Oct. 15, 1935. L. H. ALLEN ET AL 2,017,644

SERVICE OBSERVATION SYSTEM

Filed Jan. 6, 1933 9 Sheets-Sheet 1

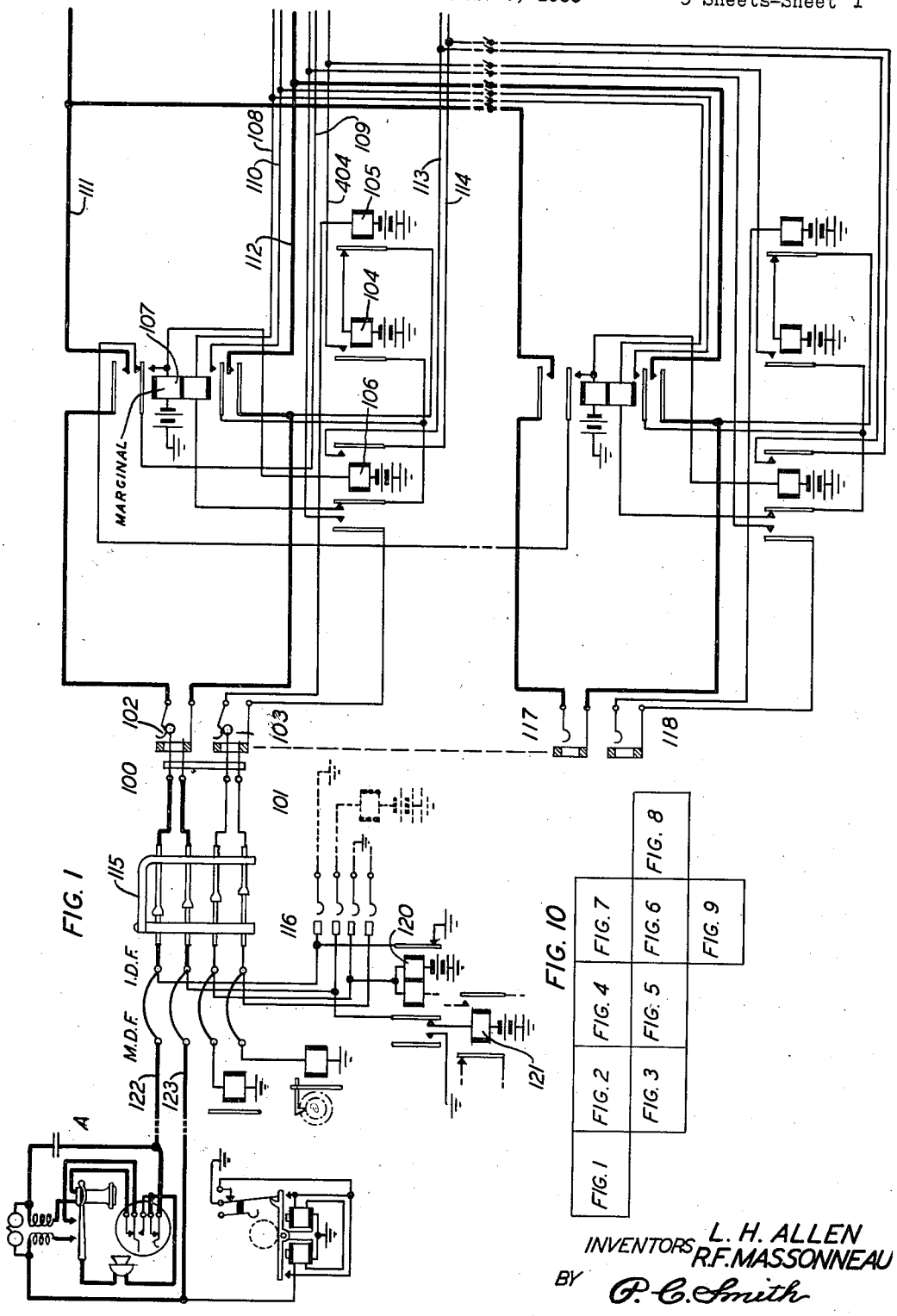

FIG. 1

FIG. 10

		FIG. 8	
	FIG. 7	FIG. 6	FIG. 9
FIG. 4	FIG. 5		
FIG. 2	FIG. 3		
FIG. 1			

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SERVICE OBSERVATION SYSTEM

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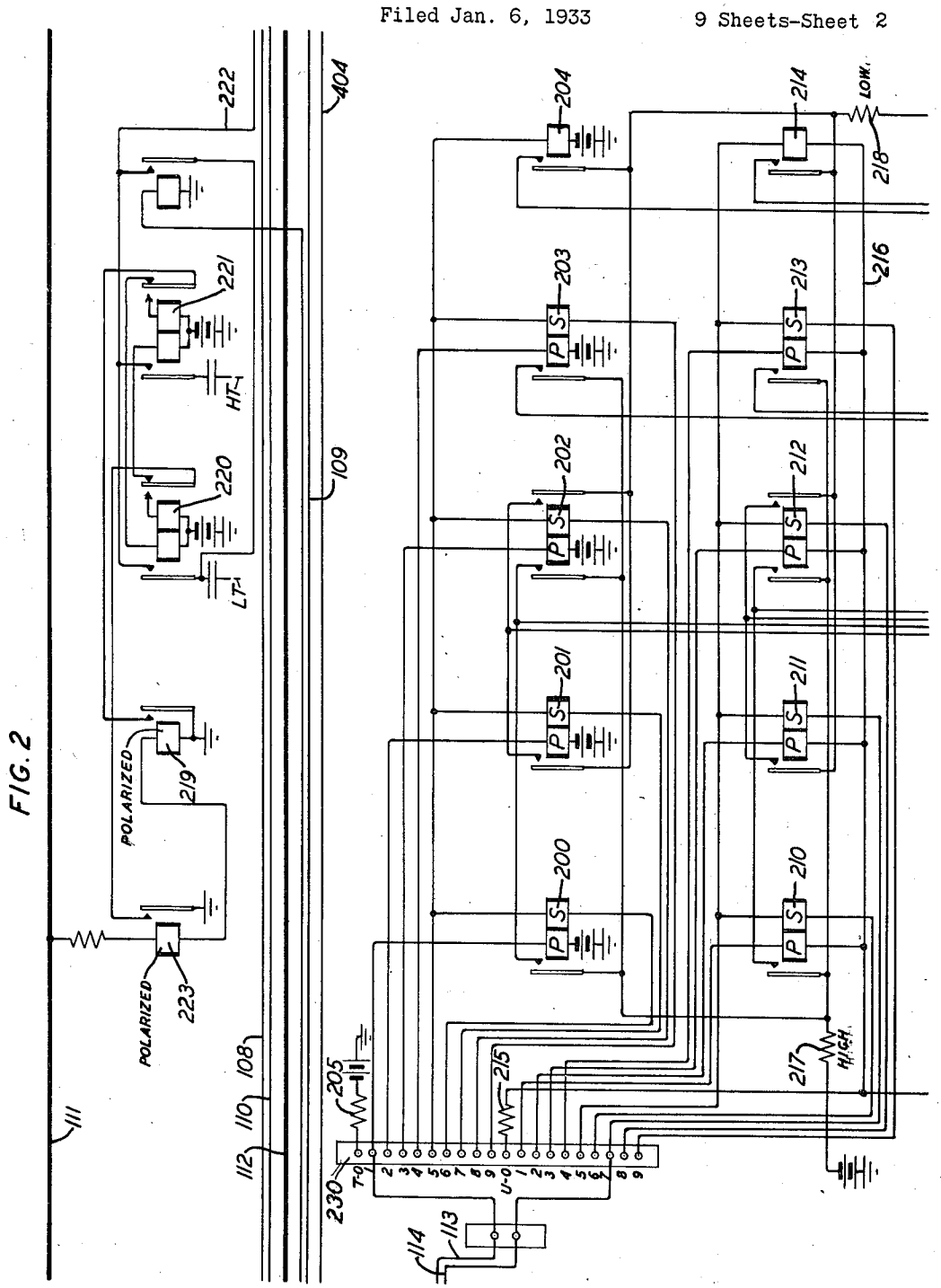

FIG. 2

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SERVICE OBSERVATION SYSTEM

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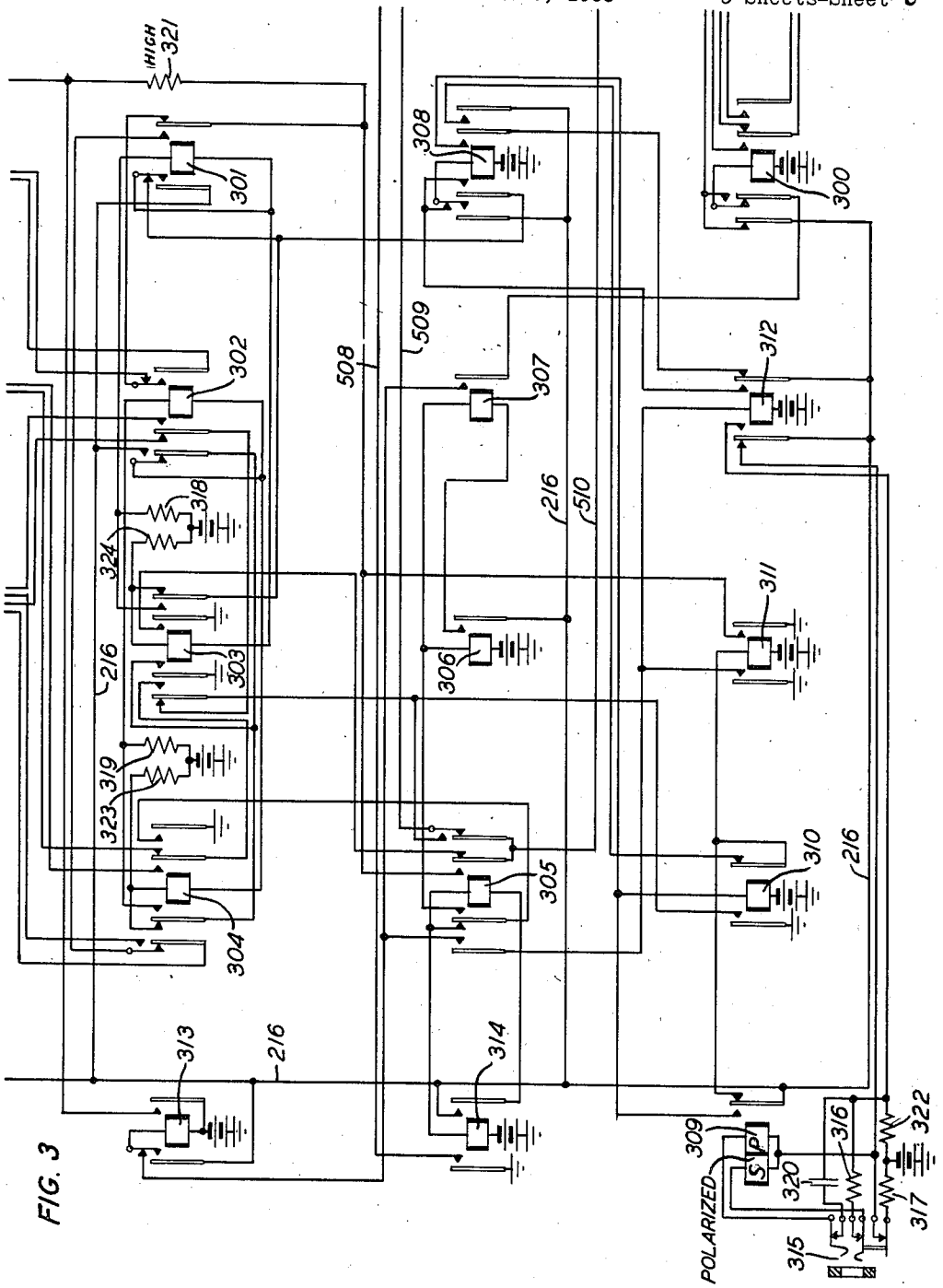

