

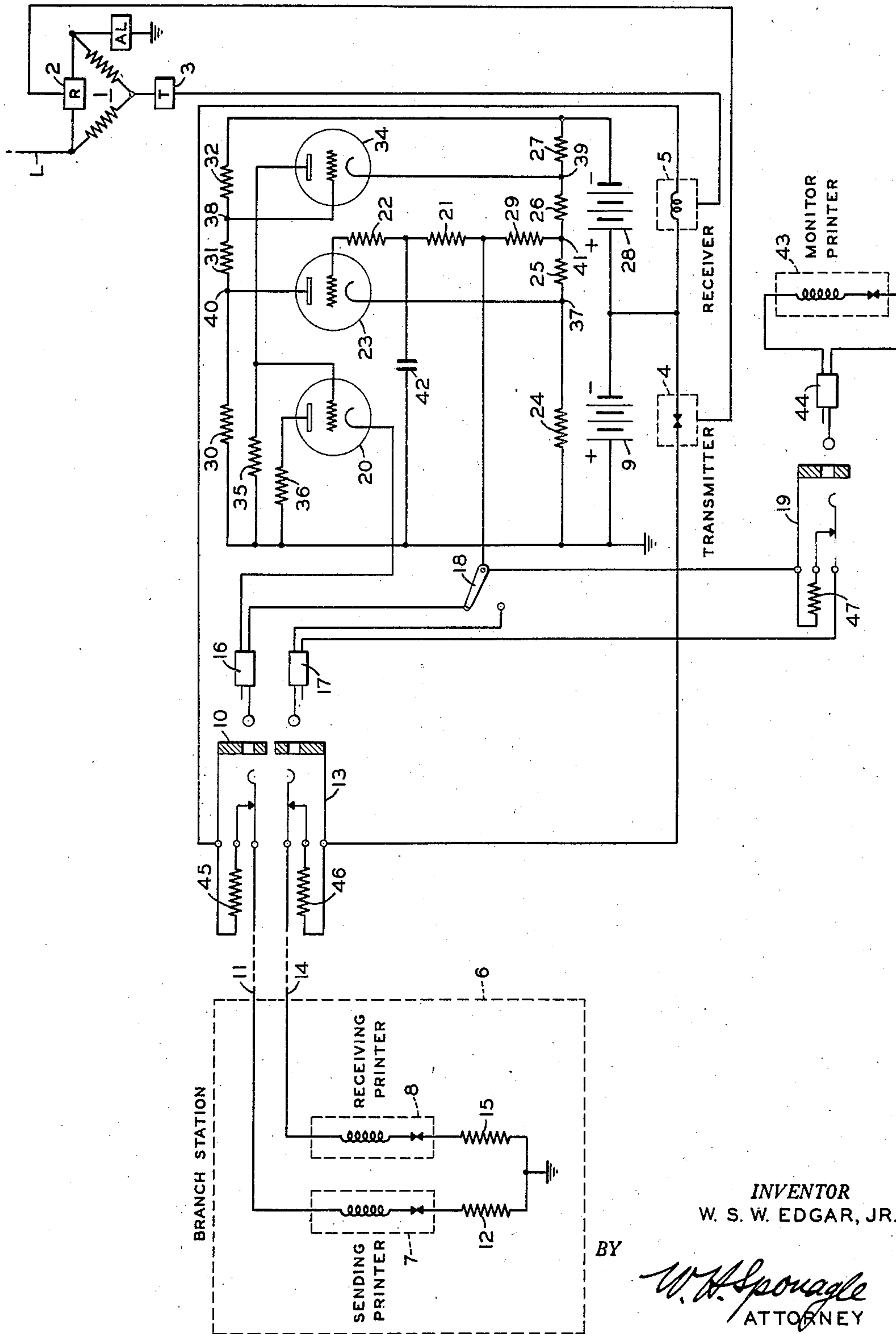
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TELEGRAPH REPEATER

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TELEGRAPH REPEATER

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This invention relates to telegraph systems and has particular reference to telegraph signal repeaters of the half duplex type arranged to permit full duplex signaling over a main line circuit.

