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2,069,223

INTERCONNECTING TELEGRAPH REPEATER SYSTEM

Filed July 24, 1935

2 Sheets-Sheet 1

FIG. 1

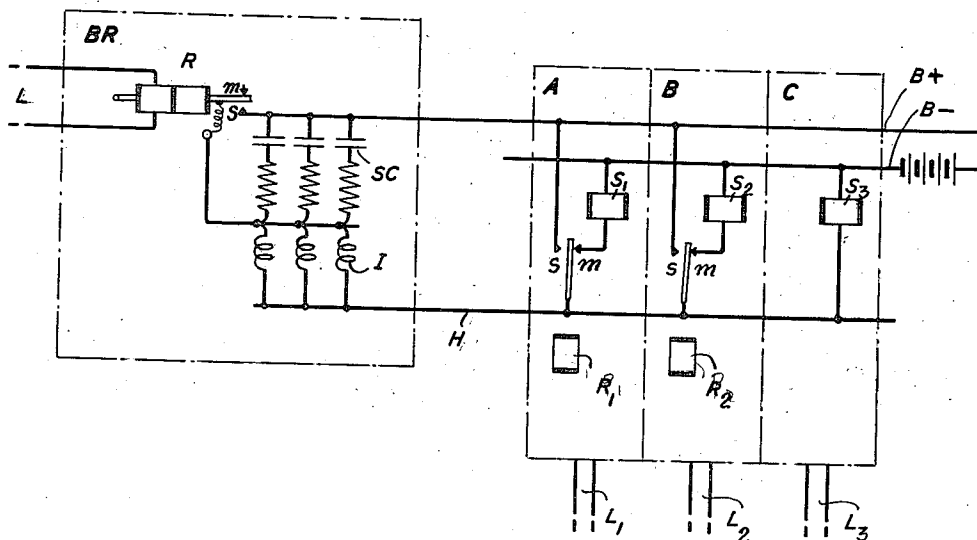
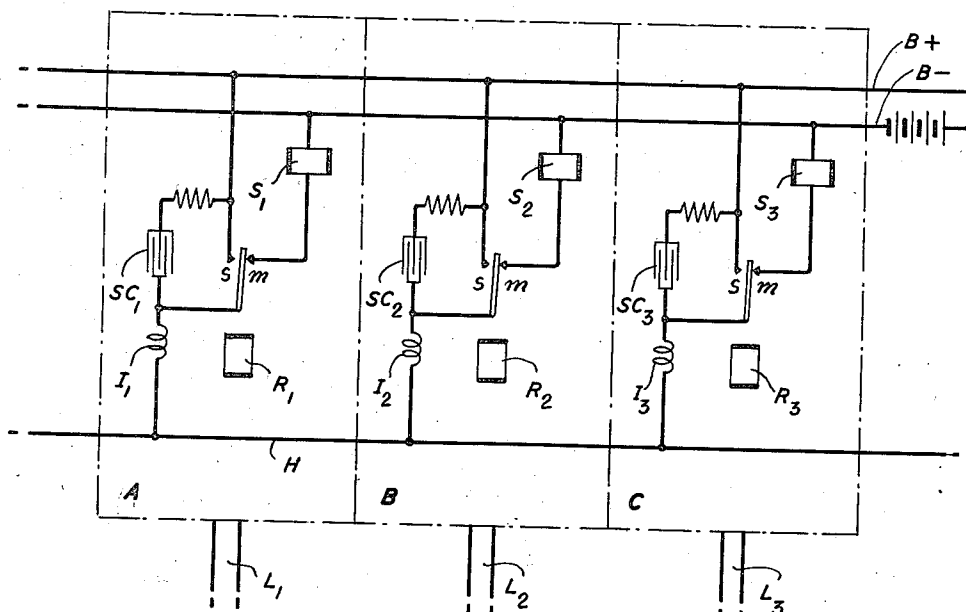


