

June 15, 1943.

L. M. POTTS

2,321,618

SPACE DISCHARGE OSCILLATING RELAY

Filed Sept. 18, 1939

FIG. 1

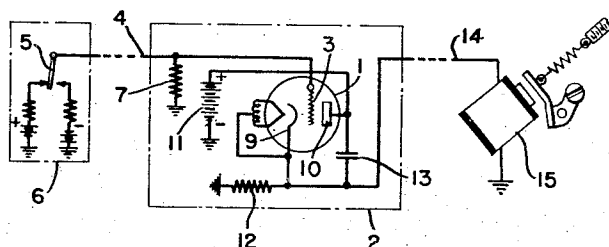


FIG. 2

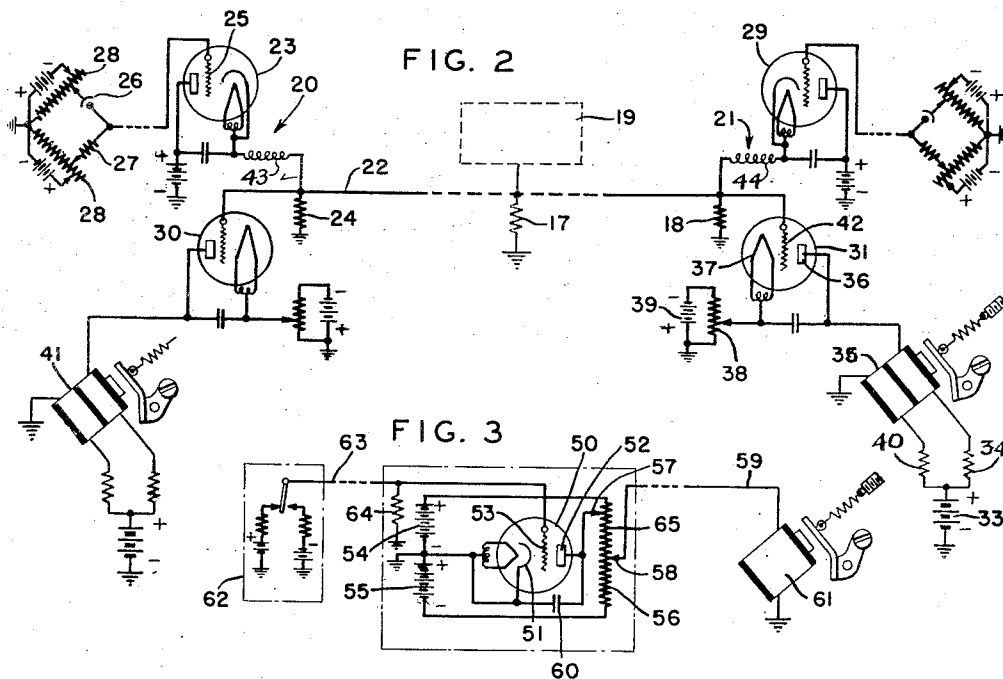


FIG. 3

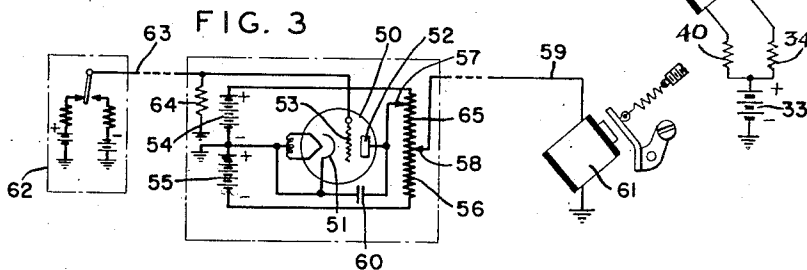
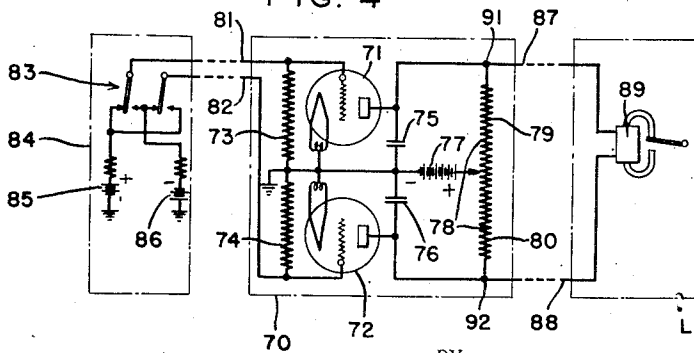


