, be only one trunk for each level. For each group of trunks there must be either the same split or non-split arrangement on both frames, not both arrangements. Consequently, for any particular group of trunks, relay 605 may be assigned for the non-split and relay 606 for the split arrangement on the even office frame and similarly relays 607 and 608, respectively, may function for the odd frame.

Let it be assumed now that the trunks are arranged on a split level basis. With this arrangement, when connecting relay 318 operates, conductor 308 is connected to ground 355 operating relay 606, but ground 352 is left unconnected at this time so that relay 605 does not operate. When relay 319 operates ground 354 is connected to conductor 316 operating relay 608, but ground 353 is left unconnected so that relay 607 does not operate. Assuming that relays 606 and 608 operate as stated, indicating the satisfactory functioning of relays 318 and 319 and thereby the satisfactory connection of the marker to both office frames, grounds 613 and 614 are disconnected from conductor 615 by the lower break contacts of relays 608 and 606, thereby removing ground from the lower multiplied break contacts of relays 605 and 607 and the winding of relay 609. Relay 609 now operates as before described and connects ground through its own contacts, operated contacts of relay 610, over conductor

612 through operated contacts of relay 617 to the upper transfer contacts of relay 600. If the marker is functioning on a first trial, relay 600 will be normal and connection will be made to conductor 525, discussed hereinbefore.

If the trunks are arranged on a non-split basis, then grounds 352 and 353 are connected by the operation of relays 318 and 319, grounding respectively conductors 309 and 317, assuming that these relays operate satisfactorily. Relays 605 and 607 now operate and disconnect the grounded conductor 615 from the upper winding of relay 609, which operates as before, starting the trunk testing circuit of Fig. 5.

The before-given discussion assumed that relays 318 and 319 operated satisfactorily. Assume now that the trunks are arranged on a non-split basis and that relay 605 fails to operate, indicating that relay 318 has failed to effect a proper connection to the even office frame. Although relay 607 operates at this time indicating that relay 319 functioned properly, ground from the upper winding of relay 609 is not removed, thereby preventing the operation of this relay and the connection of ground to conductor 612 so that the relays of Fig. 5 can start testing the trunk group. A similar result is obtained if relay 607 fails to operate and relay 605 operates, or if both relays 605 and 607 fail to operate. If the trunk groups are arranged on a split horizontal basis, relays 606 and 608 function in the same manner as relays 605 and 607, removing ground from the upper winding of relay 609 only if both relays operate. If the marker is now operating on a first trial, relay 600 will be normal, and due to the non-operation of relay 609 the call will be blocked. After an interval the timing mechanism 440, which begins to count time when the marker is taken in use, causes a release signal to be sent over conductor 441 to the sender 108. The sender then releases itself from the marker, and the marker restores to normal. This is described in detail in the Carpenter patent and in the Carpenter application aforesaid.

The sender will now select another marker for a second trial, and this will cause slow releasing relay 602 in the second marker to operate by reason of a signal received from the sender 108. Relay 602 in operating closes a circuit from ground through its upper make contacts and the multiplied windings of relays 601 and 600 to battery. These relays now operate and lock to ground 616. Assume now, as a basis of description, that the trunk group is arranged on a non-split basis and that relay 607 operates due to the grounding of conductor 317 which is extended to the odd frame, but that relay 605 associated with the even frame due to some trouble condition fails to operate. A circuit is then closed to operate relay 604, which circuit extends from battery through the winding of relay 604, upper break contacts of relay 605, upper inner operated contacts of relay 607 to ground 616 on the operated lower inner contacts of relay 600. The operation of relay 604 opens the operating circuit of relay 602, which starts to release. This relay is arranged to release slowly so that on normal second and third trials of the marker it will not have time to release if there is the usual difference in time between the operation of relays 605 and 607, which would be the result of a difference in operating time of relays 318 and 319. On second and third trial calls, relay 604 may be expected to operate momentarily, but it will release before relay 602 has had time to release and with its

lower break contacts close a locking circuit for relay 604, which locking circuit will be herein-after described. Assuming now relay 604 operated, as before stated, due to a trouble condition

5 on the even frame, it then locks through its upper inner make contacts, lower break contacts of relay 602 and lower inner make contacts of relay 600 to ground 616. Ground on the operated con-

