

May 5, 1942.

L. M. POTTS

2,281,596

TELEGRAPHIC TRANSMISSION BY SPACE DISCHARGE CONTROL

Filed March 7, 1938

2 Sheets-Sheet 1

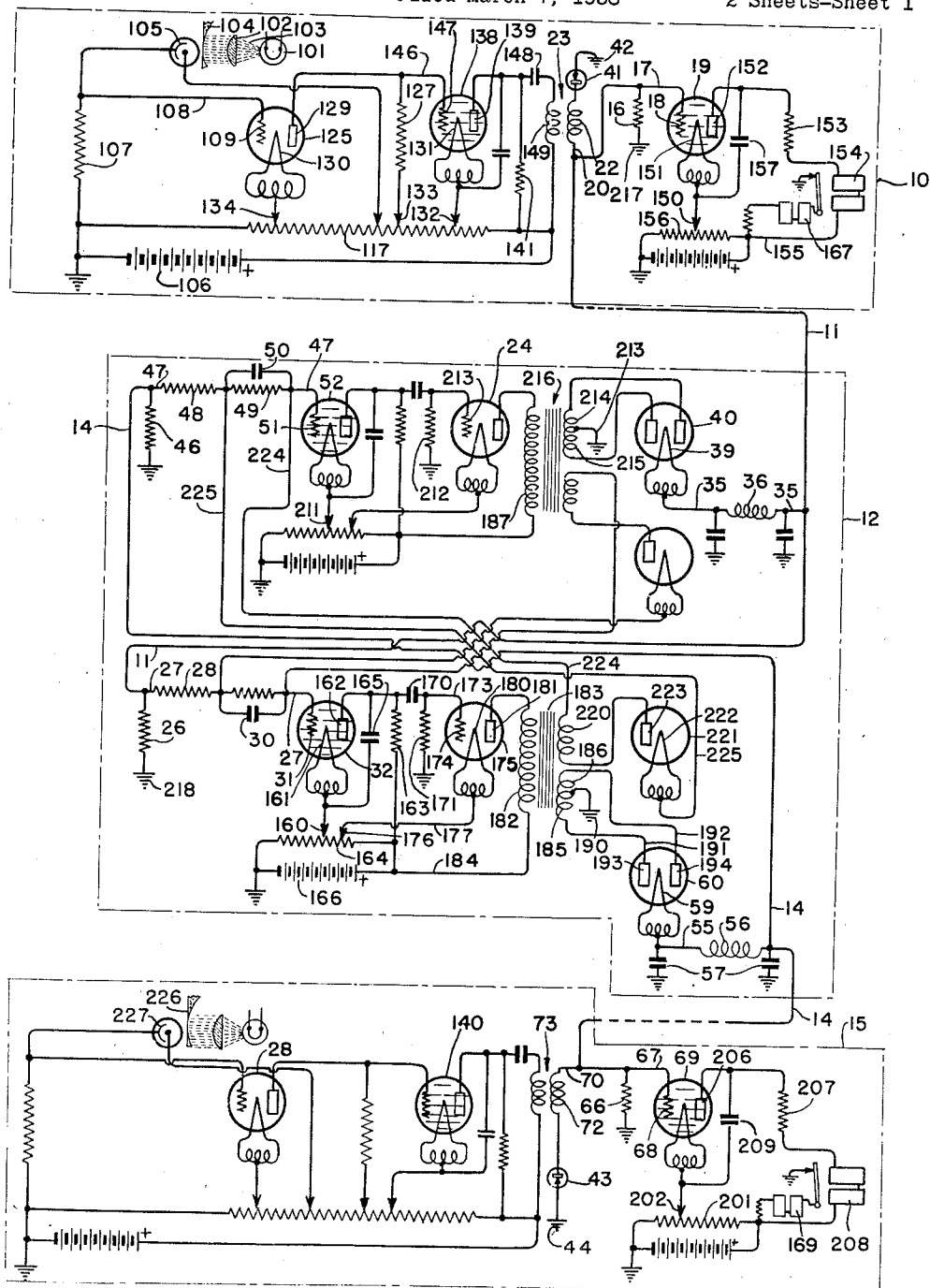


FIG. 1

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2 Sheets-Sheet 2

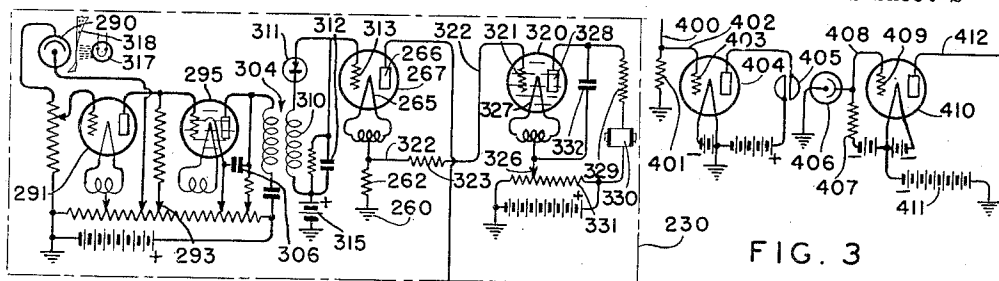


FIG. 3

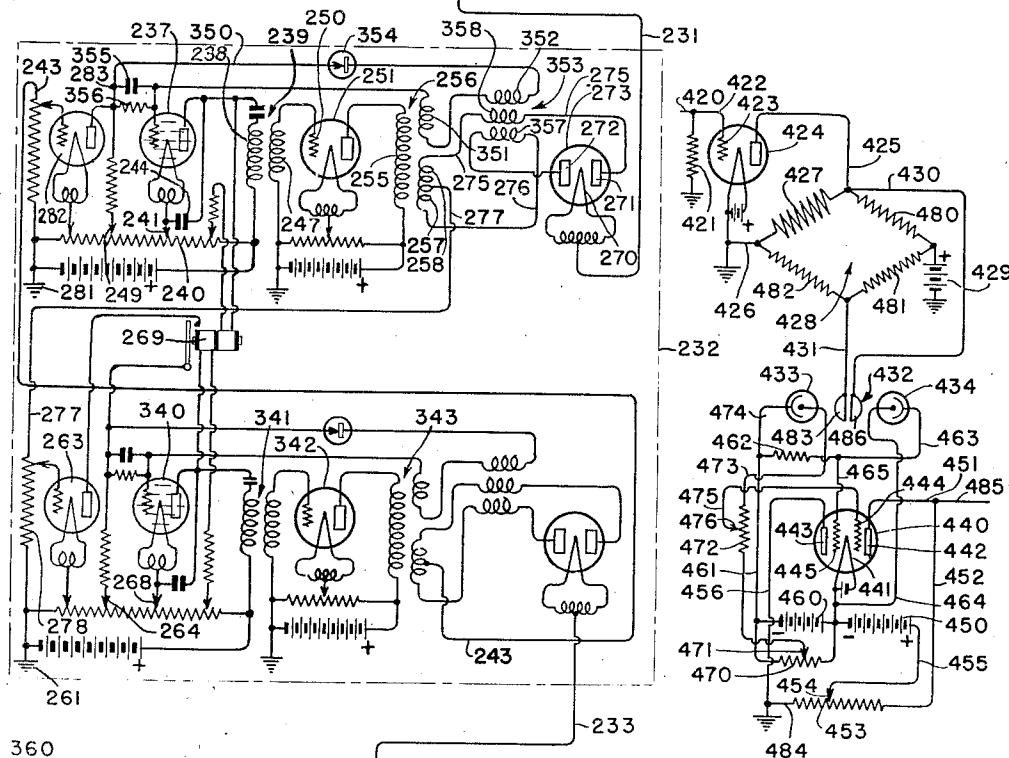


FIG. 4

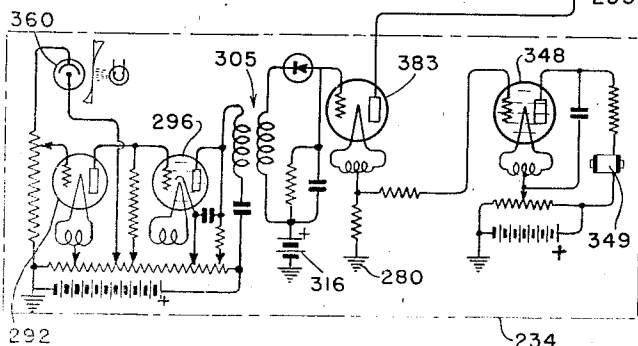


FIG. 2

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2,281,596

TELEGRAPHIC TRANSMISSION BY SPACE
DISCHARGE CONTROLLouis M. Potts, Evanston, Ill., assignor to Tele-
type Corporation, Chicago, Ill., a corporation
of Delaware

Application March 7, 1938, Serial No. 194,305

12 Claims. (Cl. 178—71)

This invention pertains to telegraph systems and apparatus and more particularly to such systems in which distance between terminal stations renders necessary an intermediate station equipped with repeating devices to renew the strength of the signal impulses.

The invention pertains more particularly to systems which serve a large traffic at a high speed of transmission in which time required for operation of mechanical armatures of magnetic relays may become a restraining feature in the speed of operation of the system both from the viewpoint of speed of generation of telegraphic impulses and also from the viewpoint of repeating the impulses at a repeater station where transit time of an armature in an electromagnetic relay introduces distortion into the time dimension of a repeated impulse.

The main object of the present invention resides in the provision of telegraph signal instrumentalities which are capable of satisfactory and reliable operation for high speed transmission and which do not introduce detrimental distortion at such transmitting speeds.

Accordingly, the present invention has as its principal features the provision of terminal transmitting equipment in which telegraph signal impulses are generated by thermo-electronic and photo-electronic devices for transmission, and the provision of terminal receiving equipment in which received impulses are amplified by electronic devices for recording, together with repeating equipment comprising reflect suppression means and electronic devices wholly independent of any mechanically movable member.