It is customary where a line circuit is operated on a full duplex basis to provide at the terminals of the circuit individual receiving and sending legs. Either or both of these legs may be extended by individual extension lines to a branch station. Independent signaling may be effected simultaneously over the main line circuit and the receiving and sending legs in accordance with well known principles. It sometimes becomes necessary to combine the legs in some manner because of a failure of one of the extension lines or of the apparatus associated therewith in order to provide temporary receiving and transmitting facilities to a branch station connected to the sending and receiving legs. A combined sending and receiving leg is often made necessary as a permanent arrangement in cases where there is available only one extension line to a branch station. One arrangement of this character forms the subject matter of an application of V. R. Tolen, Serial No. 458,611, and entitled "Telegraph repeater," filed concurrently herewith. In the system disclosed in said copending application both sending and receiving signals may be transmitted over the combined leg, but such operations cannot of necessity be simultaneous. The effect upon the main line circuit is that the signaling is on what is known as a half duplex basis.

When the terminal apparatus of a telegraph system is arranged to combine the sending and receiving legs, it sometimes is necessary to communicate with the remote terminal of the duplex main line circuit at a time when this terminal is transmitting. If the apparatus at the remote terminal is arranged in the conventional manner for full duplex operation whereby individual sending and receiving legs are provided, the operation of a local transmitter at the station having the combined sending and transmitting leg would result in the transmission over the main line circuit and the reception by the remote station's receiving leg of unintelligible signals.

Hence, it is one of the objects of the instant invention to provide an improved apparatus whereby the sending and receiving legs of a system normally operated on a full duplex basis may be combined to enable the system to be operated on a half duplex basis and whereby the main line signaling at all times may be effected on a full duplex basis.

Another object of the invention is to provide,

in a system having a combined sending and receiving leg, means whereby signals originating in the combined leg may be sent to a main line circuit as intelligible signals irrespective of the simultaneous application to the combined leg of signals received from the main line circuit.

A further object of the invention is to provide an electronic repeater associated with a local circuit having two transmitters of like character and arranged in a novel manner to repeat signals from one transmitter but not the other.

Still another object of the invention is to provide an electronic repeater of the character described which is operable with both transmitters in concurrent operation.

An additional object of the invention is to provide a novel circuit arrangement to increase the gain in a direct coupled amplifier.

These and other objects of the invention are attained in the embodiment of the invention chosen for illustration and will become apparent from the following description which is taken in conjunction with the single figure of the accompanying drawing.

In the following description the values of resistances and voltages referred to are to be taken merely as illustrative and are not to be construed in any way as limitations, since obviously other values may be selected by anyone skilled in the art to modify the arrangement to meet any specific conditions.

The main line circuit L, which at all times is operated on a full duplex basis, is terminated in the conventional duplex impedance bridge 1. Signals received over the main line circuit operate a receiver 2. Signals are transmitted to the main line by a transmitter 3. The receiver 2 is connected to control a local transmitting device 4 by means of which the received line signals are repeated into a local receiving leg. Also, signals which are transmitted from a local sending leg operate a receiving device 5 by means of which the transmitter 3 is controlled to repeat the signals to the main line L.

The local sending and receiving legs may be extended by means of suitable extension lines to a branch station 6 at which are provided a combination transmitter-receiver 7, normally used for sending, and a combination transmitter-receiver 8, normally used for receiving. The sending leg includes a series connection of a grounded negative battery 9, the receiving device 5, a jack 10, extension line 11, the combination transmitter-receiver 7 and resistance 12, and terminates in ground at the branch station 6. The

receiving leg includes the grounded negative battery 9, the transmitting device 4, a jack 13, extension line 14, the combination transmitter-receiver 8 and resistance 15, and also terminates in ground at the branch station 6.

Such an arrangement is customarily utilized for full duplex operation of a main line telegraph circuit, and independent signaling may be effected simultaneously over both the receiving and sending legs extending to the branch station 6. In the event that a circuit failure of one of the extension lines occurs, either because of a fault in the line wire itself or because of the failure of the printing equipment located at the branch station, the branch station is deprived of either sending or receiving facilities, depending upon which leg fails.

