

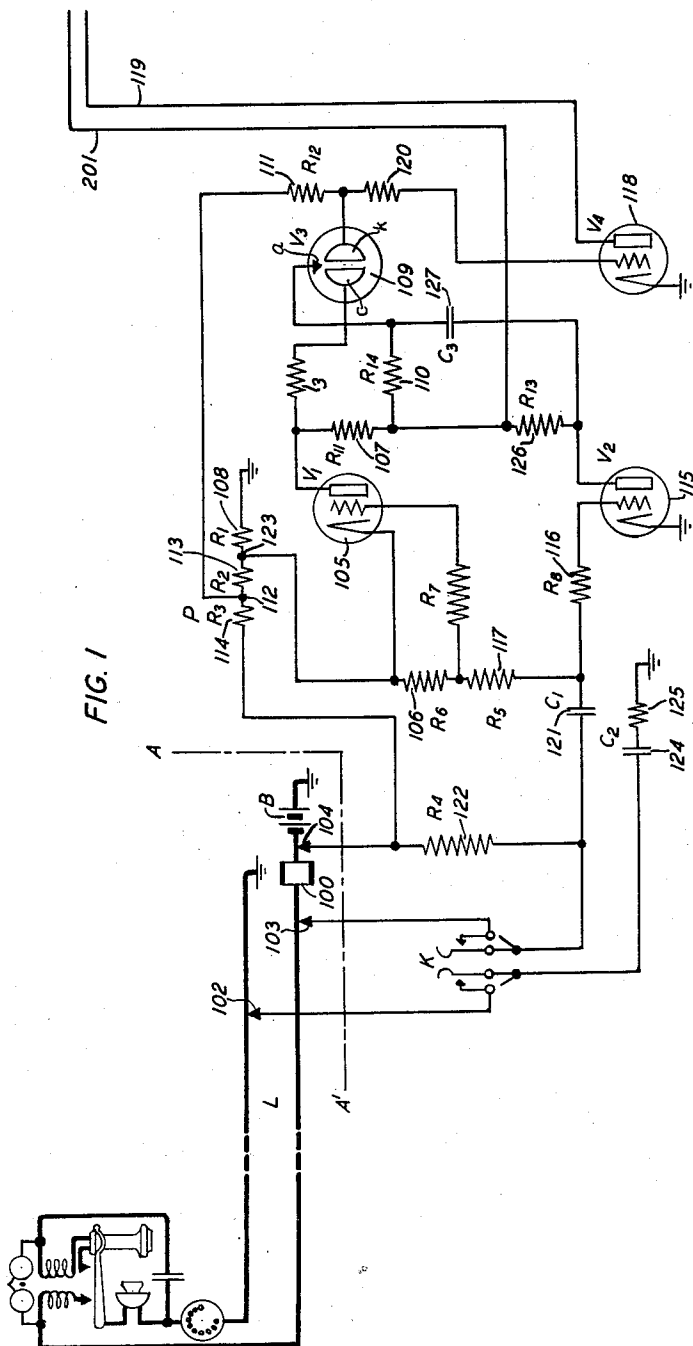
May 18, 1943

M. A. LOGAN ET AL
SERVICE OBSERVING SYSTEM

2,319,333

Filed June 14, 1941

3 Sheets-Sheet 1



INVENTORS M. A. LOGAN
L. G. SCHIMPF
BY *[Signature]*
ATTORNEY

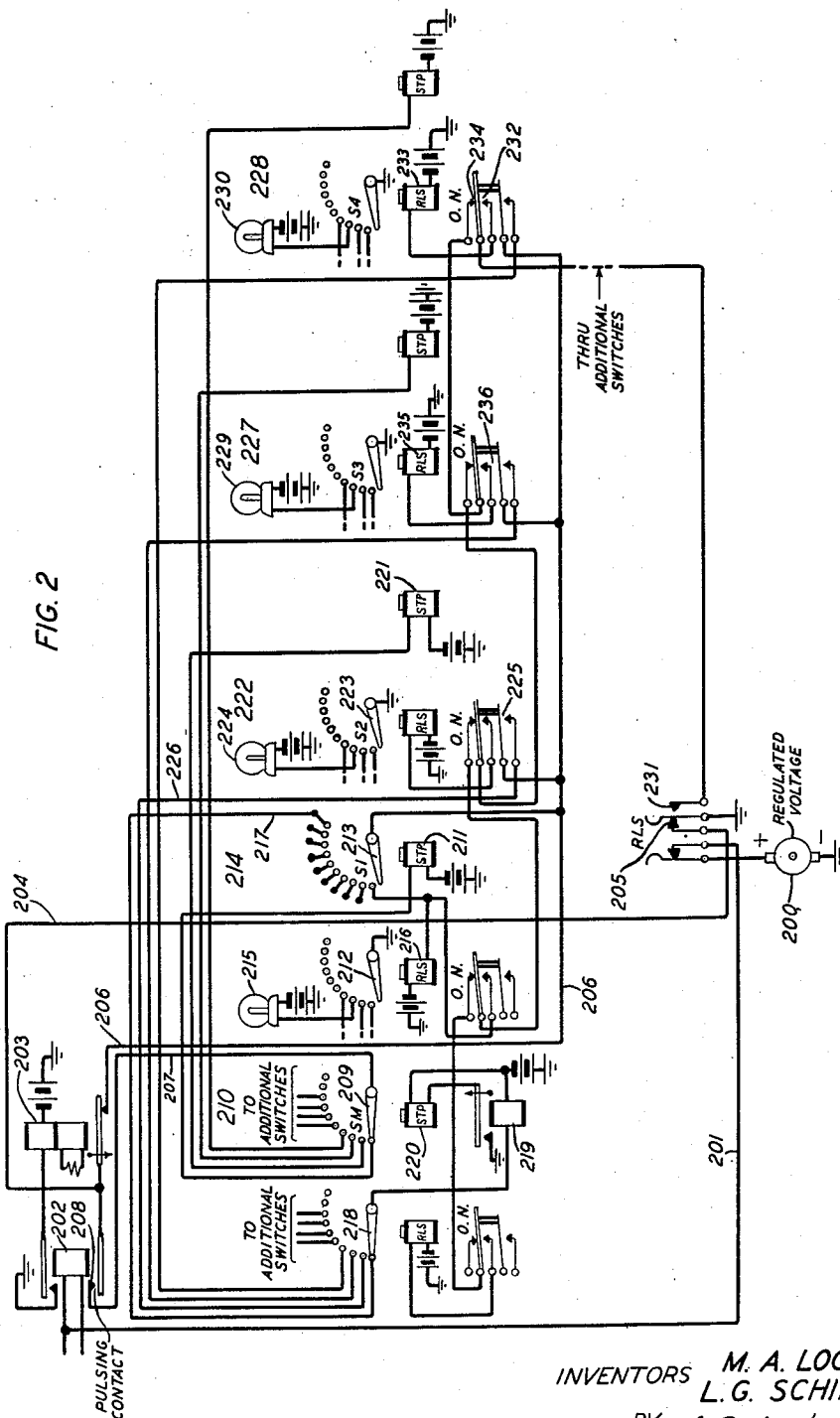