Further objects and features of invention are embodied in details of elements of the assembled system and in variations of the preferred form of the invention; namely, to provide circuits to effect two-way single-line transmission through a repeating station including means for generation of opposing potentials to prevent reflection signals, generating signal impulses in alternating current form and rectifying the alternating current signal impulses for transmission as direct current signals, repeating signals by means of a photo-cell and repeating received double-current signals by means of a polarized lamp and a pair of responsive photo-cells.

A better understanding of the invention may be had from the following description when taken in conjunction with the accompanying drawings, wherein,

Fig. 1 illustrates circuits and apparatus of a system including two substations and a repeating

station operating upon open circuit principles according to this invention;

Fig. 2 illustrates a modification thereof operating upon closed circuit principles;

Fig. 3 illustrates a repeating structure; and

Fig. 4 illustrates a double-current repeating structure.

A general structure of a system according to this invention is illustrated in Fig. 1 wherein a terminal substation 10 is shown connected by a line section conductor 11, through a main station or repeating station 12, and thence by a further line section conductor 14 to a terminal substation 15 associated with station 10 for intercommunication.

Operation of the structure illustrated in Fig. 1, when broadly contemplated, is upon a principle of telegraphy wherein a line conductor not actively in operation for transmission of intelligence signals, is in a signaling condition without any applied electrical potential, wherein two or more stations have receiving instruments permanently connected in parallel paths from the line conductor to ground, and wherein any station may transmit to all stations by applying an electrical potential to the line, thereby causing currents to flow from the line to operate receivers at all stations including the home station receiver.

In Fig. 1, two line conductors 11, 14 are shown, each of which operates as described above, the two conductors being illustrated in signaling condition without electrical potential and being permanently associated as line sections with receiving recorders and with repeating equipment to communicate to the associated line section any signaling potential impressed upon either line section.