The repeater embodying the instant invention enables such a branch station to be furnished temporarily with both sending and receiving facilities and, in addition, with facilities for sending at the time that received main line signals are being relayed to the branch station. Of course, since the transmitting and receiving elements of the branch station combination transmitter-receiver are connected in series, the received main line signals will not be properly recorded at the branch station. However, such a situation is not particularly serious, since under the circumstances, with the branch station operating with temporarily reduced facilities, about the only reason for desiring to send would be to direct the station connected to the remote terminal of the main line circuit to repeat something which had previously been sent but which may not have been properly received. In such a case the branch station will obtain not only a repeat of the communication erroneously received but also that portion of the communication which he himself mutilates by the operation of his transmitting apparatus.

The repeating arrangement in accordance with the invention permits the transmission of the signals sent from a branch station during the time that signals are also being received thereat so that the station connected to the remote terminal of the main line circuit is furnished with an intelligible communication.

Assume that the normal receiving leg including the extension line 14 and the combination transmitter-receiver 8 is temporarily incapacitated. Repeating apparatus which terminates in a pair of double conductor plugs 16 and 17 is connected to the sending and receiving legs by the insertion of the respective plugs in jacks 10 and 13. A switch blade 18 is placed in engagement with its upper contact, as shown, and the apparatus is conditioned to function by using the extension line 11 and the combination transmitter-receiver 7 in a combined sending and receiving leg. In this case a series circuit is formed and includes grounded negative battery 9, the transmitting device 4, the respective sleeve elements of jack 13 and plug 17, a monitor jack 19, switch blade 18 and its upper contact, the respective tip elements of plug 16 and jack 10, extension line 11, combination transmitter-receiver 7 and resistance 12 and terminates in ground. Another series circuit is formed and includes the grounded negative battery 9, the receiving device 5, the respective sleeve elements of jack 10 and plug 16 and the space discharge path of a vacuum tube 20 and terminates in ground.

Connected to the switch blade 18, which is at

a point in the first described series circuit between the transmitting element of the combination transmitter-receiving 7 and the transmitting device 4, is a circuit including resistances 21 and 22 extending to the control grid of another vacuum tube 23. The cathode of this vacuum tube is connected to a bottom voltage divider comprising the series connection of resistances 24, 25, 26 and 27. The terminals of this voltage divider are connected across the terminals of batteries 9 and 28. These batteries are arranged to aid one another, and the positive terminal of the combination is connected to ground. It has been found in practice that, when the total voltage of the batteries 9 and 28 is approximately 250 volts, satisfactory results may be obtained when the approximate values of the bottom voltage divider resistances 24, 25, 26 and 27 are 7,500, 2,500, 5,000 and 10,000 ohms respectively. Another connection is made to the control grid circuit of tube 23 through a current limiting resistance 29 to a point on the bottom voltage divider for a purpose to be described. The value of the resistance 29 should be high enough to prevent the short-circuiting of the transmitting device 4.

The amplifier repeater is also provided with a top voltage divider comprising the series connection of resistances 30, 31 and 32. The terminals of this voltage divider are also connected across the terminals of batteries 9 and 28. For the voltage previously specified, the approximate values of the top voltage divider resistances 30, 31 and 32 should be 0.15, 0.6 and 0.6 megohms, respectively. The anode of tube 23 is connected to the top voltage divider in a manner to influence the control grid of another vacuum tube 34, said grid also being connected to this voltage divider. The cathode of the tube 34 is connected to a point on the bottom voltage divider, and the anode is connected through a relatively high resistance 35 to the grounded positive terminal of battery 9. The control grid of tube 20 is also connected to the anode of tube 34 and, consequently, is influenced by the operation of the latter tube. Space current for the tube 20 is derived from the grounded positive terminal of battery 9 through a resistance 36 and also flows through the receiving device 5 to which the cathode of the tube is connected.