FIG. 4



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## UNITED STATES PATENT OFFICE

2,321,618

## SPACE DISCHARGE OSCILLATING RELAY

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Application September 18, 1939, Serial No. 295,414

16 Claims. (Cl. 178—58)

This invention pertains to telegraph systems and particularly to such systems in which space discharge devices are embodied as parts thereof in the functions of transmitters, receivers, and relays.

The main object is to provide methods and apparatus for the operation of telegraph circuits with current of low value transmitted over the lines.

Another object is to provide methods and apparatus for the control of telegraph apparatus by the potential of the line.

Another object is to provide methods and apparatus for accomplishing these objects with a minimum number of thermionic tubes.

A feature of the invention is the provision of a system of telegraph transmission between two stations in which the transmitting, relaying, and receiving control is performed exclusively by space discharge devices.

The above objects are attained by connecting the plate of a space discharge gas filled tube in a telegraph line circuit for transmission and then supplying the grid of the tube with signal impulses for control of transmission, by connecting such a tube to the line conductor of a telegraph system and by connecting a mechanical telegraph recorder in series with the plate of such a tube at a receiving and recording telegraph station.

A more complete understanding of the invention may be had from the following description, taken in conjunction with the accompanying drawing in which,

Fig. 1 illustrates a receiving space discharge relay in combination with a telegraph receiver magnet controlled thereby;

Fig. 2 illustrates a complete two-way transmission system using space discharge relays;

Fig. 3 illustrates a receiving relay having novel features of adjustment and control; and

Fig. 4 illustrates a receiving space discharge relay in combination with a polarized magnet controlled thereby.

The telegraph system illustrated in Fig. 1 comprises a repeater assembly connected by transmission conductors to a transmitting substation and to a receiving recorder respectively, all equipment at the repeater being of space discharge nature without mechanical contacts. Polar signals are received and single current signals are retransmitted.

The telegraph system illustrated in Fig. 2 comprises a plurality of stations connected by a single transmission conductor. Signal generat-

ing and amplifying apparatus at each station and signal receiving and amplifying apparatus at each station are all of space discharge nature. The amplified signals are applied to an electrically biased electromagnet for purpose of recording. All signals are single current.

In the system illustrated in Fig. 3, the repeater is capable of control to emit either polar signals or single current signals according to its condition of adjustment, and in either case in response to polar signal control.

In the system illustrated in Fig. 4, polar signals are received by a relay and polar signals are retransmitted.

Referring to Fig. 1, a space discharge gas filled tube 1 in the relay assembly 2 has its grid 3 connected to a telegraph line conductor 4 which extends to a remote telegraph transmitter 5 at a station 6, the transmitter 5 supplying positive or negative current to the line conductor 4 and through the resistor 7 to ground and thereby supplying positive or negative potential to the grid 3 in the form of telegraph signals. The resistance 7 connected from the line to ground is greater in value than the series resistance of the line 4, thus providing current of low value on the line conductor 4.