FIG. 2



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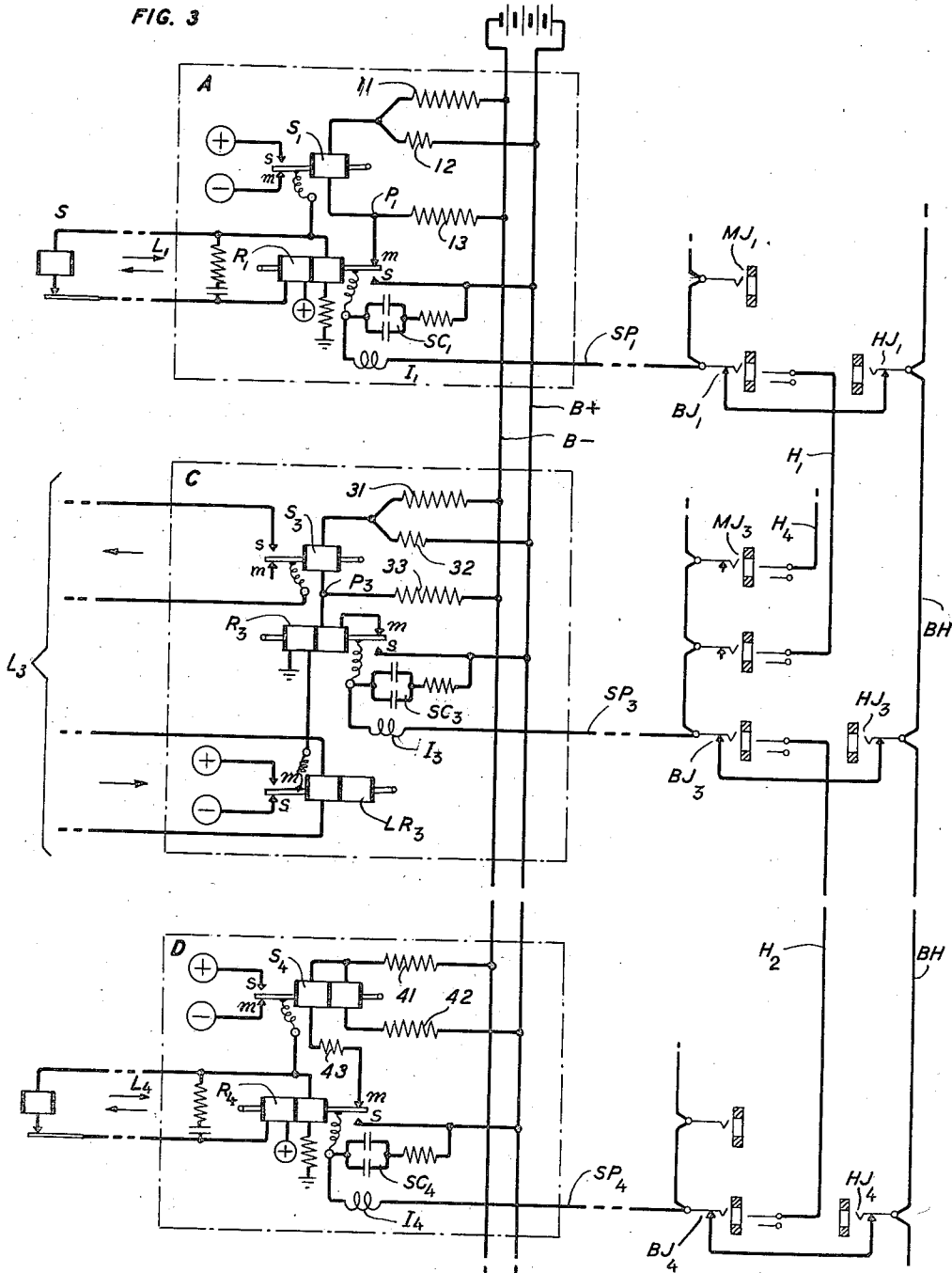
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FIG. 3



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INTERCONNECTING TELEGRAPH REPEATER
SYSTEMGeorge C. Cummings, Orange, N. J., assignor to
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Application July 24, 1935, Serial No. 32,858

8 Claims. (Cl. 178—73)

This invention relates to telegraph repeating systems and more particularly to systems of this type in which a plurality of repeaters are interconnected for two-way intercommunication between associated lines.