Where a receiving device corresponding to the receiver 5 is of a character requiring only a relatively small amount of energy for its operation, the electronic repeater may comprise only the equivalent of tube 23. However, when it is necessary to amplify the signals originating at the branch station transmitter, the tubes 20 and 34 will be necessary. Two additional tubes are needed, since it is inherent in any low frequency direct coupled amplifier that the signals appearing in the output circuits of successive tubes are out of phase by 180°. In the present instance, the signals appearing in the output circuit of the tube 23 are in phase with the signals originating at the branch station transmitter. Consequently, the signals in the output circuit of the tube 34 are 180° out of phase with the signals sent from the branch station transmitter, and the signals in the output circuit of the tube 20 are again in phase with these signals.

For a consideration of the operation of the device embodying the invention, when the sending and receiving legs are combined to utilize the extension line 11 as assumed, let it further be assumed that the transmitting element of the combination transmitter-receiver 7 and the trans-

mitting device 4 are in their marking or circuit-closing positions. Where the voltage of the grounded negative battery 9 is approximately half of the combined voltages of the batteries 9 and 28 or, in other words, 125 volts, the impedances in the series circuit including the two transmitting devices are chosen so that the potential at the switch blade 18 is approximately negative 60 volts. This potential is applied through resistances 21 and 22 to the control grid of the tube 23 and, since the cathode of this tube is connected to a point 37 on the bottom voltage divider, at which the potential is approximately negative 85 volts, the tube is conditioned for the conduction of space current. This current flows from the grounded positive terminal of the battery 9, through resistance 30 of the top voltage divider, the tube 23, and resistances 25, 26, 27 of the bottom voltage divider to the negative terminal of the battery 28. The voltage drop through the resistance 30 results in the application to the control grid of the tube 34 of a potential of approximately negative 175 volts derived from a point 38 on the top voltage divider. Similarly, the voltage drop through resistances 25, 26 and 27 causes the application to the cathode of the tube 34 of a voltage of approximately negative 165 volts derived from a point 39 on the bottom voltage divider. Consequently, since the grid of the tube 34 is at a negative potential with respect to its cathode, this tube is not conditioned for conduction. With no space current being conducted in the tube 34, there is no voltage drop across the resistance 35, and consequently the control grid of tube 20 is at ground potential. The cathode of this tube, however, is at a negative potential derived from the battery 9 through the receiving device 5. Therefore, the tube is conditioned for the conduction of space current, and a marking condition is applied to the receiving device 5.

If, while the combination transmitter-receiver 7 of the branch station 6 is inoperative, that is, with its transmitting contacts in the closed or marking position, the transmitting device 4 operates by opening the local series circuit for the relaying of a spacing signal derived from the receiver 2 in response to the reception of a spacing signal from the line L, the connection to the negative terminal of the battery 9 is broken. Consequently, the potential of the switch blade 18 and also of the control grid of the tube 23 is zero or ground derived from the branch station 6. Thus, it is seen that the grid of the tube 23 is even more positive with respect to its cathode than before, with the result that the tube continues to conduct. Since this tube controls the operation of the other two and the receiving device 5, there is no response by the latter to the spacing signal repeated from the main line circuit L to the branch station 6.

When the transmitting device 4 is inoperative, that is, in the closed or marking position, and the transmitting element of the combination transmitter-receiver 7 opens to send a spacing signal from the branch station 6, ground is disconnected from the series circuit to interrupt the flow of current therein, thereby leaving the switch blade 18 and the control grid of the tube 23 at a negative potential approaching that of the battery 9 which, as assumed, is approximately 125 volts. The grid of the tube 23 then is sufficiently negative with respect to its cathode to render the tube non-conducting. The voltage drop across the top voltage divider resistance 30 decreases, with the result that point 40 becomes less negative.