10 tacts of relay 601 will be extended through the upper break contacts of relay 602, lower make contacts of relay 604, over conductor 528 and through the winding of relay 517 to battery. Re-

15 lay 517 now operates and connects ground through its right contacts to the windings of relays 501 and 509, and of other relays, not shown, corresponding to trunks on the even frame, which by assumption was in trouble. This causes all

20 trunks on the even frame to appear busy to the trunk testing circuit. If now relay 607 fails to operate and relay 605 operates indicating that trouble exists on the odd numbered frame, then

25 relay 603 operates in a circuit from battery through its winding, upper break contacts of relay 607, upper make contacts of relay 605, lower inner make contacts of relay 600 to ground 616. Relay 603 locks through its upper make contacts

30 to ground 616 through the lower break contacts of relay 602 and the lower inner make contacts of relay 600. Relay 603 closes a circuit for operating relay 516 which circuit extends from bat-

35 tery through the winding of relay 516, over conductor 529, through lower make contacts of relay 603, upper break contacts of relay 602 to ground on the make contacts of relay 601. Relay 516

40 connects ground through its right make contacts to the windings of relays 505 and 513, and of other similar relays, not shown, of the odd frame. Consequently, the trunk testing circuit functions now as if all trunks on the odd numbered frame

45 were busy. Since relays 603 and 604 cannot operate simultaneously as their respective operating circuits are both open when relays 607 and 605 are both operated, it follows that relays 516 and 517 cannot both be operated at the same time.

50 When relay 516 operated indicating trouble on the odd numbered frame, the left inner contacts of this relay connected together conductors 533 and 534 which connect respectively with conduc-

55 tors 317 and 309, extending to the windings of relays 607 and 605 of the even and odd frames respectively. Since the trouble is on the odd frame, relay 607 did not operate, but now the winding of relay 607 is joined over conduc-

60 tors 533 and 534 with the grounded winding of relay 605. Relay 607 now operates and ground is accordingly removed from the upper winding of relay 609 as hereinbefore described. The op-

65 eration of relay 607 opens the operating circuit of relay 603, but this relay now holds on its locking circuit. Relay 609 operates and connects ground to conductor 612 through the upper con-

70 tacts of relay 610, which is operated through the series chain connection of the upper normally closed contacts of relays 501, 505,—509, and 513.

75 A trunk on the even frame is now selected as before described. If the trouble is on the even numbered frame then relay 517 in operating also connects together with its inner left contacts conductors 533 and 534. In this case relay 605

not being operated from the connecting relay 318, is operated now by the ground on the wind-

ing of relay 607. Relay 609 operates as before and a trunk on the odd numbered frame is selected.

When the trunk group is arranged on a split

basis and one of the relays 606 or 608 fails to operate then when relay 516 or 517 operates, conductors 535 and 536 are connected together and cause the non-operated relay 606 or 608 to operate from the ground on the winding of the operated relay, thereby removing ground, as before, from the upper winding of relay 609, which operates and avoids the blocking of the call.

Another feature of the before-described circuit arrangement is that whereby the marker is arranged to time out on a second or third trial when the hereinafter described irregularities occur. Relays 605 and 607 are used for the non-split, and relays 606 and 608 for the split horizontal arrangements of the office frame. If now one of the relays of the split arrangement should be operated at the same time as one of the relays of the non-split arrangement, then the marker will time out due to the non-removal of ground from the upper winding of relay 609, which consequently does not operate to start the trunk selection. This is because each of the heretofore-mentioned relays is provided with lower inner make contacts so connected that when any two dissimilar relays are operated, the upper winding of relay 609 is connected to ground in series with the two aforesaid operated make contacts. To illustrate, assume that the pair of relays 605 and 607 is properly operated, but that relay 606 is at the same time improperly operated. The upper winding of relay 609 now remains connected to ground 614 through lower inner make con-

5 tacts of relays 605 and 606 and relay 609 fails to operate. Or, suppose that dissimilarly paired relays 607 and 608 only are operated. The upper winding of relay 609 is now connected to ground 613 through lower inner make contacts of relays 607 and 608. Similar circuits may be traced for other combinations of operated dissimilar relays.

