

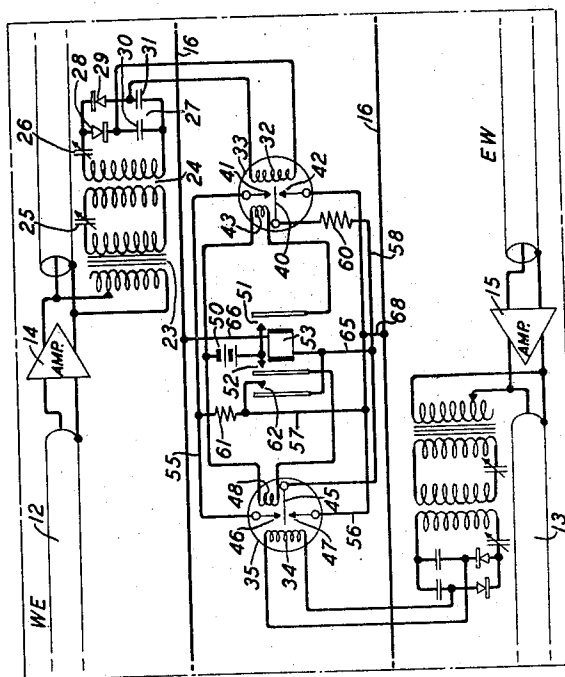
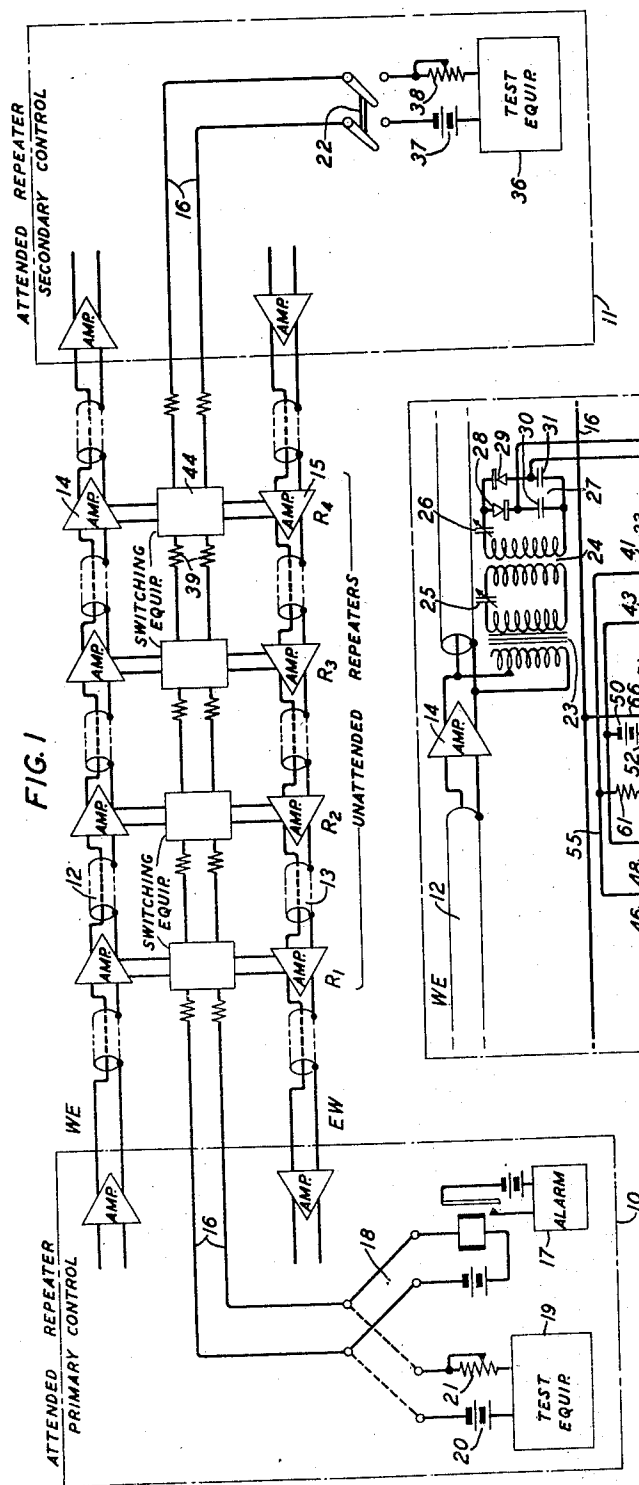
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H. H. BENNING ET AL

