June 1, 1937. E. S. GIBSON ET AL 2,082,104

TESTING SYSTEM

Filed Jan. 9, 1936 2 Sheets-Sheet 1

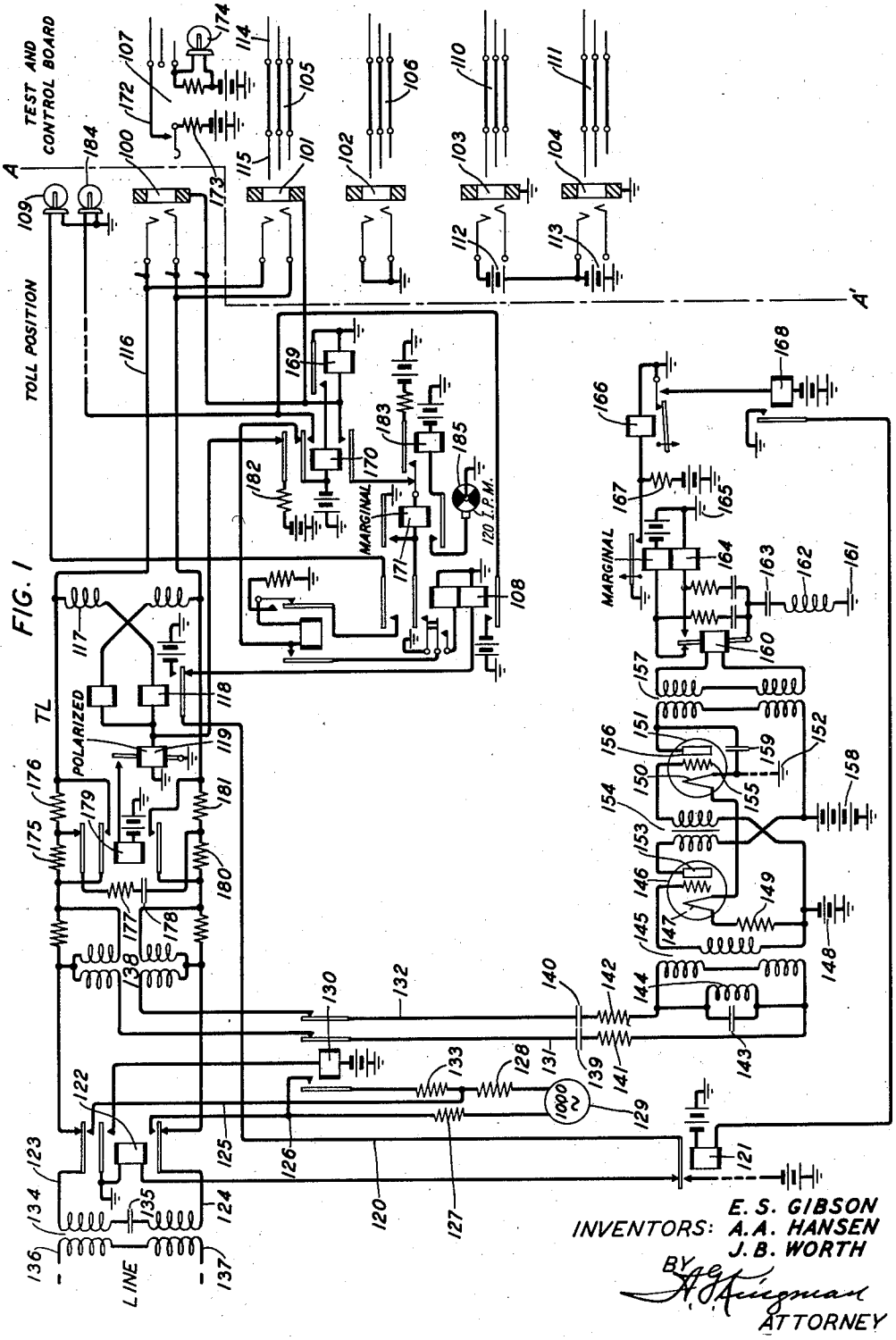

FIG. 1

INVENTORS: E. S. GIBSON
A. A. HANSEN
J. B. WORTH

BY H. J. Angsman

ATTORNEY

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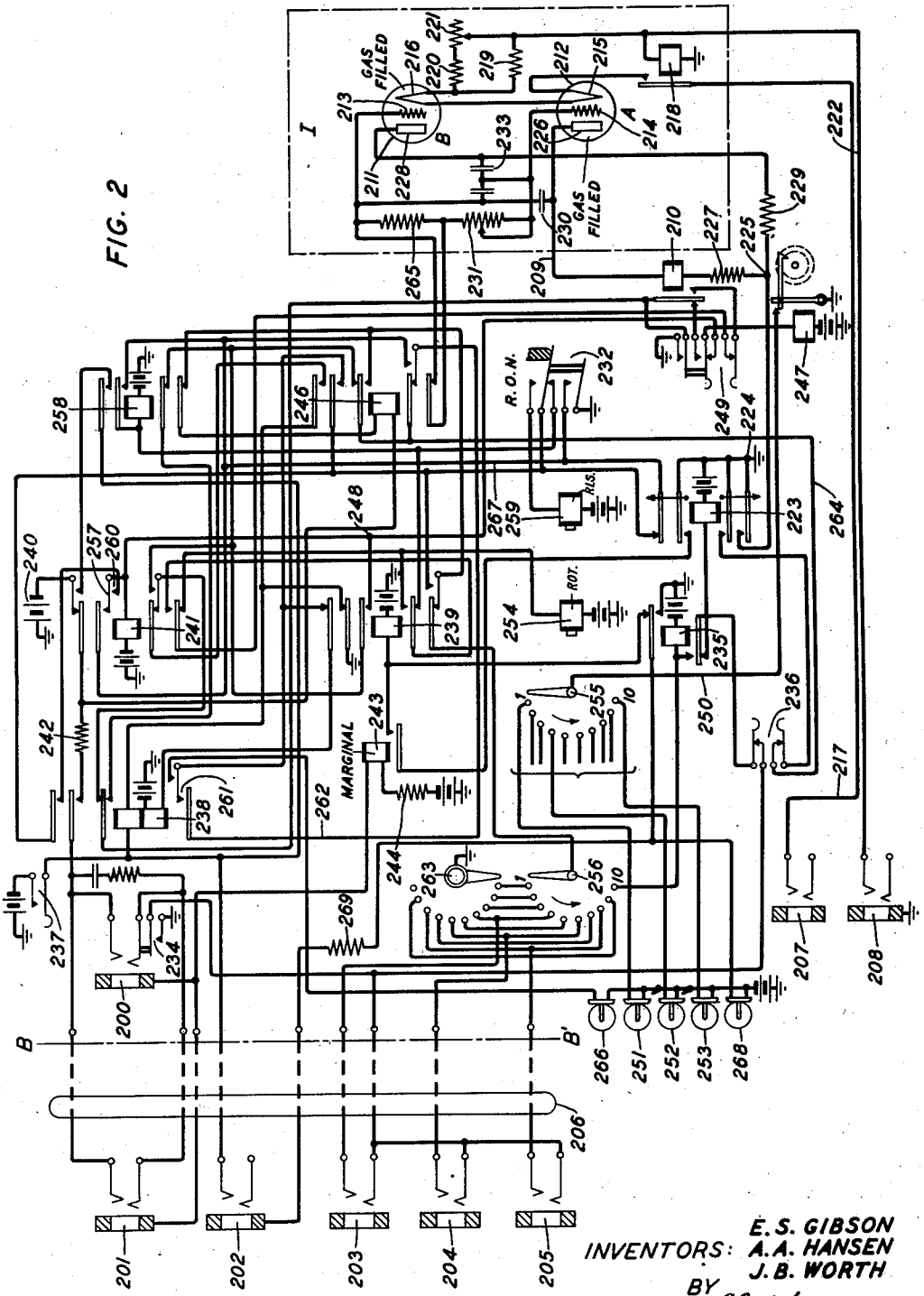
FIG. 2



INVENTORS: E. S. GIBSON
A. A. HANSEN
J. B. WORTH

BY A. J. Kingman

ATTORNEY

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2,082,104

TESTING SYSTEM

Earl S. Gibson, Ridgewood, Arnold A. Hansen, Maplewood, and John B. Worth, Tenafly, N. J.; said Gibson and said Worth assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York, and said Hansen assignor to American Telephone and Telegraph Company, a corporation of New York

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10 Claims. (Cl. 179—175)

This invention relates to testing systems and more particularly to systems for timing the duration of ringing signals received over a telephone line.

In toll line systems considerable time is frequently lost due to the failure of signal receiving apparatus to operate on the ringing signal impulses transmitted over the line by a distant operator. Toll operators are usually instructed to impress ringing current on a line for approximately two seconds which, it has been determined, is sufficiently long in most cases to cause all line apparatus to function. It now appears, however, that under adverse conditions, either normal or transient, the signal receiving apparatus of some lines occasionally fails to operate on a two-second ring and, therefore, it is desirable to determine, by suitable tests, the actual time required to cause proper functioning of the signal receiving apparatus associated with such lines.

An object of the invention is, therefore, to determine the approximate over-all ringing margin of a given telephone line, i. e., the duration of the received signal. In other words, to determine the duration of that portion of the original signal which is received at the distant end of the line after all intermediate apparatus in the circuit has functioned.

A feature of the invention whereby the foregoing object is attained, resides in the provision of two duplicate test sets which are connected to opposing ends of a line to be tested and so arranged as to alternately and automatically send and receive definitely timed ringing signals over the line. With such an arrangement the test set at one end of the line, when initially started by an attendant, sends out a definitely timed ringing signal which, if received by the test set at the other end of the line, causes a visual indication to be there given of the duration of the signal which is received, i. e., the margin of the transmitted signal over and above that required to cause any intermediate and terminal signal responsive apparatus to function. This margin may, in the case of a two-second ring, amount to one second, more or less, depending on the character of the line and the apparatus associated therewith, which delays the transmission of the signal. When the second test set has received, timed, and visually indicated the length of this marginal impulse, it returns, after a short delay, a similar timed ringing signal to the first test set which then functions to receive, time, and indicate the length of the signal impulse which reaches it in a similar manner to that described for the second test set above, after which it in turn initiates another timed outgoing ring to the other end of the line. In this manner, the two circuits continue to alternately send and receive signals as long as signals of a predetermined length are received at both ends of the line. If a signal is received by either test set which is shorter than a predetermined minimum length, the test stops.

A further subordinate feature is the provision of means whereby the length of a ringing signal transmitted by either test set can be varied as desired.