May 18, 1943

M. A. LOGAN ET AL
SERVICE OBSERVING SYSTEM

2,319,333

Filed June 14, 1941

3 Sheets-Sheet 2



INVENTORS M. A. LOGAN
L. G. SCHIMPF

BY *J. S. SchimPF*
ATTORNEY

May 18, 1943

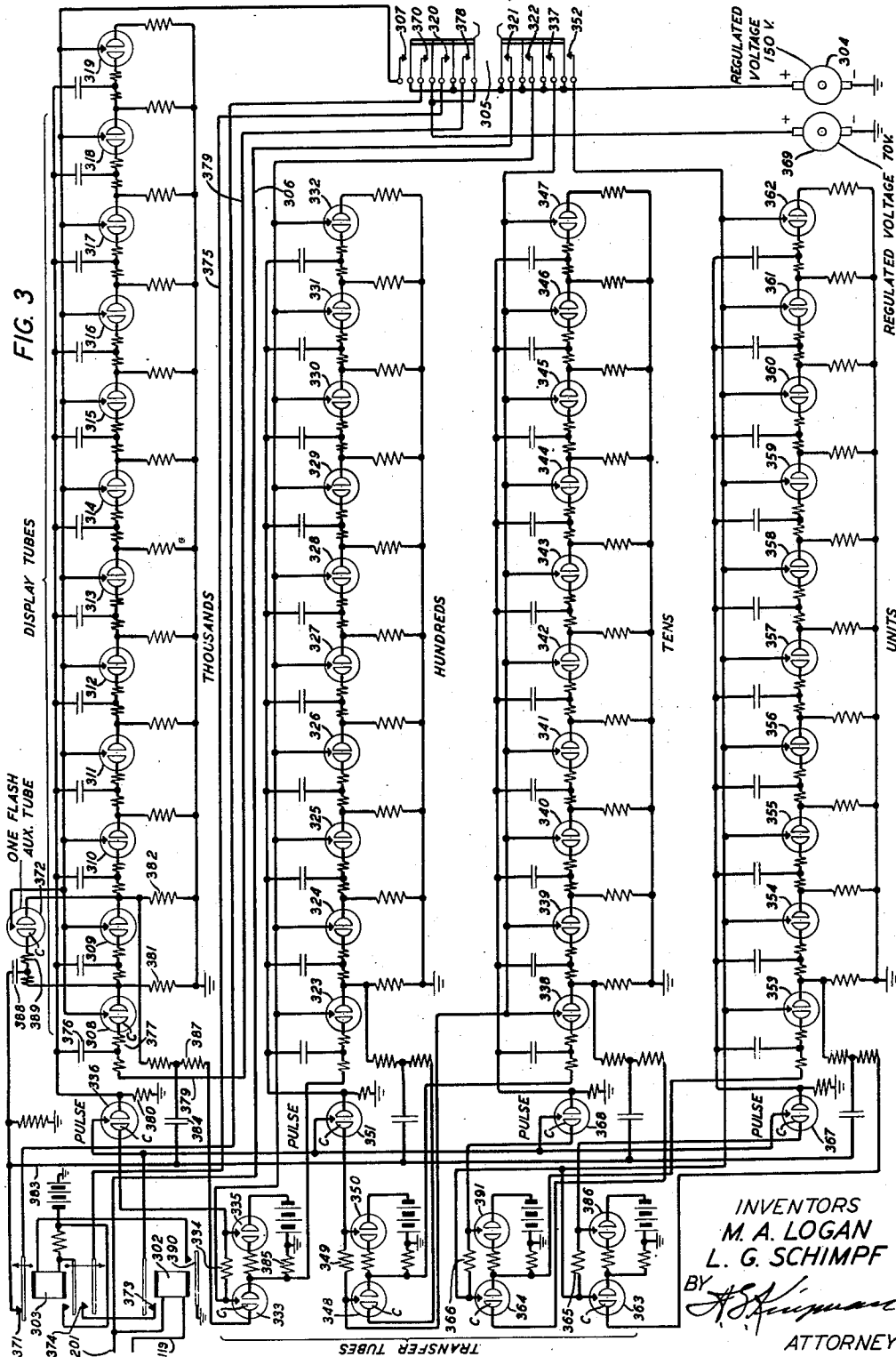
M. A. LOGAN ET AL.