It has recently been suggested to permanently assign a repeater to each outgoing line circuit at a repeater station and to interconnect these repeaters for two-way communication by means of a common circuit termed the "hub" circuit, whereby the local side of all the repeaters intended for intercommunication are connected in multiple for direct operation by the local contacts of any one of the repeaters. The windings of the transmitting relays of the repeaters are, during marking, connected over the contacts of the receiving relays to the two-way common circuit and any one of the repeaters, by operation of its receiving relay contacts, will disconnect its own transmitting relay winding and apply spacing potential to the hub circuit, thereby operating to the spacing position all the other transmitting relays connected to the hub.

In this arrangement, no impulse current flows in the hub when all repeaters are in marking condition. When a repeater applies spacing potential to the hub, it is evident that the travel time of the armature in both directions will be added to the no-current condition and subtracted from the spacing condition, thereby introducing considerable bias. It is also evident that the contacts in spacing position must carry the total current through all the transmitting relays in multiple, which thus may be very heavy. Arrangements have been suggested for connecting as many as sixteen repeaters to a single hub circuit.

It is the principal object of the invention to reduce as far as possible the load on the repeater contacts connected to a hub circuit, such as referred to.

It is a further object to arrange the local circuits of repeaters interconnected by hub circuits in such a manner that the life of the repeater contacts connected to the hub circuit will not be seriously shortened due to the large increase in load over that ordinarily carried by telegraph relays.

For the attainment of these objects, the invention contemplates a number of features.

In accordance with a feature of the invention, spark protection equipment, including capacitance, is provided for the hub contacts which is not only sufficient to provide protection under the increased load conditions but which also has

sufficient capacity to compensate for the signal bias due to the contact travel time. This feature is distinct from previously proposed arrangements whereby spark protection condensers of extra large capacitance are utilized in repeaters to keep a relay locked during the travel time of the relay associated with the condenser.

In accordance with another feature of the invention, the spark protection and bias compensating equipment comprises a plurality of units, each of which is associated with a repeater, so that repeaters may be connected to and disconnected from the hub, and compensating equipment therewith; the hub circuit will thus at any time be automatically adjusted for the number of repeaters associated therewith.

In accordance with another feature of the invention, a small inductance is serially included in each hub connection to a repeater hub contact in order to cooperate with the spark protection equipment to shape the signals passing over the hub circuit with the effect that high frequency peaks and their consequent loading of the contacts may be reduced to a minimum. These inductances are particularly provided to choke very high frequency transient oscillations set up by the small distributed capacity of the hub circuit wiring. These extremely high frequency currents have been found to constitute a serious factor in the wear of relay contacts.

In accordance with an other feature of the invention, the operating circuit for the transmitting relay of each repeater is connected to a metallic network, for example a resistance network including a potentiometer, whereby the magnetomotive force for biasing the relay to marking is reduced or entirely eliminated when the relay is subjected to spacing potential for operation to spacing and whereby, in turn, the current for operating the transmitting relay to spacing may be reduced to a minimum to relieve the load on the receiving relay contacts when a large number of repeaters are connected together.

As already stated, the interconnecting repeating system to which the invention is particularly adapted uses a single conductor for connecting a comparatively large number of repeaters for line or loop circuits in multiple, which conductor may appropriately be termed the "hub". From each repeater a single conductor or "spoke" is connected to the hub usually through switching means which may be manually or automatically operated or may be permanently set. Thus, in the case of the so-called lease set-up the single

wire connections or spokes may be directly soldered or clamped together and one or more jacks may be included in the spoke of each repeater for disconnection of the repeater from the hub and for connection by means of patching cords of either the repeater or the hub to another circuit such as a line circuit or a monitoring circuit.