Line section 11 has two permanently connected receivers; namely, a recorder receiver 167 connected from conductor 11 through conductor 17 and amplifier 19, and a repeater receiver connected from conductor 11, through conductor 27, oscillator valve 32, amplifier valve 175, and repeating coil 183. Line section 14 has two similar permanently connected receivers; namely, a recorder receiver 169 connected from conductor 14, through conductor 67 and amplifier 69, and a repeater receiver connected from conductor 14 through conductor 47, oscillator valve 52, amplifier valve 24 and repeating coil 216. In resting condition of the system, no potential is impressed upon either line section conductor, and valves 32, 52 described as oscillator valves are not in oscillating condition.

Each station 10 and 12 on line section 11, and 12 and 15 on line section 14, has a transmitter which, when in resting condition, does not produce an operating potential upon either line 11 or 14 but which, when controlled to become active by change in illumination condition of a photo-cell, produces an electrical signaling potential upon its associated line section conductor, the transmission circuit then extending from ground connection at the transmitter, through a unidirectional valve and induction coil winding of the active transmitter, to the line section conductors, and from the line section conductor extending in parallel through the two receivers of that line section to ground, thus controlling the two receivers; namely, the home recorder and the repeater receiver, each to manifest a signal of current nature.

Each such transmitter assembly includes gas-filled valve subjected to sufficient potential difference between filament and plate to effect conductivity, the valve being rendered oscillating in operation by a condenser having its terminals connected to filament and plate, respectively. Such valve systems in the drawings include gas-filled valves 19, 32, 52, 69, 138, 140, in Fig. 1, and 237, 295, 296, 320, 340, 348 in Fig. 2. These valves are three-electrode gas-filled valves and preferably may be operated with indirectly heated cathodes as illustrated in valves 295 and 296, Fig. 2. A condenser, when connected between anode and cathode, causes the valve to act as a relaxation oscillator. It is not necessary in all cases nor with all valves that the grid shall actually be positive with respect to the cathode. Some tubes under certain conditions as, for example, ample plate voltage, oscillate even when the grid is slightly negative. There is some critical value of potential of the grid which may be slightly negative or positive at or above which the tube will oscillate, and when the potential of the grid is below this value, the valve will not start into oscillation. When the proper adjustments are made, substantially direct current will flow through a conductive resistor-path having its terminals directly or indirectly connected to the two terminals of the condenser, for example, Fig. 1, through path 153, 154, 155, 156, 150, connected to terminals of condenser 157 and valve 19, or path 163, 164, 160 connected to terminals of condenser 165 and valve 32, while valve 19 or 32 is in oscillating operation and while an alternating current flows in condenser 157 or 165. In the drawings, the gas-filled valves are indicated symbolically by gray-code hatching.

It is contemplated in the structures herein shown that oscillations of the gas-filled valves will be at a frequency much higher than the telegraph code-signaling frequency, as, for example, an oscillating frequency of 10 kilocycles and a signaling speed of 66 bauds.

At station 10, the transmitter system includes photo-cell 105, amplifier valve 125, oscillator valve 133, induction coil 23 and unidirectional valve 41, connected to line conductor 11. At station 15, the transmitter includes photo-cell 227, amplifier valve 28, oscillator valve 140, induction coil 73 and unidirectional valve 43, connected to line conductor 14.

At repeating station 12, there are two transmitters, one from ground 190 through secondary windings 185, 186 of induction coil 183, through rectifier valve 60 and inductance 56 to line section conductor 14, and the other from ground connection 213 through secondary windings 214, 215,

of induction coil 216, rectifier valve 40 and inductance 36 to line section conductor 11. Repeater station 12 contains also echo suppression valves and circuits.

The term "oscillating current" is used in this specification to indicate a current comprising a succession of uniform unidirectional impulses separated by time periods of no current or of substantially no current.

The term "potentiometer resistor" is used in this description to indicate a resistor through which a supply current flows, the resistor being provided with adjustable taps or contactors by means of which currents may be derived from the potentiometer resistor for operating purposes.

The term "potential branch conductor" is used in this description to indicate a conductor connected to a current-carrying circuit and connected also to a grid of a valve, current conditions in the circuit being variable to vary the potential applied to the grid through the potential branch conductor.

Record tapes 184, 226, Fig. 1 and 318, 319, Fig. 2, may be of a standard design as illustrated in Patent No. 1,549,907 to Clokey or in copending application Serial No. 48,098 filed November 4, 1935, or of other desired design.

Describing the structure of Fig. 1 now with greater attention to detail, line section 11 is connected in substation 10 through resistor 16 to ground connection 217, through potential branch conductor 17 to grid 18 of receiving valve 19, and line section 11 is connected also through transmitting conductor 20 to winding 22 of transmitting inductor coil 23 and unidirectional valve 41 to ground connection 42.

In repeating station 12, line conductor 11 is extended through resistor 26 to ground connection 218, and is connected through potential branch conductor 27 to grid 31 of receiving valve 32, also through conductor 35 and inductance 36 to cathode 39 of retransmitting rectifying valve 40, while line conductor 14 is extended through resistor 46 to ground, and is connected through potential branch conductor 47, to grid 51 of receiving valve 52, also through conductor 55 and inductance 56 to cathode 59 of retransmitting rectifying valve 60.

In substation 15, line conductor 14 is connected through resistor 66 to ground, through potential branch conductor 67 to grid 68 of receiving valve 69, and through transmitting conductor 70 to winding 72 of transmitting induction coil 73 and unidirectional valve 43 to ground connection 44.

