

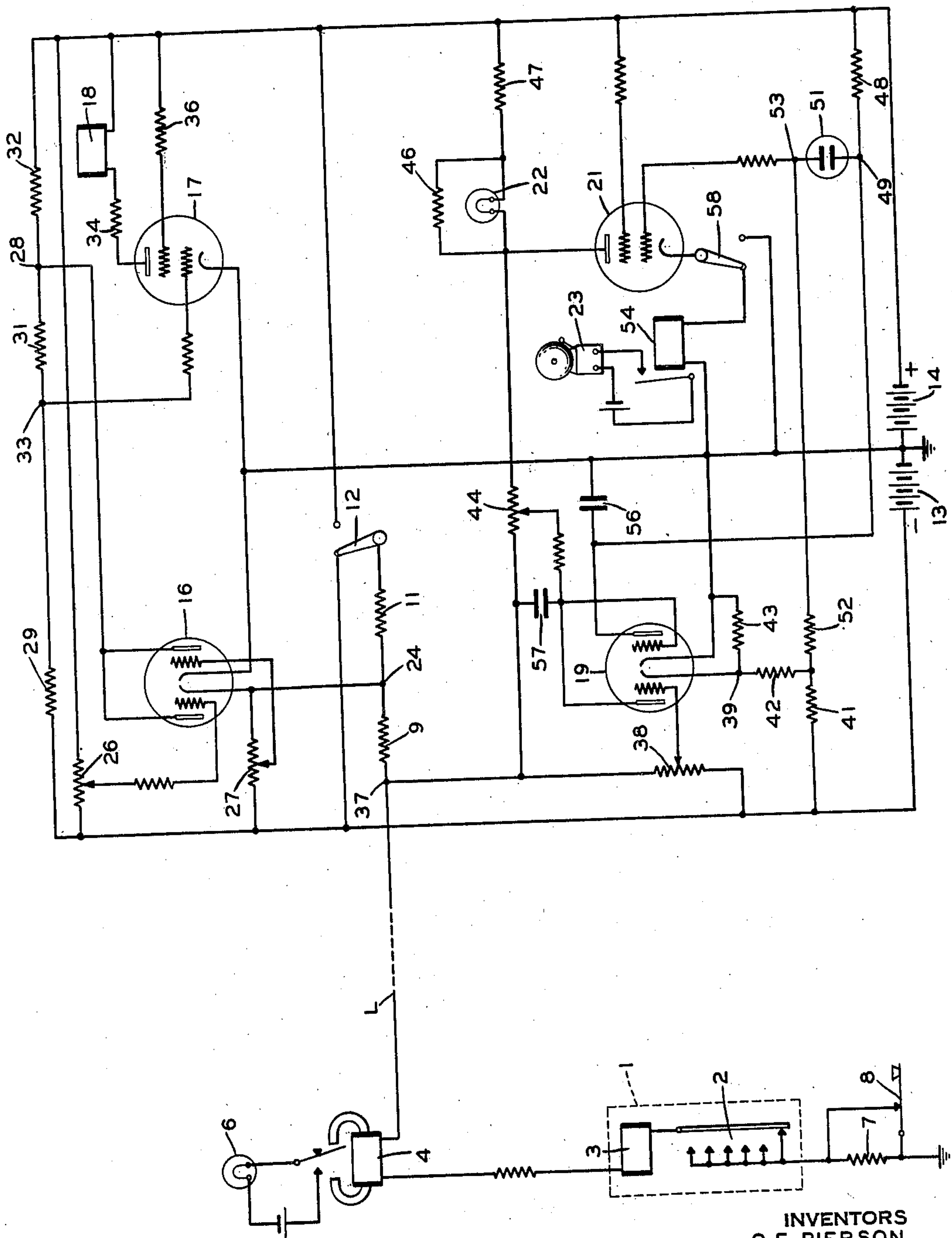
Nov. 24, 1942.

O. E. PIERSON ET AL

2,302,800

TELEGRAPH SYSTEM

Filed Feb. 29, 1940



INVENTORS
O. E. PIERSON
L. W. FRANKLIN
R. STEENECK
BY *[Signature]*
ATTORNEY

UNITED STATES PATENT OFFICE

2,302,800

TELEGRAPH SYSTEM

Oscar E. Pierson, Brooklyn, N. Y., Lawrence W. Franklin, Hasbrouck Heights, N. J., and Robert Steeneck, New York, N. Y., assignors to The Western Union Telegraph Company, New York, N. Y., a corporation of New York

Application February 29, 1940, Serial No. 321,500

6 Claims. (Cl. 178—2)

This invention relates to telegraph systems and has particular reference to a signaling system employing vacuum tube repeaters.