In the case of the ordinary appearance of lines in a switchboard, a requested interconnection of a line with another line may be established by the plugging in of a single-wire patching cord, and connections to other lines may be simultaneously set up through simple multiple jacks and other patching cords or in any other convenient manner.

The arrangement is particularly suitable for automatic set-up of interconnections as by relays or by more complicated switching means, since only a single connection need be established for each line and its repeater. It is furthermore evident that interconnection of a great number of lines for broadcast purposes may be greatly facilitated by this arrangement.

The invention will now be described in some of its preferred forms and reference will be made to the accompanying drawings in which,

Fig. 1 illustrates a telegraph repeater system for interconnection of a plurality of signaling circuits by means of a multiple circuit, such as disclosed in an application for F. S. Kinhead and G. A. Locke, Serial No. 32,866 filed on even date herewith; the circuit in Fig. 1 particularly shows a feature of the invention in accordance with which distortion of signals by the repeaters is reduced and the current load on the relay contacts operating into the hub circuit is minimized;

Fig. 2 shows a circuit arrangement similar to that of Fig. 1, except that the means for reducing distortion and current load is distributed among the various repeaters; and

Fig. 3 is a more detailed circuit diagram of a circuit similar to that of Fig. 2 with further features included for reducing current load in the hub circuit.

Referring now particularly to Fig. 1, the repeating system comprises a plurality of repeaters A, B and C for line circuits L_1 , L_2 and L_3 , respectively. Each repeater comprises a receiving relay R_1 , R_2 , for producing signals in the local hub circuit H, interconnecting the contacts of these relays, and a sending relay S_1 , S_2 , and S_3 for retransmitting signals impressed on the hub circuit into the line circuits. With all the receiving relays in marking position as shown in the drawings, the sending relays will be connected in multiple from the battery conductor B— to the hub conductor H and will be currentless. It is of course not essential that all the repeaters have a receiving relay R; thus repeater C is capable only of responding to signals from the other repeaters for transmission of signals into its corresponding line circuit, that is, for one-way transmission.

The system is further shown as comprising a repeater BR, which may be similar to any of the other repeaters A, B and C or may be a special broadcasting repeater, having a receiving relay R for transmitting into the hub circuit from the associated line circuit L. Whenever the contact of relay R is closed the circuit will be completed for all the sending relays S_1 , S_2 , and S_3 in multiple for operation of those relays into spacing position and transmission of a spacing signal over their individual lines. When the contact of relay R again opens the hub circuit will be-

come currentless and the sending relays S_1 , S_2 and S_3 will return to their marking position for transmission of a marking signal over the line circuits L_1 , L_2 and L_3 , respectively.

A system of this type is particularly suitable for interconnection of a large number of repeaters. The system has been found to operate satisfactorily with as many as sixteen repeaters interconnected by a single hub conductor and it is possible that this number may be increased. It is, therefore, evident that when the repeaters are made up of relays of standard design and of reasonable cost, the current in the hub circuit may be of the order of from .5 to 1 ampere which, of course, constitutes a heavy load on the spacing contacts or receiving relay R.

In order to prevent this load from being further increased by transient conditions, the contacts of relay R are connected through an inductance network to the hub conductor H, whereby the high frequency peaks of the current in the hub circuit, will be cut down.

Spark protection condensers SC are furthermore connected across the spacing contacts in series with suitable resistances, particularly for relieving the spacing contact when relay R operates to marking. In a permanent set-up of this circuit it is, of course, satisfactory to place a single condenser SC and a single coil I in circuit with the spacing contact of relay R, the size of these devices being in proportion to the number of repeaters operated over the hub circuit. However, when the number of repeaters, which may be connected to the hub circuit varies from time to time it will be advantageous to have the sparking condensers SC and inductance coils I subdivided into equal units which may be added or removed from a circuit as repeaters are added or removed from the hub conductor, in order that operating conditions over a hub may be the same no matter how many repeaters are attached thereto.