FIG. 3

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SERVICE OBSERVATION SYSTEM

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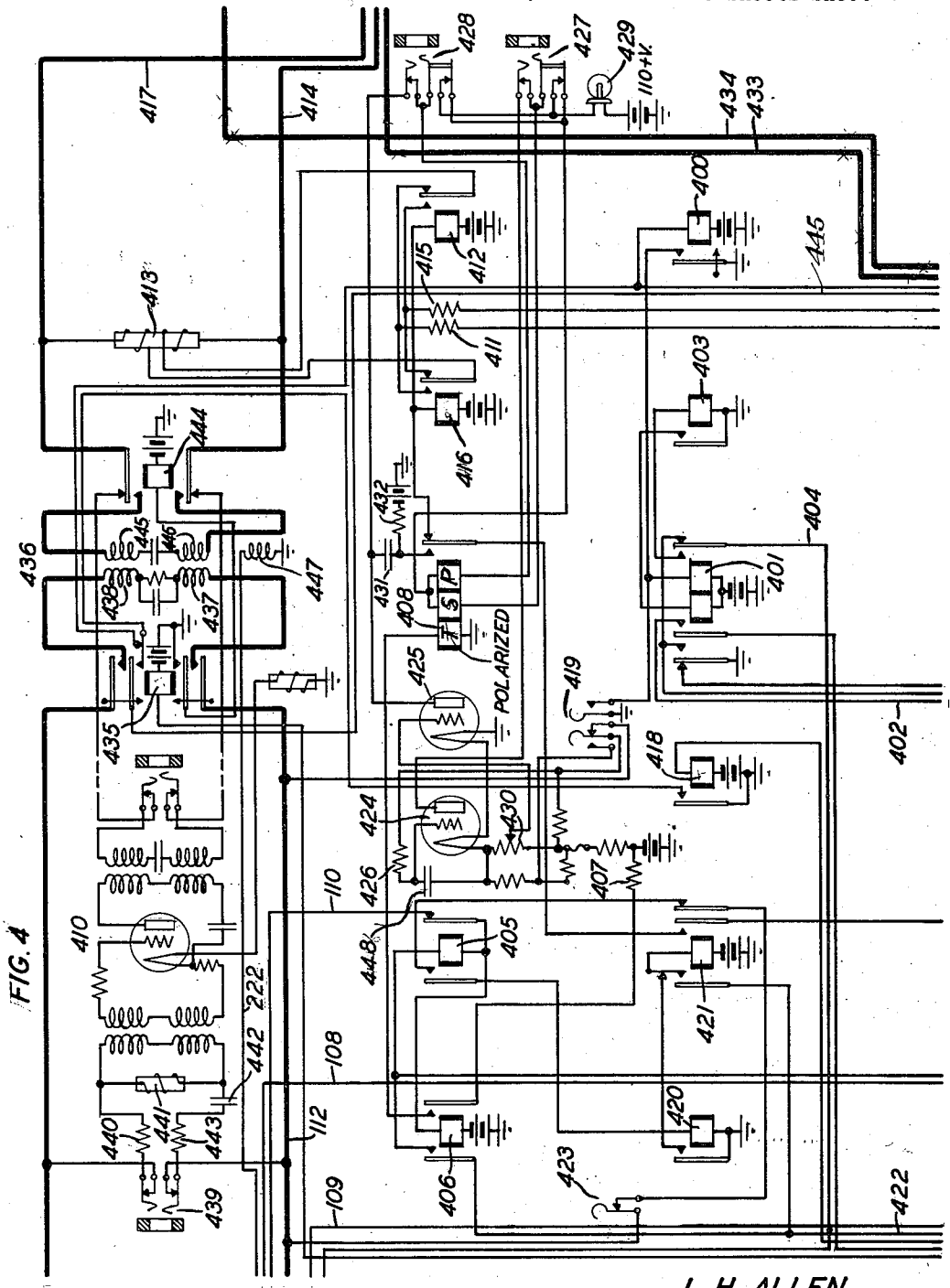

FIG. 4

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SERVICE OBSERVATION SYSTEM

Filed Jan. 6, 1933 9 Sheets-Sheet 5

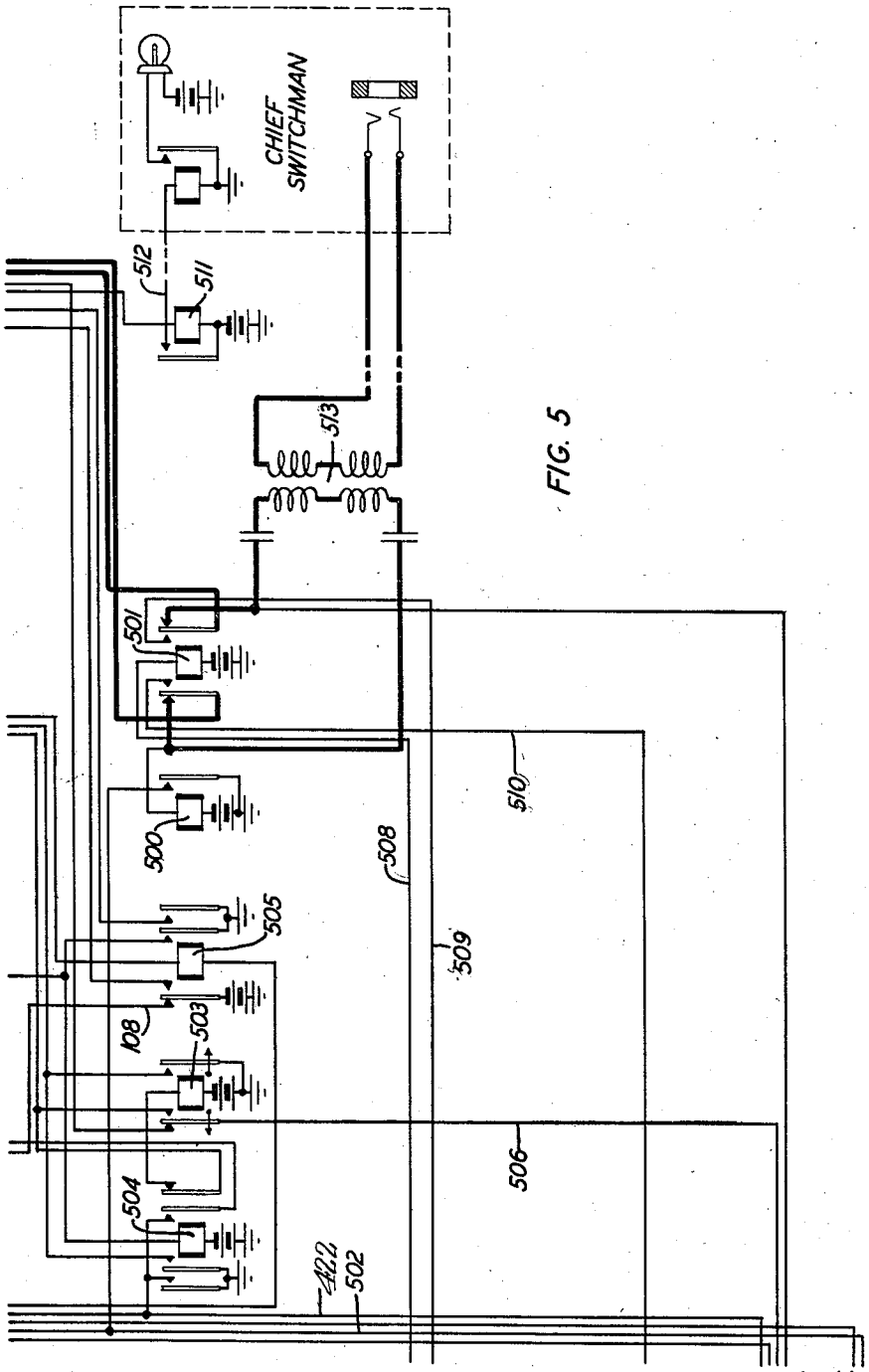

FIG. 5

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SERVICE OBSERVATION SYSTEM

Filed Jan. 6, 1933 9 Sheets-Sheet 6

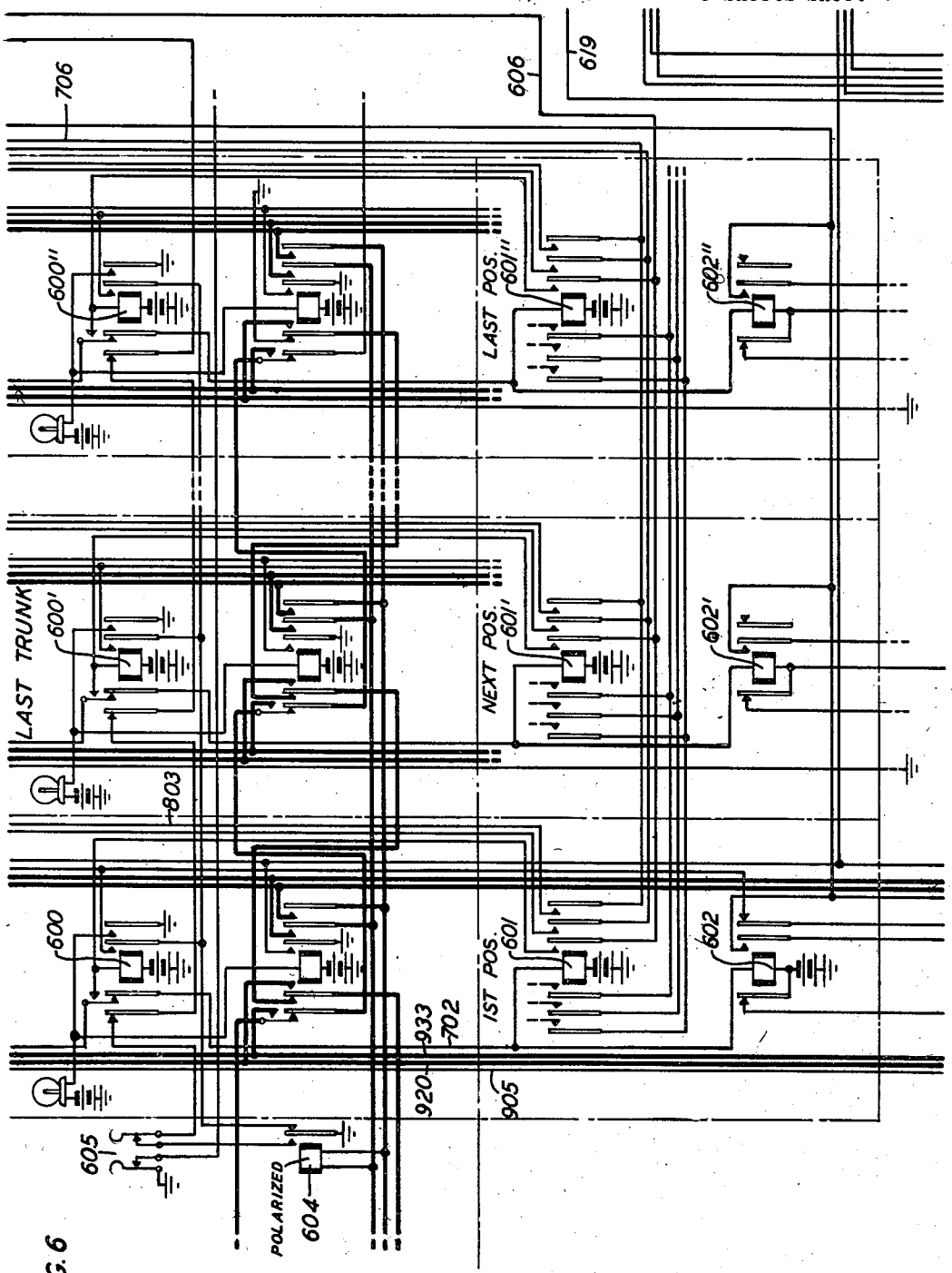

FIG. 6

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SERVICE OBSERVATION SYSTEM

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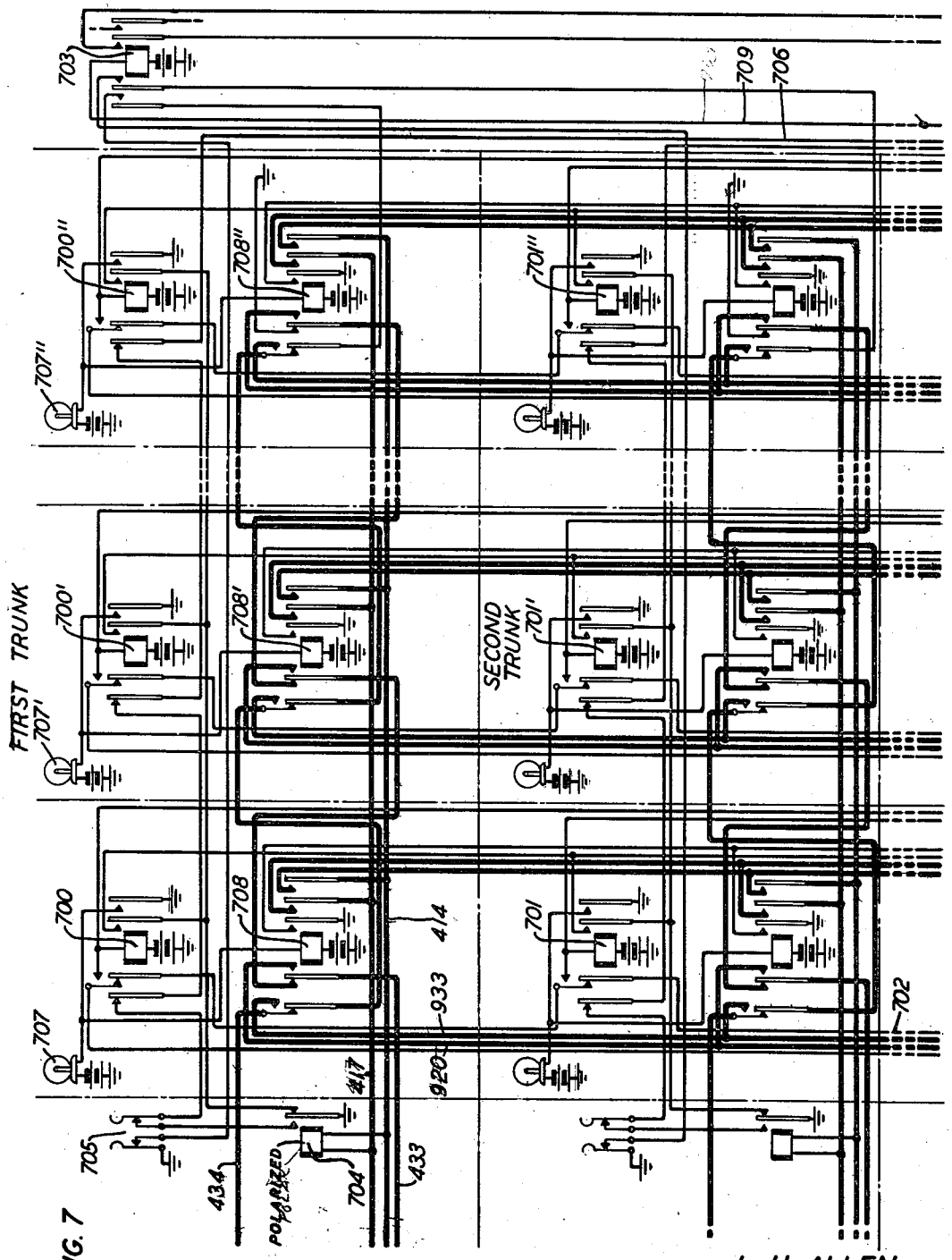