Another feature resides in means whereby, following the transmission of a signal, the test set circuit is held in abeyance for an interval sufficient for the return signal from the other end to be received. If this return signal is not received, the circuit restores to normal.

A further feature resides in a novel timing arrangement employing two hot cathode gas-filled tubes which are so arranged and adjusted that the control electrodes regain control of their respective tubes and stop the discharge upon attaining a predetermined negative potential. The potentials of the grid are controlled by a condenser-resistance arrangement which may be easily adjusted for slow or fast tube operation by either increasing or decreasing the resistance.

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

Fig. 1 of which, to the left of the broken line AA', represents a typical voice frequency signaling toll line TL, employing 1000 cycles interrupted at the usual ringing frequency of 20 cycles, which line terminates at a toll operator's position in a jack **100**. In this same figure, but to the right of the broken line AA', is shown a multiple jack **101** of this same toll line located at a test and control board together with a ground jack **102**, battery jacks **103** and **104**, patching cords **105** and **106**, **110** and **111**, and an abbreviated schematic of one end of a toll cord **107** of a type adapted to function with toll lines such as TL; and

Fig. 2 shows, to the right of the broken line BB', the wiring and apparatus of the test box of the invention and to the left of the broken line a plurality of jacks **201**, **202**, **203**, **204** and **205** also located at the before-mentioned test and control board to which jacks the test box may be connected by wires **206** in case it is desired to locate the test box at some point distant from

the test and control board, but from which point the test is to be controlled.

For the purpose of describing the invention, it will be assumed that the toll line TL (Fig. 1) is to be tested as to the length of ring necessary to transmit thereover in order to operate the lock-up relay 108 which controls the line lamp 109 or the sleeve circuit of a connected cord and that the person conducting the test, hereinafter called the tester, has elected to locate the test box at, and control it from, the test and control board at which the line appears in multiple jack 101, it being understood that the test can be made in the same manner if desired at the toll switchboard where the line also terminates in jack 100.

With the foregoing assumption the tester places the test box in some convenient place on or near the keyshelf of the test board and connects the line jack 101 to the test box line jack 200 by means of a simple patching cord 105 and patches, by means of cords 110 and 111, the battery jacks 103 and 104 to jacks 207 and 208 of the test box.

It is also necessary that a duplicate test box similar in every respect to the box shown on Fig. 2 be connected to the distant end of the toll line in the same manner as just described for the near end of the line.

A detailed description of the operation of the invention will now be given by first describing the functioning of the interrupter circuit I, which transmits current pulsations over lead 209, through the winding of relay 210 which responds in unison with said pulsations.

The gas-filled ionic tubes 211 and 212 are of the type in which the grid elements 213 and 214 can control the deionization as well as the ionization of the tube, that is to say, after the tubes are ionized a sufficient reduction in the potential of the grid elements 213 and 214 in respect to the corresponding cathode elements 216 and 215 results in deionization.

The cathode elements 215 and 216 are connected in series and are energized in a circuit that is traced from the upper terminal of battery 112, through the tip conductors of jack 103, patching cord 110 and jack 207, over conductor 217, through operated contacts of relay 218, cathode elements 215 and 216 in series, through fixed resistance 219 and the multiple resistance path consisting of a fixed resistance 220 in series with a rheostat 221, over conductor 222, through tip conductors of jack 208, patching cord 111 and jack 104 to the lower terminal of battery 112. Relay 218 is operated in a circuit from ground through the winding of relay 218, over conductor 222, through tip conductors of jack 208, patching cord 111 and jack 104 to the upper terminal of grounded battery 113. When relay 223 operates, as will be hereinafter described, positive ground 224 is connected through its lower outer contacts to junction point 225, whence the circuit to anode element 226 of tube 212 is completed through resistance 227 and the winding of relay 210, and to anode element 228 of tube 211 through resistance 229. Due to voltage drop, the potential difference between the cathode element 215 and the anode element 226 of tube 212 is greater than the potential difference between the cathode element 216 and the anode element 228 of tube 211. Consequently, when the circuit through the cathode elements 215 and 216 is closed, as before described, and both tubes start to heat at the same time as a result of the greater anode-cathode difference of potential in the case of tube 212, this tube ionizes before tube 211.

Assuming then that tube 212 ionizes first, there will be an immediate drop in the potential of the lower terminal of condenser 230, due to the current flow in resistance 227 and the winding of relay 210, which will be transmitted through condenser 230 to the grid 213 of tube 211, causing the potential of grid 213 to be reduced correspondingly and to assume a negative value thereby preventing the immediate ionization of tube 211. Due to the proximity of the grid 214 of tube 212 to its cathode element 215, the potential of grid 214 is slightly higher than that of the cathode 215 and the ionization of tube 212 is thereby maintained. A current will now flow from the higher positive potential of the grid 214, through the variable resistance 231, lower outer normally closed contacts of relay 246 to the upper terminal of condenser 230 which is connected to the grid 213 of tube 211. After a short interval the charge of condenser 230 will be adjusted so that the potential of the grid 213 equals that of grid 214. Consequently, tube 211 now ionizes and there will be an immediate reduction in the potential of the right-hand terminal of condenser 233 due to flow of current through resistance 229. This reduction in potential is transmitted through condenser 233, causing the potential of its left-hand terminal to be reduced correspondingly. Since this left-hand terminal is connected to the grid 214 which, as hereinbefore stated, is at a potential only slightly more positive than the cathode element 215 of tube 212, grid 214 now assumes a negative potential, causing the immediate deionization of tube 212. Due to this deionization, the current through the anode circuit of tube 212 ceases and condenser 230 is now charged to nearly full battery potential as was condenser 233 when tube 212 was ionized. Condenser 230 immediately after being charged, as before stated, now begins to discharge through tube 211, and through the lower outer operated contacts of relay 246 and variable resistance 231 to grid 214, thereby raising the potential of grid 214 to a positive value equal to that of grid 213 of tube 211 and causing the ionization of tube 212. Immediately afterwards, tube 211 is again ionized, as before described, and the cycle of ionization and deionization continues automatically. By varying the setting of the variable resistance 231, the cyclic speed may be varied. Increasing the resistance reduces the frequency of the interruptions, and vice versa.