Since the local side of all the repeaters operate on what may be called an inverted neutral basis, that is, with no current during marking condition and current during spacing condition, it is evident that the signals in the hub circuit will be biased in favor of the marking signals due to the travel time of the armature of the relay R, during which no current will be flowing either when the armature travels from marking to spacing or from spacing to marking. Advantage may be taken of the present arrangement to reduce the signal bias by increasing the capacity of the spark protection condensers SC beyond that which is necessary purely for spark protection purposes. For a satisfactory result it may be necessary to increase the condenser capacity from two to four times over that required for spark protection. By also distributing this additional capacitance equally among the condenser units it will always be possible to obtain the same bias correction by providing that the number of condenser units is equal to the number of repeaters connected to the hub.

Whereas the contact protection shown in Fig. 1 is confined entirely to the contacts of the broadcasting repeater BR, such an arrangement will not answer the usual requirement of an interconnecting repeater system, since one important feature of this system resides in the fact that any one of the repeaters is capable of transmitting into all the other repeaters connected to the hub circuit.

The circuit in Fig. 2 is arranged for contact

protection of the receiving relays of any one repeater without increasing the amount of protection in the total system beyond that shown for the broadcast repeater in Fig. 1.

5 The repeater system shown in Fig. 2 comprises interconnecting repeaters A, B and C with receiving relays R_1 , R_2 and R_3 and sending relays S_1 , S_2 and S_3 . In this arrangement spark protection condensers SC_1 , SC_2 and SC_3 are connected across the spacing contacts of the receiving relays R_1 , R_2 , and R_3 , respectively, and these
10 contacts are connected through inductance coils I_1 , I_2 , I_3 , respectively to the hub conductor H in one direction and to the conductor B+ from battery in the other direction; the marking contact of the receiving relays are connected through windings on the sending relays to conductor B— from the battery.

With the circuit as shown in Fig. 2, that is, with
20 all receiving relays in marking position, all the condensers SC are connected in multiple between conductor B+ and the hub conductor and all the windings of the sending relays S are connected in multiple between conductor B— and the hub conductor. Thus during all-marking condition the whole circuit is currentless.

When any one of the receiving relays, say relay R_1 , is operated to spacing it applies positive potential directly from conductor B+ to the hub conductor at its spacing contact thereby operating all the sending relays except relay S_1 . It is evident that all the inductances I_2 , I_3 , etc. will be included in this operating circuit to choke the initial current rush into their respective sending relay windings and that this effect will be
35 further aided by the inductance I_1 included serially in this circuit.

When relay R_1 is again operated to its marking position the short circuit for condensers SC_1 , SC_2 , SC_3 etc. which exists at the spacing contact of relay R_1 is opened and all these condensers become charged over a circuit from conductor B+ and marking contact of all the receiving relays and the windings of all the sending relays thereby relieving the spacing contact at relay R_1 . It will thus be seen that in this manner all condensers SC are at any time effective in protecting the spacing contacts of any one of the receiving relays and their capacities
40 are added together by a multiple connection to protect any one of the contacts to the same extent.

Also this arrangement may be conveniently utilized to reduce the no current bias due to travel time of the armatures of any of the receiving relays by increasing the capacitance of each of the condenser units as described in connection with Fig. 1.

It is apparent that the arrangement shown in Fig. 2 lends itself particularly well to systems in which the number of repeaters interconnected together may be varied at any time and in which the interconnection between them may be set up by either automatic or manually operated switching means since by the connection of a repeater to the hub circuit a corresponding unit of spark potential and signal bias preventing condenser SC as well as an inductance unit I will automatically be included in the circuit.

70 The system shown schematically in Fig. 3 is similar to the systems shown in Figs. 1 and 2, but includes additional features of the invention whereby the current flow over the spacing contacts of the receiving relays may be reduced.

75 This system comprises a line circuit L_1 con-

nected through a repeater A, a line circuit L_3 connected through repeater C and a line circuit L_4 connected through repeater D. From each repeater a spoke conductor SP_1 , SP_2 and SP_3 leads to suitable switching arrangements for inter-
5 connection of the repeaters by one-wire connections.