2,319,333

SERVICE OBSERVING SYSTEM

Filed June 14, 1941

3 Sheets-Sheet 3



UNITED STATES PATENT OFFICE

2,319,333

SERVICE OBSERVING SYSTEM

Mason A. Logan, Summit, N. J., and Luther G. Schimpf, St. George, N. Y., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application June 14, 1941, Serial No. 398,052

9 Claims. (Cl. 179-175.2)

This invention relates to telephone service observing systems and more particularly to a pulse detecting and repeating amplifier for controlling a device for recording the digits of a dialed number for use in connection with service observing equipment of the type disclosed in the pending application of H. G. W. Brown et al., Serial No. 338,874, filed June 5, 1940.

An object of the invention is to detect, amplify and record the instantaneous voltage changes in a telephone line during the operation of a subscriber's telephone dial without interfering with the normal operation of the equipment involved in establishing the desired connection and more specifically to enable accurate detection and recording of these small line potential variations.

A feature of the invention resides in means including a normally conducting thermionic vacuum tube and a normally non-conducting vacuum tube whose input circuits are associated with the line in such a manner that when the pulsing contacts of the associated dial are opened, said normally conductive tube is momentarily rendered non-conducting and when the contacts of the dial are closed, said normally non-conducting tube is momentarily rendered conducting, means including a gas-filled discharge device responsive to the momentary cessation of current in the output circuit of the normally conducting tube to close a circuit to control a recording device and other means responsive to a momentary current impulse in the output circuit of the normally non-conducting vacuum tube to open the circuit for controlling the recording device.

Another feature resides in a step-by-step switch arrangement for recording the dial pulses detected by the foregoing described tube arrangement.

Another and related feature resides in means for preventing an initial circuit closure from causing the switch to make a record unless it is followed immediately by a second closure.

Still another feature resides in an arrangement of gas-filled tubes, in place of a step-by-step switch arrangement, for recording the dial pulses. In this arrangement there are as many rows of gas-filled discharge devices as there are code digits in the number dialed, each impulse of each digit causing the glow discharge of an individual tube in the digit row which tube continues to glow until released at the conclusion of the dialing operation, the number dialed being determined by counting the number of tubes which are glowing in each row. In case a single initial impulse is detected, i. e., a momentary opening of the line

such as might be caused by the accidental depression and subsequent release of the subscriber's switchhook before starting to dial, thereby causing a single closure of the recorder circuit, the first tube of the first row will be discharged and start to glow in the usual manner but unless this impulse is followed immediately by a second impulse, the next impulse or circuit closure, such as the first occasioned by the regular operation of the dial, will cause the second tube in the row to be disabled and discharge the third tube instead thereby indicating to the observer that the first tube should be ignored in counting the number of tubes glowing in that row.

The invention will be understood from the following description when read in connection with the accompanying drawings:

Fig. 1 of which shows the pulse detector and amplifier;

Fig. 2 shows a step-by-step switch recorder; and

Fig. 3 shows an alternative recorder employing a plurality of gas-filled discharge tubes which are caused to discharge and glow in response to the detection and amplification of successive dial pulses.

Referring to the drawings, a subscriber's line L is shown terminating at a telephone exchange in grounded battery B in series with the usual line relay 1. The pulse detecting and amplifying equipment shown below and to the right of the broken line AA' and connected to the subscriber's line is for the purpose of observing thereon by means of temporary connections indicated at points 102, 103 and 104. A key K is provided which is operated to connect the detector to the line when the observer desires to record the number dialed by the subscriber in establishing a connection. For the purpose of the following description, battery B will be assumed to have a potential of 48 volts and the source of regulated direct current 200 a potential of 150 volts.

When the detecting and amplifying arrangement of Fig. 1 is connected at points 102, 103 and 104 to the line, the grid of vacuum tube 105 will have a zero bias with respect to its filament due to the fact that it is connected thereto through the high resistance 106 of the order of 100,000 ohms and therefore the plate circuit of tube 105 will conduct its normal output current in a circuit from the positive pole of source 200, release key RLS, conductor 201, high resistance 107 (50,000 ohms) to the plate of tube 105, and from the filament thereof to ground in series with low resistance 108 (60 ohms).