One form of vacuum tube repeater provided by the instant invention is adapted for use in a telegraph system in which the intelligence signals comprise coded combinations of make and break signals. The code transmitter is located at a remote station and is connected to a line circuit which is terminated in ground at said station. Battery is supplied to the signaling circuit at a central station and is normally of one polarity. However, it is contemplated that an auxiliary signaling channel to the remote station be provided which utilizes the line circuit extending between the two stations and which is operated on a polar basis. Means are provided at the central station for reversing the normal line potential to actuate a signal at the remote station. Also, means are provided at the remote station for modifying the value of the line current which is utilized for the transmission of marking or selecting signals and, at the central station, a device is provided which is responsive to the modified line current which is relayed to said device by means of a vacuum tube repeater under certain conditions.

The central station is provided with facilities for repeating the coded intelligence signals to a receiving device. The repeating facilities comprise a plurality of space discharge devices such as vacuum tubes or thermionic relays instead of the electromagnetic relays used in such systems heretofore. The use of thermionic relays obviates a number of objectionable features which are inherent in the electromagnetic relay. These latter devices involve moving parts which are subject to wear and change in adjustment so that considerable maintenance is required to maintain repeaters utilizing such relays in operation. Furthermore, electromagnetic relays require a definite time for operation and cannot be employed for repeating signals above a certain rate which is often reached in practice. If this transmitting rate is exceeded or if the relays get out of adjustment, the repeater will not function satisfactorily.

Hence it is a major object of the invention to provide a telegraph system employing thermionic relays for the repetition of make and break signals to a receiving device irrespective of the polarity of the line potential employed.

Another object of the invention is the provision of an electronic repeater arranged to relay make and break signals from a line circuit to a re-

ceiver and means for transmitting polar signals over the line circuit without interfering with the operation of the repeater.

Another object of the invention is the provision of a vacuum tube repeater which is utilized to relay marginal signals received from a line circuit and which, at the same time, is unresponsive to coded make and break signals transmitted over the line circuit.

Another object of the invention is to provide a vacuum tube repeater in accordance with the foregoing object which will be operative irrespective of the polarity of the potential connected to the line circuit.

Other objects and advantages of the invention will appear from the following description taken in conjunction with the accompanying drawing which is a diagrammatic representation of an illustrative embodiment of the invention.

The telegraph system embodying the instant invention includes a remote station at which is located a telegraph transmitter 1 of the start-stop type which comprises a transmitting element 2 and a receiving element 3. A polarized relay 4 is included in the circuit extending from the line L and is utilized to operate a signal which may be a lamp 6. The line circuit L, after being extended through the winding of the relay 4, the receiving element 3 and the code transmitter 2, is terminated in ground at the remote station. Adjacent the ground connection is a resistance 7 which is connected serially in the circuit but is normally short-circuited by a key switch or push button 8.

At the central station the line circuit L is connected through resistances 9 and 11 to the lever of a switch 12 which is normally maintained on its left hand contact thereby connecting the line circuit to a source of negative potential 13. A source of positive potential 14 is also provided at the central station and is connected to the right hand contact of the switch 12.

The repeater employed for the repetition of the coded intelligence signals includes a vacuum tube 16 which is a double triode and may be of the 6C8G type. This tube is provided with two cathodes, two control grids and two anodes, one set of which is arranged to respond to the line signals when negative potential is connected to the circuit and the other set of which is arranged to respond to the line signals when positive potential is connected to the circuit. Obviously this tube could be replaced by a pair of three element tubes to accomplish the same purpose. The plates or anodes of the tube 16 are connected to-

gether and are employed to control the input circuit of a vacuum tube 17. This tube comprises a cathode, anode, control grid and a screen grid and may be of the type 25L6G. As pointed out previously the input circuit of this tube is controlled by the tube 16 and the output circuit includes the selecting magnet 13 of a receiving device which may be a printer, a reperforator or the like connected to the anode of the tube. It will presently appear that the signals which are transmitted from the code transmitter 2 of the remote station are received by the selecting magnet 13 of the receiving device.

The central station also includes facilities which are responsive to an auxiliary signal transmitted from the remote station by the operation of the push button 8. These facilities include a vacuum tube 19 which is a double triode and may be of the type 6C3G. Of the two sets of elements provided in this tube, one responds to signals sent from the remote station when the line is connected to one pole of battery and the other set responds to signals transmitted from the remote station when the line is connected to the other pole of battery. The output circuit of this tube is arranged to control the operation of a tube 21 which may be similar in type to tube 17. The output circuit of this tube includes a visible signal 22 which may be a lamp or an equivalent device and an audible signal such as a bell 23.

The purpose of the various signaling arrangements provided in this system is to enable an attendant at either the remote station or the central station to signal or call in an attendant at the other station without interfering with the operation of the intelligence signals being transmitted over the circuit. The operation of the push button 8 is initiated when the distant station desires to call in the attendant at the central station. As will appear presently this is accomplished by operating the signals 22 and 23. In addition, the attention of the attendant at the remote station may be attracted by the movement of the switch 12 at the central station to its right hand contact whereby positive potential is connected to the line circuit to cause the operation of the relay 4 and the signal which is controlled thereby. The operation of these various signals will be described in the following detailed portion of the specification.

