Oct. 29, 1935. E. I. GREEN ET AL 2,018,850

UNATTENDED REPEATER SYSTEM

Filed June 9, 1934 2 Sheets-Sheet 1

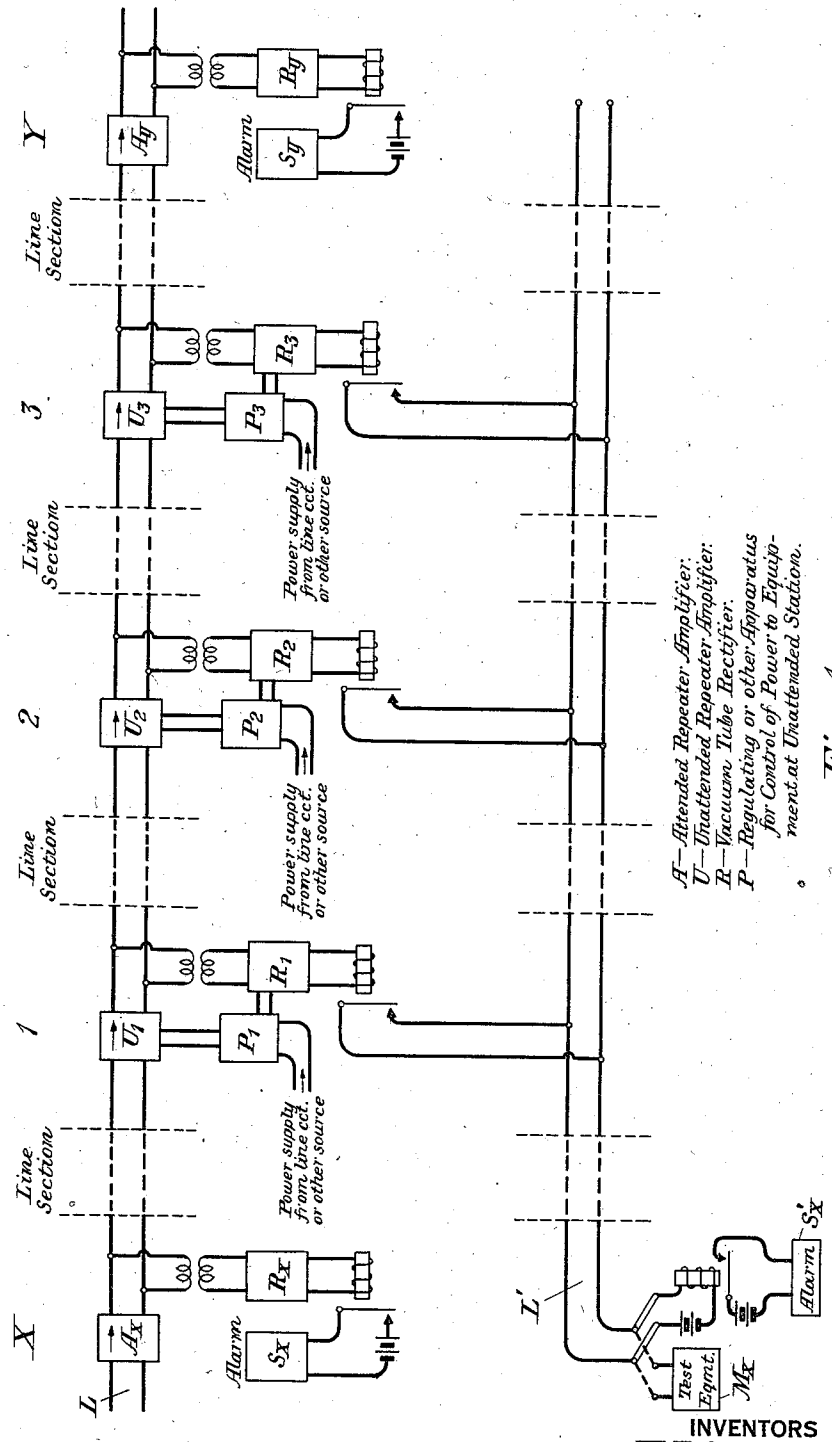

Fig. 1

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UNATTENDED REPEATER SYSTEM

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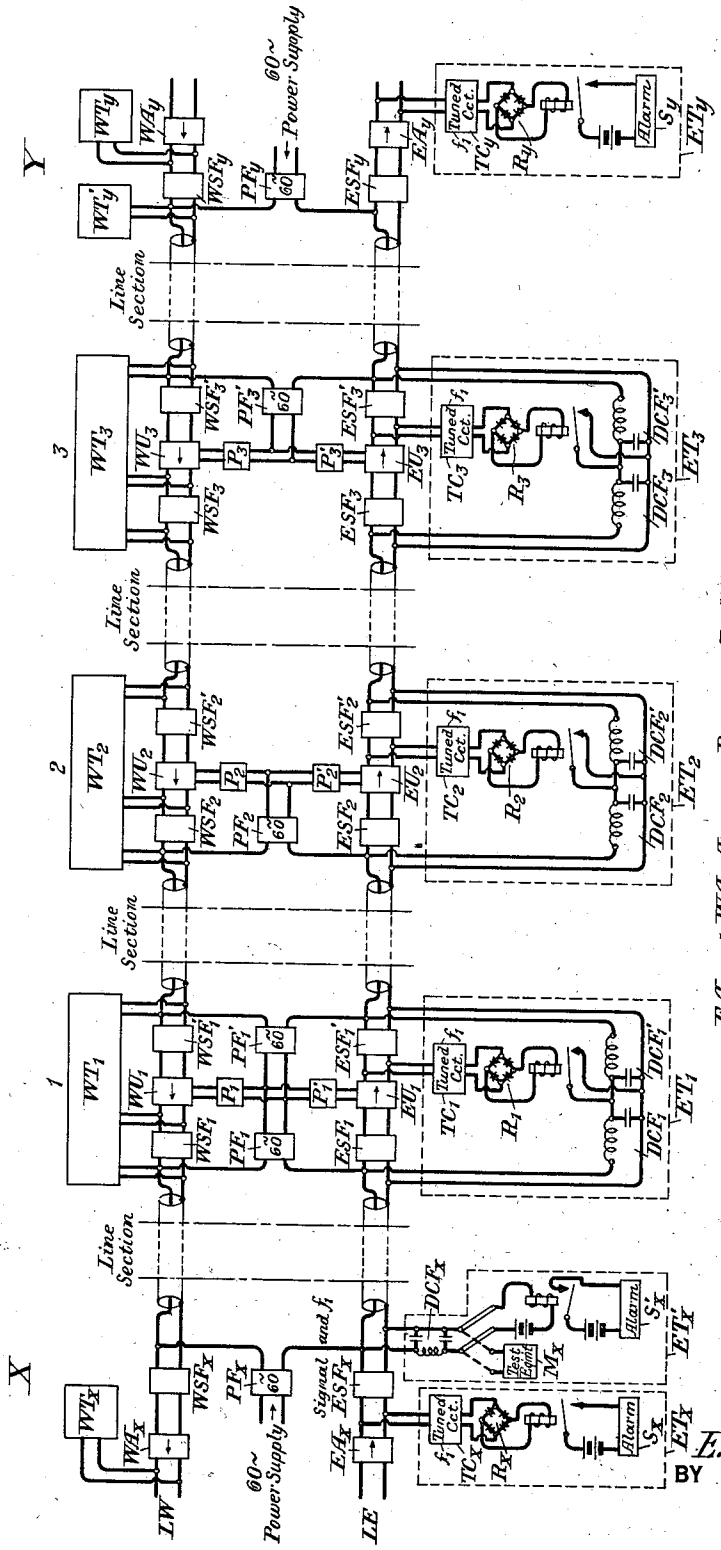

EA and WA- Attended Repeater Amplifiers.
EU and WU- Unattended Repeater Amplifiers.
ESF and WSF- Signal Filters.
PF - Power Filters.
DCF - Direct Current Filters.
TC - Tuned Circuit.
P - Transforming and Rectifying Apparatus for Power Supply to Amplifier.
R - Rectifier.

Fig. 2

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UNATTENDED REPEATER SYSTEM

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Application June 9, 1934, Serial No. 729,922

19 Claims. (Cl. 177—311)

This invention relates to transmission systems and more particularly to systems involving unattended repeater stations.

In the development of new types of transmission systems, particularly those employing wide ranges of frequencies, it is desirable to employ repeaters spaced at more frequent intervals. Because of the large number of repeaters involved, it is desirable that some of the repeaters be left unattended especially as repeaters have been developed which are sufficiently reliable in performance to be left unattended in suitable housings for considerable periods of time.

Regardless of the degree of reliability which is attained in the development of such unattended repeaters, however, the possibility of an occasional failure can never be entirely ruled out. Where more than one unattended repeater is employed between adjacent attended stations, it is desirable, in the event of failure of one of the unattended repeaters, to have available some means whereby the attendant at an attended repeater station may readily determine which unattended repeater is inoperative. It is one of the purposes of the present invention to provide facilities whereby this information may be obtained at attended repeater points.

The indication at the attended repeater point may be based upon the ability of the unattended repeater to amplify (*a*) the voice, television or other signals transmitted; or (*b*) the indication may be based upon the ability of the amplifier to transmit a pilot frequency or frequencies.