FIG. 7

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SERVICE OBSERVATION SYSTEM

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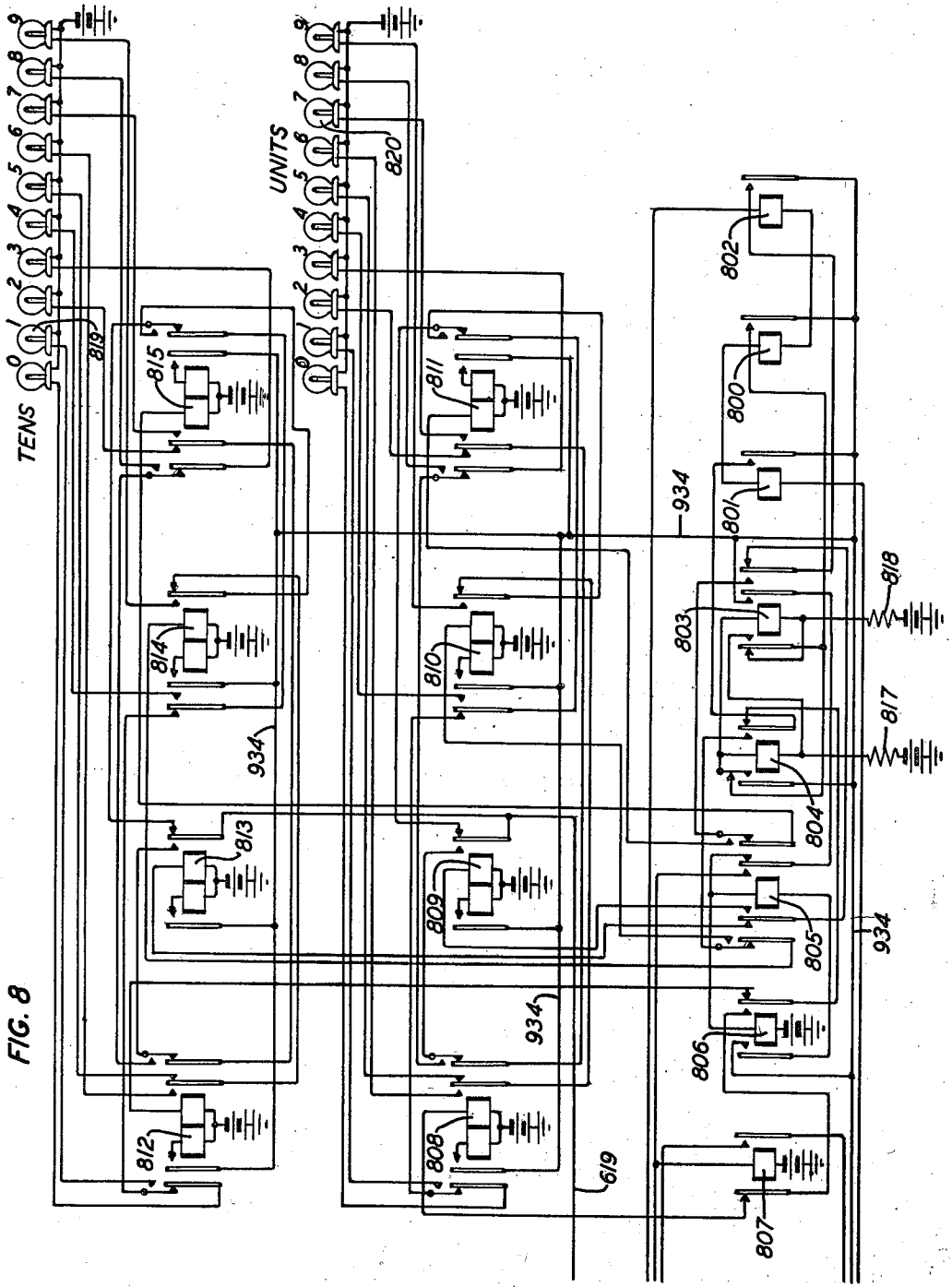

FIG. 8

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SERVICE OBSERVATION SYSTEM

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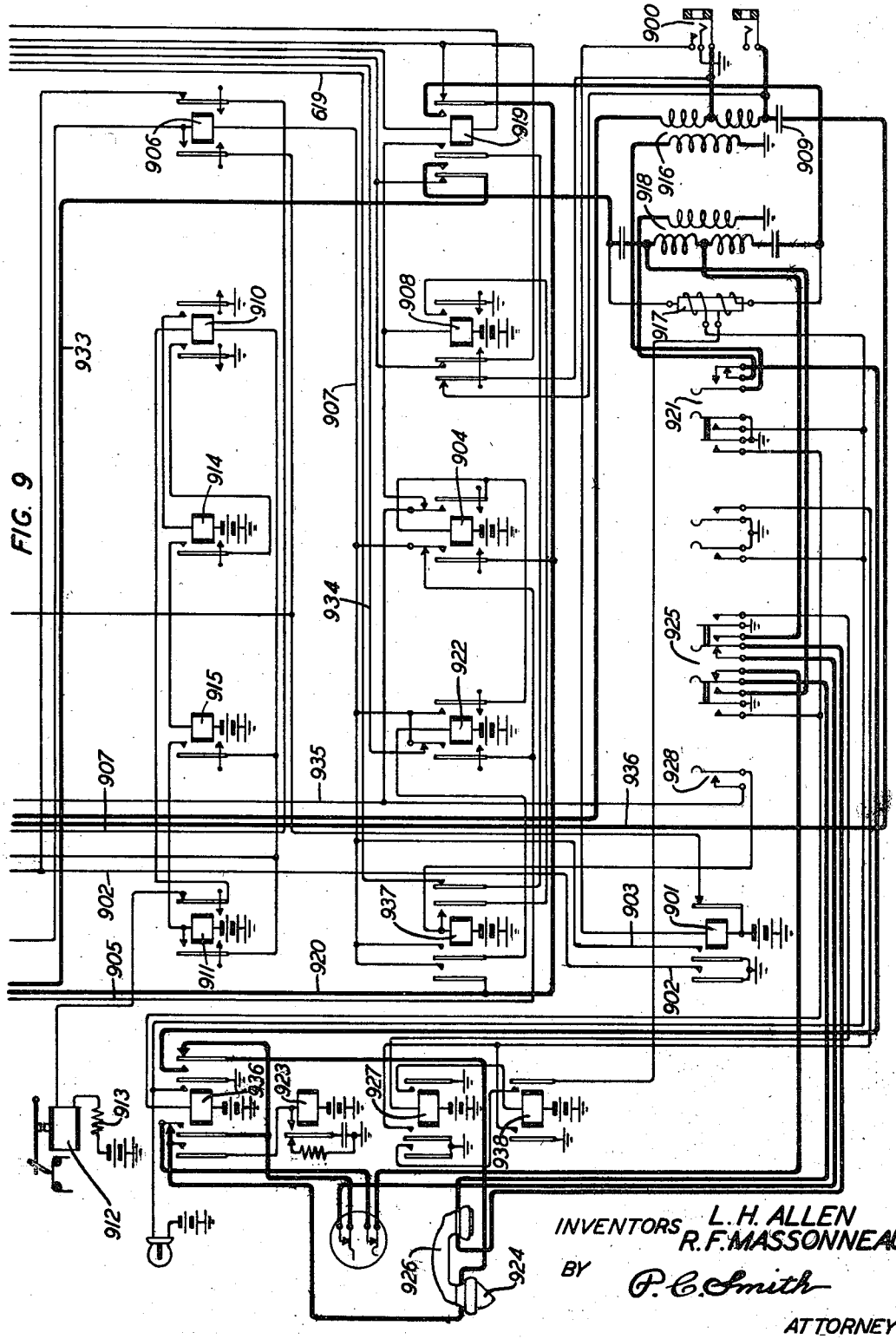

FIG. 9

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Patented Oct. 15, 1935 2,017,644

UNITED STATES PATENT OFFICE

2,017,644

SERVICE OBSERVATION SYSTEM

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Application January 6, 1933, Serial No. 650,474

22 Claims. (Cl. 179—175.2)

This invention relates to telephone exchange systems and is more particularly concerned with what is known as centralized service observation equipment, that is, apparatus for studying from a central point the quality of service given on a particular subscriber's line.

In such systems, where machine switching apparatus is employed at the central office for setting up connections, it sometimes happens that a subscriber will complain of poor service. The substance of these complaints embraces almost the entire range of telephone service and necessarily includes such items as wrong numbers, don't answer calls, overcharges and the like any or all of which may be either due to the improper use of the calling device or the faulty performance of the central office equipment. It becomes necessary, therefore, when a subscriber complains of poor service, to determine from an actual observation of his line whether poor service is actually being rendered and, if so, to determine the cause.

There are two ways of doing this. One is to provide at the local office a special observation desk equipped with apparatus and circuits for taking all the required observation on subscribers' lines. The observation operator presiding over the desk, in such a case, may inspect the operation of all switching equipment involved in the particular subscriber's line responsive to the origination of a call thereon. The other is to provide switching facilities at the local office in which subscribers' lines are located and by which the lines to be observed are connected over a common trunk to a central observing point. The operator located thereat can then observe, monitor or supervise, the service on groups of trunk lines extending to a plurality of outlying offices or exchanges and to which trunk lines are connected the subscribers' lines under observation.

Our invention has to do with the latter of the two methods and is particularly concerned with a central observing bureau provided with a plurality of service observation desks at each of which are extended the trunks connecting with the several outlying offices.

One of the features of our invention is to be found in the automatic distribution of incoming service observation calls amongst all of the observation desks at the central bureau wherein a preferential arrangement is provided in which an incoming trunk signal is given at an observation desk only if said desk is occupied and idle; the signal being advanced to the next preferential desk if the previous one is either busy or unoccupied.

Another novel feature of our invention is concerned with the transmission of a group of impulses to the service observation desk at which a call is taken up for observation to designate the numerical indication of an arbitrary number assigned to the line making the call from a particular local office so that the central operator, in observing the service on said line over a trunk in that office, may identify the line connected thereto by its numerical designation.

Yet another feature of our invention is concerned with the means provided at the central observing bureau whereby an operator may both talk and listen either to the subscriber whose line is under observation or to any one of the maintenance force in the office with which the central observation desk is then operatively connected over an observing trunk line.

Yet another feature of our invention has to do with an arrangement between calling observing lines, the observing trunk and the observation position whereby a calling line may not be connected to the observation trunk if, prior to the initiation of a call, said trunk has not been locked into said position through the occupation thereof, thereby insuring service observation on said line from the very inception of the call.

In accordance with the invention, therefore, one specific embodiment of which is disclosed herein by way of illustration this is accomplished in the following improved manner: At the local office the group of lines to be observed at the central bureau is connected to circuit control devices for extending one of such lines when calling over a trunk connecting said office with the central service observation bureau. A group of registers is associated with the connecting trunk to which each of said lines is cross-connected in accordance with an arbitrary number assigned for identification purposes.

The connecting trunk contains the usual sensitive and amplifying devices of the type disclosed in Patent 1,795,656 to R. F. Massonneau, granted March 10, 1931 but in addition thereto, an impulse circuit is provided which cooperates at the proper time with the above mentioned registers to transmit a group of impulses characteristic of the arbitrary identifying number assigned to a line to be observed.

The service observation connecting trunks radiate from the central service observation bureau to all of the local offices embraced in the service observation area and each of these trunks

is multiplied to all the observation desks at the bureau. A preference lock-out arrangement associates together at each desk all the trunks from the various offices, and the taking up of a trunk from any office at a preferred desk automatically advances the preference of a succeeding call from any office to the next succeeding idle desk.

Each desk is provided with an appropriate impulse responsive device and a lamp display indicator controlled thereby both of which, at the proper time, become associated with the trunk which has been locked into the position. The group of impulses designating the number assigned at the local office to the calling line is received by said responsive device for setting said indicator to display at the position the identifying number of the line under observation.

When, therefore, a subscriber's line which is marked for observation, initiates a call the line is automatically connected to the trunk extending to the central observation bureau. The preference lock-out circuit operates to extend the connection to the first preferred desk which is both idle and occupied and a lamp associated with the trunk is lighted to indicate the appropriation of the trunk for service observation purposes. Immediately thereafter, that is, after the trunk has been locked into position, the impulse circuit at the local office is operated in conjunction with the operated registers and impulse circuit to transmit to the operator's position the group of impulses which identify the assigned number of the calling line under observation.

The observation desk is provided with appropriate equipment to supervise all the functions necessary in the setting up of a call, the operator listening to the various impulses and signals transmitted over the subscriber's line to set up the call while a pen register records said impulses and signals. The operator is further provided with means for fully controlling the disposition of the subscriber's line and may talk to the subscriber or to a maintenance man in the connecting office if desired. When the operator is satisfied with the observations on the line or is otherwise satisfied that all possible action has been taken thereon, said line may be either further held or disconnected in which latter event the trunk is returned to normal, the indicator is extinguished and the desk cleared for other incoming service.