What is claimed is:

1. In a telephone system, a group of trunks, a marker arranged to make a plurality of trials to extend a call over said group of trunks, a series of test relays in said marker for testing the respective trunks of said group, and a circuit arrangement associated with said series of test relays for selecting the idle trunk nearest one end of the group on a first trial by the marker and for selecting the idle trunk nearest the other end of the group on a subsequent trial by the marker.

2. In a telephone system, a group of trunks, a marker arranged to make a plurality of trials to extend a call over said group of trunks, a plurality of test relays in said marker for making a simultaneous test of all the trunks in said group, a selecting circuit cooperating with said test relays to examine the tested trunks in a definite order if the marker is engaged in a first trial and to examine said trunks in a different order if the marker is engaged in a subsequent trial, and means controlled by said selecting circuit to select for use the first idle trunk encountered.

3. In a telephone system, a group of trunks, a marker arranged to make a plurality of trials to extend a call over said group of trunks, a plurality of test relays in said marker, means for connecting said test relays respectively to said trunks to make a simultaneous test thereof, all relays corresponding to busy trunks operating and those corresponding to idle trunks remaining deenergized, a selecting circuit cooperating with said test relays for selecting an idle one of said trunks, means for extending said selecting circuit to the contacts of successive test relays in a given order to select the first idle trunk nearest one end

of said group on a particular trial by said marker, and means for extending said selecting circuit to the contacts of successive test relays in the reverse order to select the first idle trunk nearest the opposite end of said group on a different trial by said marker.

4. In a telephone system, two selector switches, a group of trunks divided into two subgroups, the first of which appears in the first of said switches and the second of which appears in the second switch, a set of links leading to said first switch and a second set of links leading to the second switch, means for testing all of said trunks and for selecting one in either subgroup, means for testing the links reaching the corresponding switch, means effective if all of the tested links are busy for repeating the test of said trunks and for preventing the selection of a trunk in the subgroup containing the first selected trunk, and means effective if an idle trunk is found in the other subgroup on said second test for testing the links of the set reaching the switch corresponding to said other subgroup.

5. In a telephone system, a pair of selector switches, a group of trunks divided into two subgroups, one of which appears in the first switch and the other in the second switch, a plurality of link paths extending to said first switch, a second plurality of link paths extending to the second switch, means for testing all of said trunks and for selecting an idle one in either the first or the second subgroup, means for testing the link paths extending to the corresponding switch, means effective if all of the tested link paths are busy for repeating the test of all of the trunks in said trunk group, means for rendering artificially busy all trunks in the subgroup containing the first selected trunk to cause the selection of an idle trunk in the other subgroup on the retest, and means effective if an idle trunk is found on retest in said other subgroup for testing the link paths extending to the corresponding switch.

6. In a telephone system, a pair of automatic switches, a group of trunks divided into subgroups, said subgroups appearing respectively in said automatic switches, a marker arranged to

make repeated trials to establish a connection over said trunk group, means for establishing a connection between the marker and both of said switches, means in the marker for testing simultaneously all of the trunks in said group, means for testing the condition of the connections established between the marker and said switches, means effective if the connection between the marker and either of said switches is unsatisfactory on a first trial by the marker for causing the marker to bring about a second trial, and means effective if on a subsequent trial by the marker the test of the connection to either of said switches is unsatisfactory for causing all trunks on such switch to appear busy to the marker and for causing the marker to proceed with the selection of an idle trunk in the subgroup appearing in the other of said switches.

7. In a telephone system, a pair of automatic switches, a group of trunks divided into two subgroups, one of which appears in the first switch and the other in the second switch, a common marker arranged to make repeated trials to establish a connection over said trunk group, means effective when the marker is seized for establishing a connection between the marker and both of said switches, testing means in the marker for making a simultaneous test of the trunks in both subgroups, means in the marker for making separate tests of the condition of the connections established between it and said switches, means effective if either connection between the marker and one of said switches tests unsatisfactory or if both connections are unsatisfactory on a first trial of the marker for causing the marker to release and bring about a second trial, and means effective if on a subsequent trial by the marker the test of the connection to either one of said switches is unsatisfactory for causing all trunks in the subgroup appearing on said switch to test artificially busy to the marker and for causing the marker to proceed with the test of the subgroup of trunks appearing in the other of said switches.

RALPH E. HERSEY.