The tube 1 comprises also a hot cathode 9 and a plate anode 10. A plate battery 11 is connected from ground to the plate 10, and a resistor 12 is connected from the cathode 9 to ground, to complete a plate circuit. A condenser 13 is connected between the cathode and the anode to render the tube circuits oscillatory and to place the tube circuits under control of grid 3. A conductor 14 is connected in parallel with the grounded resistor 12, the conductor extending through a telegraph selector magnet 15 of a recorder to ground to complete a transmission circuit. The recorder may be according to U. S. Patent No. 1,904,164 granted to S. Morton et al., and is symbolized herein by a showing of the selector magnet 9, Fig. 4 of the S. Morton et al. patent. The selector magnet in Fig. 1 and in the remaining figures will be assumed to be illustrated with its armature attracted.

In operation, movement of the middle contact member of the transmitter 5 at substation 6 to effect application to the line conductor 4 of a signal of positive potential at substation 6 as shown will bias the grid 3 to render the tube 1 conducting. Condenser 13, charged by battery 11 beginning immediately after each extinction of the discharge in the tube, now will be discharged in a negligible time interval through

electrodes of the tube 1, reducing potential at terminals of condenser 13 and shunting from the tube 1 substantially all current from battery 11, the battery current being limited by joint resistance of resistor 12 and transmission circuit 14, 15 in parallel, and flowing through condenser 13 for an appreciable time to recharge the condenser. Stray current which may flow at this time over line 4 from control grid 3 is of a negligible amount. When the condenser's terminal potential rises to the ignition point of tube 1, the cycle is completed and the condenser again discharges. Oscillation of the circuit of tube 1 and of condenser 13 continues throughout the continuance of the signal, or as long as the line conductor 4 remains connected to positive battery at substation 6.

During oscillation of circuits of tube 1, current flows from grounded battery 11 through condenser 13 in process of recharging, conductor 14 and electromagnet 15 to ground.

The described current flows through the conductor 14 and through the electromagnet 15 in substantially contiguous impulses, and forms a substantially uniform continuous or direct current through magnet 15.

Upon reversal of the contactual conditions of transmitter 5, thus connecting the line conductor 4 through transmitter 5 to negative battery, a negative signal is propagated in line 4, biasing grid 3 to render circuits of tube 1 nonoscillating. Condenser 13 then recharges in full and remains in charged condition, terminating the described current which effected a signal in the conductor 14 and in the electromagnet 15.

Thus, polar signals are received by potential only at the relay 2 from the substation 6 and are retransmitted by relay 2 to the selector magnet 15 wholly by space discharge means in relay 2 and without the operation of any mechanical contact in the relay.

The telegraph system illustrated in Fig. 2 comprises a plurality of identical stations of which 19, 20, and 21 are shown connected by a single transmission conductor 22. Transmission apparatus at station 20 consists of a relay tube 23 whose electrical connections are identical with those of tube 1, Fig. 1, the output circuit being line conductor 22 in parallel with resistor 24, thence through resistors 17 and 18 in parallel to ground. The transmitting apparatus at each station is connected to the line conductor 22 through a filter designated 43 at station 20 and 44 at station 21 provided to suppress the oscillations at the transmitting stations from the line conductor. Means for supplying a polar signal to grid 25 comprises a photoelectric cell 26 and resistor 27, both having adjustable contacts on a potentiometer 28. By proper adjustment of the contacts, a higher current through the photoelectric cell 26 caused by an illuminative control (not shown) may produce a positive potential on grid 25 and a lower current through the cell 26 may produce a negative potential on grid 25. Control of the photoelectric cells may be as disclosed in United States Patent No. 2,177,077, granted Oct. 24, 1939, to L. M. Potts. Similar arrangements are provided for tube 29 at station 21 and for a similar tube at station 19. Resistance of each resistor 17, 18, and 24 is high compared with resistance of line 22, and line currents are of low intensity.