A clearer conception of the scope and purpose of the invention may be obtained from a consideration of the following description and attached drawings in which:

Fig. 1 shows a subscriber's line connected to an outgoing service observation trunk equipped with parallel extension circuits to a plurality of other lines;

Figs. 2 to 5, inclusive, show the outgoing equipment and cooperating circuits of said outgoing service observation trunk;

Figs. 6 and 7 show a number of incoming service observation trunks from different local service observing offices including the trunk shown in Figs. 2 to 5 from the central office of Fig. 1. These trunks terminate in a plurality of central observation positions, the circuit equipment of one of which is shown in detail in Figs. 6, 8, and 9;

Fig. 8 shows the observing line number indicating circuit furnished for each central observation position; and

Fig. 10 shows how Figs. 1 to 9 are to be arranged with respect to each other in order to disclose the invention completely.

The subscriber's line A, which is one of a plurality of lines terminating in the contacts of the line finder 116, in entering the central office, is first connected to the main distributing frame MDF. From here it is extended to the terminal racks of the intermediate distributing frame IDF. At said intermediate distributing frame, the line is connected to the desired terminals in the bank of the line finder frame 116. When, however, it is desired to make observations on the subscriber's line A a shoe 115 is attached to the line side of intermediate distributing frame. This shoe is the terminating end of a pair of cords 100 and 101. To complete the association of the line A with the outgoing trunk extending to the central observing bureau, the plugs of said cords are inserted, respectively, in the jacks 102 and 103 in which the observation trunk terminates, provided at some convenient location in the vicinity of the distributing frame. In this manner, the line A is connected by means of a special trunk to the plurality of central observation positions, which trunk extends to each one of said positions as shown in Fig. 7.

In a like manner any desired number of other lines, similar to line A, may be extended to the central observation positions over the same outgoing trunk through parallel connection extensions thereto by means of other connecting shoes and cords plugged into trunk multiple jacks such as 117 and 118. The number of jacks multipled to each trunk depends on the number of lines which are to be observed over a given period of time. For the purpose of this description, it is assumed that a maximum of 100 lines may be connected to the special service trunk, and that line A comprises one of the lines in such an observing group. It is further assumed that line A, for purposes of identification, is given the arbitrary number 17.

Assuming, therefore, that line A is connected to the service observation trunk through jacks 102, 103, as described, then, when the subscriber removes his receiver from the switchhook a circuit is completed from ground on the right contacts of cut-off relay 120, tip conductor 122 of the subscriber's loop, ring conductor 123 of the subscriber's loop, left inner contacts of relay 120, winding of relay 121 to battery and, in parallel thereto, ring of cord plug 100, sleeve of jack 102, contacts of relay 105, winding of relay 104 to battery. Both relays 121 and 104 operate, the former to close circuits for starting a line finder switch in motion for connection with the terminals of the calling line on the line finder frame 116 and the latter to initiate operations for extending the service observing trunk to an idle and occupied observing position at the central observation bureau.

The operation of relay 104 closes a partial path from battery on the back contacts of relay 505, conductor 108, lower winding of relay 107, back contact of relay 106, contacts of relay 104, conductor 404, to the right back contacts of relay 401. Now if the trunk is in a condition to accept the call; that is, if an operator is servicing any one of the observing positions at the central observation bureau to which the trunk has access, relay 401 may or may not be operated depending on whether or not the position has become occupied prior to the initiation of the call by the calling line under observation.

Now, a position at the central observation bureau is made responsive to the seizure of a trunk terminating thereat by the operator plugging her telephone headset into the telephone jacks 900 located at that position. When this takes place, a circuit is closed for relay 901 extending from ground on the make-contacts of the monitoring jacks 900 to the winding of said relay causing said relay to operate. Relay 901, over its left inner contacts, connects ground to conductor 903 and causes the operation thereby of relay 601 over a path extending from ground on conductor 903, left normal contacts of relay 904, conductor 905, left inner normal contacts of relay 700 of the first trunk of all service observing trunks incoming from outlying offices and capable of connection to said position, left inner normal contacts of relay 701 of the second trunk, similar contacts of similar relays of all other trunks, including the left inner normal contacts of relay 600 of the last trunk, conductor 702, winding of relay 601 to battery, and. in parallel therewith, through the winding of relay 602 to battery causing both of these relays to operate. Another circuit is closed from battery through the winding of relay 703, conductor 709, right inner contacts of relay 602, conductor 902, to ground on the left outer contacts of relay 901. Relay 703 operates. By the operation of relay 703 ground is connected to conductor 434 of the first observation trunk of Fig. 7 from ground on the left contacts of trunk key 705, left outer contacts of relay 703, left outer normal contacts of relays 708'',—707', 708, there being one such relay for each position to which the trunk is connectible, to conductor 434. Similar circuits, controlled by relay 703, connect ground to conductors corresponding to conductor 434 of other trunks. This ground closure in each idle trunk further extends over the respective trunks to the local offices from which the trunks extend and there complete a circuit, for example, over the left back contact of relay 501, winding of relay 500 to battery. Relay 500 operates and closes a circuit extending from ground over its contacts, conductor 502, right inner back contacts of relay 300, conductor 506, left back contacts of relay 503, winding of relay 400 to battery. Relay 400 operates and closes an obvious circuit through the right winding of relay 401 which also operates. If, now, relay 401 becomes operated during the time that the set-up of a call is already in progress such as that of line A above described, the path extending from battery on the back contacts of relay 505 to the right armature of relay 401 will now be completed in a circuit over the right front contacts of relay 401, winding of relay 403 to ground. Relay 403 operates and closes a locking path to the left winding of relay 401 to hold it operated after relay 400 releases which it subsequently does as explained hereinafter. Relay 107 is now in series with relay 403 in the above described circuit and does not operate since it is marginal. Nothing further happens until the line finder whose movement was started by the operation of relay 121 succeeds in connecting with the terminals of the line 116 in the well known manner whereupon a circuit is completed from a ground source in said line finder, second brush and terminal from the bottom on line finder frame 116, right winding of relay 120, to battery, and in parallel therewith over the tip of shoe cord 101 and tip of the trunk jack 103, winding of relay 105, to battery. Relay 120 operates and opens the circuit of the line relay 121 and relay 105 operates and opens the above traced circuit of relays 403 and 107. Since relay 107 was not operated but only relay 403, relay 403 releases, in turn releasing relay 401. Since relay 105 remains operated for the entire duration of the call, line A can not become connected to the service observation trunk for any observations on that call. Hence, if an operator happens to make the position available after a call has been started and before the line finder has found the calling line, the operation of relays 403 and 401 locks out the line from any possible connection with the service observation trunk since it is not desirable to make observations on any line unless such observations can be made from the very inception of the call.

The same thing is true regardless of whether one line or all the lines of the line group initiate calls just before the operator makes the position available. For, in this case, the circuit of relay 403 is paralleled through the winding of each relay 107 of the separate extension circuits to each of which the separate lines of the group are extended but none of which relays can operate since each one of them is marginal. As each line is found by a line finder circuit, each of the parallel paths to relay 403 is opened by the release of relay 104 in each of the extension circuits, relay 403 and hence relay 401, releasing when the circuit of the last line to be locked out is opened by the release of relay 104 of its extension circuit.

When, however, the operator makes the position available at a time when none of the lines are calling, relays 400 and 401 operate as already described. A circuit is now closed from battery through the winding of relay 503, right outer back contact of relay 504, conductor 402, left inner front contacts of relay 401, to ground on the contacts of relay 500. Relay 503 operates, locks over a circuit through the right outer contacts of relay 504, left front contacts of relay 503, conductor 506, right inner back contacts of relay 300, conductor 502, to ground through the contacts of relay 500. Relay 503, by opening its back contacts, opens the circuit of relay 400 which now releases and causes the release of relay 401 unless at the termination of this preliminary test, a line has initiated a call and closed the circuit for relay 403 which then holds relay 401 locked over its left winding after relay 400 releases as above described. If, however, no line circuit has initiated a call during the time when relay 401 is operated, said relay will release after the preliminary test. With relays 503 operated, the trunk is in a receptive condition to lock in an observing line for the purposes of service observation. On the other hand, if no position is occupied, relay 400 does not operate. relay 503 does not operate in which event the trunk is in a non-responsive condition and can be made so only through the operation of the preliminary test described above.

It is also evident from the operations so far described that while the circuit of relay 400 is not closed through if no position is occupied, the same condition must likewise prevail if all positions are occupied and busy. For, if each position is busy, it will be shown hereinafter that the circuit of relay 703 becomes opened when the last position becomes occupied and busy and ground, therefore, is not available on conductor 434 and relay 400 can not operate.

Assuming now, that the above preliminary test has been made and relays 500 and 503 operated,

the trunk circuit is now prepared to lock in the calling line on which a call is originated thereby resulting in the operations of relay 104 and relay 105 as already described, and further operates to extend said line over the trunk line to an occupied operator's position at the central observation bureau.

With relay 503 operated, ground on its front contacts is extended through the right back contacts of relay 401, conductor 404, and over the previously described circuit including the lower winding of relay 107 and battery on the back contacts of relay 505. Relay 107, being marginal, did not operate at the time it was included in the circuit of relay 403 as already described. But when relay 401 released, ground from the right contacts of relay 503 was connected to conductor 404 and the winding of relay 403 eliminated from the circuit of relay 107 so that said relay now operates and locks over its top winding and top inner contacts, conductor 109, winding of relay 505, to ground on the left outer back contacts of relay 401. Relays 106 and 505 now operate through the locking contacts of relay 107. Relay 106 opens the operating circuit of relay 107 over its left inner contacts and causes the ground on conductor 404 to be thereby extended through the bottom inner contacts of relay 107 to conductor 110, right contacts of relay 405, winding of relay 406 to battery, operating relay 406, while over its top and bottom outer contacts, respectively, relay 107 further extends the calling line over conductors 111 and 112 of the trunk to the input terminals of the monitoring amplifier 410. Relay 406 operates and locks in series with the winding of relay 405, left contacts of relay 406, conductor 422 to ground on the left outer contacts of relay 504, which last mentioned relay operated over an obvious circuit when relay 505 operated. Relay 405, however, remains short circuited by said locking ground and said ground over 110. The operation of relay 406 connects battery through resistance 407 over its right contacts to the tertiary winding T of the polarized relay 408 to place this relay on its back contact and partially prepares a circuit for later locking relays 406 and 405 in series.

Relay 505 operated, disconnects battery from conductor 103 so that no other calling line can be locked in as long as relay 505 remains operated. Relay 505 further connects battery through its left front contacts, resistance 411 and normal contacts of relay 412, lower winding of retardation coil 413 to conductor 414 of the trunk extending to the central observing bureau. Relay 505 also connects ground over its right outer contacts, resistance 415, normal contacts of relay 416, top winding of retardation coil 413 to conductor 417 of said trunk.

The connection of battery and ground through retardation coil 413 to the trunk extending to the central observing bureau completes the circuit of polarized relay 704 bridged across said trunk conductors 414 and 417. Relay 704 operates and connects ground on its front contacts over the right contacts of key 705, to the chain path which is looped through the left outer back contacts of all relays 700 of the particular trunk. This ground will then seek battery over a circuit path to the winding of a relay 700 of the position occupied, as is evidenced by the operation of relay 601. For example, if the position occupied happens to be the one marked by relay 601; that is, the positional circuit shown in Figs. 6, 8, and 9 and, besides, all other positions are vacant, then the circuit will be completed from ground on right contacts of key 705, left back contacts of relays 700, 700',—700'', conductor 706, right outer contacts of relay 601, conductor 803, winding of relay 700 to battery, operating relay 700. On the other hand, if more than one position is in a receptive condition, say the positions identified by marking relays 601, 691', and 601'', all of which relays would be operated, then the ground on conductor 706 would form a plurality of parallel paths over the right outer contacts of relays 601, 601' and 601'' respectively, to the windings of relays 700, 700', and 700'' respectively, tending to cause all of these relays to operate. The operation of any one of them, however, say relay 700, opens the left back contacts of said relay and through which the chain circuit to the other relay 700' and 700'' is extended. The opening of the chain opens the circuit to each of the relays 700' and 700'' so that these relays either do not operate or are released when relay 700 locks through its left inner front contact, conductor 905, left normal contacts of relay 904 of the position circuit locked in with the trunk, conductor 903, to ground on the right inner front contacts of relay 901.

Should the trunk so connected with a calling line be other than the first of all the trunks connectible to the position, then the above circuits would be completed to the corresponding trunk relays such as 701, 701'—701'' of the second trunk or relays 600, 600'—600'' of the last trunk. If the trunk taken into use is the second one and relay 701 is operated, then the locking circuit of this relay extends from its left inner contacts over the left back contacts of relay 700 to ground on conductor 905 as previously described.

In case two or more trunks are simultaneously taken by calling lines at their respective central offices and there is but one observation position available at the central observation bureau, then the relay corresponding to relay 700 of each trunk will operate over separate circuits like the one above traced. However, since the locking circuit of each of these relays is controlled over a chain circuit extending over back contacts of all trunk relays of preceding trunks, the preferred trunk at the beginning of the chain will open the locking circuit of the later and less preferred trunks. If, for example, the second and the last trunks are simultaneously taken and the position marked by the operation of relay 601 is the only one available, then the trunk relays 600 and 701 are both operated. But since the trunk of which relay 701 forms a part is first in the locking chain preference, the operation of relay 701 opens the locking path to conductor 905 for other trunk relays having later preference, whereupon relay 600 releases.