The lines L_1 and L_4 may be two-way loop circuits each connected to a subscriber's station which usually are equipped with teletypewriters having a receiving winding and transmitting contacts, as shown for line L_1 . The line L_3 may be a four-wire circuit with two wires for each direction of transmission. In each case the repeaters will have their line side particularly adapted for
10 requirements of their associated line circuits.

The repeater A is equipped with receiving relay R_1 and sending relay S_1 . A suitable source of positive and negative potential is connected to the line side of the repeaters.

For transmission of signals into the line circuit L_1 the relay S_1 is operated to its marking and spacing contacts thereby applying negative and positive potential alternately through the differentially wound relay R_1 , which remains unaffected, to the line circuit to the subscriber's station. The signals originating at the subscriber's station are transmitted by opening and closing of the line at the keyboard contacts. In this case the line winding of relay R_1 becomes alternately deenergized and energized and the relay is operated to its spacing contact by its biasing winding and to its marking contact by its line winding in a well-known manner.

The local side of the repeaters are supplied with current from a suitable source, which may be a battery, over the common conductors B+ and B—. It is, of course, possible for this purpose to use the same source as is used for the line side of the repeaters. It is a distinct advantage of this type of interconnecting repeater that its local side is entirely separated from its line side, because the potential used for operation of the local side may be independent of the potential requirements of the line side and thus
40 may be the same as is used in standard practice for switchboard operations.

The sending relay S_1 has a normally energized winding one side of which is connected to an intermediate potential supplied through resistances 11 and 12 from the common conductors B+ and B— and the other side of which is connected through resistance 13 to conductor B—. Due to this arrangement a marking current flows in the relay S_1 which thus supplies marking potential to its line circuit. From a point P_1 between the winding of relay S_1 and resistance 13, a circuit leads over the marking contact of relay R_1 through inductance I_1 and over the spoke connection SP_1 to a set of jacks on the testboard, such as the broadcasting jack BJ_1 and monitoring jack MJ_1 . From jack BJ_1 a normally closed connection leads over hub jack HJ_1 to a broadcasting hub BH. Similar circuits may be traced through other repeaters normally connected
60 through their spoke conductors to the broadcasting hub BH.

It will thus be seen that when all the repeaters are in marking condition the hub BH will be connected to the same potential of each repeater and that no signaling current will be flowing in the hub or in the spoke connections SP so long as this condition is maintained.

When a spacing signal arrives over one of the line circuits to operate the associated receiving
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relay to spacing, the conductor B+ will be connected directly to the associated spoke connection and thus to the hub BH which thus will apply positive potential to the sending relay windings of all the other repeaters, thereby operating the sending relays for transmission of a spacing impulse over their associated line circuits. Thus, when the hub BH applies a positive potential over the spoke connection SP₁ to the point P₁ in repeater A, the current will be reversed in the winding of relay S₁ and the relay will operate to spacing. When the hub BH is again placed in marking condition positive potential will be removed from point P₁ and the current of relay S₁ will reverse to operate the relay into marking.

It has become a well established practice in teletypewriter systems to use single line repeaters in which the relays are operated into one position by a biasing winding and into the other position by a line winding which would carry a current twice as great as that in the biasing winding to overcome the biasing winding and operate the relay to the other position. The receiving relay shown in repeater A operates on this principle. In the circuit disclosed in the Kinkead-Locke application Serial No. 32,866, already referred to, also the sending relay has two windings and operates on that same well-known principle. In the present arrangement the sending relay has a single operating winding which, of course, may constitute a plurality of windings connected in series or in multiple and all operating in unison, and the operation into alternate positions is obtained by reversing the current in the winding. It will thus be seen that by such an arrangement it is not necessary to overcome a biasing winding to operate the relay into either position. The current reversals are obtained by including the winding relay S₁ in the simple resistance network 11, 12 and 13 and by merely opening and closing the single conductor from point P₁ over the hub circuit to conductor B+ at any one of the other repeaters. Even though additional current will be flowing from the spoke conductor over resistance 13 in repeater A and corresponding resistances in other repeaters, during spacing condition, the total current consumption by each repeater during spacing may readily be reduced by 33% or more.