Apparatus provided further in substation 10 comprises an illuminant 101 and lens 102 producing a beam 103 controlled by records in a control form 104 to control a photo-cell 105 which is energized by a battery 106. Details of such an arrangement applied to a Wheatstone-code transmission tape are described in Patent No. 1,549,907 granted to Clokey, and details of such an arrangement applied to a Baudot-code transmission tape are described and claimed in a copending application Serial No. 48,098 filed November 4, 1935, by L. M. Potts. Photo-cell 105 and resistor 107 constitute a potentiometer which, through a potential branch conductor 108, determines a potential applied to grid 109 of amplifier valve 125 which, when photo-cell 105 is dark, substantially estops current in the plate circuit of the valve. In response to control of cell 105 by light, the potential of grid 109 is rendered more positive with reference to cathode 130, permitting a current in the plate circuit in-

cluding contactor 134, cathode 130, anode 129, resistor 127, contactor 133 and a part of potentiometer resistor 117 as a source of energy, the described circuit being a potentiometer circuit having a potential branch conductor 146 extending to grid 147 of gas-filled oscillator valve 138.

Valve 138 has a plate circuit including contactor 132, cathode 131, anode 139, resistor 141 and a portion of resistor 117 as a source of direct current energy. Adjustment of contactors 132 and 133 is such that valve 138 oscillates when photo-cell 105 is dark and plate current in valve 125 is minimum. This is the normal resting condition. As shown, contactor 133 is slightly negative with reference to contactor 132 but may be slightly positive as permitted or required by characteristics of the associated valves and circuits.

When photo-cell 105 is illuminated, grid 109 is made more positive and current flows in the potentiometer plate circuit of valve 125, rendering grid 147 more negative which stops oscillation of valve 138.

Valve 138 is rendered oscillating in operation by a condenser having its terminals connected to cathode and anode, respectively. When valve 138 oscillates as described, it supplies an alternating current through condenser 148 and primary winding 149 of induction coil 23 for transmission purposes, oscillation being stopped in code-signal manner by a more negative potential applied to grid 147 by control of photo-cell 105 when illuminated. When alternating current flows in primary 149, the secondary 22 as permitted by unidirectional valve 41 supplies a potential of oscillating current of positive polarity to line section conductor 11.

In substation 10, a local recording circuit includes a part of potentiometer resistor 156, contactor 150, filament 151 of valve 19, plate 152, resistor 153, recorder relay 154, and conductor 155, valve 19 being rendered oscillating by condenser 157. Current through recorder magnet 154 is substantially constant direct current.

An armature and back contact on receiving relay 154 energizes a recording selector magnet 167 over an obvious circuit.

In the repeating station 12, a previously mentioned potential branch conductor 27 is connected from the line section conductor 11 for repeating purposes through resistor 28 and condenser 30 to grid 31 of gas-filled oscillator valve 32 with a plate circuit including contactor 160, filament 161, plate 162, resistor 163, and part of potentiometer resistor 164 as a source of direct current energy. Condenser 165 renders the valve 32 oscillating. An output circuit for oscillator valve 32 includes grounded battery 166, resistor 163, condenser 170, resistor 171, and ground, the described output circuit constituting a potentiometer to supply a variable potential over conductor 173 to grid 174 of amplifier valve 175 from which valve the output current is an oscillating current in a circuit including contactor 176, conductor 177, filament 180, plate 181, primary winding 182 of induction coil 183, conductor 184, and a part of potentiometer resistor 164 as a source of direct current energy. Oscillating current in winding 182 generates alternating currents in both halves 185, 186 of a secondary winding which is rectified by rectifying valve 60 and is applied as a direct current to line section conductor 14, the retransmitting path including ground connection 190, both halves 185, 186 alternately of the split secondary winding of induction coil 75

183, alternately over conductors 191, 192 and plates 183, 194, thence as direct or rectified current over filament 59, conductor 55, inductance 56 to line section conductor 14, the retransmission circuit being completed to ground through resistor 46 in repeating station 12 and resistor 66 in substation 15 connected in parallel to ground.

Equipment provided at substation 15 duplicates the equipment described for substation 10, including a receiving valve 69, potentiometer resistor 201, contactor 202, plate 206, resistor 207, receiver relay 208, condenser 209, and recorder selector magnet 169.

In repeating station 12, a previously mentioned branch potential conductor 47 is connected from the line section conductor 14 through resistor 48 and condenser 50 to a grid 51 in a gas-filled receiving oscillator valve 52 analogous to the receiving valve 32. An alternating current is generated in resistor 212 and grid 213, thus generating an oscillating current in winding 187 and alternating currents in windings 214 and 215 of induction coil 216, which alternating currents are rectified by valve 40 and are applied to line section conductor 11 as signals of current of positive potential with reference to ground connections 217 and 218.

Means for estoppel of reflection signals in the repeating station 12 is provided by induction coil winding 220, rectifier valve 221, and condenser 50. An initial positive electrification of line section conductor 11 and associated grid 31 results in oscillation of valve 32 which produces an oscillating current in primary winding 182 of induction coil 183, thereby producing alternating potentials in secondary induction coil winding 220 which, as permitted by rectifying valve 221, results in charging the condenser 50 over a circuit including filament 222, plate 223, winding 220 as a source of energy, conductor 224, condenser 50, and conductor 225, which current maintains condenser 50 charged with its negatively charged terminal connected to grid 51, thus maintaining the grid 51 negative with reference to contactor 211 as long as conductor 225 remains positively electrified, despite positive electrification of line section conductor 14. Resistor 49 provides a leak circuit for discharge of condenser 50 after cessation of the signal.

Rectifier valves 60 and 221 have their plates electrified simultaneously by secondary windings of induction coil 183, and both of the valves apply their rectified currents to the grid 51, positively and negatively, respectively, but precedence is given to valve 221 by direct connection over conductor 225 from its filament 222 to grid 51 while a delaying element illustrated in the form of a network comprising an inductance 56 and two condensers 57 is included in the connection of valve 60 from its filament 59 through conductor 55, inductance 56, local extension of line section conductor 14, conductor 47, resistor 48, and condenser 50 to grid 51. Accordingly, the grid 51 is electrified negatively by induction coil winding 220 and valve 221 in advance of reflectional positive electrification of conductor 14 by valve 60 and reflection signals are estopped. By virtue of its position in the circuit structure illustrated at 12 in Fig. 1, the filter 56, 57 acts to filter out any high frequency oscillations and also acts as a signal delaying network in the main retransmission circuit extending from filament 59, over line section conductor 14 to substation 15. Any distortion introduced by this network is insignificant.

nificant and does not interfere with the signals.