The operation of the interrupter I having been discussed, the operation of the other features of the invention in conjunction with interrupter I will now be described. Let it be assumed that the toll line TL has been connected with the test set of Fig. 2, as before described, by patching the test and control board jack 101 by cord 105 to jack 200. When the plug 114 of patching cord 105 is inserted into jack 200, the contacts 234 are closed, operating the relay 223 through a circuit from battery through the winding of relay 223, lower back contacts of relay 235, upper break contacts of key 236 to ground through contacts 234. Relay 223 connects ground 224 at its lowermost contacts to the interrupter circuit I, as before mentioned, in order to complete the anode circuits of tubes 211 and 212. As before described, these tubes now start to ionize and deionize alternately. Relay 210 operates when tube 212 ionizes, but at this time relay 210 has no function. In order to start the circuits to functioning

the start key 237 of the test set is operated, which operates relay 238 in a circuit from battery through contacts of key 237, upper winding of relay 238 to ground on the upper middle contacts of relay 239. Relay 238, in operating, connects battery 240 through the uppermost normally closed contacts of relay 241, resistance 242, upper middle make contacts of relay 238, tip contacts of jack 200 and plug 114, over tip conductor of patching cord 105, through tip contacts of plug 115 and jack 101 to the tip conductor 116 of the toll line TL. From this conductor, the circuit is continued through the winding of retardation coil 117 and relays 118 and 119 to ground. Relay 119 now operates, releasing relay 179. Relay 119 is normally operated in a circuit from ground through its winding, upper outer break contacts of relay 170 and resistance 182 to battery. When jack 200 was patched to jack 101, relay 170 operated, as will be hereinafter described, releasing relay 119 and lighting busy lamp 184 from battery through its upper front contacts. The release of relay 179 removes the short-circuit around the series transmission pads consisting of resistances 175, 176, 180 and 181 and disconnects the shunt pad consisting of the condenser 178 and resistance 177 in series. Relay 118 also operates and connects battery over lead 120 and through back contacts of relay 121 and winding of relay 122 to ground. Relay 122 operates and transfers, with its upper and lower outer armatures, line conductors 123 and 124 to ringing conductors 125 and 126, respectively, which connect through resistances 127 and 128 to the source 129 of voice frequency signaling current generally arranged to deliver current at 1000 cycles per second. Relay 122, in operating, also operates relay 130 in a circuit from ground on the upper inner contacts of relay 122 through the winding of relay 130 to battery. In operating, relay 130 disconnects with its left-hand contacts leads 131 and 132 of the signal receiving circuit and with its left-hand contacts bridges the ringing termination resistance 133 across conductors 125 and 126. 1000 cycle current is now transmitted through the operated upper, outer and lower front contacts of relay 122, over conductors 123 and 124, through right-hand windings of repeating coil 134 and condenser 135, thence by induction through the left-hand windings of repeating coil 134 to the outgoing line conductors 136 and 137 and thence to the distant telephone office at which apparatus equivalent to or identical with that shown on Figs. 1 and 2 is installed. Let it be assumed now that in response to the outgoing signal that an incoming signal of 1000 cycle current is received over the toll line. A description of the functioning of the distant apparatus whereby this responsive signal is produced and transmitted will be available from the description of the operation of the apparatus of Fig. 1 and Fig. 2 hereinafter to be given. The incoming signal aforesaid is received through repeating coil 134 and condenser 135, thence through the upper and lower back contacts of relay 122, left-hand windings of repeating coil 138, through back contacts of relay 130, over conductors 131 and 132, through condensers 139 and 140, resistances 141 and 142, and the 1000 cycle tuned circuit consisting of condenser 143 and retardation coil 144. The condensers 139 and 140 and the resistances 141 and 142 are provided to raise the impedance of the circuit. The tuned circuit is provided so that only frequencies close to 1000 cycles are passed through transformer 145 to the grid circuit of the associated ionic amplifier tube 146. The cathode element 147 of tube 146 is heated in a circuit from battery 148, through resistance 149, cathode 147, cathode 150 of ionic detector tube 151 to ground 152. The anode 153 of tube 146 is in series with the left-hand winding of the transformer 154. In response to the incoming signaling current, tube 146 delivers an amplified current through its anode circuit which is passed by induction through the transformer 154 to the grid 155 of tube 151. In response to the input to tube 151, the direct current in the anode circuit of tube 151 is increased from some small normal value to a much higher value. This anode circuit is traced from anode 156 through the left-hand winding of transformer 157 to battery 158.