A signal impressed upon line conductor 22 is effective upon grids of tubes as 30 and 31 at all stations. Each grid is provided with electrical

connections similar to those of tube 1, Fig. 1. The plate circuit for tube 31 includes battery 33, resistor 34, upper or operating windings of an electrically biased selector magnet 35, plate 36, cathode 37 and grounded resistor 38 which is connected to a battery 39 for biasing the tube 31. A biasing circuit for selector magnet 35 includes battery 33, resistor 40, and a biasing winding of the magnet 35. Current from tube 31 balances out the biasing magnetic field.

For operation of the structure of Fig. 2, contacts of potentiometer 28 are adjusted to render grid 25 negative when cell 26 is dark and positive when cell 26 is illuminated. Dark photo cells and negative potentials on grids of the tubes 23 and 29 estop oscillation of circuits of tubes 23 and 29, the circuit of the latter tube being a duplicate of tube 23. Line conductor 22 attains ground potential through resistor 24 and others. Adjustment of resistor 38 and battery 39 is such that ground potential on line conductor 22 estops oscillation of tubes 30 and 31. There is, therefore, no current in the operating windings of magnets 35 and 41 and currents in the biasing windings cause the armatures of those magnets to occupy their non-operating position. This is the normal condition of the system when not transmitting electrical signaling impulses.

When transmitting an electrical signal impulse on line 22, illumination on the photoelectric cell 26 produces a positive potential on grid 25 which permits tube 23 to oscillate, producing a positive potential on line conductor 22 and on grid 42 of tube 31. Positive potential on grid 42 permits tube 31 to oscillate, producing a current in the upper or operating winding of magnet 35, thus reversing the position of the armature of magnet 35 and holding it reversed to manifest a received signal. The signal on line 22 also operates tube 30 to produce a home record.

In the structure illustrated in Fig. 3 a gas filled tube 50 comprises cathode 51, anode 52 and grid 53. Current for the plate circuit and for the output or retransmission circuit is supplied from batteries 54 and 55 through a potentiometer resistor 56 having an adjustable contact 57 connected to the anode 52 and a further adjustable contact 58 connected to an output or line circuit 59. The cathode is connected to ground and a condenser 60 is connected from cathode to anode. The output circuit 59 includes a signal responsive device or telegraph receiver 61 which may be either polar or neutral in construction. Telegraphic signals according to two-current practice are supplied in nature of biasing potentials to grid 53 from substation 62 over line conductor 63. Output signal currents may be according to practice of polar signaling or single current signaling.

Operation of the system in response to a signal of positive potential maintained on line conductor 63, as shown at substation 62, will effect a positive biasing of grid 53 permitting the tube 50 to oscillate, producing two substantially continuous currents as follows:

A first current flows through battery 54 and top portion of potentiometer resistor 56, while a second current of lesser intensity flows through battery 55 and bottom and middle portions of potentiometer resistor 56, the first and second currents uniting in contact 57, the differential current flowing thence through condenser 60 to

ground. During the described period of current contact 57 is substantially at ground potential, and resultantly there is manifested at contact 58 a negative potential produced from battery 55 by virtue of the described second current. There results a third current in a path including contact 58, conductor 59 and signal responsive device 61 to ground.

In response to change to a signal of negative nature at substation 62, the grid 53 becomes biased negatively, thus increasing the ignition point of the plate circuit of the tube 50 to a value above the potential of the contact 57. Condenser 60 then recharges but does not discharge and oscillation of the tube 50 ceases. Current flows from negative battery at substation 62 through line conductor 63 and resistor 64 to maintain a negative biasing condition on grid 53. Current flows also in potentiometer resistor 56 from batteries 54 and 55, producing a ground potential at or about the middle point of the resistor 56. As shown in the drawing, contact 58 is adjusted to the described point of ground potential and no current flows in line conductor 59 during continuance of the negative signal on line 63.

With contact 58 adjusted as shown at the point of ground potential in the resistor 56, received signals are polar and retransmitted signals are single current.