Direct current source 200 is also connected over conductor 201, to the anode *a* of gas-filled discharge tube 109 in series with high resistance 110 (20,000 ohms) and the cathode *k* is connected in series with resistance 111 to a potentiometer point 112 between low resistance 113 (30 ohms) and resistance 114 (294 ohms), which potentiometer point is at approximately -11 volts with respect to ground on the assumption that battery B is 48 volts as above mentioned. These two potentials, being in an aiding direction, apply a potential of 161 volts across the anode-cathode gap of tube 109 which, however, due to the characteristics of the tube is insufficient to cause a discharge therebetween in the absence of ionization which does not occur as long as vacuum tube 105 is conducting and current flows in resistance 107, for the reason that the drop across this resistance (of the order of 125 volts) is applied to the control gap of tube 109, i. e., cathode *k* and control electrode *c*, in series opposition with the 11-volt drop at point 112 in the potentiometer P and the 150-volt source 200 which difference is only about 36 volts.

At this time the grid of vacuum tube 115 is about $7\frac{1}{2}$ volts negative with respect to its grounded filament due to its connection in series with resistances 116, 117 and 106 of 250,000, 100,000 and 100,000, respectively, to a point 123 between resistances 113 and 108 of the potentiometer P. Tube 115 is therefore substantially non-conducting at this time.

Vacuum tube 118, whose output circuit is through conductor 119, relay 202 of the recorder and the direct current source 200, is also non-conducting at this time for the reason that its grid is 11 volts negative with respect to its filament due to its connection through resistance 120 (100,000 ohms) and resistance 111 (5,000 ohms) to point 112 in the potentiometer P. Furthermore, condenser 121 is normally charged to approximately 40 volts with its left-hand plate negative and its right plate positive due to its connection in a circuit from the negative pole of battery B, high resistance 122, condenser 121, resistances 117 and 106, to point 123 in the potentiometer P, which, under the assumed condition is approximately $7\frac{1}{2}$ volts negative. The foregoing is the normal condition of the detector amplifier when it is conditioned for operation by its connection to the line at points 102, 103 and 104 and prior to the initiation of a call on the line.

When the subscriber calls by removing the receiver from the switchhook, line relay 100 operates, in accordance with the usual practice, and the observer is appraised thereof by means, not shown, associated with the service observing set previously referred to and disclosed in the pending application of H. G. W. Brown et al., Serial No. 338,874, filed June 6, 1940, whereupon the observer, if she desires to obtain a record of the number about to be dialed, operates key K thereby connecting the ring conductor of the line to the left-hand plate of condenser 121 and the tip of the line to an equivalent balancing circuit to ground comprising condenser 124 and high resistance 125.

After key K is operated, and during the interval before the dial contacts open for the first series of pulses, point 104 in the line, to which condenser 121 is connected, will be somewhat less than -48 volts due to a circuit from this point to ground including the resistance of the line conductors and the closed dial and switchhook con-

tacts at the subscriber's station. This drop in voltage at point 104 causes a change in potential on the left plate of condenser 121 to a less negative value and therefore a momentary surge of current flows through resistances 117, 106 and 108 to ground thereby causing a drop in potential across resistances 117 and 106, the drop across 106 being effective to drive the grid of vacuum tube 105 positive with respect to its filament, which, however, merely tends to increase the current in the plate circuit a small amount with a corresponding small increase in the potential drop across resistance 107 which, however, is not sufficient to fire the control gap of tube 109. However, when the subscriber actuates and releases his dial, and the pulsing contacts open for the first pulse, the voltage on the ring conductor is restored to its original value, i. e., -48 volts thereby causing another change in condenser 121 whereby a reverse current momentarily flows through resistances 108, 106 and 117 thereby causing a voltage drop across resistance 106 which drives the grid of tube 105 negative with respect to the filament during the brief charging period of condenser 121. This negative grid condition causes a momentary cessation of the plate current of tube 105. The grid of tube 115 is also driven more negative, but as this tube is not conducting at this time, no change in its plate circuit results.

During the short interval the plate current in tube 105 is suppressed, and no current flows through resistance 107, the potential between cathode *k* and control electrode *c* of tube 109 increases to a value equal to the potential of source 200, i. e., 150 volts, plus the 11-volt potential of point 112 of the potentiometer P, or approximately 161 volts, which is sufficient to cause this gap to fire and cause ionization, whereupon the main gap, i. e., anode *a* to cathode *k* fires due to this same potential of 161 volts which is connected thereacross as previously mentioned, the circuit for which can be traced from source 200, conductor 201, resistance 110, anode *a*, cathode *k*, resistance 111, to point 112 of the potentiometer P which is approximately 11 volts negative with respect to ground, i. e., the opposite or negative pole of source 200. Current now flows in the above-mentioned circuit and causes a drop across resistance 111 which drives the grid of vacuum tube 118 sufficiently positive to cause this tube to conduct, the circuit being from source 200, conductor 201, winding of relay 202, conductor 119 and the plate and filament of tube 118 to ground. The current in this circuit is sufficient to cause operation of relay 202 thereby closing an obvious circuit to operate slow-release relay 203 which opens its lower contact to remove ground on conductor 204, applied at contacts 205 of release relay RLS, from conductor 206 for a purpose to be later described.

Relay 202 in operating also closes its lower contacts 208 thereby connecting ground, on conductor 204, to conductor 207 which causes operation of the pulse recording equipment to be later described.