During normal idle conditions the transmitter element 2 of the remote station's telegraph apparatus 1 maintains the line circuit L closed to the negative potential of battery 13 at the central station. The values of the sources of potential 13 and 14 are assumed, for the purposes of this description, to be 120 volts and the sources are connected to ground as shown. Obviously other voltages may be employed where different types of tubes and other values of resistances than those illustrated herein to describe the invention are used. Also, it will be understood that the current values and voltages referred to herein are predicated on the assumed supply voltages and the particular apparatus shown, and it is not contemplated that such disclosure limit the invention thereto. The value of the line current under these conditions is approximately 65 milliamperes and, flowing through the resistance 11 which may be 600 ohms, produces a negative potential at the point 24 of approximately 80 volts. This potential is applied directly to the left hand cathode of the tube 16, the associated control grid of which is connected

to a potentiometer 26. The potentiometer is connected between the positive and negative potentials of the batteries 13 and 14 and is adjusted so that the potential of the grid is held at approximately 100 volts negative. Thus, it is seen that the left hand grid of the tube 16 is at a negative potential with respect to its associated cathode, and therefore this section of the tube is non-conductive. The cathode of the right hand section of the tube 16 is connected directly to ground and its associated grid is connected to a potentiometer 27 which may be of the order of $1\frac{1}{4}$ megohms and which is connected between the negative potential of battery 13 and the cathode of the left hand portion of tube 16. Under the idle circuit condition, with the point 24 having a potential of approximately 80 volts negative, the potentiometer 27 is adjusted to make the potential applied to the grid of the right hand section of the tube 16 approximately 100 volts negative. Thus, it is seen that since this grid is at a negative potential with respect to its grounded cathode the right hand section of the tube 16 is also non-conductive. The respective anodes of the two sections of the tube 16 are connected together and also to a point 28 of a voltage divider comprising a resistance 29 which may be of the order of $1\frac{1}{2}$ megohms, a resistance 31 which may be of the order of $\frac{8}{10}$ megohms and a resistance 32 which may be of the order of $\frac{3}{10}$ megohms connected in series relation between the negative and positive potentials of batteries 13 and 14, respectively. Thus, the potential which is applied to the anodes of the tube 16 is approximately 90 volts positive. With no current being conducted through either section of the tube 16 the potential at the point 33 is approximately 20 volts positive and this potential is applied to the control grid of the vacuum tube 17. The cathode of this tube is connected directly to ground thereby making this tube conducting, since the control grid is at a positive potential with respect to its cathode. Positive plate potential is connected to the anode of tube 17 through the winding 18 of the receiving device and a resistance 34, thereby maintaining a marking condition of the receiving device in response to the marking line condition. The tube 17 is also provided with an auxiliary grid which is connected through a resistance 36 to positive potential to improve the operating characteristics of the tube in a well-known manner.

When the remote station desires to transmit to the central station the transmitting element 2 sends coded combinations of selecting and non-selecting signals which comprise respectively makes and breaks of the line circuit L. The selecting signal is represented by a closed line condition and causes the central office apparatus to respond in the manner described to energize the receiving device 16. When a spacing signal is sent from the transmitter 2 the line circuit is opened and the potential of the point 24 is the full potential of the battery 13 or, in other words, 120 volts negative in the case assumed. Such a change of potential is effected by the absence of current being conducted through the resistance 11, thereby producing no voltage drop across this resistance. The potential of the left hand grid of the tube 16 remains at 100 volts negative and is now positive with respect to the left hand cathode. Hence, this portion of the tube becomes conductive. It will be noted at this point that, since both terminals of the poten-

tiometer 27 are connected to negative 120 volts, the potential which is applied to the right hand grid of the tube 16 is also 120 volts negative and, since the associated cathode is connected to ground, this portion of the tube remains non-conducting.

With the left hand portion of the tube 16 conducting the current passing therethrough is supplied from the positive bus bar through the resistance 32. Therefore, a voltage drop across this resistance is produced whereby the potential of the point 33 is changed from its normal positive potential to a negative potential. Thus, the control grid of the tube 17 becomes negative with respect to its grounded cathode, thereby rendering this tube non-conductive. Therefore, no plate current is being supplied to this tube through the winding 18 of the receiving device and this instrument is conditioned for non-selection in response to the non-selecting signal sent from the transmitter 2. From the foregoing description it is apparent that the repeating apparatus functions in a manner to reproduce, at the receiving instrument, the signals transmitted from the sending device with the line circuit connected to negative potential.