Presume now that the contact 58 has been shifted and is adjusted to a point above the middle point on the resistor 56 and indicated as 65 on the resistor 56. During a positive signaling condition on line 63, with contactor 57 substantially at ground potential, the contactor 58 now in position at 65 receives a negative potential from battery 55, and during a negative signaling condition on line 63 with the middle point of resistor 56 substantially at ground potential, the contactor 58 receives a positive potential from battery 54. Accordingly, in response to signals of positive and negative polarity respectively received from line conductor 63, the repeating equipments of Fig. 3 will retransmit signals of negative and positive polarity, respectively. Thus, polar signals are received and polar signals are retransmitted.

It has been described in detail above that with contact 58 adjusted as shown there will be retransmitted single current marking and spacing signals of current and no-current characteristics, respectively. During receipt of a positive signal, the ground potential will be located near the contact 57. It will be obvious that when contact 58 is adjusted to the point of the ground potential during receipt of a positive signal there will result a transmission of single current signals of no-current and current characteristics, respectively, thus effecting reversal of the characteristics of the two classes of signals by readjustment of the relay devices.

By varying the position of contact 57 on the resistor 56, potential impressed on anode 52 may be varied and a desirable potential may be attained.

For any position of adjustment of contact 57, there is a corresponding first position on resistor 56 at which ground potential is manifested during receipt of a signal of positive nature, a corresponding second position on resistor 56 at which ground potential is manifested during receipt of a signal of negative nature, and a corresponding third position on resistor 56 at which a potential of one polarity is manifested during

receipt of a signal of marking nature and a potential of similar voltage but of reversed polarity is manifested during receipt of a signal of spacing nature. Contact 58 may be adjusted to any one of these three critical points, or near them, according to the characteristics desired in the retransmitted signals in the output conductor.

Fig. 4 illustrates a system in which the principles shown in Fig. 1 are duplicated and are arranged in opposing manner to produce polar repeated signals.

At relay assembly 70 there are provided two gas filled tubes 71, 72, two line resistors 73, 74, two condensers 75, 76, a battery 77, and a retransmitting resistor 78 divided into two parts 79, 80. Line conductors 81, 82 connect the apparatus of repeating station 70 to transmitter 83 in substation 84 and through contacts of the transmitter the line conductors are connected variably to positive and negative grounded batteries 85, 86, as shown. Conductors 87, 88 connect the apparatus of the relay assembly to signal responsive device 89.

By reason of the construction of transmitter 83 there will be connected at all times a positive signal over one of the line conductors to one of the tubes and a negative signal over the other line conductor to the other of the tubes. Resultantly, according to principles traversed in description of Fig. 1, one or the other of the tubes will be oscillating, and the conductor junction 91 or 92 of the oscillating tube will be substantially grounded through the condenser of the oscillating tube circuits, while the remaining conductor junction will not be grounded.

In operation, presuming that the transmitter 83 in the condition shown represents a marking signal, positive battery 85 is connected over line 81 to grid of tube 71 wherein the circuits are oscillating and junction 91 is substantially grounded, while negative battery 86 is connected over line 82 to grid of tube 72 which is accordingly biased against oscillation. Resultantly, a charging current flows through battery 77, resistor part 79, and condenser 75 while current flows as a retransmitted signal through battery 77, resistor part 80, line conductor 88, upward through signal responsive device 89, line conductor 87 and condenser 76, constituting a polar signal of marking nature in the device 89. Upon reversal of the contactual condition of transmitter 83, battery 85 is connected over line conductor 82 to grid of tube 72, permitting oscillation of the circuits thereof, while battery 86 is connected over line conductor 81 to grid of tube 71, estopping oscillation, thus substantially grounding the junction 92 and rendering the junction 91 ungrounded. Resultantly, a charging current flows through resistor part 80, while current flows as a retransmitted signal through battery 77, resistor part 79, line conductor 87, downwardly through signal responsive device 89, line conductor 88, and condenser 76, constituting a reversed polar signal of spacing nature in the device 89.