As soon as condenser 121 of the detector has reached a steady charge and the current through resistances 117 and 106 ceases, and the potential difference between the grid and filament of vacuum tube 105 restores to zero, this tube again passes its normal full plate current in the circuit including resistance 107. Gas-filled tube 109, due to its so-called "trigger" characteristic, continues

to pass current cross its main gap thereby maintaining the grid of tube 118 positive and therefore relay 202 will hold operated until the dial contacts are again closed at the end of the first pulse at which time the ring of the line again becomes more positive, i. e., less negative, and a current surge again flows from the ring conductor through condenser 121 and resistances 117, 106 and 108 to ground. As before, no effective change in the plate current of tube 105 occurs but the grid of tube 115 is momentarily driven sufficiently positive to cause plate current to flow therein in a circuit from source 200, conductor 201, resistance 126 and plate and filament of tube 115 to ground. Current flowing in resistance 126 causes a difference in potential to exist between its terminals which is applied to condenser 127 in series with the resistance 110 in such a direction that its upper plate is charged positively and its lower plate negatively which has the effect of lowering the potential of anode α of tube 109 to such a value that this tube ceases to conduct whereupon the potential of the grid of tube 118 is restored to the potential of point 112 in potentiometer P, i. e., -11 volts, whereupon this tube 118 ceases to conduct and relay 202 releases. When condenser 121 regains a static condition, the grid of tube 115 is again biased negatively with respect to its filament and ceases to conduct and the detector amplifier is again ready to function as before when the dial contacts are opened again for the second pulse. The foregoing cycle is repeated for each pulse of the first digit dialed, i. e., relay 202 operates each time the dial contacts are opened and released when the contacts are closed. Relay 203, which is slow to release, holds operated in a well-known manner during the closed period of the dial contacts while the digits are being dialed, but releases at the end of each series of pulses.

Operation of step-by-step switch recorder

As previously mentioned, relay 203 operates as soon as relay 202 is energized in response to the first interruption of the dial contact and this relay being slow to release, holds operated during the intervals relay 202 is released which occurs each time the dial contacts are closed. As soon as relay 202 operates for the first time it closes its pulsing contacts 208 thereby extending ground, on conductor 204, over conductor 207, wiper 209 and the first contact of selector switch 210 to battery in series with the stepping magnet 211 which controls the movement of wiper brushes 212 and 213 of selector switch 214 which brushes are advanced one step each time the pulsing contacts 208 of relay 202 are closed.

It will be noted that each of the contacts of the left-hand bank of switch 214 is connected through an individual lamp such as 215 to battery and that the wiper 212 is grounded.

If we assume, for purposes of description, that a four-digit code is being used, and the number dialed is 3333, then when the wiper 212 takes three steps in response to the first or thousands digit, and stops, lamp 215 will be lighted and remain lighted until the switch is released by operation of release relay 216.

When relay 202 releases at the conclusion of the pulses representing the first digit, relay 203 releases after a short interval thereby closing its lower back contact and extending ground, on conductor 204, over conductor 206 to wiper 213 of switch 214 which further extends this ground over conductor 217 to the first contact of the left-

hand bank of switch 210 on which wiper 218 is now standing thereby completing a circuit to operate slow-to-release relay 219. Operation of relay 219 closes an obvious circuit to operate the stepping magnet 220 which advances wipers 209 and 218 one step into engagement with the second or No. 2 contact of their respective banks whereupon relay 219 releases.

At the completion of the pulses of the first digit, therefore, the wipers 212 and 213 of switch 214 are standing on the third or No. 3 contacts of their respective banks, lamp 215 is lighted and wipers 209 and 218 of switch 210 are advanced and are standing on their respective No. 2 contacts. When the subscriber actuated his dial to transmit the next three interruptions for the second or hundreds digit of the called number, relay 202 again operates and releases following the pulses and relay 203 operates and holds operated until this series is completed. Due to the fact that wiper 209 of switch 210 is now standing on the second contact of its bank, the pulsing circuit controlled by contacts 208 of relay 202 now includes the stepping magnet 221 of switch 222 and therefore the three impulses of the hundreds digit cause the wiper 223 of switch 222 to advance to and stop on the third contact of the bank of this switch to light lamp 224 connected to this contact. At the end of the series of impulses, relay 203 releases thereby again closing its back contact and completing the circuit to step wipers 209 and 218 of switch 210 ahead to engage the third contacts of their respective banks, the circuit being traced from ground on conductors 204, back contact of relay 203, conductor 206, off-normal contacts 225 of switch 222, conductor 226, No. 2 contact and wiper 218 of switch 210 to battery in series with relay 219. This relay (219) in operating energizes the stepping magnet 220 which causes the wipers 209 and 218 to move ahead to the next point (3) contacts, thereby deenergizing the relay 219.

The foregoing steps are repeated for the tens and units digits dialed except that the wipers of switches 227 and 228, respectively, are set on the third contact of their respective banks to successively light lamps 229 and 230. The transfer of the pulsing circuit being effected by the advance of switch 210 as before.

At the completion of the unit pulses, lamps 215, 224, 229 and 230 are lighted and the wipers 209 and 218 are advanced to the fifth bank contact upon release of relay 203.

Lamps 215, 224, 229 and 230 remain lighted as an indication to the observer that the number dialed was 3333.

When the observer desires to erase this indication, she operates release key RLS thereby opening contacts 205 and closing contacts 231 which connect ground over off-normal contacts 232 of switch 228 to operate release magnet 233 whereupon switch 228 restores thereby closing its normal contact 234 and transferring the release ground to release magnet 235 over off-normal contacts 236. This action is repeated until all switches are restored.