If, however, there is more than one position available, the observation trunk which was locked out of the first position will be transferred to the next preferred position available or, if only one other position is available, then it is transferred to that position. This is accomplished as follows: Assuming the trunks taken into service to be the first and last, then, when relay 700 operates it opens the circuit of relays 601 and 602. Relay 602 releasing, closes a circuit for operating relay 906 extending from battery through the left back contacts of relay 602, winding of relay 906 to ground on conductor 903. The operation of relay 906 extends battery from the contacts of relay 602, front contacts of relay 906 to the winding of relay 602' of the next position. If that position is occupied then the circuit of relays 601' and 602' is completed in the same manner as was that of relays 601 and 602. With the operation of these

relays and the failure of trunk relay 600 to lock into the first position and the consequent opening of its circuit by the release of relay 601, a circuit is now completed from ground at the front contacts of relay 604, right contacts of key 605, left back contacts of relays 600, 600'—600'', right inner contacts of relay 703, conductor 606, right inner contacts of relay 601', winding of relay 600' to battery. Relay 600' operates, locks to ground on conductor 903 of the position marked by relay 602' and performs the same functions with respect to future operations as is performed by relay 700 of the trunk assumed to have been locked in the first position.

It will be noted that the battery supply for relay 602 of the first position is connected permanently to the winding of this relay while that of relay 602' of the next position is furnished either from the back contacts of relay 901 or from the back contact of relay 602 and both through the front contact of relay 906, all of said relays being in the first position. Therefore, if the first position is occupied and relays 901 and 602 operate in consequence, as already described, any trunk taken for observation service by a calling line is locked in the first position even though the second position may also be occupied at the same time because, until a trunk with a calling line locked thereto is connected to the first position, there is no way of extending battery from this position to the winding of the marking relay of the next position even though said next position is occupied. Since, however, the occupation of the second position is ineffective until relay 602' is operated, and since this relay cannot operate because its battery is cut off at the preceding position by the opening of the back contacts of relays 602 and 901, the only possibility of a trunk being locked into the second position is by furnishing a battery supply for relay 602' through the back contacts of relay 602 and the front contacts of relay 906 as already described. This event, however, occurs only when a trunk has been locked into the first position as is evidenced by the release of relay 602 and the operation of 906 at which time the previously traced battery supply is connected to the winding of relay 602'. That is to say, the service observation trunks are locked into the observing positions at the central observing bureau in a definite preferred order and a trunk is not switched from one position to the next until the previous positions are all busy with trunks locked in with respective calling lines connected thereto.

Should the first position be unoccupied and the second position occupied, then the service observation trunk will be locked in to the second position, for, in this case, the fact that the first position is unoccupied causes relay 901 to be normal, in which event battery through its back contact is connected directly to relay 602' of the second position which relay then operates in the same manner as relay 602 operated at the time the operator at the second position plugged her telephone headset into the position jack of her position.

It is to be further observed that there is no restriction on the number of trunks which can thus be used compared to the number of available positions, except that the number of simultaneous observations possible is limited, of course, to the number of positions. When all positions are busy, therefore, all trunks which are not in use are immediately placed in an unresponsive condition so that any calling line in the group marked for observation at the local office to which each of the trunks extends will not be locked to the trunk. It will be recalled that the signal for trunk responsiveness is a ground on conductor 434 which eventually results in the operation and locking of relay 503. This ground comes through a chain of back contacts of the trunk lock-in relays 708, 708'—708'' and through an operated set of contacts of relay 703. Relay 703, however, is a relay which is common to all the service observation trunks, there being one pair of contacts for each of said trunks on said relay. The circuit of relay 703, however, is paralleled to the right inner contacts of relay 602, 602'—602'' and is completed by relay 602 of the first position over conductor 902 which is grounded as soon as the first position is occupied and is further provided with a by-path over the back contacts of relay 906 to ground over conductor 903. Consequently, when the first position is occupied relay 703 is operated over the front contacts of relay 602 as already described. Relay 602, however, releases when the position is locked to the trunk so that one of the operating paths for relay 703 is opened. Further, when relay 906 operates for the purpose of transferring operating battery to relay 602' of the next position, another path for holding relay 703 is opened. However, the operation of relay 602' in the next position closes another circuit to hold relay 703 to ground on conductor 902 of that position. And when this position becomes busy, by being locked-in with a trunk, the holding circuit for relay 703 is advanced to relay 602'' of the next position until finally, the last position is reached at which time, as soon as the position becomes busy and relay 602'' is released and relay 906 operated, the last holding circuit of relay 703 will have been opened. Relay 703 releases and, so long as all positions are occupied and busy, relay 703 cannot thereafter operate. Since, however, conductor 434 of each trunk is connected to one of a pair of contacts on relay 703 and since, further, the responsive ground signal over a trunk conductor 434 is possible only if relay 703 is operated it is evident that if all positions are busy, the remaining idle trunks are left in an unresponsive condition thereby avoiding the connection of any calling lines thereto.

Referring to the operation of the first trunk locked into the position marked by relay 602, the operation of relay 700, lights the trunk lamp 707 at the position to identify the trunk to which a calling line has been locked. It further closes an obvious circuit for relay 708 which operates and closes through the trunk conductors 433, 434, 417, and 414 to the equipment of the service observing operator in preparation for observing subscriber dial impulses.

Relay 708 further closes a circuit for relay 908 extending from ground on its right inner contacts, conductor 935, right normal contacts of relay 904, winding of relay 908 to battery. Relay 908 operates and, by opening its left outer contacts, removes the shunt around the operator's receiver (not shown) after condenser 909 has been connected through to talking conductor 414 by way of conductor 936, thereby preventing any possible click to the operator during the initial surge of current into the condenser. Relay 908 is slow to operate in order to provide means for discharging the trunk cable prior to connecting impulse responding relays, to be described hereinafter, to the trunk conductors thus eliminating

the possibility of falsely operating any of said relays.

In the meanwhile the operation of relay 504 closes the locking ground for relay 406 as above described. Relay 504 further connects supplementary ground to conductor 404 from its left inner contacts, right back contacts of relay 401, and at its right outer contacts, opens the circuit of relay 503 which releases after an interval. Relays 406 and 405 are placed under the control of relay 504 to insure their operation in those cases where the terminals of the calling line on the line finder frame are at the bottom of the line finder contact bank in which case the line finder hunting time is small. With the connection of the line finder to the terminals of the calling line and the cut-off relay 120 operated in the well known manner, the circuit of relay 104 is opened as already described and ground is removed from conductor 110. If the travelling time of the line finder elevator is very small, ground over conductor 110 may not be on for a sufficiently long time to operate relay 406 and the consequent operation in series with it of relay 405 when the calling line is found by the line finder and relay 104 releases. Consequently, when relay 504 operates and relay 406 has not yet operated, it is operated by the supplementary path above described except that, in this case, relay 405 is operated in series with it since the absence of ground in conductor 110 indicates the line to have been found and, therefore, no longer necessary to keep relay 405 short circuited. Relay 405 operated connects the winding of relay 420 over its front contacts and right back contacts of relay 421 to conductor 112 of the line by way of normal contacts of key 422, and opens the original path of relay 406.

As soon as the subscriber's line locked to the observation trunk becomes associated with a register sender or first selector in the known manner, relay 420 operates in parallel with the pulsing relay of the sender in a circuit completed from ground through said relay, over conductor 112, bottom outer contacts of relay 107, sleeve of trunk jack 102, ring of connecting cord 100, second from the top terminal and associated brush of connecting line finder 116, winding of said relay in the sender to battery. Relay 420 operates and closes an obvious circuit for operating relay 421. Relay 421 operates, locks to ground on conductor 422, disconnects relay 420 from conductor 112 of the line which relay then releases, and further connects ground from the right inner contacts of relay 505 to the armature of relay 408.

The observation trunk circuit as well as the operator's position to which the trunk is locked, are now ready to respond to the next operations of the subscriber's line under observation which will generally be that of dialing the called subscriber's number. Before describing pulsing operations, however, it is desirable to proceed with that portion of our description which has to do with the identification to the service observer of the arbitrary line member assigned to the line on which observations are to be made.

At the time a calling line is to be supervised and is, therefore, connected to the trunk extending to the central observing bureau by the connection cord-shoe 115 as already described, the line itself is assigned an arbitrary numerical designation as one of a group of one hundred lines. Conductor 113 of the line extension circuit is cross connected to one of ten terminals TO—9 on the cross connecting block 230 depending on the tens digit of said arbitrary designation, while conductor 114 is cross connected to one of ten terminals U—0–9 of said block depending on the units digit of said arbitrary designation. Relays 200 to 203, inclusive, operate through their primary windings (P) for the tens digit "1" to "4" respectively, relay 204 operating alone for the tens digit "5". For the digits 6 to 9 inclusive, relays 200, 201, 202 or 203 respectively operate through their secondary windings (S) in series with the winding of relay 204. For the tens digit 0, battery is supplied through resistance 205. The unit digit registration is made through the operation of relays 210 to 214, inclusive, and in a similar manner to that described for the tens digit except that ground instead of battery is supplied to the windings of these relays as more completely described hereinafter.

When relay 106 operates as already described and conductors 113 and 114 are joined at the right contacts of said relay, one of the relays in the tens group is operated in series with one of the relays in the units group. As an example, it has been assumed that the arbitrary designation number assigned to calling line A is 17 and conductor 113 of the extension circuit connecting with said line is connected to terminal T—1 and conductor 114 to U—7. Upon the operation of relay 106 and the consequent joining of conductors 113 and 114, a circuit is closed from battery through the primary winding P of relay 200, terminal T—1, conductor 113, contacts of relay 106, conductor 114, terminal U—7, secondary winding S of relay 211, winding of relay 214, conductor 216, left outer back contacts of relay 300, conductor 422 to ground on the left outer front contact of relay 504. Relays 200, 212, and 214 operate. Relay 200 connects battery through high resistance 217 to the left inner contacts of relay 302. Relay 211 prepares a partial path through low resistance 218 to the left outer front contact of relay 304, while relay 214 performs no useful function at this time.

Now the arbitrary designation 17 is to be transmitted to the central observation position to which the trunk is locked so that the operator thereat may note such designation and thereby identify the line which is being observed. This indication is transmitted in the form of a pulse code of the kind commonly used in automatic telephone systems to transmit called line designations. It comprises a code of four impulses for each digit, two of which are of either light or heavy negative polarity and the other two of which are either positive or no polarity. For a further description of an impulse code of this kind, reference is made to Patent 1,844,147 to E. H. Clark, dated February 9, 1932.

When, therefore, the trunk is locked into a position and relay 504 operates as before described, the ground on conductor 422 is further extended over the left outer back contacts of relay 300, conductor 216, back contacts of relay 309, winding of relay 311 to battery. Relay 311 operates and closes an obvious circuit for relay 312 which also operates. Relay 309 is polarized, is without a biasing spring and its armature may therefore be either on its front or back contact or between the two. If it is neither on its back contact or front contact at the time the line observing circuit is locked to the trunk then ground on conductor 216 is extended through the back contacts of relay 312 over the following parallel paths: (1) through the left back contacts of re-

lay 312, secondary winding (S) of relay 309, middle contacts of jack 315, resistance 316, resistance 322 to battery; (2) through the left back contacts of relay 312, primary winding (P) of relay 309, top contacts of jack 315, condenser 320, resistance 322 to battery; (3) through the left back contacts of relay 312, bottom contacts of jack 315, resistance 317 to battery. The closure of the above circuits serves to place the polarized relay 309 on its back contact as soon as the charging current of condenser 320 has died down. If, on the other hand, the armature of relay 309 is in its front contact initially, then the grounding of conductor 216 establishes an immediate circuit for relay 310 which operates at this time and releases as soon as relay 309 breaks its front contact as a result of the effects of the three circuits described above. As soon as the armature of relay 309 makes its back contact, relay 311 operates, in turn operating relay 312 as described. Relay 312 closes a circuit for relay 308 extending from ground on conductor 216, right front contacts of relay 312, left normally made contacts of relay 308, winding of relay 308 to battery. Relay 312 on its left front contacts further closes the charging circuit of condenser 320 which, being in series with the primary winding (P) of relay 309, the charging current flowing through said winding causes the operation of said relay as the current flow is now in the proper direction for operation. Relay 308 operated locks over its left outer contacts to ground on conductor 216, closes a path extending from ground on the right front contacts of relay 312, left inner contacts of relay 308, left normal contacts of relay 301, winding of relay 301, resistance 318 to battery. Relay 301 operates. Prior to the operation of relay 301, however, the same ground is extended to both sides of the winding of relay 303 as follows: to one side by way of the left normal contacts of relay 301 and supplemented after its operation by ground on conductor 216 through its left front contacts, while to its other side the ground on conductor 216 is extended over the right outer back contact of relay 303, to the winding thereof. Relay 303 being thus short circuited, does not operate at this time. Relay 308 further closes a supplementary holding path for relay 311 from ground on conductor 216 over its right outer contacts and normal contacts of relay 310 to the winding of relay 311.