Operation of the structure illustrated in Fig. 1, when considered in review, is briefly as follows: For a resting period, a signal of marking nature is generated throughout the system. Photo-cells 105 and 227 are illuminated, signal-receiving selector magnets 167 and 169 are energized, and there is no current on line section conductors 11 and 14 which are at ground potential by virtue of connection to ground through resistors 16, 26, 46, and 66.

Illumination of photo-cell 105 effects conductivity in vacuum valve 125 which produces a potential of more positive polarity on grid 109 of valve 125 and a potential of more negative polarity on grid 147, thus estopping oscillation in gas-filled valve 138 and thus estopping generation of any potential in secondary induction coil winding 22 connected to line section conductor 11. An identical condition is maintained in photo-cell 227, vacuum valve 28, gas-filled valves 140 and secondary induction coil winding 72 connected to line section conductor 14.

In repeating station 12, ground potential upon grids 31 and 51 of gas-filled valves 32 and 52 estop oscillation, and no potential is generated upon conductors 35 and 55 connected to line section conductors 11 and 14.

To generate a signal of spacing nature in the system, transmitting mechanism controlled by tape 104 interrupts beam 103 to darken valve 105 to vary the potential on grid 109 to render the valve 125 non-conductive, thereby permitting grid 147 to acquire the potential of contactor 133 to permit oscillation in the system of gas-filled valve 138, thereby producing potentials in secondary induction coil winding 22 to produce a signal current of positive potential on line section 11, thus activating valve 19 to operate home recorder relay 154 to deenergize home recorder selector magnet 167 to effect a spacing signal in its recorder, and activating also valve 32 which in turn activates valves 175 and 60 to produce a signal current of positive potential on line section 14 (and a negative signal potential on condenser 50 and on grid 51 to estop reflection signals), thus activating valve 69 to operate remote receiver relay 208 to deenergize recorder selector magnet 169 to effect a spacing signal in its recorder.

The structure illustrated in Fig. 2, when broadly contemplated, is operated upon the closed-circuit single-current principle of telegraphy wherein a line conductor, when not active in communication, carries a continuous and uniform electrical current, in which all stations have receiving instruments permanently connected in series in the circuit of the line conductor, in which a source of current is included in the circuit of the line conductor, and in which an operator at any station may impress a signal upon the circuit of the line conductor by opening and closing that circuit in code manner to operate receivers at all stations including the home station receiver.

In Fig. 2, two line conductors are shown each of which operates as described above, the two conductors being associated as line sections through repeating equipment to communicate to the associated line section any spacing signal impressed upon either line section.

Described briefly, substation 230 is connected over line section conductor 231 to repeater station 232, which is connected by a further line section conductor 233 to a second substation 234,

and each of the two line sections carries a current generated at the repeating station 232. Line section circuit 231 comprises a line conductor 231, a local conductor 277, two resistors 262, 278, a substation receiver 320, a repeating station receiver 263, a substation keying valve 267, and a source of current comprising an oscillator valve 237 generating an oscillating current, an induction coil 256 generating alternating potentials from the oscillating current, and a rectifier valve 273 generating from the alternating potentials a rectified current for signaling. Corresponding equipment is provided for line section conductor 233. Repeating station 232 has means for echo suppression.

Described in greater detail, line section circuit 231 extends from ground connection 260 at substation 230 to ground connection 261 at repeating station 232, through resistor 262, filament 265 and plate 266 of keying valve 267, line section conductor 231, filament 270 and plates 271, 271 of rectifying valve 273, local conductors 275, 276, induction coil windings 357, 358, two induction coil windings 257, 258 as a source of alternating potential, for energy, local conductor 277, and resistor 278. A similar line section circuit 233 extends from ground connection 280 at substation 234 to ground connection 281 at repeating station 232.

Energy for the line section circuit 231 is generated at repeating station 232 by a gas-filled oscillator valve 237 having a cathode connected to contactor 241 and a grid connected to contactor 249. Both contactors are on potentiometer resistor 240, the potentials of the grid and cathode being such that valve 237 oscillates by reason of condenser 244 and generates an alternating current in primary winding 238 of induction coil 239. Alternating potentials are generated in secondary winding 247 of induction coil 239, effective upon grid 250 of amplifier valve 251 to generate an oscillating current in primary winding 255 of induction coil 256. Responsive to oscillating current in primary winding 255, alternating potentials are generated in companion secondary windings 257, 258 which, cooperating with rectifier valve 273, produce a rectified current for signaling in the line section circuit 231.

At substation 230, energy from the described line section circuit 231 is applied through resistor 323 and potential branch conductor 322 to grid 321 to control an oscillator valve 320 to energize a recorder relay or magnet 330 in a plate circuit including cathode 327, anode 328, resistor 329, recorder magnet 330, potentiometer resistor 331 and contactor 326, the valve 320 being rendered oscillating by condenser 332. Recorder 330 may be any type of recorder responsive to direct current such as illustrated in U. S. Patent No. 1,904,164.

At repeating station 232, energy from the line section circuit extension conductor 277 controls potential upon a grid of a signal receiving vacuum valve 263, rendering the grid more negative than ground potential and sufficiently negative with reference to the cathode of valve 263 to render the plate circuit of the valve non-conducting. The non-conducting condition of valve 263 permits the grid of a gas-filled oscillator valve 340 to attain the potential of contactor 264 while its cathode manifests the potential of contactor 268, the two potentials having a difference such that oscillator valve 340 is permitted to oscillate, which, through induction coil 341, amplifier valve 342, and induction coil 343,

supplies signaling current to line section conductor 233. Similar equipment is provided for line section conductor 233 and its extension conductor 243.