The incoming 1000 cycle current is interrupted at a frequency of about 20 cycles per second and consequently a pulsating direct current of this frequency is delivered to the left-hand winding of transformer 157. To remove the 1000 cycle current from the anode circuit of tube 151 a shunting condenser 159 of small capacity is used. In response to the 20 cycle input current, an alternating current is induced in the right-hand winding of transformer 157 through the winding of polarized relay 160, which therefore operates at a 20 cycle rate. When the armature of relay 160 makes its left-hand contacts, as shown in the drawings, there is a flow of charging current from battery through upper winding of relay 164, left-hand contacts of relay 160, condenser 163 and retard coil 162 to ground thereby charging condenser 163. When the armature of relay 160 moves to its right-hand contacts condenser 163 discharges in a circuit traced from its lower terminal through winding of retardation coil 162, grounds 161 and 165, lower winding of relay 164, right-hand contacts of relay 160 to upper terminal of condenser 163. Condenser 163 and the winding of retardation coil 162 are so designed as to form with the windings of relay 164 a 20 clycle tuned circuit. Accordingly condenser 163 can be fully charged and discharged only when the operating rate of relay 160 is close to 20 cycles. Consequently, since relay 164 is marginal, it does not operate except when the operating rate of relay 160 is very close to 20 cycles. This arrangement is to avoid the possibility of false operation due to the regular voice currents on the line. When relay 164 operates ground is connected to the left-hand terminal of the winding of slow releasing relay 166 which is thereby short-circuited and consequently releases. Relay 166 is normally operated through an obvious circuit including resistance 167. Relay 166 in releasing closes an obvious circuit through the winding of relay 168, which operates and thereby operates relay 121 through an obvious circuit. Relay 121 in operating connects battery over conductor 120, through back contacts of relay 118 and the lower winding of relay 108 to ground. Relay 108 operates.

When plugs 114 and 115 were inserted into jacks 101 and 200 respectively, a circuit was closed through marginal relay 243 which is traced from battery through resistance 244, winding of relay 243, sleeve contacts of jack 200 and plug 114, over sleeve conductor of patching cord 105 through sleeve contacts of plug 115 and jack 101 to ground through the winding of relay 169, which operated. Relay 243, however, did not operate at that time. When relay 169 operated it operated relay 170 over an obvious circuit. Relay 108 in

operating connects ground at its upper inner contacts to the winding of marginal relay 171 which is thereby connected in multiple with the winding of relay 169 through the operated lower contacts of relay 170. Marginal relay 171 functions in the case of regular toll line operation, to effect the flashing of the toll cord supervisory lamp in cooperation with relay 183 and interrupter 185. However, when the toll line TL is connected to the test box of this invention marginal relay 171 does not operate. Relay 243 now operates however and thereby operates relay 239 in a circuit traced from ground on the upper inner operated contacts of relay 223 through contacts of relay 243 and winding of relay 239 to battery. Also, lamp 268 is lighted as an incoming ringing signal, being energized in multiple, through the upper break contacts of relay 235, with the winding of relay 239. Relay 239 operated operates relay 241 in a circuit from battery through the winding of relay 241, upper inner contacts of relay 239, upper inner back contacts of relay 246, lower contacts of key 236, to ground on the lower inner contacts of relay 223 now operated due to the closure of contacts 234 when plug 114 was inserted in jack 200.

Register 247 is also operated in multiple with relay 241 in a circuit traceable from junction 248, through upper inner back contacts of key 249 and winding of register 247 to battery. Register 247 responds to each incoming ringing signal and accordingly records the number of incoming ringing signals received during each test. Register 247 connects ground to conductor 250 so as to light, as will be hereinafter described, the incoming signal lamps, which are represented in part by lamps 251, 252 and 253. Relay 241 in operating completes a circuit through the winding of the rotary magnet 254 of a selector timing switch of which the brushes 255 and 256 with associated contact banks are illustrated.

This circuit may be traced from ground on the lower inner contacts of relay 223, through lower contacts of key 236, upper inner back contacts of relay 246, lower inner front contacts of relay 241, upper inner back contacts of relay 238, front contacts of relay 210, lower contacts of key 249, lowermost front contacts of relay 241, lower inner front contacts of relay 239, and winding of magnet 254 to battery. As relay 210 operates and releases under control of the interrupter circuit I, selector brushes 255 and 256 advance one step at a time in the direction of the arrows. When brush 255 makes contact with associated terminal 1, lamp 251 is lighted in a circuit traced from battery through lamp 251, brush 255 and associated contact 1 to ground on the operated contacts of register 247. When brush 255 advances to the second contact another lamp, which is connected to the second contact, but which is not shown, is lighted. In similar manner, succeeding lamps are lighted. When ringing current, incoming over line conductors 136 and 137, ceases, resulting in the release of relay 164, the re-operation of relay 166, and the release of relays 168, 121 and 108, the winding of relay 171 is disconnected from its multiple relation with the winding of sleeve relay 169. This causes the release of relays 243 and 239. The lighted lamp 268 is now extinguished immediately due to the opening of its energizing circuit. The release of relay 239 opens the circuit through selector magnet 254 stopping further movement of brushes 255 and 256. The lamp connected to the bank terminal on which brush 255 stops remains lighted for a short interval until extinguished as hereinafter described. When relay 241 operated a circuit was closed for holding relay 241 which is traced from ground on lower operated off-normal selector contacts 232 through make contacts 257 and winding of relay 241 to battery. Register 247 is also held from the ground on the right-hand winding terminal of relay 241, through upper break contacts of key 249. The release of relay 239 prepares a circuit for operating relay 258. When relay 210 next closes its front contacts after the release of relay 239, relay 258 operates in a circuit from battery through the winding of relay 258, lower inner back contacts of relay 239, operated lowermost front contacts of relay 241, lower break contacts of key 249, front contacts of relay 210, upper inner break contacts of relay 238, lower inner make contacts of relay 241, upper inner break contacts of relay 246, lower contacts of key 236, to ground on the lower inner front contacts of relay 223. A circuit is now closed for operating relay 238 through its upper winding. This circuit is traceable from battery on the uppermost make contacts of relay 241, the uppermost make contacts of relay 258, upper winding of relay 238 to ground on the upper middle contacts of relay 239. Relay 238 operated, holds through its lower winding in a circuit traceable from battery through its lower winding, uppermost break contacts of relay 239, contacts 261 of relay 238, lower, inner, break contacts of relay 246, lower contacts of key 236 to ground on lower inner contacts of relay 223. Relay 238 operated closes a circuit for energizing the selector release magnet 259 which is traced from battery through the winding of magnet 259, upper front contacts of off-normal springs 232, uppermost contacts of relay 238 and operated contacts 260 of relay 241 to the operating ground on the winding of relay 241. The selector accordingly restores to normal, releasing relays 241, 258 and register 247, due to the release of the off-normal contacts 232. Also, the lamp 251 or a similar lamp, light through the brush 255, is extinguished.