In the telegraph system disclosed there are provided facilities for operating a signal at the remote station in response to an operation performed at the central station. Such a signal may be used for any desired purpose such as to indicate to the attendant at the remote station that the central station desires him to stop his transmission into the central station or for any other purpose which may be desired. Since there is not a positive way of preventing the remote station from transmitting except by disabling its transmitting equipment, it is obvious that the operation of a signal requesting or instructing the remote station to stop transmission may not have the desired effect. The signal lamp may be burned out, the signal control circuits may be defective or the attendant may not see or may choose to ignore the signal. In any event, to prevent the loss of any of the transmission originating at the remote station, it is necessary to provide facilities at the central station to record any transmission from the remote station which is made after the operation of the signal requesting him to stop.

At the remote station the polarized relay 4 is connected with the line circuit L in such a manner that the circuit which is controlled thereby is opened as long as the line circuit is connected to negative potential. Consequently, when it is desired to signal the remote station, the switch 12 is moved to its right hand contact thereby connecting the positive potential of battery 14 to the line circuit L. This causes the relay 4 to respond whereby the circuit controlled by its contacts is closed to operate a signal which, in this case, is the lighting of a lamp 6. Under these conditions, when a marking signal is being sent from the transmitter 2, the potential at the point 24, caused by the voltage drop in the resistance 11, is approximately 80 volts positive. Considering first the left hand portion of the tube 16, the control grid is influenced by the same potential as in the previous case which was 100 volts negative. Hence, this section of the tube is non-conducting since the control grid is at a negative potential with respect to its cathode. The potentiometer 27 is at this time connected between the negative bus bar and the point 24 which has a positive potential of 80 volts. The

slider of this potentiometer is adjusted so that under these conditions the potential which is applied to the control grid of the right hand portion of the tube 16 is 10 volts negative. Consequently, since the cathode of the right hand portion of this tube is at ground potential the right hand portion of the tube 16 is also non-conducting. As seen from the previous description, with both sections of the tube 16 non-conducting, the tube 17 is in a conducting condition thereby applying a marking condition to the winding 18 of the receiving device.

When a non-selecting signal is sent from the transmitter 2 the current through the resistance 11 is reduced to zero, thereby changing the potential at the point 24 to 120 volts positive. This potential is applied to the cathode of the left hand portion of the tube 16, the grid of which is maintained at a negative potential, thereby preventing this section of the tube from becoming conducting. However, since one terminal of the potentiometer 27 is now at 120 volts positive potential, the slider of the potentiometer is at a positive potential of 10 volts. This potential is applied to the control grid of the right hand portion of the tube 16, thereby rendering this section conducting, since its cathode is at ground potential. The conduction of plate current through the resistance 32 again produces a negative potential at the point 33, thereby rendering the tube 17 non-conducting and the receiving device controlled thereby non-selecting.

The operation of the signal by which the remote station can call in the central station attendant will be described first with the line circuit L connected to negative potential by the switch 12 being positioned on its left hand contact. Normal operation of the transmitter 2 is ineffective to operate this call-in signal. Consider the case where a selecting signal is being sent from the remote station transmitter. The line circuit is closed so that the normal line current of approximately 65 milliamperes is conducted through resistances 9 and 11. The voltage at the point 37 is 65 volts negative. Connected between this point and the negative bus bar is a potentiometer 38 which may be of the order of $1\frac{3}{4}$ megohms. The adjustable slider of this potentiometer is connected to the control grid of the left hand section of the tube 19 and is at a negative potential of approximately 90 volts. The cathode of this section of the tube 19 is connected to a point 39 of a voltage divider comprising a resistance 41 which may be of the order of 4000 ohms, a resistance 42 which may be of the order of 400 ohms and a resistance 43 which may be of the order of 800 ohms connected in series between the negative bus bar and ground. Thus, the potential of the point 39 and consequently the cathode of the left hand section of tube 19 is at a negative potential of approximately 20 volts. The grid of the left hand section of the tube 19 being at a negative potential with respect to its associated cathode, this section of the tube is non-conducting. The cathode of the right hand section of the tube 19 is connected directly to ground. Connected in series relation with the potentiometer 38 is a potentiometer 44 which may be of the order of $1\frac{3}{4}$ megohms, a signal lamp 22 which is shunted by a resistance 46 and a resistance 47 which may be of the order of 1000 ohms. This series arrangement of resistances is connected between the negative and positive potentials of the batteries 13 and 14 respectively. When the potential of

the point 37 is 65 volts negative, in response to a selecting signal when the line circuit is connected to negative potential, the adjustable slider of the potentiometer 44 is adjusted so that it is at a positive potential of approximately 2 volts. This potential is applied to the anode of the left hand section of the tube 19, but since the grid is negative with respect to its associated cathode no current flows in this section of the tube. The positive potential of the slider of the potentiometer 44 is also applied to the control grid of the right hand section of the tube 19 and since its associated cathode is connected to ground, this section of the tube is rendered conducting. The anode of the right hand section of the tube 19 is connected through a resistance 43 which may be of the order of 2 megohms to the positive bus bar. Plate current being supplied to the right hand section of tube 19 produces a voltage drop through the resistance 43, whereby the potential at the point 49 is approximately 2 volts positive. Connected to the point 49 is one terminal of a glow discharge tube, such as a neon tube 51, the other terminal of which is connected through a resistance 52 which may be of the order of 4 megohms and through resistance 41 to the negative bus bar. Consequently, the potential at the point 53 is approximately 28 volts negative. This potential is applied to the control grid of the vacuum tube 21, the cathode of which is connected through the winding of a relay 54 to ground. Thus, a selecting condition applied to the line L by the transmitter 2 when the line is connected to negative potential is effective to render the vacuum tube 21 inoperative, thereby preventing operation of the signals controlled thereby.