While the invention has been illustrated as embodied in several specific structures, it will be understood that it is not limited by any specific structure but may be embodied in other structures in identical or in modified form.

What is claimed is:

1. In a telegraph system, a repeating station apparatus comprising a combination of a gas filled triode tube, batteries, a condenser, an input conductor, an output conductor, a resistor, and

electrical connections, said tube having cathode, anode, and grid, means to impress on said grid a succession of signals of different polar characteristics received over said input conductor, means between said resistor and said tube for varying the locations of critical potential points on said resistor, and means between said resistor and said output conductor for adjusting said output conductor into electrical connection with any one of said critical potential points.

2. In a telegraph system, a gas filled tube, batteries, a condenser, a resistor, an output conductor, said tube comprising cathode, anode and grid, means to impress on said grid signals of marking and spacing character, connection means for manifesting on said resistor a ground potential at one point in response to impressment of a marking signal on said grid and at another point in response to impressment of a spacing signal on said grid, and means to connect said output conductor either to said one point or to said other point.

3. In a telegraph system, a gas filled tube, batteries, a condenser, a resistor, means for impressing on said tube received signals of marking and spacing nature, means including conductive connections for generating on said resistor critical potentials at different points on the resistor, and take-off means for delivering repeated signals of polar or of single current nature.

4. In a telegraph system, a triode gas filled tube having a cathode, anode, and grid, a battery connected from said anode to ground and a resistor connected from said cathode to ground forming a plate circuit, a condenser connected directly from said cathode to said anode, a charging circuit for said condenser comprising said resistor, said condenser, and said battery, an oscillatory circuit including said cathode, anode and condenser, and means to impress signal impulses on said grid effective under certain operating conditions to discharge said condenser through said tube to initiate oscillations in said oscillatory circuit which oscillations continue provided the grid remains positive, and effective under other conditions to facilitate the charging of said condenser when said tube is rendered nonconductive.

5. In a telegraph transmission system, a telegraph station, a remote telegraph station, a triode gas filled tube having cathode, anode and grid, at said first-mentioned station, a battery connected from said anode to ground and a resistor connected from said cathode to ground forming a plate circuit for said tube, a condenser connected directly from said cathode to said anode, means to impress received signals in the form of variable polar potentials on said grid, a retransmission circuit connected directly to said resistor and extending to said remote station, and a signal receiving device comprising a gas filled triode tube having cathode, anode and grid, at said remote station, said last mentioned grid connected directly to said retransmission circuit at said remote station.

6. In a telegraph system, two triode gas filled tubes, condensers individual to said tubes, a battery and a resistor common to said tubes, means including a telegraph transmitter and direct connections to said tubes for applying polar signals to said tubes, means including direct circuit connections for substantially grounding one end or the other of said resistor in response to operation of one or the other of said tubes, said

battery connected to a mean point of said resistor, and a signal responsive device connected between the two terminals of said resistor and grounded on one terminal or the other as one or the other of said tubes is operated.

7. In a telegraph system, a plurality of stations, a line circuit passing through all the stations, a resistance connected from the line to ground at each station to maintain the line at substantially ground potential with no battery potentials applied at any station, a grid controlled thermionic tube at each station having its grid connected to the line, a condenser connected between the cathode and anode of said tube to form a relaxation oscillator therewith wherein the oscillations continue at the same amplitude provided positive potential is impressed on said line, a recorder controlling magnet connected in the plate circuit of the tube at each station, and transmitting means associated with each grid circuit to change its potential for controlling the flow of the plate current in each tube only during the oscillation of said relaxation oscillator to operate its associated magnet.

8. As in 7 in which the resistances connected from the line to ground are much greater in value than the series resistance of the line whereby the potential for controlling the grid is uniform at all stations.