Since the rate at which the interrupter circuit I operates is predetermined and known, the rate at which the brush 255 advances is correspondingly known. Consequently the length of the received ringing signal is indicated by the maximum number of lamps lighted.

With relay 238 operated and relays 241, 258 and 239 normal, battery on the uppermost, back contacts of relay 241 is connected through resistance 242 and upper operated middle contacts of relay 238 to the tip contacts of jack 200 thereby causing the transmission of a ringing signal outward over the toll line conductors 136 and 137 in the manner hereinbefore described in connection with the operation of key 237. A circuit is also closed for lighting the out ringing lamp 266 which is traced from battery through lamp 266, lower contacts of relay 238, over conductor 262, lower inner break contacts of relay 246, lower contacts of key 236 to ground on the lower inner make contacts of relay 223. Another circuit is also now closed for energizing the winding of selector rotary magnet 254. This is traced from battery through the winding of magnet 254, lowermost back contacts of relay 241, lower contacts of key 249, front contacts of relay 210, upper, inner, front contacts of relay 238, lower, inner back contacts of relay 258, upper, inner, back contacts of relay 246, lower contacts of key 236 to ground on the lower inner contacts of relay 223. The ring-

ing condition is maintained on the line while the selector is advanced under control of the interrupter circuit I and the relay 210. Ground is connected to a terminal of the bank associated with selector brush 256, by manually operating the grounded brush 263 of a dial switch. The particular terminal on which brush 263 stands determines the length of the outgoing ringing signal as will now be explained. When the selected bank terminal is reached by brush 256 relay 246 operates in a circuit traceable from ground on brush 263 through the selected contact of the associated dial switch over the connecting strap to the selected bank terminal, through brush 256, lowermost break contacts of relays 239 and 258, winding of relay 246 to battery 240 through the uppermost back contacts of relay 241. Relay 246 in operating locks through its upper, inner front contacts to holding ground on conductor 264, transfers the holding circuit for relay 238 which was hereinbefore traced from holding ground on conductor 264, to off-normal ground on the lower contacts of spring combination 232. Relay 246 in operating also causes the ionic tube interrupter circuit I to function at a slow rate by removing the short circuit around the resistance 265, which is normally maintained through the lowermost contacts of relay 246, thereby increasing the resistance in the condenser timing circuit. Three hundred thousand ohms, in practice, has been found to be a convenient value for the resistance 265. Relay 246 also opens, at its upper, innermost back contacts the operating circuit for the stepping magnet 254, which was hereinbefore traced, thereby stopping the further motion of the selector switch, it also energizes the release magnet 259 through a circuit traced from battery through the winding of magnet 259, upper front contacts of off-normal springs 232, upper middle contacts of relay 246, contacts 261 of relay 238, lower inner make contacts of relay 246 to off-normal ground on conductor 267. When the selector switch restores, the off-normal springs 232 restore to normal, opening the locking circuit of relay 238, which releases, disconnects with its upper middle contacts battery 240 from the toll line and extinguishes the out-ringing lamp 266.