It should be pointed out that the plate current being conducted through the right hand section of the tube 19 prevents the charging of a condenser 56 which is connected between the anode of this section of the tube and ground. Also, the characteristics of the neon tube 51 are such that the 30-volt potential difference comprising the negative 28 volts of the point 53 and the positive 2 volts of the point 49 is not sufficient to produce a discharge of the tube. The potential necessary to cause such a discharge is approximately 75 volts. Consequently the potential of the point 53 is not influenced by that of the point 49.

When the line L is opened in response to a non-selecting signal sent from the transmitter 2, no current flows through the resistances 9 and 11. Consequently the potential of the point 37 is 120 volts negative. Accordingly, the potential of the sliding element of the potentiometer 38 is also 120 volts negative and this potential is applied to the grid of the left hand section of the tube 19. Consequently this section of the tube remains non-conducting since its control grid is still at a negative potential with respect to its associated cathode. The change of the potential at the point 37 from 65 volts negative to 120 volts negative produces a negative potential of approximately 35 volts at the sliding element of the potentiometer 44. Since this potential is employed to control the right hand portion of the tube 19, this section of the tube is also rendered non-conducting because the grid is at a negative potential with respect to its associated cathode. Under these conditions plate current ceases to flow in the right hand section of the tube 19 and the condenser 56 starts to accumulate a charge. The capacity of this condenser and

the value of the resistance 43 are so chosen that the condenser receives only a relatively small percentage of a full charge in the time required to transmit a non-selecting signal from the transmitter 2. Therefore, the potential of the point 49, although during the charging period it becomes more and more positive, does not attain a value such that the potential difference between the points 49 and 53 is sufficient to cause the breakdown of the neon tube 51. Consequently, the negative potential of point 53 remains connected to the control grid of the tube 21, thereby preventing its operation. Thus, it is seen that the signals which are controlled by the tube 21 are not actuated when a normal non-selecting signal is sent from the remote station transmitter. The repeater is arranged so that the time required to charge the condenser 56 until the potential at the point 49 reaches the breakdown value for the tube 51 is in excess of the time required to transmit one character from the remote station transmitter. Since this character comprises a plurality of selecting and non-selecting signals, it is conceivable that a number of non-selecting, or open line conditions, may follow one another so that the charging period for the condenser 56 is not interrupted under some conditions until a whole series of non-selecting signals up to as many as the complete number of signals required for each character has been sent.

Upon the closure of the line circuit L which is effected by the transmission of a selecting signal, the potential at the point 37 is restored to its former value of 65 volts negative. Similarly the potential which is applied to the grid of the right hand section of the tube 19 from the potentiometer 44 is restored to its former positive value thereby again rendering this section of the tube conducting. With the conductivity of the right hand section of the tube 19 reestablished, a discharge path for the condenser 56 is provided so that the condenser may be discharged and thereby reset the timed circuits controlled thereby. It may be desirable to connect a small condenser 57 having a capacity of the order of .005 microfarad between the grid of the right hand section of the tube 19 and the point 37. The purpose of such a condenser is so that when the first selecting signal is received following one or more non-selecting signals, the charging current taken by such a condenser momentarily raises the positive potential which is applied to the grid of the right hand section of the tube to a higher than normal value. This increases the conductivity of this section of the tube so that the discharge of the condenser 56 is more rapid, thereby quickly restoring the normal potential of the point 49. The value of the condenser 57 is chosen so that a complete discharge of the condenser 56 will be effected during a single selecting signal.

If now the attendant at the remote station desires to call in the attendant at the central station, the key 8 is opened for a period of time longer than that required to transmit a character code combination. The opening of this key introduces the resistance 7 into the line circuit thereby reducing the value of the current employed to transmit a selecting signal from approximately 65 milliamperes to about 45 milliamperes. It is assumed that when this key is opened the line circuit is idle in which condition current is flowing therein although it will be obvious that the central station apparatus will