9. In a telegraph system, a recorder controlling magnet having two windings one of which normally carries no current, means to continuously supply current to the other winding to hold the armature of the magnet, a telegraph line, said line carrying no current for the normal marking condition of the recorder, and means comprising a relaxation oscillator wherein the oscillations continue at the same amplitude provided positive potential is impressed on said line to supply current to said first-mentioned winding to release the armature of the magnet.

10. In a telegraph system, a gas tube including a cathode plate and grid, a line circuit, a direct current path including the plate of the tube, an alternating current path in parallel with the direct current path, a signal transmitting device connected to the grid to initiate oscillation in the alternating current path and alter the flow of the current in the direct current path when the transmitter raises the grid voltage above a critical value, said oscillations being effective to return the flow of the direct current to its first stage when the transmitter reduces the grid voltage below the critical value, the line circuit being connected at such a point in the direct current path that current flows in one direction for one condition and in the other direction for the other condition.

11. In a telegraph system, a telegraph circuit, terminal stations associated with the circuit, an intermediate station associated with the circuit, a resistance greater than the resistance of the circuit connecting two sides of the circuit at at least one of the stations, all portions of said circuit being maintained conductive for both positive and negative signaling conditions, means to change the potential between the two sides of the circuit at any station, a grid controlled thermionic tube at each station having its grid connected to said circuit, a condenser connected between the cathode and anode of said tube to form a relaxation oscillator therewith wherein the oscillations continue provided positive potential is impressed on said circuit, an electromagnet in a local circuit at each station, and means to control the flow of

current in the local circuit only during the oscillation of said relaxation oscillator solely by the change of potential on the line.

12. In a telegraph system, a telegraph circuit, a thermionic tube having a cathode, a grid and a plate, the telegraph circuit being included in a direct current path associated with the plate, an oscillating circuit including a capacitor associated with the plate, means to initiate oscillations in the oscillating circuit by changes in the grid potential, and means to maintain direct current in the telegraph circuit by the charging current for the capacitor and means to interrupt the line current by the discharge current.

13. As in 12, and an electrical filter between the oscillating circuit and the line to block the leakage of the alternating current to the line.

14. In a telegraph system, a transmitter, a receiver, and a repeater, said repeater including a gas tube having a cathode, anode, a grid, an oscillatory circuit in said repeater including the cathode, anode, and a condenser, a circuit for charging said condenser, a line conductor connecting said transmitter to said grid for impressing signal impulses on the grid to cause the oscillatory circuit to oscillate, which oscillations continue at the same amplitude provided the grid remains positive, and a signaling circuit including said receiver in parallel with the condenser charging circuit whereby current is supplied to said receiver during said oscillation of said oscillatory circuit.

15. In a telegraph system, a plurality of stations connected by a single transmission conductor, signal generating apparatus at each station including space discharge gas filled tubes, all of

5 said apparatus being of space discharge nature, high terminal impedances at each station, whereby the current on the line is of minimum value, means for connecting the grids of the receiving station space discharge gas filled tubes directly to the transmission line, whereby said tubes are controlled solely by the potential of the line, and electrically biased electromagnetic recording devices at said receiving stations controlled by said space discharge tubes to effect recording operations in accordance with the signal impulses impressed on the transmission line.

16. In a telegraph system, a triode gas filled tube having cathode, anode, and grid, a battery connected from said anode to ground and a resistor connected from said cathode to ground forming a plate circuit, a condenser connected directly from said cathode to said anode, a charging circuit for said condenser comprising said resistor, said condenser, and said battery, an oscillatory circuit including said cathode, anode, and condenser, means to impress signal impulses on said grid effective under certain operative conditions to discharge said condenser through said tube to initiate oscillations in said oscillatory circuit which oscillations continue at the same amplitude provided the grid remains positive, and effective under other conditions to facilitate the charging of said condenser when said tube is rendered nonconductive, and a telegraphic signal receiving device parallel to said resistor and operated by a portion of the condenser charging circuit.

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