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LOCATION AND IDENTIFICATION OF FAULTS IN SIGNALING TRANSMISSION SYSTEMS

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LOCATION AND IDENTIFICATION OF
FAULTS IN SIGNALING TRANSMISSION
SYSTEMS

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This invention relates to fault location in a broad band wave transmission system, and more particularly to a method of and apparatus for both locating and identifying faults in such system.

Broad band wave transmission systems embody attended and unattended repeaters in each of two one-way paths such that each path includes in tandem at least several unattended repeaters positioned between two attended repeaters. Usually, the unattended repeaters are serviced from an attended repeater so that in case of the occurrence of a fault on the system it may be cleared by an attendant going out from the latter. Such system is so arranged that wave transmission is effected on individual coaxial conductors simultaneously in opposite directions. Each repeater in each one-way path provides for the transmission of a plurality of signals depending on the number of carrier channels embodied in the system. Among these signals is a pilot signal which is utilized to indicate at an attended repeater the failure of an unattended repeater in either direction of transmission. Heretofore, this has been accomplished by associating all unattended repeaters with a direct current circuit such that upon the failure of an unattended repeater a short circuit would be applied across the direct current circuit at that point.

This would actuate a signal at an attended repeater to announce to the attendant thereat the failure of one of the unattended repeaters. Promptly, the attendant would effect loop-resistance measurements on the direct current path to locate the unattended repeater involved in the failure. A single indication at the attended repeater would mean that the failure could be on either the eastward or the westward path and, of course, the attendant would have no way of knowing the fact. A signal individual to each path and common to all unattended repeaters in tandem in the respective eastward and westward paths may be used to indicate failure in a certain path. Thus, two indicators would be required to isolate the individual unattended repeater which had failed.

In either case, the attendant may consume considerable time at the unattended repeater involved in the failure in testing to ascertain the

nature of the fault before the proper steps may be taken to effect clearance thereof and restore normal service on the system. Prompt action on the part of the attendant is imperative in order to maintain reliable and efficient transmission and, in addition, to reduce to a minimum the out-of-service periods of the regular equipment. Accordingly, this invention contemplates an arrangement for apprising the attendant not only the location of a fault but also the nature thereof, preparatory to his going out to the attended repeater involved in the fault to effect clearance thereof.

The main object of the invention is to provide a broad band transmission system with a facile arrangement for both locating and identifying certain faults that may occur therein.

Another object is to accomplish expeditiously the fault location and identification.

A further object is to reduce to a minimum the time required to clear the faults.

Heretofore, the failure of an unattended repeater in a broad band transmission system embodying in tandem a plurality of attended and unattended repeaters individual to one-way westward and eastward paths has been announced to an attendant located at an attended repeater by an arrangement comprising the association of all unattended repeaters with a normally open direct current circuit such that the failure of one of the unattended repeaters would apply a short circuit across the direct current circuit to actuate an alarm at the attended repeater. By means of loop-resistance measurements on the direct current circuit the attendant would be able to isolate the faulty unattended repeater.

In accordance with this invention, a pair of sensitive relays is associated with the direct current circuit and both one-way amplifiers at each unattended repeater so that one contact of each sensitive relay may serve to apply a closure circuit to normally open direct current circuit, depending on whether the pilot current is too high or too low. A resistance combination comprising four different amounts is associated with the sensitive relays such that for each of four different conditions of the pilot current on both one-way paths at each unattended repeater one amount of resistance is connected in the closure circuit in series with the closed contact of

the operated sensitive relay. The difference between loop-resistance measurements, (a) with such resistance amount included in the closure and direct current circuits and (b) with such resistance amount removed therefrom, will serve to identify a fault involving a certain strength of the pilot current in a certain one-way path at each unattended repeater.