respond to the opening of the key to operate the calling signal even though the transmitter 2 is operating at the time the key is opened. Also, it will be demonstrated that the characters which may be sent while the key is open will be recorded by the receiving apparatus. With the modified selecting line current flowing through the resistances 9 and 11 the potential at the control point 37 of the call-in signal apparatus is approximately 80 volts negative. The resultant potential at the slider of the potentiometer 38 is 100 volts negative and this potential is applied to the grid of the left hand section of the vacuum tube 19, the cathode of which is maintained at approximately 20 volts negative. Consequently, the grid being at a negative potential with respect to its associated cathode, this section of the tube is ineffective to conduct current there-through. The changed potential of the control point 37 causes the potential at the slider of the potentiometer 44 to become about 10 volts negative. It has been shown that a negative potential at this point causes the right hand section of the tube 19 to become non-conductive with the attendant initiation of the charging of condenser 56. The key 8 is maintained in its open position long enough for this condenser to charge to a sufficient potential to cause the positive potential of the point 49 to increase until the potential difference which exists across the terminals of the neon tube 51 exceeds the critical breakdown voltage of this tube. As soon as the tube 51 becomes conducting the potential of the point 53 becomes approximately 35 volts positive. This potential applied to the control grid of the vacuum tube 21 causes this tube to become conducting, the anode-to-cathode current being employed to light the lamp 22 and to cause the operation of relay 54. The lamp provides a visible signal while the closure of the contacts of relay 54 energizes a bell or buzzer 23 thereby providing an audible signal. As soon as the tube 21 begins to pass current, the potential which is applied to the anode of this tube drops to a positive value of approximately 50 volts instead of the full 120 volts which is present at this point of the circuit during a non-conducting condition of the tube. As a result of this change of potential, the potential derived from the potentiometer 44 and which is applied to the control grid of the right hand section of the tube 19 becomes even more negative than initially. This feature provides a means for locking in the signal once it has been operated. Obviously, during such a condition the transmission of non-selecting signals from the transmitter 2 or the repeated operation of the key 8 will reduce the value of this potential to even lower negative values which produces no further results.

When the attendant at the central station responds to the signal thus operated he may acknowledge the reception thereof by moving the switch 12 to its right hand contact whereby positive potential is connected to the line circuit. As previously described this operation results in the operation of the signal 6 at the remote station. At the same time, operation of the switch 12 changes the potential at the point 37 from a negative value to some positive value. Now, since both terminals of the potentiometer 44 are at a positive potential, a positive potential will also be applied to the grid of the right hand section of the tube 19, thereby effecting the discharge of the condenser 56 as described with the attendant decrease of the positive potential at the point 49.

Consequently, the potential difference across the terminals of the neon tube 51 is reduced sufficiently to cause this tube to become non-conducting and thereby render the vacuum tube 21 non-conducting. Thus, the relay 54 is restored to normal thereby silencing the bell 23 and the lamp 22 is also extinguished.

It is desirable that the operation of the key 8 be ineffective to interrupt the reception of any signals which may be transmitted from the transmitter 2. If a selecting signal is being transmitted while the key 8 is open the potential which exists at the control point 24 for the code signal repeater is approximately 90 volts negative and this potential is applied to the cathode of the left hand section of the tube 16. Since the control grid of this section of the tube is maintained at approximately 100 volts negative this section of the tube remains non-conducting so that the selecting magnet 13 of the receiving device is energized to record a selecting condition as described. Similarly, since both terminals of the potentiometer 27 are connected to negative potential, the grid of the right hand section of the tube 16 is also negative with respect to its grounded cathode and this section of the tube also remains non-conducting. Obviously a non-selecting signal which is sent from the transmitter 2 will cause the response of the repeating apparatus in the normal manner irrespective of the open or closed condition of the key 8.

When the system is operating with the switch 12 on its right hand contact connecting positive potential to the line circuit, the apparatus employed to actuate the call-in signals operates as effectively as when the line circuit is terminated to negative potential. During the transmission of a selecting signal or during an idle period of the transmitter 2, the potential at the control point 37 is 65 volts positive. Under these conditions the original adjustment of the potentiometer 38 is such that the potential which is applied by the sliding element to the grid of the left hand portion of the tube 19 is 25 volts negative. Since the cathode of this portion of the tube is maintained at a negative potential of about 20 volts, this section of the tube is maintained in a non-conducting condition since its grid is still negative with respect to its associated cathode. Also, the potential which is applied by the sliding element of the potentiometer 44 to the grid of the right hand portion of the tube 19 is approximately 35 volts positive thereby rendering this portion of the tube conducting to prevent the charging of the condenser 56 as described. When the line L is opened in response to a non-selecting signal sent from the remote station transmitter, the potential of the control point 37 changes to the full positive potential of 120 volts thereby changing the potential which is applied to the grid of the left hand portion of the tube 19 by the sliding element of the potentiometer 38 to approximately 5 volts positive. Under these conditions this section of the tube is rendered conducting. The flow of current in the plate circuit of this section of the tube reduces the potential which is applied to the grid of the right hand section of the tube to a negative value thereby rendering this section of the tube non-conducting. Consequently the condenser 56 is permitted to charge in the manner described. However, as pointed out previously, the charging rate of this condenser is such that it will not become sufficiently charged to raise the potential of the point 49 to the critical value for the neon

tube 51 before the reception of the next selecting signal. When this signal is received the potential of the point 37 is changed to 65 volts positive and similarly the potential which is applied to the grid of the right hand section of the tube 19 is changed to the 85 volt positive value. Thus, the left hand portion of the tube 19 becomes non-conducting and the right hand portion becomes conducting to discharge the condenser 56 and restore the apparatus to its normal condition.