Relay 309 operated, operates relay 310 and opens the above described supplementary path which holds relay 311 thereby releasing this relay which, in turn, releases relay 312. The release of relay 312 closes a supplementary path from ground on conductor 216 to hold relay 310 operated should relay 309 prematurely release and removes the shunt around the winding of relay 303 which now operates and locks to conductor 216 in parallel with relay 302 extending from ground on its left inner contacts, left outer back contacts of relay 302, winding of relay 302, resistance 319 to battery. Relay 302 operates and short circuits relay 304 by extending ground on conductor 216 over its left outer front contacts to the winding of relay 304. Relay 304, therefore, does not operate at this time. Relay 312 released, again connects ground from conductor 216 through its left back contacts to the windings of relay 309 and to condenser 320 in such a direction as to place the relay on its back contact as soon as the charging current of condenser 320 has died down. Relay 309 released, again operates relays 311 and 312 as before, which latter relay, on operating, connects ground on conductor 216 over its left front contact in preparation of previously described circuits for reoperating relay 309 and, through its right front contacts, again connects ground to the left inner contacts of relay 308, and shunts and causes the release of relay 301 over the left inner make contacts of relay 303.

When relay 309 operates again, it causes the operation of relay 310 which again releases relays 311 and 312, the latter in turn holding relay 310 operated and opening the circuit of relay 303 which releases. Relay 303 released, removes the shunt from the winding of relay 304 which operates in a circuit from battery through resistance 323, winding of relay 304, left outer front contacts of relay 302, to ground on conductor 216. Relay 304 operated closes a circuit from ground on its right outer contacts, left inner back contacts of relay 305, winding of relay 314 to battery. Relay 314 operates. Relay 312, when released, again closes the above described circuits to place relay 309 on its back contact. At the end of two complete cycles of operation and release of relay 309 and the corresponding release and operation of relay 312, relays 301 and 303 have operated and released and, in turn, caused the operation and locking of relays 302 and 304, the latter further closing the circuit of relay 314 as already described. A third cycle of operations will cause the reoperation of relays 301 and 303 in the sequence described except that, when the relay 303 reoperates on the third cycle, a shunt circuit for relay 302 is established from ground on the left inner contacts of relay 303, left inner front contacts of relay 304 to resistance 319. Relay 302 releases but relay 304 now holds over a circuit from ground on the left inner contacts of relay 303, left outer normal contacts of relay 302 to the winding of relay 304. At the end of the fourth cycle, relay 303 releases which, in turn, opens the above holding circuit for relay 304 which also releases. The short circuit around the winding of relay 305 is now removed and this relay operates in the locking winding of relay 314.

The results of the four cycles of operation above described may be recapitulated as follows:

Relay 312 operated—operates relay 301
Relay 312 released—operates relay 303, operates relay 302
Relay 312 operated—releases relay 301
Relay 312 released—releases relay 303, operates relay 304, operates relay 314
Relay 312 operated—operates relay 301
Relay 312 released—operates relay 303, releases 302
Relay 312 operated—releases relay 301
Relay 312 released—releases relay 303, releases 304, operates relay 305.

Although the above pulsing circuit has been described in detail for the better understanding of the present invention, the same pulsing circuit is more completely described in the above mentioned patent to Clark.

At the end of four cycles, therefore, relays 301, 303, 302 and 304 are normal and relays 305 and 314 are operated. Relay 314 upon operating at the end of the second cycle closes a circuit to operate relay 501 which circuit extends from battery through the winding of relay 501, conductor 503, left contacts of relay 314 to ground, while relay 305 closes conductors 433 and 434 of the outgoing trunk to the central observing bureau

over a loop extending from conductor 433, right front contacts of relay 501, conductor 509, right outer back contacts of relay 305, which is normal at the end of the second cycle, conductor 510, left front contacts of relay 501 to conductor 434.

When relay 303 operates at the end of the third cycle, ground is connected to conductors 433 and 434 from the right inner contacts of relay 303. This condition is maintained until relay 303 is released and relay 305 operated, both of which events occur at the termination of the fourth cycle and at which time conductor 433 is disconnected from conductor 434 and ground is removed from both, conductor 433 (conductor 509) now being extended over the right outer front contacts of relay 305 to the left front contact of relay 310 and conductor 434 (conductor 510) being extended over the right inner front contact of relay 305 to the right contact of relay 311. Both of these conductors are controlled in this manner to discharge the capacity of the conductors prior to the transmission of impulses to the service observing position so as to prevent the false operation of the impulse relays at the central position as more fully described hereinafter.

Relay 305 operated, locks in series with relay 314 to ground over the right contacts of relay 314. When, now, relay 311 operates again on the release of relay 309 at the beginning of the fifth cycle, a circuit is closed from ground on its left contacts, left outer contacts of relay 305, normal contacts of relay 313, winding of relay 313 to battery. Relay 313 operates and locks to ground on conductor 216 over its left front contacts and performs functions to be noted hereinafter. The purpose of the delay measured by four cycles of operation of relay 309 before transmitting impulses which designate the arbitrary number of the observing line is to insure sufficient time for the trunk to be locked to an operator's position at the central observing bureau and to insure, further, that the position circuit is prepared to receive the impulses as well so as to enable the calling line circuit to be released in case the trunk is unable to lock itself to an observer's position.

At the end of the first four cycles of the pulsing circuit above described another group of four is started immediately thereafter to produce eight call indicator impulses. These impulses are used for transmitting a two-digit number from 00 to 99 over conductors 433 and 434 of the trunk to the control and display circuit located at the central observing position and shown as a part thereof in Fig. 8. The path from the contacts of the register relays to the contacts of the steering relays in the display circuit is always closed just one impulse before it is required as described in the above mentioned patent to Clark. That is, a negative impulse path is prepared during the transmission of the preceding positive impulse and a positive impulse path is prepared during the transmission of the preceding negative impulse. The fourth release of relay 312 as already described closes a path to place relay 309 on its back contact and, as soon as this occurs, relay 311 operates which, in turn, operates relay 312 as well as relay 313 through the left center front contacts of relay 305 as already described. Relay 313 operated, locks to ground on conductor 216 and connects 48-volt battery through high resistance 321 to conductor 510 and thence to conductor 434 of the trunk and through low resistance 218 to the armatures of the numerical register relays for digits requiring heavy negative impulses. Battery through high resistance 217 is permanently connected to the armatures of said register relays for digits requiring light positive impulses. The contacts of the register relays in Fig. 2 are wired to those of relays 301, 303, 302, and 304 in such a manner that the required battery condition may be placed on conductor 433 or 434 of the trunk at the proper time to transmit the impulses required for the particular tens and units digits as determined by the register relays operated. In order to prevent the possible opening of conductors 433 and 434 between impulses and to prevent surges due to cable capacity from disturbing pulsing conditions, direct ground is connected to both conductors during the releasing time of relay 311 at the end of a positive impulse and during the operating time of relay 312 and the releasing time of relay 310 at the end of a negative impulse. Relays 309, 311, and 312 continue to actuate relays 301, 303, 302, and 304 as already described, a positive or blank impulse being transmitted when relay 312 is operated and a negative impulse when said relay is released.

As described in the above mentioned patent to Clark, the code impulses are either (1) light negative, (2) heavy negative, (3) light positive or (4) a blank. Since the impulse code for numbers assigned for arbitrary identification of the observing line circuit is the same as that used for called subscribers' numbers as shown in said Clark patent, and since it has been assumed that the number assigned to the line observing circuit A herein used for illustration is 17 the impulse code of the four impulses for the tens digit 1 is (1) positive, (2) light negative, (3) blank, (4) light negative, while the impulse code of the four impulses for the units digit 7 is (1) blank, (2) heavy negative, (3) blank, (4) heavy negative. Consequently, when the pulsing loop is closed at the beginning of the fifth pulsing cycle with the operation of relay 301, a circuit is completed from battery through resistance 217, contacts of relay 200, left inner back contacts of relay 302, left outer back contacts of relay 303, right outer front contacts of relay 305, conductor 509, right front contacts of relay 501, conductor 433, left inner front contacts of relay 708, conductor 920, right back contacts of relay 919, winding of relay 801, winding of relay 800, winding of relay 802, left outer back contacts of relay 919, conductor 933, left outer front contacts of relay 708, conductor 434, left front contacts of relay 501, conductor 510, right inner front contacts of relay 305 to ground on the right contacts of relay 311. Relays 801, 800 and 802 are the impulsing relays and respond, respectively, to positive, negative and heavy negative impulses, all in accordance with the above mentioned patent to Clark.

The first impulse, according to the code, is positive and the polarity of the above described circuit with respect to relay 801 is likewise positive so that relay 801 operates. Accordingly, a circuit is completed from ground on conductor 903, normal contacts of relay 922, conductor 934, contacts of relay 801, right back contacts of relay 804, right back contacts of relay 806, right winding of relay 812 to battery. Relay 812 operates and locks in a circuit from battery through its left winding and left inner contacts, conductor 934, to ground.

The next impulse is a light negative and is transmitted at the end of the fifth cycle, that is, with relays 301, 302 and 303 operated, and relays

311 and 312 released. Consequently, a circuit is completed from battery on the right contacts of relay 313, high resistance 321, right inner contacts of relay 305, conductor 510, through the previously described trunk loop back to conductor 509, right outer front contacts of relay 305 to ground on the left contacts of relay 310. The direction of current flow is now opposite to that of the first pulse above described and causes the operation of relay 800 which then closes a circuit extending from ground on conductor 934, contacts of relay 800, left normal contacts and winding of relay 804, resistance 817 to battery. Relay 804 operates. Relay 803, however, is short circuited by the operating ground above traced and also from ground through the left normal contacts of relay 804 to the same ground through the contacts of relay 800, and through the left front contacts of relay 804 when this relay operates.

The next impulse, in the sixth cycle, is a blank, causing thereby a release of relay 800 which, in turn, causes a removal of the short circuit around relay 803 thereby causing this relay to operate in parallel with relay 804 from the ground extended through the left front contacts of relay 804.

The next impulse transmitted at the end of the sixth impulsing cycle is a light negative, has the same circuit path as the second impulse and likewise causes the operation of relay 800. A short circuiting path for relay 804 is now completed from ground through the contacts of relay 800, left front contacts of relay 803, to the lower side of the winding of relay 804. Relay 804 releases but relay 803 is prevented from releasing by the presence of the ground on the contacts of relay 800 through the continuity normal contacts of relay 804. Relay 803, therefore, locally holds to the contacts of relay 800 for the duration of the impulse and, when this is terminated, relay 800 releases, in turn, causing the release of relay 803.

At the end of the sixth cycle, relay 302 and 304 remain operated and cause a circuit to be completed from battery through the winding of relay 306, left inner front contacts of relay 305, right outer contacts of relay 304 to ground. Relay 306 operates, and closes a locking path through the winding of relay 307 and its own front contact to ground on conductor 216. Relay 307, however, does not operate at this time as the operating ground for relay 306 holds it short circuited.

The sending of the four impulses comprising the code of the tens digit of the arbitrary number assigned to the calling line, therefore, results in the operation and locking of relay 812. At the beginning of the third impulse, however, that is, at the instant relay 803 operates, a circuit is closed from battery through the winding of relay 806, right inner back contacts of relay 805, right inner front contacts of relay 803, to ground over conductor 934. Relay 806 operates and closes a locking circuit for itself through the winding of relay 805, left contacts of relay 806 to ground on conductor 934. Relay 805, however, is prevented from operating in this locking circuit by the connection of short circuiting ground to both sides of its winding, one of which grounds is traced above to the winding of relay 806 and is controlled through the contacts of relay 803. At the end of the last impulse, when relay 803 releases, this short circuiting ground is removed and relay 805 operates in the locking circuit of relay 806 as above traced.

The second group of impulses are those which comprise the code for the digit 7 and consists of a first blank impulse, a second heavy negative pulse, a third blank impulse and a fourth heavy negative impulse. The blank impulse is transmitted during the first impulse operation of the seventh impulse cycle. The closure of the circuit for the heavy negative impulse, which is transmitted during the second impulse of the seventh impulse cycle, completes a path from ground on the left contacts of relay 310, right outer front contacts of relay 305, conductor 509, over the trunk loop as previously described, conductor 510, right inner front contacts of relay 305, right front contacts of relay 301, left outer front contacts of relay 304, contacts of relay 211, low resistance 218, battery through the front contacts of relay 313. This circuit causes the operation of relays 800 and 802. Relay 801 operates and causes the operation of relay 804 as above described while relay 802 completes a circuit from ground on conductor 934, contacts of relay 802, right back contacts of relay 803, left inner front contacts of relay 805, winding of relay 809, to battery. Relay 809 operates and locks in a circuit from battery through its left winding and contacts, to ground on conductor 934. The termination of the impulse causes the operation of relay 803 in series with relay 804, which results in the closure of a circuit from battery through the winding of relay 807, right inner front contacts of relay 805, right inner front contacts of relay 803, to ground on conductor 934. Relay 807 operates and closes a circuit through its winding, winding of relay 919, contacts of relay 807, to ground on the right inner contacts of relay 708 to perform functions hereinafter described. Relay 919 being shunted does not operate at this time.

The transmission of the fourth and heavy negative impulse, which is transmitted during the fourth impulse of the eighth impulse cycle, completes a path from ground on the left front contacts of relay 310, right outer front contacts of relay 305, conductor 509, over the trunk loop as previously described, conductor 510, right inner front contacts of relay 305, right back contacts of relay 301, right normal contacts of relay 302, contacts of relay 214, low resistance 218, contacts of relay 313, to battery. This circuit again causes the operation of relays 800 and 802, the former causing the release of relay 804 and the latter the closure of a circuit from ground on conductor 934, right outer front contacts of relay 803, right outer front contacts of relay 805, left winding of relay 811 to battery. Relay 811 operates and locks in a circuit from battery through its right winding and right inner contacts to ground on conductor 934. At the termination of this last impulse, relays 800 and 802 both release, relay 800 causing the release of relay 803. The shunt around the winding of relay 919 is now opened and relay 919 operates in the locking circuit of relay 807. With the termination of the last impulse, and the consequent release of relay 304, the shunt around the winding of relay 307 is removed and this relay now operates in series with relay 306 to perform functions hereinafter described.