Also at substation 230, the valve 267 operates as a keying device for transmission over the described line section circuit 231. When photo-cell 290 is illuminated as a marking signal, the potential of the grid of vacuum valve 291 is rendered such that the plate circuit of valve 291 is rendered conducting, rendering the grid of gas-filled oscillator valve 295 more negative, thus stopping oscillation of valve 295 and terminating all generation of energy in secondary induction coil winding 310. Accordingly, grid 313 of valve 207 attains the positive potential of grounded battery 315, rendering conductive the plate circuit of valve 267, thus rendering conductive the entire line circuit section 231, from ground connection 260 to ground connection 261. Corresponding equipment including the keying valve 333 is provided at substation 224 for keying of line circuit section 233.

Circuit 353, included in repeating station 232 to provide means against reflection signals, includes a secondary winding 351 in induction coil 256, a secondary winding 352 in induction coil 253, a unidirectional valve 354, a condenser 355 and resistor 356 connected to grid of oscillator valve 237. Induction coil 353 has two primary windings 357, 358 included in conductors 276, 275 and in series with secondary windings 257 and 258, respectively.

While a signal current condition is being impressed upon line section conductor 231, alternate impulses pass through windings 358 and 357, respectively, so as to produce an alternating magnetic flux in induction coil 353. Secondary windings 351 and 352 are so proportioned that they produce substantially opposite and equal potentials, producing no polarization of condenser 355. However, since the two oscillators 237 and 340 are maintaining line signaling currents of positive potential upon local conductors 243 and 277, polarization of grid of valve 237 from conductor 243 and polarization of grid of valve 340 from conductor 277 maintains the valves 237 and 340 in oscillation.

When for transmission of telegraph signals of an intelligence code the photo-cell 290 is darkened, increase of resistance of the photo-cell causes the grid of vacuum valve 291 to become more negative, current ceases to flow in the plate circuit of vacuum valve 291 and the grid of gas-filled oscillator valve 295 attains the potential of contactor 293 and thus becomes more positive, permitting gas-filled valve 295 to oscillate by reason of condenser 306. There is generated in the primary winding of induction coil 304 an alternating current and in the secondary winding 310 an alternating potential and a pulsating current by reason of unidirectional valve 311. The pulsating current charges a condenser 312 connected in series with battery 315, overcoming the positive polarity of battery 315 and causing grid 313 to become sufficiently negative to render non-conducting the plate circuit of the keying valve 267, thereby interrupting in keying manner the described current in line section circuit 231.

Cessation of current in line section circuit 231 has a controlling influence upon three units of associated apparatus, permitting the grid of valve 320 to attain ground potential from ground connection 260, permitting the grid of valve 263 to

attain ground potential from ground connection 261, and terminating generation of alternating potentials in induction coil winding 352.

Ground potential upon the grid of valve 320 renders the grid more negative than before, stopping oscillation in valve 320, deenergizing recorder magnet 330 and producing a spacing signal in the recorder.

Ground potential upon the grid of valve 263 makes the grid more positive than before, renders the plate circuit of valve 263 conducting, thus making the grid of valve 340 more negative and stopping oscillation of valve 340, which renders inert induction coil 341, valve 342, induction coil 343 and rectifier 347, terminating current in line section 233 and producing a spacing signal in the line section 233 and in the receiving valve 348.

Termination of generation of alternating potentials in induction coil winding 352 leaves unopposed the potentials generated in induction coil winding 351 which, acting through unidirectional valve 354 will charge condenser 355 to impress upon the grid of valve 237 a potential which will maintain the valve 237 in oscillation despite a reflection condition immediately to be manifested upon conductor 243. By cessation of current in line section 233 the grid of vacuum valve 282 is permitted to attain ground potential through ground connection 281, making the grid more positive than before and rendering the junction point 283 more negative than before, but the now charged condenser 255 overcomes the influence of valve 282 and holds the grid of valve 237 sufficiently positive to maintain the valve 237 in oscillation. Thus echo suppression is effected by an opposition of concurrent potentials, from valve 282 and from circuit 250, respectively.

During continuance of the line signal of spacing nature originating in substation 230, the valve 237 oscillates, valve 340 does not oscillate. Alternating potentials are generated in secondaries 257, 258 of induction coil 256, but current does not flow in conductors 277, 231, 233, 243.

Upon reillumination of valve 290 to terminate the spacing signal and to restore the line signal of direct current nature, valve 267 becomes conducting, currents flow in secondaries 257, 258 and in conductors 277, 231, the grid 346 becomes biased positively, valve 340 begins oscillating and current begins in conductor 233.

In review, operation of the structure illustrated in Fig. 2 is briefly as follows: With photo-cells 290 and 360 illuminated, plate circuits of valves 291 and 292 are conducting, gas-filled valves 295 and 296 are non-oscillating, induction coils 304 and 305 are inert, the grids of keying valves 313 and 383 are made positive by their biasing batteries 315 and 316, rendering the two keying valves conducting, valves 237 and 340 are continuously in oscillation and supply rectified current of positive potential to line sections 231, 233 and to receiving valves 320 and 348 while current of negative potential is supplied to repeater valves 263 and 282 for a signal of marking nature. Receiving valves 320 and 348 in response to positive potential, oscillate and energize the recorders 330 and 349. Negative potential from conductors 277 and 243 upon grids of valves 263 and 282 render the plate circuits non-conducting and permit gas-filled valves 237 and 340 to oscillate.

To produce a signal of spacing nature, control tape 318 darkens the photo-cell 290 which renders valve 291 non-conducting and causes cell 295 to oscillate, energizing the repeating coil 304 and producing a negative electrification of grid 313 to

render keying valve 267 non-conducting to interrupt current in line section 231 and to reduce to earth potential the grid 321 which stops current in recorder 330. Cessation of current in conductors 231 and 277 and leakage through resistor 279 reduces the grid of valve 263 to earth potential, thus stopping oscillation of valve 340 and stopping current in line section 233, permitting the grid of receiving valve 348 to be reduced to earth potential, thereby stopping oscillation of valve 348 and stopping current in recorder 349, producing therein a signal of spacing nature.