The invention will be readily understood from the following description taken together with the accompanying drawing in which:

Fig. 1 is a box representation of the invention shown in connection with a broad band wave transmission system, and

Fig. 2 is a schematic circuit illustrating the invention embodied in each unattended repeater of the system shown in Fig. 1.

Referring to Fig. 1, one attended repeater station 10 is connected with remote attended repeater station 11 by a pair of coaxial conductor lines 12 and 13. Intermediate both attended repeater stations are positioned a plurality of unattended repeater stations R₁, R₂, R₃ and R₄, each of which includes a WE one-way amplifier 14 and an EW one-way amplifier 15. The attended repeater stations may be either terminating or intermediate stations. Such equipped coaxial conductor lines may be operated for broad band wave transmission in the manner pointed out in the patent of L. Espenschied et al. No. 1,835,031 granted December 8, 1931. A direct current circuit 16 is provided between attended repeaters 10 and 11 both of which will be hereinafter identified as the respective primary and secondary control repeaters.

At the primary control repeater 10, the circuit 16 is normally terminated in an alarm 17 through a manual switch 18 which may be actuated to connect the circuit 16 to testing equipment 19. Associated with the latter and disposable in series in the circuit 16 are a direct current source 20 and an adjustable resistance 21 which serves to vary the amount of direct current flowing in the circuit 16 for a purpose that will be later explained with respect to loop-resistance measurements made from the primary control repeater 10.

At the secondary control repeater 11, the circuit 16 is normally terminated in an open circuit by a switch 22 which may be actuated to connect thereto testing equipment 36. Associated with the latter and disposed in series therewith are a direct current source 37 and an adjustable resistance 38 which serves to vary the amount of direct current flowing in the circuit 16 for a purpose that will be subsequently described from the standpoint of loop-resistance measurements made from the secondary control repeater 11.

The testing equipments 19 and 36 are identical and together with the respective direct current sources 20 and 37 and adjustable resistances 21 and 38 are utilized, in response to actuations of the alarm 17 due to a closure of the circuit 16 at each unattended repeater in a manner that will be subsequently explained, to make on the circuit 16 loop-resistance measurements which will indicate the location of the closure circuit. An arrangement embodying the above apparatus for making such resistance measurements is disclosed in the patents to E. I. Green et al., Nos. 2,018,850 and 2,018,851 both of which were granted October 29, 1935.

In accordance with the invention, it will be possible to locate not only the unattended re-

peater at which the closure circuit occurred but also to ascertain (1) whether it happened either on the EW or WE coaxial conductor line and (2) in the case of pilot current which is utilized in this illustration, whether such current is too high or too low on the respective lines. Referring to each unattended repeater of Fig. 1, it will be observed that equal resistances 39, 39 are inserted in series in the circuit 16 which also has connected thereto and to the EW and WE amplifiers certain switching apparatus 44. Viewed from both the primary and secondary control repeaters, each unattended repeater includes the pair of resistances 39, 39 and the apparatus 44.

Referring to Fig. 2, each apparatus 44 comprises connected to the output of the WE amplifier 14 transformers 23 and 24 which are tuned by capacities 25 and 26 to select a pilot current for application to the input vertices of a full wave rectifier bridge 27 comprising rectifiers 28 and 29 forming two arms and capacities 30 and 31 forming the other two arms. The output vertices of the rectifier bridge 27 are connected to operating coil 32 of a sensitive relay 33. The two rectifiers 28 and 29 which are preferably of the copper-oxide type are oppositely poled so as to effect rectification of each half of the selected pilot current voltage. The output of the EW amplifier 15 is applied through identical transformers and rectifier bridge to operating coil 34 of a sensitive relay 35.

Sensitive relay 33 embodies an armature 40 adapted to be moved by the operating coil 32 into engagement with the respective upper and lower contact members 41 and 42, and a restoring coil 43. Sensitive relay 35 comprises an armature 45 adapted to be actuated by the operating coil 34 into engagement with the respective upper and lower contact members 46 and 47, and a restoring coil 48. Both sensitive relays are identical in structure and preferably of the type disclosed in the patent of J. W. Beyer et al., No. 2,066,514, issued January 5, 1937.