By means of the inductance I₁ and other inductances in the spoke connections peak values of the hub current during each spacing impulse will be reduced as described in connection with Figs. 1 and 2; and by means of spark protection condenser SC₁ and other similar condensers in other repeaters the heavy spark at the spacing contacts due to the heavy load may be eliminated. Since each repeater is provided with its own spark protection and current limiting devices, the operation and function of this equipment will be the same no matter how many repeaters may be interconnected at any time.

The repeater C is particularly arranged for terminating a four-wire line and reference should be had to the Kinkead-Locke application Serial No. 32,866, already referred to, for details of its operation. However, the repeater is modified in accordance with the invention by having a one winding sending relay S₃ connected through a resistance network 31, 32, 33 similar to that already described in connection with repeater A. Except for the inclusion in the local side of the repeater of a low resistance winding of the receiving relay R₃, the local circuit operates exactly as described for repeater A and is provided

with similar spark protection equipment and peak load reducing equipment. In addition to the usual spark protection condenser capacitance may also in this arrangement be included in each repeater circuit for reducing signal bias due to the travel time of the receiving relay armatures.

Repeater D is similar to repeater A except that the sending relay S₄ has two operating windings, the right-hand winding being the biasing winding and the left-hand winding the line winding, and that these windings are connected in a differential bridge circuit, including the common resistance 41 and bridge arm resistances 42 and 43.

Assuming that other similar repeaters are connected to the hub circuit BH a circuit may be traced through each repeater beginning at conductor B— through the left-hand winding of the sending relay over the marking contact of the receiving relay and the spoke conductor SP to the hub BH and no current will flow in this entire circuit. At the same time a current will flow from conductor B— through right-hand winding of the sending relay to the conductor B— in each repeater which will operate the sending relay to marking. When the spacing potential is applied to the hub conductor from another repeater by operation of its receiving relay to spacing, current will flow from conductor B— through resistance 41, left-hand winding of relay S₄, marking contact of the relay R₄ and spoke conductor SP₄ to positive potential on the hub conductor. This current in addition to the current through the biasing winding of relay S₄ will increase the potential drop across resistance 41 thereby reducing the current through the biasing winding to say one-third its former value, thereby requiring a comparatively low current in the left-hand winding for operation of the relay to spacing. Reduction in spacing current over the hub circuit and over the spacing contact of the active receiving relay for operation of each sending relay may also in this case easily amount to one-third or more as compared with the current required in the standard arrangement.

It should, of course, be understood that the repeaters which are intended for mutual interconnection must all be arranged either with a resistance network, such as shown for repeater A, by which the spoke conductor SP will be at an intermediate potential, or else in a resistance network such as shown for repeater D where the spoke conductor SP during marking condition will be at full negative potential or nearly so.

From the description given above it will be apparent that all signaling between the local side of all repeaters takes place over a single conductor circuit comprising the spokes SP₁, SP₃, etc. and the hub conductor BH and that, therefore, all switching operations for adding repeaters and contact protecting networks to a hub circuit or for removing them therefrom will be confined to a single conductor for each repeater. This makes it possible to arrange all repeaters in bays and to arrange the apparatus necessary for making interconnection between them on a switchboard or testboard remote from the repeaters without resort to an excessive number of lines. The spokes SP may, of course, be soldered directly to the hub for the permanent connection of certain lines, as in the case of a lease set-up. However, even in this case it is convenient to arrange contact means for disconnection of any repeater from the hub circuit and temporary