The impulse code having been transmitted and the proper register relays operated and locked in response thereto a lamp circuit is closed with the operation of relay 919 which extends from battery through the No. 1 tens lamp 819, left outer front

contacts of relay 812, left back contacts of relay 814, right back contacts of relay 815, right back contacts of relay 813, conductor 619, right back contacts of relay 937, left inner contacts of relay 919, right normal contacts of relay 904, conductor 935, right inner contact of relay 708 to ground. This circuit causes the tens digit lamp 819 to glow. Another circuit is closed from battery through the No. 7 units lamp 820, left inner front contacts of relay 811, right outer back contacts of relay 808, right front contacts of relay 809, to ground on conductor 935, as previously traced. This circuit causes the units lamp 820 to glow which, in combination with the tens lamp, displays to the operator the arbitrary number 17 of the calling line on which service observations are being made, and is maintained glowing steadily until the operator releases the call.

After the transmission of the final impulse, relay 307 operates as already described. On the next operation of relay 311, a circuit is closed for operating relay 300 extending from ground on the left contacts of relay 311, left outer contacts of relay 305, contacts of relay 307, left inner back contacts of relay 300, winding of relay 300, to battery. Relay 300 operated, opens the holding circuit for the register, steering and impulser relays including that of relay 501. All of these relays release. The operation of relay 300 and the release of relay 501 extend battery through the winding of relay 418, right outer contacts of relay 300, right back contacts of relay 501 to conductor 433 to aid in permitting the operator at the distant end to release the trunk as described hereinafter. The operation of relay 300 further opens its right back contact thus rendering the automatic release feature ineffective and, at its inner right front contact partially prepares the circuit of relay 435 to enable the observing operator to hold an observing line and talk to the subscriber thereon in case of a trouble condition, relay 435 operating in a circuit made effective when the operator at the observing position operates the position talking key as more completely described hereinafter.

The line indication impulses having been transmitted, the observation position is ready to respond to the next operations of the line under observation which will be generally that of dialing the called subscriber's number. Before describing the dial pulsing operations, however, it is desirable to explain somewhat generally the arrangement of the pulse amplifying circuit which forms a part of the service observation trunk but the combination of which with a service observation trunk, is old in the telephone art and hence not herein described in detail. It comprises, essentially, vacuum tubes 424 and 425 and the polarized differential relay 408. Vacuum 424 is the operating tube and its grid element is connected through leak resistance 426 and normal contacts of key 419 to conductor 112 of the line and is therefore subjected to the changes of potential that occur on this conductor. The plate circuit of this tube is connected through the normal contacts of jack 427, middle winding (S) of relay 408, normal contacts of both jacks 427 and 428, lamp 429 to positive battery (110V). Vacuum tube 425 is simply a balancing tube for the purpose of compensating for variations in the positive battery. The grid of this tube, that is, of tube 424, therefore, is maintained at a constant fixed potential after initial adjustment through the adjusting element 430. The plate circuit of tube 425 is connected through the normal contacts of jack 428, primary winding P of relay 408, bottom normal contacts of jack 427 and lamp 429 to positive battery (110V). The right winding (P) and secondary winding (S) of relay 408 are wound differentially with respect to each other and have an equal and opposite number of turns. Since relay 408 in this preferred embodiment of our invention does not have a biasing spring for controlling the rest position of its armature, the tertiary winding T is provided, and is so wound as to place the relay on its back contact when the right and middle windings are exactly balanced and energized at the same time when winding T is energized. The pulsing circuit is so arranged that there will be equal and opposite number of ampere-turns acting through the primary P and secondary S windings of relay 408 when the subscriber or selector loop is open and the voltage on the ring of the line is the absolute minimum.

Before the subscriber's dial is moved off-normal, the grid-to-filament potential of tube 424 becomes more positive, resulting in an increase in the plate current through the secondary winding of relay 408. This increase in ampere-turns through the secondary winding overbalances the combined ampere-turns acting through the primary P and tertiary T windings, causing the armature of relay 408 to move to its front contact and prevent the operation of relays 412 and 416 to the ground connected to the armature of relay 408 by the operation of relay 421 as already described. With relays 412 and 416 normal, the battery and ground closure over the trunk conductors 414, 417 to the central observing bureau remains in the proper direction to maintain the polarized relay 704 at the desk end of the trunk in an operated condition. When the dial contacts are opened, the grid-to-filament potential of vacuum tube 424 becomes more negative, resulting in a decrease in the plate current through the secondary winding of relay 408. This decreased current through the secondary winding is overbalanced by the combined current flowing through the primary P and tertiary T windings, and the armature of relay 408 moves to its back contact, thereby causing the operation of relays 412 and 416 in parallel. These relays operated, reverse the battery and ground connections through resistances 411 and 415 respectively and the current flow through the circuit comprising retardation coil 413 and relay 704 at the central observing bureau is reversed, thereby causing relay 704 to be released. Relay 704, when it makes its back contacts, closes a circuit from ground through its back contacts, right inner contacts of relay 708, right outer contacts of relay 602, winding of relay 910, normal contacts of relay 911, winding of pen register magnet 912, resistance 913 to battery. The pen register operates in the well known manner and records a dash on the pen register tape. Relay 408 thus operates and releases, in turn operating and releasing relays 412 and 416 for each pulse sent out from the subscriber's dial in response to which the battery and ground are alternately connected to conductors 417 and 414 of the trunk to the central observing bureau to operate and release relay 704 which, in turn, actuates the pen register 913 to record the pulses on the cooperating moving tape.

When relay 704 is released for a sufficient period of time, that is, after the reception of all the impulses of a digit, relay 910 remains on its

front contacts long enough to operate relay 914 which, on operating, extends an operating circuit from ground on the left contacts of relay 910, to relay 915 while this last relay, on operating, extends the ground which closed the circuit of relay 910 through its own front contacts to the winding of relay 911 which operates. Relay 911 locks under control of relays 902 and 704. When relay 704 is reoperated, relay 911 is released and the same cycle of operations is repeated for each series of impulses, said impulses being registered on a moving tape actuated by the mechanism (not shown) of which magnet 912 forms a part.

The restoring of the subscriber's receiver has the same effect as opening the dial contacts. As soon as the line relay in the sender is again placed across the line, relay 408 releases and causes the reoperation of relay 412 and 416, thereby ultimately causing the pen register to record the subscriber's disconnection.

Condenser 448 is connected between the grid and negative filament terminal of vacuum tube 424 in order to prevent the registration of split impulses when observing on step-by-step pay station lines as well as on subscriber's lines having maximum sub-set capacity. The battery through resistance 432 connected to the front contact of relay 408 and to condenser 431 is for the purpose of providing for satisfactory recording of impulses when observing on panel lines having maximum sub-set capacity and fast dials. When the front contact of relay 408 breaks, the charge on condenser 431 is increased which causes a current surge through the primary winding of relay 408 which aids in placing the armature of the relay on its back contact.

Immediately after the line indication numbers have been transmitted, the observation operator's circuit is placed in a talking and listening condition with respect to the calling subscriber. For this purpose, a single stage vacuum tube amplifier 410 is provided in monitoring over a subscriber's connection and it also serves as a one-way repeater to prevent noise transference to the circuit that is under observation. At all times when a call is locked into a position, however, the service observer may hear in her headset any conversation or tones taking place on the subscriber's line.

If the operator has occasion to talk to the subscriber, key 921 is operated. A circuit is now closed from ground on the left contacts of key 921 to the winding of relay 936 which, on operating, closes a circuit extending from battery through the winding of relay 923, left outer contacts of relay 936, transmitter 924, right outer front contacts of relay 936, right front contacts of talking key 921, secondary winding of induction coil 916, to ground. Key 921 also closes a circuit from ground on the left inner contacts of talking key 921, upper winding of retardation coil 917, front contacts of relay 919, conductor 933, left outer front contacts of relay 708, conductor 434, left back contacts of relay 501 to the winding of relay 500, operating this relay. Relay 500 operated closes a circuit extending from ground through the contacts of relay 500, conductor 502, right inner front contacts of relay 300, winding of relay 435 to battery. Relay 435 operated places a holding bridge consisting of windings 437 and 438 of repeating coil 436 in series extending from winding 438, top outer contacts of relay 435, conductor 111, over the subscriber's line or central office loop, conductor 112, bottom outer contacts of relay 435, winding 437, resistance 446. This loop across the line conductors prevents the central office apparatus from releasing even though the subscriber restores his receiver to the switchhook. The operation of relay 435 also closes an obvious circuit for relay 444 which operates and closes the talking conductors through to the windings 445 and 446 of repeating coil 436 to the central observing position thereby providing a two-way transmission circuit to enable the observing operator to converse with the subscriber. It must be noted, however, that the observing operator is unable to hold a subscriber's line or talk to the subscriber until the call indicator impulses for line identification have been transmitted as previously indicated since the circuit for relay 435 can not be completed until relay 300 operates, which occurs after the transmission of the line indicating impulses as already described. Relay 435 is made slow to operate in order to prevent its false operation during short closures of the contacts of relay 500 should this relay respond to line surges.

Should the observing operator, in noticing some service irregularity, desire to communicate with a switchman of the office of the subscriber's line, key 925 is operated. The circuit for relay 936 is now closed from ground on the left outer contacts of key 925 and the operation of relay 936 closes a previously described circuit for relay 923. Further, the handset receiver 926 is connected over the inner front contacts of said key to induction coil 918. Key 925 also closes an obvious circuit for relay 927 which, in turn, operates relay 938. A circuit is now closed from ground over the left outer contacts of relay 927, right contacts of relay 938, lower winding of retardation coil 917, right front contact of relay 919, conductor 920, left inner front contacts of relay 708, conductor 433, right back contacts of relay 501, right outer front contacts of relay 300, winding of relay 418 to battery. Relay 418 operates and closes a circuit extending from ground on its contacts, top inner front contacts of relay 435, conductor 445, winding of relay 511 to battery. Relay 511 operates and connects battery to sleeve conductor 512 of a tie line to the chief switchman's desk. This battery closure operates a relay, which in turn, lights a lamp at the chief switchman's desk who answers the call and converses with the operator at the central observing position through repeating coil 513 connected to the trunk over conductors 433 and 434 through the back contacts of relay 501. If, at this time talking key 921 is operated, the switchman's talking circuit is held but it further allows the operator to talk to the subscriber.

When coin collect current is connected to the subscriber's line, relay 219 operates, in turn operating relay 220 in a circuit extending from ground through its front contacts, back contacts of relay 221, left winding of relay 220 to battery. Relay 220 operates, opens the path to the winding of relay 221 and connects low tone circuit LT over its left contacts, conductor 222, winding 447 of output transformer 436 to ground. This tone is now transmitted to the operator at the central observing bureau over a previously described circuit to indicate that the coin has been collected. The operation of relay 220 also closes its locking winding through its front contacts to the front contacts of relay 223 in order to prevent relay 220 from releasing until both relays 219 and 223 are normal. This arrangement is provided to prevent the transmission of both a coin collect and coin

return signal in case relay 223 makes its front contact due to the inductive surge on the line at the time the coin magnet circuit is broken by the collection of the coin.

If coin return current is connected to a subscriber's line, polarized relay 223 operates instead and, in turn, operates slow release relay 221 over a circuit extending from ground on its contacts, right back contacts of relay 220, left winding of relay 221 to battery. Relay 221 operated opens the operating path of relay 220 and connects high tone source HT through its left contacts, conductor 222, winding 447 of the output transformer 436 to ground. This tone, in turn, is transmitted over the trunk to the operator at the central observing bureau to indicate that the coin has been returned. As in the case of coin collection and for the same reason, the operation of relay 221 closes its locking winding through its make contacts to the front contact of relay 219 in order to prevent relay 221 from releasing until both relays 219 and 223 are normal.

When the subscriber restores his receiver, relay 704 releases and a circuit is closed from ground through its back contacts, right inner contacts of relay 700, back contacts of relay 602, winding of relay 910, back contacts of relay 911, winding of pen register 912, resistance 913, to battery. A dash is now recorded to indicate that the call is terminated and the length of this dash is controlled through the pulse limiting arrangement comprising relays 910, 914, 915, and 911. The operator may then, or at any other time, release the call by operating release key 928. A circuit is now closed from ground on the right inner front contacts of relay 708, conductor 935, contacts of key 928, winding of relay 937 to battery. Relay 937 operates and locks over its right inner contacts to ground in the right contacts of relay 908, opens the circuit of the identification lamps over its right outer contact thereby extinguishing the line indication, closes an obvious circuit for relay 922 which operates and, through its left outer contacts, extends ground on conductor 903 over conductor 920, left inner front contact of relay 708 to conductor 433. Ground on this conductor is applied for the performance of functions at the local office which are described hereinafter. The operation of relay 922 causes the opening of its normal contacts and thereby causes the release of the indicating registers. Relay 922 further causes the application of a supplementary ground from conductor 907 to conductor 905 for the purpose of holding relay 700 and further closes an obvious circuit for relay 904 which operates. Relay 904 operated, opens one branch of the holding path for relay 700, opens the circuit of relay 908 which releases and, over its left front contacts, places supplementary ground on conductor 433. Relay 908 released, opens the locking ground for relay 937 which releases providing, however, that the observer has released key 928. Relay 937 releases relay 922 which, in turn, releases relays 700 and 708. Relay 708 releases relay 904. Relays 922 and 904 are made slow operating to allow ground to be applied to conductor 433 long enough to perform circuit functions in the local office to be described hereinafter. Relay 904, in releasing, connects ground to the chain circuit again operating relays 602 and 601 provided there is no lower numbered position ready to serve a call. Relay 602 upon operating releases relay 906 thereby cutting off battery to all higher numbered positions. Relays 905 is made slow to operate so that when battery is passed along to the higher numbered position, it will prevent the battery from being connected through to the second higher numbered position before relay 602 operates to cut it off. Relay 906 in conjunction with relay 602 provides a path from the common relay 703. Relay 906 being slow to operate prevents relay 703 from releasing when observing preference is being passed from a higher numbered to a lower numbered position.