The respective restoring coils 43 and 48 may be independently connected in series with a source 50 of direct current voltage by means of a right-hand contact 51 and an inner left-hand contact 52 of an electromagnetic holding relay 53. The upper contact members 41 and 46 are joined by a lead 55 and the lower contact members 42 and 47 are connected by a lead 56, both of which leads are bridged by a lead 57 embodying a 100-ohm resistance 61. The armatures 40 and 45 are connected by a lead 58 embodying a 200-ohm resistance 60. The function of the resistances 60 and 61 will be presently explained.

Terminal lead 65 of the operating winding of the relay 53 may be connected to the lead 57 by means of the outer left-hand contact 62 and is joined to the lead 58 connecting the armatures 40 and 45 of the sensitive relays 33 and 35. Terminal lead 66 of the operating winding of the relay 53 is applied to one conductor of the circuit 16 whose other conductor is applied by a lead 68 to the lead 56.

In addition to the fact that the loop resistance of the circuit 16 measured from either the primary or secondary control repeater to each unattended repeater is different for each of the latter so as to enable immediate identification thereof as pointed out in both patents of E. I. Green et al., supra, the resistances 60 and 61 may be associated with the respective contact members of the sensitive relays 33 and 35 in the closure circuit applied across the circuit 16 at

the unattended repeaters in a manner that will be presently described so as to enable differentiation between the following conditions of the pilot current thereat:

Table A

Pilot current fault	Ohms resistance in series with contact members of sensitive relays 33 and 35
EW high.....	0 ω
EW low.....	100 ω
WE high.....	200 ω
WE low.....	300 ω

The loop-resistance measurements are referred to a resistance-distance chart which indicates the location of the application of the closure circuit and the cause thereof, as such chart includes above Table A and corrections for temperature variations.

The operation of Figs. 1 and 2 is as follows:

If, for example, the strength of the pilot current on EW coaxial conductor 13 is increased 3 decibels or more above normal, the level of the rectified current supplied to the operating coil 34 of the sensitive relay 35 is increased sufficiently to effect engagement between the armature 45 and lower contact member 47. This connects to the circuit 16 a closure circuit comprising leads 53 and 56, contact member 47 and armature 45 in engagement therewith, lead 58, terminal lead 65 and operating winding of relay 53 and terminal lead 66 of relay 53. This operates the alarm 17 at the primary control repeater 10 to announce to an attendant thereat the occurrence of a fault at one of the unattended repeaters.

The attendant may now readily determine by loop-resistance measurements (a) the unattended repeater at which the closure circuit was applied to the circuit 16, (b) whether the closure circuit was due to a fault on the EW or WE coaxial conductor line, and (c) whether the strength of the pilot current was too high or too low relative to normal. This may be accomplished as follows:

First step, the attendant at the primary control repeater 10 measures the loop resistance of the circuit 16 including the closure circuit placed thereacross and identified above. Such measurement will include

1. Resistance of the circuit 16 including the series resistances 39, 39 and extending between the primary control repeater 10 and the unattended repeater at which the closure circuit occurred.

2. Resistance of the operating winding of relay 53 and of the leads extending therefrom to the circuit 16 and to the contact member of the sensitive relay whose armature was actuated into engagement therewith.

3. Resistance 60 or 61, individual or in combination, or none, connected in series with the contact member of the sensitive relay whose operated armature is in engagement therewith.

Immediately upon the operation of the alarm to announce the occurrence of the fault but before proceeding with the loop-resistance measurement mentioned above, the attendant at the primary control repeater 10 notifies the attendant at the secondary control repeater 11 so that a loop-resistance measurement may also be made

from the latter repeater. Such measurement may be achieved by actuating the switch 22 at the secondary control repeater 11 to connect the testing equipment 36 to the circuit 16. Hereinafter it is to be understood that the description of the operation of Figs. 1 and 2 is equally pertinent to loop-resistance measurements made independently from either the primary control repeater 10 or the secondary control repeater 11, or simultaneously from both thereof.