With relay 246 operated and relays 239, 238 and 241 normal, the circuit measures an interval of time sufficiently long to receive a return ring from the test circuit at the distant end of the toll line. The operating circuit for the step magnet is completed from ground through the upper middle contacts of relay 239, uppermost front contacts of relay 246, lower inner back contacts of relay 241, upper inner back contact of relay 238, front contacts of relay 210, lower break contacts of key 249, lowermost break contacts of relay 241 and winding of magnet 254 to battery. The selector timing switch is thus caused to again advance its brushes 255 and 256 under control of the interrupter circuit I and relay 210 until one of two conditions is satisfied—either (a) an incoming ringing signal is received before selector timing brushes 255 and 256 reach the tenth or last terminals or (b) the signal is not received before said tenth terminals are reached. If the ringing signal is not received, ground from the upper innermost front contacts of relay 246, upon which this relay previously locked is passed through the lowermost back contacts of relay 239 to selector brush 256, through the associated tenth terminal and the winding of blocking relay 235 to battery. Relay 235 in operating closes a locking circuit for itself which is traced from battery through its winding and lower front contacts, upper contacts of release key 236, to ground on contacts 234 of jack 200. In operating it also lights lamp 268 and opens the circuit of relay 223, which releases. Relay 223 in releasing disconnects ground 224 and thereby opens the anode circuit of the ionic tubes of interrupter circuit I, which thereby stops functioning. The operating circuit of relay 210 being likewise opened, this relay stops operating and the circuit of the rotary stepping magnet 254 is accordingly opened. The release of relay 223 also opens the previously traced locking circuit for relay 246, which releases. The release of relay 223 also energizes the winding of release magnet 259 in a circuit from battery, through the winding of magnet 259, upper contacts of off-normal springs 232, uppermost contacts of relay 223 to ground on the lower contacts of springs 232. The timing selector switch is accordingly restored to normal and the circuit for the magnet 259, before traced, is opened when the off-normal springs 232 are released. Lamp 268 remains lighted until the tester restores the circuit to normal by operating the release key 236.

Assume, however, that the incoming ringing signal is received before the timing selector circuit reaches terminal 10. Under this condition, marginal sleeve relay 243 operates in response to the incoming signal, as before described, in turn operating relay 239. The operation of relay 239 disconnects ground, at its upper middle contacts, from the circuit of rotary stepping magnet 254 and energizes release magnet 259 from ground on the upper innermost make contacts of relay 246, through lower outer operated front contacts of relay 239, upper operated off-normal springs 232 and winding of magnet 259 to battery. When the timing selector switch and springs 232 are restored to normal a circuit is closed for operating relay 258 which is traced from battery through the winding of relay 258, back contacts of springs 232, lower outer operated front contacts of relay 239 to the locking ground on the upper innermost front contacts of relay 246. Relay 258, in operating, opens the locking circuit of relay 246 which releases. Relay 246, in releasing, disconnects with its upper innermost front contacts, the grounded conductor 264 from the winding of relay 258 which releases. With relays 258 and 246 released and the selector timing switch restored to normal, the test circuit functions as described for the initial incoming ring.

It is sometimes desirable to locate the test box at a distance from the test and control board and the operation of the invention will now be described for this condition.

Before the test is started, jack 101 is patched to jack 201, the tip, ring and sleeve conductors of which are wired to the corresponding conductors of the jack 200 of the distant test box. The toll cord 107, shown in an abbreviated form, is plugged into jack 202, the tip conductor of which is wired to the lower spring of start key 237, and the sleeve conductor to a multiple connection with lamp 268 through a resistance 269. Also, before starting the test, brush 263 of the dial switch should be moved to its normal position to avoid interference and jack 102 should be patched to one of the jacks 293, 294 or 295. The tip conductors of these jacks are wired, as shown in the drawings, to terminals 4, 6 and 8, respectively, of the selector switch bank associated with the brush 256, the order of numbering being that

indicated by the direction of the arrow. It is to be understood, however, that these jacks may be wired to other terminals of the switch if desired. The sleeve conductors of jacks are multiple and are wired in multiple with the local contacts **234** of jack **200** of the test box. To provide battery for the operation of the test box, jacks **207** and **209** should be patched to conveniently located battery supply jacks, not shown, which are equivalent to jacks **103** and **104**.

Let it be assumed, for this description, that jack **102** is patched to jack **205**. With this arrangement, ground on the sleeve of jack **102** is connected through to terminal **6** of the selector switch and corresponds to the connection of ground by dial switch brush **263**, as was described in connection with the use of the test box when located directly at the test and control board. In other words, the length of the outgoing ringing signal is determined, in the case of remote operation of the test box, by the particular jack **203**, **204** or **205** which is patched to jack **102**.

When jack **102** is patched to jack **205**, a circuit is closed for operating relay **223** which can be traced from battery, through the winding of relay **223**, lower back contacts of relay **235**, upper break contacts of key **236**, ring conductors of jack **205**, cord **106** and jack **102** to ground. Relay **223**, in operating, functions as before described when it operated in response to the closing of springs **234** of jack **200**. To start the test, ringing key **172** of the cord **107** is operated, thereby connecting battery through resistance **173** over the tip conductor of cord **107** and jack **202** to the upper winding of relay **238**. This relay now operates, connecting battery **240** to the tip conductor of the toll line and from this point on the description hereinbefore given in connection with the operation of the test box, when located at the test and control board is applicable. It is to be understood, of course, due to the remote location of the test box, the indications of the lamps in the test box are not available with this method of testing. No provision is made for giving at the switchboard, indications of the outgoing ringing, but the supervisory lamp **174** of toll cord **107** plugged into jack **202** is energized for an incoming ringing signal, in multiple with lamp **268** through resistance **269**. Lamp **174** also lights for a timed out condition from ground on the upper front contacts of blocking relay **235**, when this relay operates.

The test set may be stopped at any time by removing plug **114** from jack **200**, when the test set is located at the switchboard, or by disconnecting jack **203**, **204** or **205** from jack **102**, when the test box is at a distance from the switchboard. This removes the operating ground for relay **223** which releases and thereby stops the functioning of tubes **211** and **212**. The release of relay **223** also closes a circuit from ground on lower off-normal springs **232**, through its upper outer break contacts and upper front contacts of springs **232** to battery, through the release winding **259** of the associated selector switch, which releases, if it should be off normal at this time. The release of relay **223** also causes the release of all operated relays.