In order to prevent registration of a single preliminary or switchhook pulse, the recorder circuit is arranged so that if switch 214 steps ahead only one step, due to a single operation and release of relay 202, when relay 203 releases, a circuit to energize release magnet 216 of this switch is closed from ground on conductor 204, back contacts of relay 203, conductor 206, wiper 213, and No. 1 contact of the switch to battery in series with magnet 216 which immediately re-

stores switch 214 in readiness for the pulses of the number to be dialed.

Operation of gas tube recorder

The foregoing describes the operation of a recording device employing automatic step-by-step switches as shown on Fig. 2. The operation of an alternative recording arrangement employing gas-filled glow discharge devices controlled in a similar manner by the detecting and amplifying arrangement of Fig. 1, over conductor 119 will now be described.

The arrangement of Fig. 3 is connected to the detector of Fig. 1 by means of conductors 119 and 201 and is provided with two relays 302 and 303 which correspond to relays 202 and 203 of Fig. 2 and respond in the same manner to electrical impulses in the output circuit of the amplifier tube 118, i. e., the first impulse of the digit series applied to conductor 119 causes relay 302 to operate thereby causing slow-release relay 303 to operate which holds operated during the pulsing interval whereas relay 302 alternately releases and re-operates to follow the detected impulses of the calling subscriber's dial.

In the drawing of Fig. 2 the 150-volt direct current source 200 is shown as normally connected to conductor 201 whereas in Fig. 3 a similar 150-volt regulated source 304 is shown as connected by the operation of a gang or multicontact key 305 over conductor 306 and therefore with key 305 closed and the arrangement of Fig. 3 connected to the detector circuit of Fig. 1, by means of conductors 201 and 119, relays 302 and 303 will operate in the same manner as relays 202 and 203 of Fig. 2, previously described.

When key 305 was operated, circuits were closed from the regulated 150-volt direct current source 304 as follows:

Contact 307 of key 305 to the anodes, in parallel, of the thousands digit glow display tubes 308—319.

Contacts 320 of key 305 to the lower armature of relay 303.

Contacts 321 of key 305 to the winding of relay 302, and conductor 201 to Fig. 1.

Contacts 322 to the anodes, in parallel, of the hundreds digit glow display tubes 323—332, the anode of transfer tube 333, to the anode of transfer tube 335 through resistance 334 and to control electrode c of the first or thousands digit pulse responsive tube 336.

Contacts 337 to the anodes, in parallel, of the tens digit glow display tubes 338—347, the anode of transfer tube 348, through resistance 349 to the anode of transfer tube 350 and to control electrode c of the hundreds pulse responsive tube 351.

Contacts 352 to the anodes, in parallel, of the units digit glow display tubes 353—362, the anodes of transfer tubes 363 and 364 and through resistances 365 and 366 to the anodes of tubes 368 and 391 and the control electrode c of the pulse responsive tubes 367 and 368.

In addition to the 150-volt source 304, a 70-volt regulated direct current source 369 is provided and connected over contacts 370 of switch 305 and the upper armature and back contact 371 of relay 303 to the control electrode c of tubes 372, 333, 348, 364 and 363 through condensers 388, 384, etc. This applies a surge to the tubes 372, etc., but causes no operation at this time. This source 369 is also connected over contacts 378 of switch 305 and conductor 379 to the control electrode c of tube 308.

Closure of contact 322, 337, and 352 of key 305

causes the pulsing tubes 336, 351, 368 and 367 to ionize thereby preparing these tubes to break down their main gap, i. e., anode to cathode, when the pulsing relay 302 operates. When this occurs relay 302 closes its contacts 373 and 390 causing operation of relay 303 which closes its contact 374 thereby completing a circuit from the 150-volt source 304, contact 320 of key 305, conductor 375, contact 374 of relay 303 and contact 373 of relay 302 to the anode of pulse tubes 336, 351, 368 and 367 which tubes being ionized, break down and conduct current from the anode to cathode and thence to ground in series with a high resistance (25,000 ohms) individual to each tube, as for example, resistance 380 individual to tube 336. This sudden surge of current through these individual high resistances causes an abrupt change in potential thereacross which potential change is applied across the control gap of all the tubes 308—319, 323—332, 338—347, and 353—362 through the respective associated condensers and resistances such as condenser 376 and resistance 377 for tube 308. This voltage, however, is insufficient, by itself to break down the control gaps of these tubes and cause their ionization and therefore an additional bias voltage must be added thereto in the proper direction which voltage is provided at this time, for the first tube (308) only, which may be traced from the 70-volt source 369, contacts 378 of key 305 and conductor 379 to the control electrode c of tube 308. This voltage added to the voltage across the control gap of this tube, due to the potential across the high resistance 380 is sufficient to break down the control gap. When tube 308 ionizes its main gap fires immediately due to the presence of 150 volts applied to its anode in a circuit from source 304 and contact 307 on key 305. Current flowing across the anode-cathode gap of tube 308 to ground in series with resistance 381 causes a potential drop across this resistance which is applied across the control gap of tube 309 which potential supplies the necessary bias to this gap so that the next discharge pulse across the anode-cathode gap of tube 336, caused by the next operation of relay 302, and the consequent potential drop across resistance 380, is sufficient to fire the second tube 309 of the thousands digit row of display tubes. Tube 309 in turn fires its main gap and places a bias potential across the control gap of the third tube 310, due to the drop across resistance 382 and so on, each tube firing in succession in response to the successive pulse discharges of tube 336 until the dial pulses of the first digit are completed and relay 303 releases. The ignited tubes remain in a discharging condition until the potential source 304 is disconnected by release of key 305.