Second step, the measuring current flowing in the circuit 16 is gradually increased to a predetermined value which serves only to operate the relay 53 located in the nearest unattended repeater at which the closure circuit was applied to the circuit 16. This is accomplished because the resistances 39, 39 embodied in the circuit 16 are proportioned to effect such operation. The operation of relay 53 closes its contacts 51, 52 and 62. The closing of contacts 51 and 52 applies battery 50 to the respective restoring coils 43 and 48 of the sensitive relays 33 and 35 which coils are energized to return the operated armature 45 of the sensitive relay 35 to normal, as it was the only operated armature and therefore the only one capable of being returned to normal. This restoring operation serves to interrupt the closure circuit including the resistances 60 and 61, individual or in combination, or none, connected in series with the respective contact members 41, 42, 46 and 47 of the sensitive relays 33 and 35, and to substitute therefor a short circuit which will be presently described.

Third step, the attendants at the respective primary and secondary control repeaters 10 and 11 again measure the loop resistance of the circuit 16. Now, such measurement would include the portion of the circuit 16 extending between the respective primary and secondary control repeaters 10 and 11 and the unattended repeater at which the closure circuit occurred together with the short circuit applied thereacross comprising leads 53, 56 and 57, closed contact 62 of operated relay 53, operating winding of relay 53 and terminal lead 66 of the latter.

Fourth step, both attendants note any difference between the loop-resistance measurements made in the first and third steps and further that such difference would be equivalent to the value of the resistance 60 or 61, individual or in combination, or none, connected in the closure circuit in series with one of the contact members 41, 42, 46 and 47 of the sensitive relays 33 and 35 as mentioned above under the first step. Thereafter, reference to resistance-distance will enable both attendants to determine (a) the unattended repeater at which the closure circuit was applied to the circuit 16, (b) whether the application of the closure circuit was due to a pilot current variation on either the EW or the WE coaxial conductor line, and (c) whether the strength of the pilot current was too high or too low. As there was 0-ohms resistance in the closure circuit in series with the contact member 47 of the sensitive relay 35, reference to Table A above will show that this indicates that the strength of the pilot current on the EW coaxial conductor line was too high.

Fifth step, the measuring current of the circuit 16 is reduced to a certain value which is insufficient to maintain the relay 53 in the operated condition and therefore this relay is returned to the unoperated condition. If the application of the closure circuit to the circuit 16

were of an intermittent nature, or if such application were caused by a transient disturbance, then alarm 17 would fail to reoperate. However, if the operation of alarm 17 were repeated both attendants would conclude that the application of the closure circuit was occasioned by a permanent fault and would thereupon proceed to repeat the above testing steps for the purpose of properly identifying the location of the fault and the nature thereof. Thereafter, an attendant with the proper information at his disposal would proceed to the faulty unattended repeater to remove in a minimum time the cause giving rise to the application of the closure circuit to the circuit 16.

If the strength of the pilot current on EW coaxial conductor line 13 is decreased by 3 decibels or more below normal, the level of the rectified current supplied to the operating coil 34 of the relay 35 is decreased sufficiently to effect engagement between the armature 45 and the contact member 46. This connects to the circuit 16 a closure circuit comprising leads 68 and 56, lead 57 including 100-ohm resistance 61, lead 55, contact member 46 and armature 45 in engagement therewith, lead 58, terminal lead 65, operating winding of relay 53 and terminal lead 66. This operates the alarm 17 at the primary control repeater 10 to announce to the attendant thereat the occurrence of a fault at one of the unattended repeaters. Both attendants repeat the above loop-resistance measurements which, in this case, indicate by the difference between the results of the first and third steps that the 100-ohm resistance 61 was connected in the closure circuit in series with the contact member 46. Reference to the resistance-distance chart will show that this indicates that the pilot current on the EW coaxial conductor line 13 was too low.