Reflection signals are generated in valve 282 from extension conductor 243 but are stopped at the point 283 by counter electromotive force in condenser 355 generated in a local circuit 359 by valve 237 acting through induction coil 239, valve 251, induction coil 256 and valve 354.

The function of relay 269 is to start the system into oscillation, initially. Should batteries be removed to facilitate test or replacement of parts as is customary practice, then upon restoring the battery connections, an earth potential upon grids of valves 263 and 282 will render those valves conducting and would render both valves 237 and 340 non-oscillating but for the fact that relay 269 then unenergized will hold open the plate circuit of valve 263, thus permitting the grid of gas filled valve 340 to attain a potential which will permit valve 340 to start into oscillation whereupon the plate current of valve 340 will energize relay 269 over an obvious circuit and also will generate a current in line 233 and in local conductor 243, polarizing the grid of valve 282 to render its plate circuit non-conducting thereby starting gas-filled valve 237 into oscillation. Closing of contacts of relay 284 places valve 340 under control of valve 263. During transmission of signals of intelligence, at all times one or the other of valves 237 and 340 will be oscillating and relay 269, having windings in both of the two plate circuits, will be energized continuously.

Circuit 231, because it has an operating potential applied in series connection at a median point between ground terminals 260 and 261, manifests a positive potential with reference to ground at resistor 262 in substation 230 and manifests a negative potential with reference to ground at resistor 278 in repeater station 232. The marking condition of signaling in the substation 230 and in the repeating station 232 includes the oscillating condition of a gas-filled valve 320 at substation 230 and 237 at repeating station 232. At substation 230, a direct connection is made from line section conductor 231 to grid of gas-filled valve 320 to render the valve conductive and oscillating, while at repeating station 232 the negative extension conductor 277 is connected to grid of a signal reversing vacuum valve 263 whose plate circuit is connected to grid of gas-filled valve 340. Thus at substation 230 a signal receiving oscillating valve is rendered active in response to a positive condition of an associated signaling line circuit while at repeating station 232 a signal receiving oscillating valve is rendered active in response to a negative condition of an associated signaling line circuit.

Structure of Fig. 3 comprises a conductor 400 for received signals, a leak resistor 401 for discharging the conductor 400 to ground potential upon cessation of a signaling current, a potential branch conductor 402 to grid 403 of amplifying valve 404, a flashing lamp 405, a photo-cell 406, resistor 407, a potential branch conductor 408

to grid 409 of amplifier valve 410, a battery 411, and an output conductor 412.

In operation, a received marking signal of positive polarity upon conductor 400 will polarize the grid 403 to permit illumination of lamp 405 to vary the potential impressed upon grid 409 to permit a signal current of marking nature to flow in output conductor 412 from battery 411. Interruption of signaling potential on conductor 400 will effect ground potential upon grid 403, interrupting current from lamp 405 and darkening the photo-cell 406, thus changing the potential supplied to grid 409 and interrupting the signaling current in output conductor 412. Received signals as of static electrical discharges, if too short or too weak to illuminate the lamp 405, will not be repeated into conductor 412.

Structure of Fig. 4 resembles that of Fig. 3, but provides for a polar output suitable for double-current working, comprising a conductor 420 for received signals, a leak resistor 421 for discharging the conductor 420 to ground potential after cessation of signaling current in line conductor 420, a potential branch conductor 422 extending to grid 423 of amplifying valve 424 which derives plate current from conductors 425, 426 connected to ends of a high value resistor 427 in a Wheatstone bridge structure 428 supplied with current from a battery 429 and supplying current from detector-bridge points over conductors 430, 431 to a polar flashing lamp 432 serving two photo-cells 433, 434. A twin-triode valve 440 has a common filament 441, two independent plates 442, 443 and two independent grids 444, 445 with circuits as follows: A plate circuit for plate 442 including battery 450, filament 441, plate 442, conductor 451, conductor 452, resistor 453, contactor 454, and conductor 455. A plate circuit for plate 443 including battery 450, filament 441, plate 443, conductor 456, resistor 453, contactor 454, and conductor 455. A potentiometer circuit for grid 445 including battery 460, conductor 461, resistor 462, conductor 463, photo-cell 434, and conductor 464 and comprising further a potential branch conductor 465 from conductor 463 to grid 445. A potentiometer circuit for grid 444 including battery 460, resistor 470, contactor 471, resistor 472, conductor 473, photo-cell 433, and conductors 474, 461 and comprising further a potential branch conductor 475 which connects contactor 476 to grid 444.

In operation, a resting condition of a received signal of marking nature or positive potential on conductor 420 polarizes grid 423 positively and renders the valve 424 conducting between conductor 425 and ground, thus rendering the shunted bridge arm 427 lower in resistance than its companion bridge arm 482. Current from battery 429 flows through resistor 480 and valve 424 to ground without effect, flowing also through resistors 481, 482 to ground without effect and flowing through resistor 481, conductor 431, lamp 432, conductors 430, and valve 424 to ground, illuminating electrode 486 of lamp 432 controlling photo-electronic cell 434, changing potential on grid 445 and offering a path for current from filament 441 to plate 443. Current flows from negative pole of battery 450 through cathode 441, anode 443 and conductor 456 to ground, and from positive pole of battery 450 through conductor 455, and contactor 454, thence through one part of resistor 453 and conductor 484 to ground without effect, and also flows effectively through a remaining part of resistor 453, conductor 452 and output conductor 485 with positive terminal

of battery 450 connected to output conductor 485 and negative terminal of battery 450 connected through conductor 456 to ground, constituting a signaling condition of positive potential or marking nature on output conductor 485.