When the second display tube 309 fires and a drop in potential occurs across resistance 382, this voltage is applied to the control electrode c of transfer tube 333 which gives this tube the proper bias so that it will ionize in response to release of relay 303. When this occurs the closure of contact 371 connects the 70-volt source 369 over conductor 383 to the control electrode c of the first transfer tube 333 in series with condenser 384 and resistance 387 whereupon tube 333 ionizes and, as its anode is connected to the 150-volt source 304 at this time, its main gap fires thereby causing a drop in potential to appear across its cathode resistance 385 which is applied as an operating potential across the control gap of the second transfer tube 335 and as a bias voltage to the first tube 323 of the hundreds

row. Transfer tube 335 thereupon fires and lowers the potential on the control electrode c of the first pulsing tube 36 to prevent its further ionization during the succeeding dial intervals and hence no more display tubes in the thousands row will be discharged in response to pulses of the second digit of the called number.

The recording of the second, third and fourth digits follows in the same manner as previously described, i. e., when the pulsing relay 302 operates, followed by the operation of slow-to-release relay 303, tubes 323 and 324, etc., fire in successive order and at the end of the pulse group, relay 303 releases to cause the operation of transfer tube 348 and the second transfer tube 350, which latter tube fires its main gap thereby disabling pulsing tube 351. The operation of tube 348, also applies an enabling bias to the first tube in the tens digit row 338, which then operates on the first closure of relay 302 during the tens digit, and so on until the end of the dialed number, whereupon the observer is appraised of the digit dialed by counting the number of glowing tubes in the four display rows.

At the conclusion of the last or units digit pulses, relay 303 releases and transfer tube 363 is ionized and fires immediately thereby ionizing and firing the second tube 386 which disables pulse responsive tube 367 to prevent subsequent false impulses from firing further tubes in the last or units row.

Absorbing a single initial impulse

In case the subscriber's switchhook contact should be accidentally opened and subsequently closed before the dial is operated, or for any reason a single line interruption occurs in advance of the dialing operation, an impulse will be detected in the manner described which would cause operation and release of relays 302 and 303 which lights the first tube 308 of the thousands row and conditions the recorder to receive the first regularly dialed digit impulse on the second or hundreds row of tubes. To avoid this possibility the first row of tubes is arranged to absorb a single initial impulse as follows. When relay 303 releases at the conclusion of the initial impulse, assuming that only a single impulse is received, 70-volt source 369 is connected over contact 370 of key 305 and the back contact 371 of relay 303 to the control electrode c of the first transfer tube 333 in series with condenser 384 and resistance 387 and also to the control electrode c of auxiliary tube 372 in series with condenser 388 and resistance 389, but it will be noted that the first display tube 308 which is now fired, does not apply an enabling biasing to the control gap of transfer tube 333 whereas it does apply such a bias to the auxiliary tube 372 so if only the first display tube 308 is fired, only the auxiliary tube 372 will ionize at this time, whereupon the main gap will fire thereby applying an enabling bias to control electrode c of transfer tube 333 due to the potential drop across resistance 382. Tube 333, however, is not ionized until relay 303 operates and releases again at the end of the first series of dial impulses at which time it fires its main gap as previously described followed by ionization and discharge of tube 335 which places an enabling bias on the first tube 323 in the second row. The current flowing in the resistance 382 due to the main gap discharge of tube 372 causes a rise in potential on the cathode of the second tube 309 of the first row so that this

tube does not fire in response to the first impulse of the regularly dialed number, but the potential drop across resistance 382 applies an enabling bias to the control electrode c of the third tube 310 so that the first impulse of the dial impulse will be recorded on the third tube 310. Due to the fact that the second tube 309 remains dark and the third tube is lighted, the observer will understand that she is to ignore the first tube in her calculation and begin counting with the third tube.

What is claimed is:

1. In a telephone service observing system, a line having a normally constant direct current potential, and means for detecting and recording abrupt changes in said line potential, said detecting means including first, second and third thermionic vacuum tubes and a gas-filled discharge tube, each tube having input and output circuits therefor, said first vacuum tube being arranged to be normally conducting and all of said other tubes normally non-conducting, means connecting the input circuits of said first and second tubes to a point in said line and so arranged that an abrupt decrease in the potential of said line at said point will cause said first tube to momentarily cease to conduct, means in the output circuit of said first tube responsive to the momentary cessation of current therein to cause said gas-filled tube to discharge and conduct, means in the output circuit of said gas-filled tube responsive to current flowing therein to cause said third vacuum tube to conduct, said input circuit of the second vacuum tube being so arranged that when an abrupt increase in the line potential occurs, said second tube will be caused to momentarily conduct, and means in the output circuit of said second tube responsive to a momentary current flow therein to stop the flow of current in the output circuit of said gas-filled tube and thereby restore said third vacuum tube to a non-conducting condition, said recording means comprising a relay in the output circuit of said third tube responsive to current flowing therein, and a plurality of luminous devices sequentially energized responsive to successive operations of said relay.