When it is desired to operate the call-in signals at the central station, the key 8 at the remote station is opened as before for a period of time in excess of that required for the transmission of a character code combination. The opening of this key at a time when a selecting line condition exists modifies the line current from its 65 milliamperes normal value to a value of approximately 45 milliamperes. The potential at the point 37 becomes approximately 80 volts positive, thereby changing the potential which is applied to the grid of the left hand section of the tube 19 by the potentiometer 23 to approximately 15 volts negative. It will be apparent that since the cathode of this section of the tube is maintained at approximately 20 volts negative, the associated grid is therefore positive with respect to the cathode, thereby rendering this section of the tube conducting. The right hand section of the tube 19 is rendered nonconducting in the manner described and the condenser 56 takes on a charge. When this condenser has become sufficiently charged, the neon tube 51 becomes conducting to render the tube 21 conducting thereby operating the signals 22 and 23 as before. However, in this instance, once the key 8 is restored to its closed condition, the potential applied to the grid of the left hand portion of the tube 19 is changed to its normal negative value of 25 volts thereby rendering this section of the tube non-conducting. Since both terminals of the potentiometer 44 are connected to positive potential, the interruption of the plate current flowing in the left hand portion of the tube 19 restores the positive potential to the grid of the right hand portion of the tube thereby discharging the condenser 56 and restoring the signals 22 and 23 to normal. Thus, it is seen that with the line circuit connected to positive potential, the operation of the key 8 results in the operation of the call-in signals but these signals are not locked in as in the previous case. However, the signals are maintained operative as long as the key 8 is open and will be repeatedly operated in response to successive operations of the key 8 providing that such operations are of the required time duration.

It will also be shown that the functioning of the apparatus associated with the receiving device 18 is not interrupted by the operation of the key 8 while the line circuit is connected to positive potential. When the line current is reduced to 45 milliamperes in response to the operation of the key 8, the potential at the point 24 is changed to approximately 90 volts positive. Since this potential is applied to the cathode of the left hand portion of the tube 16, the control grid of which is maintained at a negative potential of approximately 100 volts, this section of the tube remains non-conducting. Also, the adjustment of the potentiometer 27 is such that the connection of one of the terminals thereof to the positive 90 volt potential of the control point 24 results in a negative potential being applied by the sliding element thereof to the

grid of the right hand section of the tube 16. Since the cathode of this section of the tube is at ground potential, this section also remains non-conducting and consequently the tube 17 is continued in a conducting condition to record the selected signal on the receiving device 18.

The nature of the call-in signal apparatus is such that a break in the line circuit or a fault of such a character as to reduce the value of the line current below the critical point is detected. The functioning of the apparatus for this purpose is believed obvious in view of the foregoing description since it is immaterial so far as the vacuum tube relay circuits are concerned whether the line circuit is opened by the transmitter or by a failure of the line conductors. It should be noted that if a line failure occurs while the system is operating on negative potential, the call-in signals 22 and 23 will be operated and locked in as described. However, at this time it is impossible for the attendant at the central station to determine the reason for the operation of these signals. However, when the switch 12 is moved to its right hand contact to connect positive potential to the line circuit, if the signals had been operated in response to a signal initiated by the key 8, the connection of positive potential to the line circuit would restore these signals. With the line circuit open, the connection of positive potential thereto is ineffective to restore these signals to normal since the maintenance of the open line circuit is in effect the same condition as the maintenance of the key 8 in its open condition. It has been seen that the latter condition is effective to maintain the signals 22 and 23 operated. Therefore, the movement of the switch 12 to its right hand contact continues these signals operated while an open line circuit exists. It may be desirable to provide facilities for silencing the audible signal 23. In this case the cathode of the tube 21 is connected through a switch 52 which on its left hand contact connects the cathode through the winding 54 of the signal relay to ground. In order to silence the signal 23 the switch 53 may be moved to its right hand contact, thereby opening the circuit through the signal relay permitting the restoration of the audible signal 23 to normal and at the same time maintaining the anode-cathode circuit of the tube 21 closed directly to ground. Such a facility maintains the visible signal 22 in operation as long as the faulty line condition exists. As soon as the fault is cleared and the line circuit restored to normal, the connection of positive potential thereto results in the discharge of the condenser 56 and the restoration of the signal 22 to normal thereby indicating to the attendant at the central station that the defective line has been repaired and normal operation may be resumed.