The speed of the interrupter circuit I may be varied by means of the variable resistance **231**. This resistance with the condensers **230** and **233** may be designed so that the interrupter functions at the rate of five, four, three, etc., pulses per second. A convenient means of checking the pulsing rate is provided by the key **249** and register **247**. The operation of key **249** closes a circuit from ground on the upper outer contacts of key **249** through back contacts of relay **210**, upper inner front contacts of key **249** and winding of register **247** to battery. Register **247** now automatically counts the operations of relay **210**. By noting the number of operations in thirty or sixty seconds, or some other convenient period of time, and adjusting the variable resistance **231** as necessary, the rate of pulsing may be adjusted quite accurately.

What is claimed is:

1. In a signal timing circuit, a line, a source of signaling current, means for connecting said source to one end of the line, and a signal receiver connected to the other end of the line, said receiver comprising a progressive indicating means, switching means for controlling the progress of said indicating means, timing means for controlling said switching means at a predetermined rate, and means responsive to the received signal for causing said timing means to control said switching means and to cause said switching means to advance said indicating means.

2. In a signal timing circuit, a line, a source of signaling current, means for connecting said source to one end of the line for a certain interval of time and a signal receiving arrangement connected to the other end of the line, said arrangement comprising a plurality of visual signal devices, switching means for controlling the display of said devices in successive order, timing means for controlling said switching means to successively display said signals at a predetermined rate, and means responsive to the received signal for causing the timing means to control the switching means and for causing the switching means to control the signal device.

3. In a signal timing arrangement, a line, a source of signaling current at each end of the line, means for connecting one of said sources to one end of the line and signaling receiving and transmitting apparatus connected to the other end of the line, said apparatus comprising progressive indicating means, switching means for controlling the progress of said indicating means, timing means for controlling said switching means at a predetermined rate, means responsive during the continuance of a received signal for causing said timing means to control said switching means and to cause said switching means to advance said indicating means, and means operated upon cessation of said received signal for connecting the respective source of signaling current to the line and for causing said switching and timing means to hold the connecting means operated a predetermined interval of time.

4. In a signal timing arrangement, a line, a source of signaling current and a signal timing test at each end of the line, said test set comprising a progressive switching mechanism, a progressive visual signal indicating device controlled by said switching mechanism, an interrupter for advancing said switching mechanism at a predetermined rate, means for connecting each set with the line, ringing means associated with each set for connecting the associated current source to the line and for connecting said interrupter to said switching mechanism, manual means for initially operating one of said ringing means, adjustable means responsive to the switching mechanism advancing to a predetermined position for arresting said switching

mechanism and disconnecting the interrupter therefrom, means associated with each set responsive to a signal received over the line to connect the interrupter to advance the switching mechanism and thereby advance the indicating means accordingly during the continuance of said signal, and means operated upon the cessation of said received signal to automatically operate said ringing means to connect the associated current source to the line under control of said switching means and interrupter.

5. In a signaling timing system, a line, a source of signal current at each end thereof, means for connecting the source at one end to the line for a predetermined interval, means at the other end for indicating the length of the signal received and thereafter automatically connecting the source thereat to the line for a predetermined interval, and means at the first end for indicating the length of said second signal and thereafter again connecting the source thereat to the line for a third predetermined interval.

6. The method of determining the ringing margin of a telephone line which consists in transmitting a ringing signal of predetermined duration over the line, indicating the duration of the received signal at the other end in a progressive device and thereafter automatically transmitting ringing signals of said first predetermined duration back and forth over said line alternately and receiving them in progressive devices as long as the signals received at either end actuate the progressive devices thereat to indicate a signal of predetermined duration.

7. The method of determining the ringing margin of a telephone line which consists in transmitting a ringing signal of predetermined duration over the line, indicating the duration of the received signal in a visual signal device at the other end of the line, automatically transmitting a return signal of predetermined duration back over the line responsive to cessation of said received signal and the indication of a signal of predetermined duration in said device, indicating the duration of the return signal received at the first end of the line in a visual signaling device, automatically transmitting a return signal of predetermined duration over the line to the second end of the line responsive to cessation of the signal received and a predetermined indication of its duration, and automatically continuing the operation as long as signals of a predetermined duration are indicated at each end of the line.

8. In a timing circuit, two gas-filled discharge devices each comprising a cathode, an anode and a control electrode, a connection including a condenser between the anode of the first one of said devices and the control electrode of the second device, another connection including another condenser between the control electrode of the first device and the anode of the second device, a high resistance connection between the respective control electrodes and an electroresponsive device in the anode circuit of one of the devices.

9. In a timing circuit, a pair of gas-filled discharge tubes each comprising a hot cathode, an anode and a grid electrode, a condenser connected between the anode of one tube and the grid of the second tube, another condenser connected between the grid of the first tube and the anode of the second tube, a high resistance connected between the grids of the two tubes, and a relay in the output circuit of one of said tubes.

10. In a timing circuit, a pair of gas-filled discharge tubes each comprising an anode, a cathode and a grid electrode, a condenser connected between the anode of one tube and the grid of the other tube, another condenser connected between the remaining anode and grid, a high resistance connected between the grids of the two tubes, a relay in the output circuit of one of said tubes, and means for varying said high resistance.

EARL S. GIBSON.
ARNOLD A. HANSEN.
JOHN B. WORTH.