In the meanwhile the ground connected to conductor 433 as above described closes the circuit to the winding of relay 418 over a previously described circuit causing this relay to operate. Relay 418 operated, closes a circuit from ground on its contacts, top inner normally made contacts of relay 435, winding of relay 400 to battery, operating this relay. Relay 400 in turn closes an obvious circuit to the right winding of relay 401 which likewise operates. Relay 401 operated, disconnects ground from the winding of relay 505, allowing it to release, and further connects ground through high resistance relay 403 to conductor 404. Relay 505 released opens the circuit of relay 504 causing this relay to release, disconnects ground from the armature of relay 408, and disconnects battery and ground through resistances 411 and 415 and retardation coil 413 from conductors 414 and 417 of the trunk to the central observation position. Relay 505 further connects battery to conductor 108 which, in conjunction with battery through the winding of relay 504, performs a function in the line observing circuit to be noted hereinafter.

As previously stated, the operation of relay 401 connects ground through the winding of relay 403 to conductor 404. The removal of ground from conductor 109 when relay 401 operates causes relays 107, 106, and 505 to release. Relays 107 and 106 released, disconnect conductors 111, 112 and 101 of the subscriber's line from the common observing circuit, releases relay 403 which disconnects ground from conductor 404, and opens conductors 113 and 114 to the register relays in the common observing circuit. If, at this time, any one or more of the lines connected for observation are originating a call and the sleeves of the lines have not yet been grounded or made busy, relay 107 of each of the individual extension line circuits associated with these lines will be connected in circuit as previously described for connecting the next preferred line in the observing groups to the observing trunk as previously described.

A key 705 is provided, individual to each trunk to open the ground on the conductor 434 which is a signal to the local originating apparatus that calls will not be accepted on this trunk. The path for locking-in a call from the front contact of relay 704 is also opened by the key 705. This is done to prevent a call from constantly coming into the control desk when some trouble occurs at the local originating office causing the originating office apparatus to fail to release.

What is claimed is:

1. A service observation system comprising a plurality of three or more observation positions, a line the service on which is to be observed, a service observation trunk capable of connection in a preferential order of rotation with any of said positions, means responsive to the occupation of any one of said positions for rendering said trunk connectible to said position, means responsive to the initiation of a call by said line for connecting said line to said trunk, means responsive to the occupation of said position

prior to the initiation of the call by said line for locking said line to said trunk and means responsive to the locking of said line to said trunk for locking said trunk to said position.

2. A service observation system comprising a plurality of three or more observation positions, a group of lines the service on which is to be observed, a service observation trunk capable of connection in a preferential order of rotation with any of said positions, means responsive to the occupation of one of said positions for rendering said trunk connectible to said position, means responsive to the simultaneous initiation of calls by a plurality of said lines for connecting that line which is in the preferred order of choice, to said trunk, means responsive to the occupation of said position prior to the initiation of the call by said lines for locking said line to said trunk, and means responsive to the locking of said line to said trunk for locking said trunk to said position.

3. A service observation system comprising a group of lines the service on which is to be observed, said lines being arranged in a definite order or preference, a plurality of observation positions, a service observation trunk, means responsive to the occupation of one of said positions for rendering said trunk connectible to said position, means responsive to the occupation of said position prior to the initiation of a call by any of said lines for connecting a preferred one of said lines to said trunk, and means responsive to the initiation of a call by each of said lines prior to the occupation of said position for rendering each of said lines non-connectible to said trunk for the period of each of said calls.

4. A service observation system comprising a group of lines the service on which is to be observed, a plurality of observation positions, a service observation trunk, means responsive to the occupation of any one of said positions for rendering said trunk connectible to said position, means responsive to the occupation of said position for connecting one of said lines when calling to said trunk, and means responsive to the simultaneous initiation of calls by a plurality of said lines for connecting that one of said lines which is in the preferred order of choice to said trunk.

5. A service observation system comprising a plurality of three or more observation positions, a group of lines the service on which is to be observed, a service observation trunk capable of connection in a preferential order of rotation with any of said positions, means responsive to the occupation of any one of said positions for rendering said trunk connectible to said position, means responsive to said connection for making said trunk connectible to any of said lines when calling, and means responsive to the connection of one of said lines when calling to said trunk for rendering the remainder of said lines when calling unconnectible to said trunk.

6. A service observing system comprising a plurality of three or more observation positions arranged in a definite order of preference, a plurality of service observation trunks connectible to each of the said positions in said definite order or preference, a plurality of lines the service on which is to be observed associated with each of said trunks, means responsive to the occupation of one of said positions for rendering all of said trunks connectible to said position, means responsive to the occupation of said position for locking a line in one of said groups when calling to its said associated trunk, means responsive to the locking of said line to said trunk for locking said trunk to said position, and means responsive to the interlocking of said line, said trunk and said position for rendering the next position connectible to the remainder of said trunks on the occupation of said next position.

7. A service observing system comprising a plurality of observation positions arranged in a definite order of preference, a plurality of service observation trunks, a plurality of lines, the service on which is to be observed, associated with each of said trunks, means responsive to the occupation of one of said positions for rendering all of said trunks connectible to said position, means responsive to the occupation of said position for locking a line in one of said groups when calling to its associated trunk, means responsive to the locking of said line to said trunk for locking said trunk to said position, means responsive to the interlocking of said line, said trunk and said position for rendering a less preferred position connectible to the remainder of said trunks only if another position ahead in the order of preference is busy and occupied.

8. A service observation system comprising a plurality of observation positions arranged in a definite order of preference, a plurality of service observation trunks, a line the service on which is to be observed associated with each of said trunks, means responsive to the occupation of all of said positions for rendering each of said trunks connectible at each of said positions in a definite order of preference, means responsive to the initiation of a call by each of said lines for connecting each of said lines to its associated trunk, means responsive to the connection of each of said lines to each of its said respective trunks for locking each of said trunks to one of said positions in a definite order of preference, and means responsive to the locking of trunks to each of said positions for disconnecting the lines from each of the remaining of said trunks not locked to a position, and for rendering each of said trunks thereafter non-connectible to said respective lines so long as each of said positions is busy and occupied.

9. In a service observation system, a plurality of central offices, a group of lines the service on which is to be observed in each of said offices, each of said lines having an arbitrary designation, a plurality of service observation positions, an observation trunk extending from each of said central offices to each of said positions, a register circuit and an impulse circuit associated with each of said trunks, means responsive to each of the lines of an office when calling for operating the register circuit of the trunk from that office in accordance with the arbitrary designation of said line, an impulse receiving circuit in each position connectible with each of said trunks, means responsive to the occupation of one of said positions for rendering each of said trunks connectible to said position, means responsive to a line when calling for connecting said line to the observation trunk extending from said office, means responsive to the connection of a line to said trunk for locking said trunk to said position, means responsive to the interconnection of said line, said trunk and said position for operating said impulse circuit for transmitting over said trunk series of impulses as defined by said operated register circuit, and means in the impulse receiving circuit of said locked-in position responsive

to said series of impulses for operating said impulse receiving circuit to display the arbitrary designation of said calling line.

10. A service observation system comprising a line the service on which is to be observed having an arbitrary designation, an observation position, an observation trunk, an impulse circuit and a register circuit in said trunk, said register circuit being associated with said line in accordance with the arbitrary designation of said line, means responsive to the occupation of said position for rendering said trunk connectible to said position, means responsive to the occupation of said position for connecting said line when calling to said trunk, means responsive to the connection of said line to said trunk for locking said trunk to said position, means responsive to the connection of said line to said trunk for operating said register circuit in accordance with the arbitrary designation of said line, means responsive to the locking of said trunk to said position for operating said impulse circuit to transmit a series of impulses as defined by said operated register circuit, and means in said trunk responsive after the transmission of said series of impulses for establishing a talking connection between said line and said position.

11. A service observation system comprising a line the service on which is to be observed having an arbitrary designation, an observation position, an observation trunk, an impulse circuit and a register circuit in said trunk, said register circuit being associated with said line in accordance with the arbitrary designation of said line, means responsive to the occupation of said position for rendering said trunk connectible to said position, means responsive to the occupation of said position for connecting said line when calling to said trunk, means responsive to the connection of said line to said trunk for locking said trunk to said position, means responsive to the connection of said line to said trunk for operating said register circuit in accordance with the arbitrary designation of said line, means responsive to the locking of said trunk to said position for operating said impulse circuit to transmit a series of impulses defined by said register circuit, means in said trunk responsive after the transmission of said series of impulses for establishing a talking connection between said position and said line, an auxiliary line and other means in said trunk also responsive after the transmission of said series of impulses for establishing an alternate talking connection between said position and said auxiliary line.

12. A service observation system comprising a line having a coin box, the service on which line is to be observed, an observation position, an observation trunk, means responsive to the occupation of said position for rendering said trunk connectible to said line when calling, means responsive to said connection of said line to said trunk for locking said trunk to said position, other means for establishing a signaling connection between said line and said position over said trunk, means in said trunk responsive to the operations of the coin box of said line, and means responsive to said last mentioned means for transmitting to said position distinctive signals of said operations.

13. In a telephone system, a service observation network comprising a plurality of three or more operators' positions, a plurality of observing lines, a trunk line for extending each of said lines to each of said positions in a definite order of preference, means responsive to the connection of one of said lines to said trunk when calling for operatively connecting said trunk to a preferred one of said positions and means responsive to said connection for rendering said trunk non-connectible at any other of said positions.

14. In a telephone system, a service observation network comprising a plurality of three or more operators' positions, a plurality of observing lines, a plurality of trunk lines for extending said lines to each of said positions in a definite order of preference, means responsive to the connection of one of said lines to each of said trunks for operatively connecting each of said trunks to one of said positions in a definite order of preference, and means in each of said trunks responsive to each of said connections for rendering each of said trunks non-connectible at any other of said positions.

15. The combination in a service observation network of an observing line having an arbitrary designation, an observing position, a trunk line for extending said observing line to said observing position, means in said trunk for locking said line to said trunk, registering means in said trunk for recording said arbitrary designation of said line, impulsing means in said trunk for transmitting a plurality of groups of impulses in accordance with said designation record, means in said position responsive to said connection of said trunk to said position for starting the operation of said impulse circuit and other means in said trunk for registering said transmitted impulses.

16. In a telephone system, a central office, a plurality of outlying offices, a plurality of observation trunks in each outlying office, each of said trunks being directly connected to a subscriber's line terminating at the office, a trunk line extending from each outlying office to the central office, an observation switchboard at the central office, means responsive to the initiation of a call on a subscriber's line terminating at any of the outlying offices for connecting the associated observation trunk with one of said trunk lines and for connecting the trunk line to said switchboard, and means thereafter effective to prevent any further connections to the switchboard as long as said first connection is maintained.

17. In a multi-office telephone system comprising a central office and a plurality of outlying offices, an operator's position at the central office, lines terminating at the outlying offices, means controlled by the operator for rendering said position connectible to any of said lines, means for connecting one of said lines to the position, means controlled by an operator for disconnecting said line from the position, means responsive to the initiation of a call on another line for connecting that line to the position, and means for rendering said last connecting means ineffective in case the first line is disconnected from the position subsequent to the initiation of the call on said other line.

18. In a telephone system, a line, means for extending a talking connection from the line, an operator's position, a voice current amplifier, means for establishing a monitoring connection from said first connection to said position via said amplifier, and means controlled by the operator for excluding said amplifier from the connection.

19. In a telephone system, a line, means for extending talking connections from the line, an operator's position, a voice current amplifier, means responsive to the establishment of said

talking connection for extending a monitoring connection to said position via said amplifier, and means controlled by the operator for converting said monitoring connection into a talking connection and for excluding said amplifier therefrom.

20. In a telephone system, a line, means for extending a talking connection from the line, an operator's position, a transmitter and a receiver at the position, an amplifier, means for establishing a monitoring circuit from said connection to said receiver via said amplifier, and means controlled by the operator for connecting the transmitter to said circuit and for excluding said amplifier therefrom.

21. In a telephone system, a plurality of branch offices, subscribers' lines terminating at said offices, line indicating and supervisory equipment common to said office, common means and means individual to each of said lines for associating the same with said equipment responsive to the initiation of a call on the line, and means for preventing a second line from being associated with said equipment while the first line is still associated therewith.

22. In a telephone system, a plurality of outlying offices, a central office, a plurality of subscribers' lines at each outlying office, means for extending connections from said lines, a trunk line extending from each outlying office to the central office, means at each outlying office responsive to the initiation of a call on a line for connecting the line with the trunk extending to the central office and for signaling an observing operator, and means responsive to the extension of a connection from the calling line to a further point for signaling the observing operator.

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