While the invention has been described in conjunction with an illustrative embodiment thereof, it will be understood that the types of tubes disclosed and the values of resistances and the resultant potentials caused by various operations are not to be considered as limiting the scope of the invention in any manner. The scope of the invention is set forth in the appended claims.

What is claimed is:

1. In a telegraph signaling system, a line circuit, connecting a central station to a remote station at said remote station, a make-and-break signal transmitter, a marginal signal transmitter and a polarized device connected to said line circuit, at said central station, a make-and-break

signal receiver, an indicator to be operated by marginal signals and a polar signal transmitter to operate said polarized device, two electronic relays connected to said line circuit at said central station, one to repeat the make-and-break signals to said receiver and the other to repeat the marginal signals to said indicator, and means including said relays to operate said receiver and said indicator simultaneously and independently irrespective of the operation of said polar signal transmitter.

2. In a signaling system, a subscriber's station comprising a transmitter of make-and-break signals and a polarized receiving device, a central station, a line circuit interconnecting said stations, and, at said central station, a source of direct current potential, polar transmission means utilizing said source and said line circuit to operate said polarized device, a receiver of make-and-break signals, an impedance connected so as to be subjected to voltage variations of said line circuit produced by said transmitter and said transmission means, space discharge means having two output circuits arranged to control the operation of said receiver-of make-and-break signals and two input circuits, and means including said impedance for biasing said input circuits to render both of said output circuits inoperative in response to make signals of both polarities and, in response to signals of either polarity, to render one or the other of said output circuits operative depending upon the polarity, whereby to repeat said signals to said receiver irrespective of the operating condition of said polar transmission means.

3. In a signaling system, a subscriber's station comprising a code transmitter and a polarized receiving device, a central station, a line circuit interconnecting said stations, and, at said central station, a source of direct current potential, polar transmission means utilizing said source and said line circuit to operate said polarized device, a code receiver, an impedance connected between said source and said line circuit, said impedance and a portion of said source forming a terminating network, space discharge means having two output circuits arranged to control the operation of said code receiver and two input circuits, each including two electrodes, one electrode of each of said input circuits being connected to the respective ends of said network, means for connecting the other electrode of each of said input circuits to respective intermediate points of said network so as to include one portion of said network in both of said input circuits, and means controlled by said anode transmitter and said polar transmission means for varying both the magnitude and the polarity of the potential impressed upon said terminating network, whereby depending upon the polarity of the potential one or the other of said output circuits is rendered operative to relay said code signals to said code receiver.

4. In a system for duplex signaling over a line circuit connecting two stations, means at one of said stations for transmitting coded signals, a receiver at the other of said stations responsive to said coded signals, means for simultaneously

effecting polar signaling over said line circuit, and an electronic repeater associated with said receiver for relaying thereto said coded signals independently of the transmission over said circuit of said polar signals, said repeater comprising a source of direct current potential, an impedance connected between said source and said line circuit and means including two space discharge paths, each having an anode, a cathode and a grid, said anodes being associated with said receiver, the cathode and grid of one path being connected respectively to one terminal of said source and to an intermediate point of said impedance, and the cathode and grid of the other path being connected respectively to one terminal of said impedance and to an intermediate point of said source in such a manner that only one of said paths is rendered conducting at a time.

5. In a telegraph signaling system, a transmitter of coded make-and-break signals, a receiver of said signals, two space discharge paths having a common output circuit associated with said receiver and each having an input circuit including a pair of electrodes, a source of direct current potential, a line circuit interposed between said transmitter and said receiver, an impedance connected between one terminal of said source and one terminal of said line, means for connecting one electrode of each of said pairs of electrodes to said source, means for connecting the other electrode of said pairs of electrodes to said impedance, a switch, means including said switch to vary the polarity of said line circuit terminal, and means including said transmitter to vary the value of the line circuit terminal potential and thereby control said input circuits in a manner to render conducting one of said paths when said line circuit is open and the terminal thereof is of one polarity and the other of said paths when said line circuit is open and the terminal thereof is of the opposite polarity, and for rendering non-conducting both of said paths when said line circuit is closed, irrespective of the polarity of the terminal thereof.

6. In a telegraph signaling system, a code transmitter, a code receiver, two space discharge paths having a common output circuit associated with said receiver, and each having an input circuit including a cathode and a control electrode, a source of direct current potential, a line circuit, an impedance connected between the negative terminal of said source and one terminal of said line circuit, means for connecting the cathode of one discharge path and the control electrode of the other path to said source, means for connecting the control electrode of said one discharge path to an intermediate point of said impedance and the cathode of the other path to the line terminal of said impedance, a switch, means including said switch to control the polarity of said line circuit terminal, and means including said transmitter to vary the value of the line circuit terminal potential and thereby control the input circuits of both of said paths.

OSCAR E. PIERSON.
LAWRENCE W. FRANKLIN.
ROBERT STEENECK.