As a consequence, the point 38 also becomes less negative and has a value of approximately negative 155 volts. This potential, being applied to the grid of the tube 34, tends to condition the tube to become conducting. At the same time the interruption of the space current of the tube 23 results in a decrease in the voltage drop across resistances 25, 26 and 27 of the bottom voltage divider, with the result that points 37 and 39 become more negative, the latter having a value of approximately negative 170 volts. This potential being applied to the cathode of the tube 34, also tends to cause the conduction of space current in this tube. This arrangement forms an important feature of the amplifier, since not only is the control grid of the tube 34 influenced by the tube 23 but also the cathode of tube 34 is influenced thereby and in an opposite sense. Consequently, the gain obtained in the amplifier stage including the tube 34 is materially greater than that obtainable where only the control grid potentials are varied in accordance with the operations of the tube 23.

With the conduction of space current through the tube 34, the voltage drop across the resistance 35 results in the application to the control grid of the tube 20 of a potential which is sufficiently negative with respect to its cathode to interrupt the space current in the tube and also through the receiving device 5. Thus, the spacing signal originating at the branch station transmitter is repeated to the receiving device 5 by means of which the transmitter 3 is controlled to further repeat the spacing signal to the main line circuit L.

The operation of the system described up to this point is in general accordance with well known half-duplex principles of operation. If, while the transmitting device 4 is operating to repeat signals received from the main line circuit L to the branch station combination transmitter-receiver 7, the operator at the branch station operates the transmitting element of the combination transmitter-receiver, the receiving element of this device will not record the signals sent by the transmitting device 4 in a proper manner, since these signals will be mutilated.

Of the four signaling combinations possible with both the transmitting device 4 and the transmitting element of the combination transmitter-receiver 7 in simultaneous operation, three have been described. The fourth one of these combinations is when both transmitters are in their open circuit positions for the transmission of spacing signals. In this case, ground is disconnected from one end of the combined sending and receiving leg by the transmitting element of the combination transmitter-receiver 7, and negative battery 9 is disconnected from the other end of the combined leg by the operation of the transmitting device 4. The connection of the grid of the tube 23 through resistance 29 to a point 41 on the bottom voltage divider conditions the tube for non-conduction, since the point 41 is sufficiently more negative than the point 37, to which the cathode of the tube is connected, to bias the tube to cut off. Consequently, the amplifier repeater functions to repeat the spacing signal sent from the branch station to the main line circuit.

If it is desired to use the extension line 14 as part of the combined sending and receiving leg, the switch blade 18 is placed in engagement with its lower contact. The series circuit including the transmitting device 4 then includes the com-

bination transmitter-receiver 8 of the branch station 6. The operation of the amplifier repeater is the same as that previously described.

A condenser 42 is connected from a point in the circuit of the control grid of tube 23 to ground for the purpose of preventing the impression upon this grid of transient voltages caused by the operation of either transmitter and having values in excess of the steady state voltages which appear in the combined sending and receiving leg. The transient voltages result from the opening and closing by the transmitters of the circuit including the inductance of the receiving element of the combination transmitter-receiver. Such voltages, if allowed to influence the grid of the tube 23, would cause false operations of the repeater.

When the system is arranged for normal full duplex operation with individual sending and receiving legs, a monitor printer 43 comprising transmitting and receiving elements may be connected in either the sending or receiving leg by the insertion of a plug 44 into jacks 10 or 13, respectively.

The sending and receiving legs are normally connected through contacts of jacks 10 and 13, respectively, and include the respective resistances 45 and 46. Such resistances are proportioned to balance the resistance of either the monitor printer 43 or the amplifier repeater, depending upon which is plugged into the jacks, so that at all times the current flowing in the sending and receiving legs is substantially the same. The monitor jack 19, into which the plug 44 is inserted for monitoring purposes when the apparatus is arranged to combine the sending and receiving legs, is also provided with a similar resistance 47 for substantially the same purpose.

The nature of the invention may be ascertained from the foregoing description of an illustrative embodiment thereof, it being understood that other modifications embodying the same inventive idea may be made within the scope of what is claimed without departing from the spirit of the invention.