If the strength of the pilot current on WE coaxial conductor line 12 is increased 3 decibels or more above normal, the level of the rectified current supplied to the operating coil 32 of the relay 33 is increased sufficiently to effect engagement between the armature 40 and contact member 42. This connects to the circuit 16 a closure circuit comprising leads 68 and 56, contact member 42 and armature 40 in engagement therewith, lead 58 including 200-ohm resistance 60, terminal lead 65, operating winding of relay 53 and terminal lead 66. This operates the alarm 17 at the primary control repeater 10 to announce to the attendant thereat the occurrence of a fault at one of the unattended repeaters. Both attendants repeat the above loop-resistance measurements which, in this case, indicate by the difference between the results of the first and third steps that the 200-ohm resistance 60 was connected in the closure circuit in series with the contact member 42. Reference to the resistance-distance chart will show that this indicates that the pilot current on the WE coaxial conductor line 12 was too high.

If the strength of the pilot current on WE coaxial conductor line 12 is decreased 3 decibels or more below normal, the level of the rectified current supplied to the operating coil 32 of the relay 33 is decreased sufficiently to effect engagement between the armature 40 and contact member 41. This connects to the circuit 16 a closure circuit comprising leads 68 and 56, lead 57 including the 100-ohm resistance 61, lead 55, contact member 41 and armature 40 in engagement therewith, lead 58 including the 200-ohm resistance 60, ter-

minal lead 65, operating winding of relay 53, and terminal lead 66. This operates the alarm 17 at primary control station 10 to announce to the attendant thereat the occurrence of a fault at one of the unattended repeaters. Both attendants repeat the above loop-resistance measurements which, in this case, indicate by the difference between the results of the first and third steps that the 100-ohm resistance 61 and the 200-ohm resistance 60 were both connected in the closure circuit in series with contact member 41. Reference to the resistance-distance chart will show that this indicates that the pilot current on the WE coaxial conductor line 12 was too low.

In the above it was assumed for illustration that a fault occurred at only one of the four unattended repeaters at one time so that the loop-resistance measurements computed independently from the respective primary and secondary control repeaters 10 and 11 would both serve to locate readily the same unattended repeater involved in the fault. The occurrence of similar faults simultaneously at unattended repeaters R₁ and R₄, or any combination of two unattended repeaters, would be located and identified in accordance with the procedure described above, except the attendant at primary control repeater 10 would measure the loop resistance only with respect to unattended repeater R₁ while the attendant at the secondary control repeater 11 would measure the loop resistance only in connection with unattended repeater R₄. This is so because increasing the current in the circuit 16 as pointed out in the second step would effect the operation only of the holding relay 53 embodied in the unattended repeater at which the closure circuit was effected and which is nearest to primary control repeater 10 or the secondary control repeater 11.

Accordingly, primary control repeater 10 would cause the operation of the holding relay 53 at unattended repeater R₁ while secondary control repeater 11 would cause the operation of the holding relay 53 at unattended repeater R₄. Hence, the loop-resistance measurements accomplished by the primary control repeater 10 would relate exclusively to unattended repeater R₁ and those performed at secondary control repeater 11 would relate exclusively to unattended repeater R₄. Reference to the resistance-distance chart would readily locate the unattended repeaters involved in the faults and identify the respective causes thereof.

The simultaneous occurrence of the same fault at unattended repeaters R₁, R₂ and R₄, or any combination of these or more unattended repeaters, would be located and identified in accordance with a combination of the routines mentioned previously in connection with faults involving (a) a single unattended repeater, and (b) two unattended repeaters. Thus, primary control repeater 10 would take care of the loop-resistance measurements relating to unattended repeater R₁; secondary control repeater 11 would handle the loop-resistance measurements concerning unattended repeater R₄; and either primary control repeater 10 or secondary control repeater 11 would dispose of the loop-resistance measurements involving unattended repeater R₂, depending on which of the former was first available for this purpose. Reference to the resistance-distance chart would readily locate the unattended repeaters involved in the faults and identify the respective reasons therefor.