connection thereof, for example, to a monitoring equipment or to some other line circuit upon special request. Thus, the repeaters may be normally connected through their jacks BJ and HJ to a broadcasting hub BH and broadcasts may be received over the lower side of line L₃ and the spoke conductor SP₃ for operation of a large number of other repeaters into their individual line circuits. Any one repeater may be disconnected from this broadcast by insertion of a plug in its jack HJ. Any two repeaters may be interconnected independently of the hub circuit as by a patching cord H₂ inserted in jacks BJ₃ and BJ₄ whereby direct connection would be established between line L₃ and L₄ for two-way communication. An additional line may be added to this circuit, for example, by plugging the patching cord H₁ into jacks MJ₃ and BJ₁ thereby adding line L₁ to the circuit. Line L₁ may be disconnected from the hub circuit BH and added to another hub circuit, for example, by means of the patching cord H₁ plugged into jack BJ₁ and into a jack corresponding to jack MJ₁ for a line normally associated with another hub circuit. It will also be possible to interconnect two hub circuits and their associated lines by means of the patching cord H₁ by plugging the cord into, for example, jack MJ₁, and to a corresponding jack MJ for a line associated with another hub circuit.

What is claimed is:

1. A local one-wire circuit, a plurality of polar signal transmitting relay means each connected to said circuit for energization in multiple in response to an operating potential applied to said circuit, a plurality of signal receiving relay means each having two-position contact means for alternately connecting a source of said operating potential to said circuit and disconnecting it from said circuit in response to alternate signal impulses through said receiving relay means, and bias correcting circuit means having capacitance connected between said one-wire circuit and said source of potential, the capacitance of said bias correcting circuit means being dimensioned in proportion to the number of said transmitting relay means connected for multiple energization to said one-wire circuit to compensate for the travel time of said contact means.

2. A circuit combination in accordance with claim 1 in which said bias correcting circuit means comprises a capacitance unit for each of said transmitting relay means.

3. A circuit combination in accordance with claim 1 in which said bias correcting circuit means is divided into a plurality of equal capacitance units, each connected directly across a corresponding one of said contact means, the total capacitance of said plurality of units being equal to that required for compensation of travel time of any one of said contact means for the operation of all of said transmitting relay means.

4. A circuit combination in accordance with claim 1 in which said one-wire circuit includes wave shaping means having inductance to reduce the peak value of the impulse current in said circuit,

said inductance being dimensioned in proportion to the capacitance of said bias correcting circuit means.

5. A plurality of signal line circuits, a local multiple circuit, a plurality of signal repeating means connected for two-way intersignaling between said line circuits over said local circuit, each of said repeating means comprising transmitting relay means having operating windings connected for polar operation to said local circuit, a resistance network connecting said operating windings to a source of marking potential for operation of said transmitting relay means to marking; each of said repeating means further comprising receiving relay means having two-position contact means connected to said local circuit for applying in one position a spacing potential to said plurality of networks for operating said plurality of transmitting relay means to spacing.

6. A circuit combination in accordance with claim 5 in which said contact means in each repeating means is connected to said local circuit means for disconnecting in said one position said network of the same repeating means from said local circuit and for applying said spacing potential simultaneously to all the other of said networks for operation of said plurality of transmitting relay means to spacing.

7. A plurality of signal line circuits, a plurality of signal repeating means for two-way signaling over said line circuits, each of said repeating means comprising transmitting relay means having operating windings for polar operation and a metallic circuit network connecting said operating windings to a source of marking potential for operation of said relay means to marking, a local one-wire circuit interconnecting equipotential points in said network of all of said repeating means, and each of said repeating means further comprising receiving relay means having two-position contact means for applying in one position a spacing potential to said one-wire circuit for operating to spacing the transmitting relay means in the others of said repeating means.

8. A local one-wire circuit, a plurality of signal line circuits, a plurality of signal repeating means for two-way signaling between said line circuits over said one-wire circuit, each of said repeating means comprising transmitting relay means having an operating winding for polar operation, receiving relay means having two-position contact means, and a circuit network including a potentiometer for supplying an intermediate potential to one side of said winding and a high resistance for supplying marking potential to the other side of said winding for operation of said transmitting relay means to marking, said contact means in one position connecting said one-wire circuit to said other side of said winding and in the other position connecting said one-wire circuit to spacing potential for operation to spacing of said transmitting relay means of all other of said plurality of repeating means.

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