What is claimed is:

1. In a telegraph system, a duplexed main line circuit, a local circuit associated with one terminal of said main line circuit including transmitting and receiving legs, sending and receiving apparatus in each of said legs, a repeater between said main line circuit and said transmitting and receiving legs, means associated with said repeater for preventing the reflection into said main line circuit of signals received therefrom, and means to condition one of said legs for transmission of intelligible signals from the sending apparatus therein to said duplexed line circuit concurrently with the application of signals to said leg from said duplexed line circuit and for the repetition of intelligible signals from said duplexed line circuit over said leg to the receiving apparatus therein during idle periods of transmission over said leg to said duplexed line circuit.

2. In a telegraph system, a main line circuit, a local circuit including combined sending and receiving leg facilities, a signal repeater, means for associating said repeater with said local circuit for operation to relay to said main line circuit signals originating in said sending leg facilities and to prevent the relaying to said main line circuit of signals destined for said receiving leg facilities, and means for utilizing one of said legs for combined sending and receiving, including

means for repeating to said main line circuit intelligible signals transmitted over said combined sending and receiving leg both during busy and idle periods of application of signals from said main line circuit to said combined sending and receiving leg.

3. In a telegraph system, a duplexed main line circuit, a first series local circuit including a main line signal receiver, a local transmitter and local receiver, said local receiver being responsive both to said main line signal receiver and to said local transmitter, a second local circuit including a main line signal transmitter, an electronic repeater having an input circuit connected to said first local circuit for repeating to said local receiver signals received over said duplexed main line circuit and an output circuit connected to said second local circuit for repeating to said duplexed main line circuit signals originating at said local transmitter, and means for biasing said repeater to relay to said main line signal transmitter only the signals originating at said local transmitter irrespective of the concurrent operation of said main line signal receiver.

4. In a telegraph system, a duplexed main line circuit, a first local circuit including a main line signal repeating device, a transmitter and a receiver, said receiver being responsive both to said repeating device and to said transmitter, a second local circuit including a main line signal transmitting device, an electronic repeater having an input circuit connected to said first local circuit for repeating to said local receiver signals received over said duplexed main line circuit and an output circuit connected to said second local circuit for repeating to said duplexed main line circuit signals originating at said local transmitter, means utilizing potentials of a point in said first local circuit to render said repeater operative in response to operations of said transmitter and inoperative in response to operations of said repeating device whereby only said transmitter signals actuate said transmitting device, and means for biasing said repeater to repeat said transmitter signals to said transmitting device irrespective of the concurrent operation of said repeating device.

5. In a telegraph system, a series circuit including two impulse transmitters and having one terminal connected to a grounded source of direct current and the other terminal connected to ground, a signal translating device, an electronic repeater having its output circuit connected to control said translating device, means for connecting the input circuit of said repeater from ground to a point on said series circuit between said transmitters whereby the signals of both of said transmitters modify the input potential to said electronic repeater, and means for biasing the input circuit of said repeater to repeat the signals of one of said transmitters only irrespective of the concurrent operation of both of said transmitters.

6. In a telegraph system, a duplexed main line circuit, a first local circuit including a main line signal receiver, a local transmitter and a local receiver, said local receiver being responsive both to said main line signal receiver and to said local transmitter, a second local circuit including a main line signal transmitter, an electronic repeater, means utilizing potentials derived from said first local circuit to control the operation of said repeater to relay to said main line signal transmitter signals from said local transmitter and to prevent the relaying to said main line sig-

nal transmitter of signals from said main line signal receiver, and means utilizing an auxiliary potential to condition said repeater for said operation irrespective of the concurrent operations of said main line signal receiver and said local transmitter.

7. In a telegraph system, a duplexed main line circuit, a local circuit including a series connection of a grounded source of negative potential, a main line signal repeating receiver, a local receiver and a local transmitter connected to ground, said local receiver being responsive to operation of said main line signal repeating receiver and to operation of said local transmitter, a main line

5 signal transmitter, an electronic repeater connected to derive input potentials from a point in said series circuit for rendering operation of said repeater responsive to said local transmitter and unresponsive to operation of said main line signal repeating receiver, the output circuit of said electronic repeater being connected to control said main line signal transmitter, and means utilizing an auxiliary negative potential to condition the input circuit of said repeater for said operation irrespective of the concurrent operations of said main line signal repeating receiver and said local transmitter.

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