In the case of two alarms occurring simultaneously in the same unattended repeater, the following conditions would exist:

Table B

Pilot current fault	Ohms resistance in series with contact members of sensitive relays 33 and 35
EW high—WE high	0 ω and 200 ω
EW low—WE low	100 ω and 300 ω
EW high—WE low	0 ω and 300 ω
EW low—WE high	100 ω and 200 ω

In each of the above cases, a loop-resistance measurement would show the condition of lowest resistance which measurement would serve to direct an attendant to the unattended repeater involved in the fault, in the manner indicated above, but only with the information that thereat a single fault existed. At the proper unattended repeater a routine check of both sensitive relays 33 and 35 would show the existence of the second fault. Thereupon, appropriate adjustments could be made to effect a clearance of both faults on the occasion of one trip on the part of the attendant.

What is claimed is:

1. In a signaling system comprising in combination two one-way paths, at least two attended repeaters and a plurality of unattended repeaters therebetween disposed in tandem in said paths, means at each repeater to transmit a plurality of signaling currents including a pilot current on each path, circuit means extending from each attended repeater to each unattended repeater, indicating means connected to said circuit means at an attended repeater, means at each unattended repeater responsive to certain changes of the condition of the pilot current on each one-way path to apply a closure circuit to said circuit means whereby said indicating means is actuated to announce the occurrence of said changes, and means to make resistance measurements on said circuit means to ascertain the location of said closure circuit; means included in said closure circuit to identify said certain changes of the condition of the pilot current and the one-way path involved in said closure circuit, said identifying means comprising a plurality of different amounts of resistance each of which amounts represents an increase or decrease in the strength of the pilot current on each one-way path, means responsive to a predetermined increase or decrease in the strength of the pilot current to dispose one or more said amounts of resistance in said closure circuit to make one resistance measurement and further means responsive to a change in the condition of said circuit means and said closure circuit to remove one or more said amounts of resistance from said closure circuit to make a second resistance measurement, the difference between both resistance measurements being equivalent to one or more said amounts of resistance representing a certain change of the condition of the pilot current on a certain one-way path.

2. In a signaling system comprising in combination two one-way paths, at least two attended repeaters and a plurality of unattended repeaters therebetween disposed in tandem in said paths, means at each repeater to transmit a plurality of signaling currents including a pilot current on each path, circuit means extending from each

attended repeater to each unattended repeater, indicating means connected to said circuit means at an attended repeater, means at each unattended repeater responsive to certain changes of the condition of the pilot current on each one-way path to apply a closure circuit to said circuit means whereby said indicating means is actuated to announce the occurrence of said changes, and means to make resistance measurements on said circuit means to ascertain the location of said closure circuit; means included in said closure circuit to identify said certain changes of the condition of the pilot current and the one-way path involved in said closure circuit, said identifying means comprising a plurality of resistance elements disposable singly or in combination in said closure circuit to represent a too high or too low condition of the pilot current on a certain one-way path, and electromagnetic means responsive to a change in the condition of said circuit means and said closure circuit to interrupt said closure circuit and to substitute therefor a short circuit, the difference between resistance measurements on said circuit means involving the conditions of the closure circuit and of the short circuit being equivalent to the resistance elements singly or in combination representing a certain change of the condition of the pilot current on a certain one-way path.

3. In a signaling system comprising in combination two one-way paths, at least two attended repeaters and a plurality of unattended repeaters therebetween disposed in tandem in said paths, means at each repeater to transmit a plurality of signaling currents including a pilot current on each path, circuit means extending from each attended repeater to each unattended repeater, indicating means connected to said circuit means at an attended repeater, means at each unattended repeater responsive to certain conditions of the pilot current to apply a closure circuit to said circuit means whereby said indicating means is actuated to announce the occurrence of said conditions, and means to make resistance measurements on said circuit means to ascertain the location of said closure circuit; means included in said closure circuit to identify said certain conditions of the pilot current and the one-way path involved in said closure circuit, said identifying means comprising a plurality of different amounts of resistance each of which amounts represents a certain condition of the pilot current on a certain one-way path, electromagnetic means responsive to a certain condition of the pilot current in each one-way path to connect one or more amounts of resistance in the closure circuit to make one resistance measurement and further electromagnetic means responsive to a change in the condition of the closure circuit to remove the one or more amounts of resistance therefrom to make a second resistance measurement, the difference between the two resistance measurements being equivalent to an amount of resistance representing a certain condition of the pilot current on a certain one-way path.