2. A system in accordance with claim 1, characterized in this that said luminous devices consist of a plurality of gas-filled glow-discharge tubes arranged in rows and that circuit means are provided and so arranged that successive operations of said relay, which follow each other within a predetermined time interval, will successively energize individual glow tubes in one row and when the interval between release and reoperate of said relay exceeds said time interval, a circuit change will be effected to cause the successive energization of individual glow tubes in the second row in response to succeeding operations of said relay.

3. A system in accordance with claim 1, characterized in this that said luminous recording devices comprise a plurality of gas-filled glow-discharge tubes arranged in rows and that means including a plurality of groups of other gas-filled discharge devices, individual to each row, are provided and so arranged that the first succession of said relay operations which follow each other within a predetermined time interval will successively energize the individual glow tubes in a first row and when the interval between release and reoperate of said relay exceeds said time interval, certain of the associated groups of other

gas-filled tubes will be energized to cause succeeding operations of said relay to successively energize the glow tubes of the second row.

4. A system in accordance with claim 1, characterized in this that said luminous recording devices comprise a plurality of gas-filled glow discharge tubes arranged in rows and means including a plurality of groups of other gas-filled discharge tubes individual to each row, are provided and so arranged that the first succession of said relay operations which follow each other within a predetermined time interval will successively energize individual glow tubes in a first row and when the interval between release and reoperate of said relay exceeds said time interval, certain of the associated group of other gas-filled tubes will be energized to cause succeeding operations of said relays to successively energize the glow tubes of the second row, and other gas tube means responsive to a single initial operation and release of said relay not followed within said predetermined time interval by succeeding operations of the relay to disable the second glow tube of the first row and cause the next operation of the relay to energize the third tube of the row.

5. In a service observing system for telephone lines, over which open-circuit pulses are transmitted, means for recording said pulses including first, second and third thermionic vacuum tubes and a three-element gas-filled discharge tube, said first and second tubes having their input circuits so arranged and connected to the line, their output circuits associated with said discharge tube and the input circuit of said third tube being so connected to the output circuit of said discharge tube that when said line is closed, said first tube conducts and said other tubes are blocked, when said line is opened, said first tube is momentarily blocked and rendered non-conducting, said discharge tube in response to cessation of current in the output circuit of said first tube becomes ionized and permits current to flow in its output circuit to unblock said third tube and render it conducting in a circuit including a pulse responsive relay, and when said line is again closed, said second tube is momentarily unblocked and rendered conducting to block said gas tube and render said third tube non-conducting to release said relay.

6. In a service observing system for telephone lines, over which open-circuit pulses are transmitted, means for detecting and recording said pulses including a gas-filled discharge tube, a recording relay controlled thereby, and a pair of thermionic vacuum tubes for controlling said gas tube having their input circuits connected to the line and so arranged that when the line is closed, a first one of said vacuum tubes is conducting and a second non-conducting, and having their output circuits connected to said gas tube in such a manner and so arranged that when said first tube is conducting, said gas tube is disabled, and means common to said input circuits responsive to an open-circuit pulse to momentarily render said first tube non-conducting to permit said gas tube to discharge and

operate said relay, said common input circuit means being also responsive to a subsequent closure of the line to render said second vacuum tube momentarily conducting to stop said gas tube discharge and release said relay.

7. In a service observing system for telephone lines, over which groups of open-circuit pulses are transmitted, a relay, means including a gas-filled discharge tube associated with said line adapted to cause operation of said relay when said line is opened and to release when the line is closed and means controlled by said relay for recording the number of pulses of each group transmitted, said means comprising a plurality of gas-filled glow-discharge tubes arranged in rows corresponding to the number of groups of pulses transmitted, a gas-filled pulsing tube individual to each row and responsive to operation of said relay for controlling the sequential ignition of the glow tubes therein, and other means including a plurality of groups of gas tubes also individual to each row for successively conditioning another row of glow tubes and disabling the respective pulse tubes at the end of each pulse group.

8. A service observing system for telephone exchanges, a line over which open-circuit pulses are transmitted, a relay and means for operating the relay in response to an open-circuit pulse on said line and for releasing said relay in response to a closure of said line, said means comprising a pair of thermionic vacuum tubes having their input circuits connected to said line, the first one of which being conditioned to conduct normal plate current, and the second to be non-conducting, when said line is closed, a three-element gas-filled tube having its control circuit connected to the output circuit of said first tube in such a manner that when current is flowing therein said gas tube is disabled and prevented from ionizing, means in the input circuit of said first tube in response to the opening of said line to momentarily cause it to be non-conducting thereby removing the disabling condition from said gas tube and permitting it to discharge and conduct, and means responsive to said conductive discharge to operate said relay.

9. In a system for recording open-circuit pulses transmitted over a line, a device for recording said open-circuit pulses, a normally conductive vacuum tube and a normally non-conductive vacuum tube, input and output circuits for each tube, means including a connection between each input circuit and said pulsing circuit so arranged that when said pulsing circuit is opened said first tube is momentarily rendered non-conductive and when said pulsing circuit is closed, said second tube is momentarily rendered conductive, and means responsive to the momentary cessation of current in the output circuit of the first tube to close a circuit to control said recording device and other means responsive to a momentary current impulse in the output circuit of the second tube to open the circuit controlling said recording device.

MASON A. LOGAN.
LUTHER G. SCHIMPF.