A received signal of negative potential or spacing nature received on conductor 420 electrifies grid 422 negatively, renders valve 424 non-conducting and increases resistance from conductor 425 to ground. Current from battery 429 flows in the four resistors, 480, 427 to ground and 481, 432 to ground without effect and flows also through resistor 480, conductor 403, lamp 432, conductor 431 and resistor 482 to ground, illuminating electrode 483 of lamp 432, controlling photo-electronic cell 433, changing potential on grid 444 and offering a path for current from filament 441 to plate 442. Current from battery 450 flows over an output circuit including ground, conductor 484, resistor 453, contactor 454, conductor 455, grounded positive pole and free negative pole of battery 450, filament 441, plate 442, and conductor 451, whence current flows through conductor 452 and resistor 453 without effect, and also flows effectively over output conductor 485, with negative terminal of battery 450 connected to output conductor 485 and positive terminal connected through conductor 484 to ground, a signaling condition of spacing nature on output conductor 485.

Thus as positive and negative telegraphic signals are received over conductor 420, each is amplified and retransmitted as a positive or negative signal upon output conductor 485, except that received signals as of static discharges which are too weak or too short to illuminate the lamp 432 are not repeated.

The invention has been described by use of specific applications as examples, but may be utilized in modified forms.

What is claimed is:

1. In a telegraph system, a normally continuously conducting signaling circuit, a source of alternating potential in said circuit, a thermoelectric space discharge rectifying tube having cathode and anode in said circuit, said circuit normally carrying a rectified current, a thermoelectric triode tube having its cathode and anode in said circuit, means responsive to received signals for suppressing operation of said source to stop said current in signaling manner, and further means responsive to other received signals for polarizing the grid of said triode tube to stop said current in signaling manner.

2. In a telegraph two-way single line repeating system, two line sections, two normally non-oscillating thermo-electronic valves each responsive to a signal of commutated direct current received from one of said line sections to begin oscillation and to generate a comparatively rapid alternating current, rectifiers operated by said alternating current to supply a direct-current signal to the other of said line sections, and further rectifying means associated with each of said valves and operative when said associated valve is oscillating to generate alternating current and to rectify said alternating current to prevent oscillation of the other of said valves.

3. In a telegraph system, two line sections, two normally non-oscillating thermo-electronic valves each having its grid connected to one of said line sections, means operative over one of said line sections to transmit a positive direct-current signal to cause one of said valves to oscillate, and means responsive to said valve in

oscillation to generate a rapid alternating current and apply through a rectifier a direct-current positive signal to the other of said line sections and to generate an alternating current and apply through a rectifier to the grid of the other of said valves a direct-current negative potential.

4. In a telegraph system, two line sections, two thermo-electronic valves each responsive to a positive signal upon its grid received from one of said line sections to begin oscillation to generate a rapid alternating current and to apply through a rectifier a positive signal to the other of said line sections and to generate and apply to the grid of the other of said valves a negative potential, and a delaying filter between said rectifier and the line section to which said positive signal is applied.

5. The method of repeating direct-current telegraph signals which comprises the steps of generating alternating currents in response to received direct-current signals, amplifying a portion of the alternating currents, rectifying and retransmitting the rectified currents, amplifying a further portion of the alternating currents, and rectifying and utilizing the further rectified currents to suppress reflection signals.

6. In a telegraph repeater, an amplifier valve directly responsive to marking and spacing received signals of positive and negative potentials, flashing lamps directly responsive to output signals from said amplifier valve, photo-cells responsive to illumination by said flashing lamps, and means controlled by the photo-cells for reproducing and retransmitting marking and spacing signals of positive and negative potentials corresponding to the signals received by said amplifier valve.

7. In a telegraph system, two telegraph stations, a transmission line connecting said stations and connected with ground return at each station, receiving tubes and potential branch conductors at each station, a source of current included in said transmission line in series connection at a location between said potential branch conductors of said line, line-signal responsive oscillatory means at one of said stations controlled to oscillate in response to a received direct-current signal of positive potential upon said line with respect to ground, and line-signal responsive oscillatory means at the other of said stations controlled to oscillate in response to a received direct-current signal of negative potential upon said line with respect to ground.

8. In a telegraph system, means for initiating oscillation comprising, a relay, an oscillatory system, a plurality of oscillators in said system, a control circuit including contacts of said relay for rendering said system initially oscillatory when said relay is unenergized, and a plurality of energizing circuits for said relay rendering said relay responsive to energization by a plurality of said oscillators.

9. In a telegraph system, two lines, means for impressing high-speed direct current printer signals on either of said lines and a two-way repeater for relaying said signals from either line to the other line, said repeater comprising a source of oscillations of a relatively high frequency compared to the frequency of said printer signals, two vacuum tubes having the input circuits thereto connected to the respective lines, means including said vacuum tubes and source of oscillations for repeating signals from each line to the other line and means responsive to the transmission of signals over either line to the

repeater for locking out the other half of the repeater so long as the signals continue.

10. In a telegraph system, two lines and a two-way repeater adapted to repeat signals from either of said lines to the other line, said repeater comprising two space-discharge devices having their output circuits each associated with one of the respective lines, a source of alternating current associated with each of said space-discharge devices, means including said devices and said source for repeating signals received over either of the lines and means for preventing the signal appearing in the output circuit of one of said space-discharge devices from being repeated by the other space-discharge device.

11. In a telegraph system, two lines, means for impressing signals on both of said lines and a two-way repeater adapted to repeat said signals

from either of said lines to the other line, said repeater comprising a space discharge device, a source of alternating current and a rectifier for each line and means including either of said space-discharge devices and the associated rectifier for controlling one of said lines in accordance with signals received over the other line.

12. In a telegraph system, a line, means for impressing high-speed direct current printer signals on said line, receiving means, means connected to said line and said receiving means for regenerating said signals, said last mentioned means comprising an oscillation generator, a space-discharge device connected to said line and arranged to control the connection of said generator to said receiving means and a rectifier between said generator and said receiving means.

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