4. In a signaling system comprising in combination two one-way paths, at least two attended repeaters and a plurality of unattended repeaters therebetween disposed in tandem in said paths, means at each repeater to transmit a plurality of signaling currents including a pilot current on each path, circuit means extending from each attended repeater to each unattended repeater, indicating means connected to said circuit means at an attended repeater, means at

each unattended repeater responsive to a certain condition of the pilot current on each one-way path to apply a closure circuit to said circuit means whereby said indicating means is actuated to announce the occurrence of said condition, and means to make resistance measurements on said circuit means to ascertain the location of said closure circuit; means associated with said closure circuit to identify said certain conditions of the pilot current and the one-way path involved in said closure circuit, said identifying means comprising a plurality of different amounts of resistance each of which amounts represents a certain condition of pilot current on a certain one-way path, means responsive to a predetermined variation of the strength of the pilot current on a certain one-way path to connect one or more said amounts of resistance in said closure circuit, and means responsive to a change in the condition of said circuit means and the closure circuit applied thereacross to remove from said closure circuit said one or more amounts of resistance, the difference between resistance measurements including one or more said amounts of resistance and excluding one or more said amounts of resistance being equivalent to an amount of resistance representing a certain condition of the pilot current on a certain one-way path.

5. In a signaling system comprising in combination two one-way paths, at least two attended repeaters and a plurality of unattended repeaters therebetween disposed in tandem in said paths, means at each repeater to transmit a plurality of signaling currents including a pilot current on each path, circuit means extending from each attended repeater to each unattended repeater, indicating means connected to said circuit means at an attended repeater, means at each unattended repeater responsive to a certain condition of the pilot current on each one-way path to apply a closure circuit to said circuit means whereby said indicating means is actuated to announce the occurrence of said condition, and means connected to said circuit means at an attended repeater to make resistance measurements on said circuit means to ascertain the location of said closure circuit, means included in the closure circuit to identify said certain condition of the pilot current and the one-way path involved in said closure circuit, said identifying means comprising a plurality of different amounts of resistance each of which amounts represents a certain condition of the pilot current on a certain one-way path, electromagnetic means responsive to a predetermined variation in the strength of the pilot current on a certain one-way path to connect one or more

said amounts of resistance in the closure circuit to make one resistance measurement, and electromagnetic means responsive to a change of condition on said circuit means; and closure circuit applied thereacross to interrupt said closure circuit and to substitute therefor a short circuit to make a second resistance measurement, the difference between the two resistance measurements being equivalent to an amount of resistance representing the condition of the pilot current on a certain one-way path.

6. In a signaling system comprising in combination two one-way paths, at least two attended repeaters and a plurality of unattended repeaters therebetween disposed in tandem in said paths, means at each repeater to transmit a plurality of signaling currents including a pilot current on each path, circuit means extending from each attended repeater to each unattended repeater, indicating means connected to said circuit means at an attended repeater, means at each unattended repeater responsive to a certain condition of the pilot current on each one-way path to apply a closure circuit to said circuit means whereby said indicating means is actuated to announce the occurrence of said conditions, and means to make resistance measurements on said circuit means to ascertain the location of said closure circuit; means associated with said closure circuit to identify said certain condition of the pilot current and the one-way path involved in said closure circuit, said identifying means comprising a plurality of different amounts of resistance to represent different conditions of the pilot current on both one-way paths, a pair of sensitive electromagnetic relays arranged so that one thereof is connected to one one-way path and the second thereof to the other one-way path and operated in response to a predetermined variation in the strength of the pilot current on said one-way paths to connect one amount of resistance in the closure circuit, and a holding electromagnetic relay operated in response to a change in the condition of said circuit means and said closure circuit applied thereacross to return said operated sensitive relays to the unoperated condition thereby interrupting said closure circuit while at the same time applying a short circuit to said circuit means, the difference in resistance measurements involving said closure circuit and said short circuit being equivalent to an amount of resistance representing the condition of the pilot current and one-way path involved in the application of said closure circuit to said circuit means.

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