In a system having so few communication channels superimposed on it that the signals passing through the unattended repeater will be intermittent in character, it would be preferable to base the indication upon a pilot frequency or frequencies which are continuously transmitted.

Various types of signaling systems for indicating failure of a repeater and for determining the location of the repeater which has failed, may be provided. For example, the system may be arranged to transmit continuously through the unattended repeaters an alternating current which may be either the normal signaling currents passing over the system or a special pilot frequency. Each unattended repeater may be so related to a direct current path common to all of the unattended repeaters of the group, that upon failure of the repeater to operate, a change will be produced in the condition of the direct current path thereby producing a signal at an attended repeater station. The attendant upon observing the signal may then test over the direct current path to determine the point at which the change in condition has occurred, as, for example, by making resistance measurements.

The invention may also be embodied in an arrangement in which, when the repeater fails, the location of the repeater may be indicated at an attended station directly, without the necessity of any testing operation. For example, instead of using a direct current path, a plurality of pilot frequencies, one corresponding to each unattended repeater, may be transmitted over the circuit from the attended station through the various unattended stations. Each unattended station is arranged to exercise control over the pilot frequency assigned to that particular station, and upon the failure of a particular unattended repeater that repeater will be identified by the fact that the pilot frequency corresponding thereto produces no indication at the indicating point.

Also, the invention may be embodied in an arrangement in which, instead of transmitting separate pilot frequencies or other signaling currents for testing purposes over each one-way transmission circuit of a two-way system, as is contemplated in the arrangements above described, a combined indicating arrangement for both directions may be used. For example, failure of the unattended repeater for either direction at a given repeater station may be caused to produce at an attended repeater an indication of the station at which the failure has taken place. An additional signal individual to each directional path and common to all of the unattended repeaters in tandem in that path, may be used to indicate failure of any repeater in the path. By means of the two indications the individual repeater which has failed may be ascertained.

While only arrangements corresponding to the first type of system above mentioned are disclosed herein, the general principles of the invention may be embodied in organizations of types other than those illustrated, without departing from the spirit of the invention as defined in the claims appended hereto. Systems of the second type above described, are disclosed and claimed in the joint application of E. I. Green and F. A. Leibe, Serial No. 729,923, filed June 9, 1934, which bears a divisional relation to the present application. Systems of the third type above described, are disclosed and claimed in an application of F. A. Leibe, Serial No. 729,921, filed June 9, 1934.

The invention will now be more fully under-

stood from the following detailed description thereof when read in connection with the accompanying drawings in which Figure 1 illustrates an embodiment of the invention employing an auxiliary direct current path for indicating the location of the repeater which has failed, and Fig. 2 illustrates an arrangement in which the direct current path for indicating the location of the repeater which has failed, is derived from the transmission circuit itself.

Referring to Fig. 1, L designates a portion of a transmission circuit having attended repeater stations X and Y with unattended repeater stations at points 1, 2 and 3 between stations X and Y. An attended repeater A_x is located at station X, and associated with the output of said repeater through a suitable transformer is a rectifier R_x. As long as transmission passes through the repeater A_x the rectifier R_x rectifies a portion of the received transmission and thereby energizes a relay. The received currents to be rectified may be either normal signaling currents or, as previously stated, where the number of channels normally transmitted is too small to assure that some signal will be transmitted at all times, a pilot frequency may be transmitted over the line L to hold up the relay. If the repeater A_x or any portion of the transmission circuit ahead of said repeater should fail, there will be no current in the output of the rectifier R_x and the relay will be released to actuate the alarm signal S_x.

At station Y a similar rectifier R_y is associated through a transformer with the output of the attended repeater A_y, and controls through its relay an alarm signal S_y. The operation of the alarm S_y will indicate failure of the repeater A_y, or failure in the circuit ahead of the repeater A_y.

At stations 1, 2 and 3, unattended repeaters U_1, U_2 and U_3, are provided. A rectifier R_1 is associated by means of a transformer, with the output of the unattended repeater U_1 and rectifies a portion of the output thereof to hold up a relay. Similarly, a rectifier R_2 is associated with the output of the repeater U_2, and a rectifier R_3 is associated with the output of the repeater U_3. Power for supplying the filament and other operating currents to the repeaters and rectifiers, may be supplied either from a local source or from the line circuit L itself, where the line circuit is arranged to transmit the power. The power thus supplied at station 1 passes through apparatus P_1 for regulating the control of the power to be supplied, thence to the repeater U_1 and the rectifier R_1 over the two paths indicated in the drawings. Apparatus P_1 may be of any well known type of power supply equipment. Similar regulating equipment P_2 and P_3 are provided at stations 2 and 3.

In order to indicate failure of an unattended station, and to enable an attendant at an attended station to locate the position of the repeater which has failed, an auxiliary direct current path L' is provided and associated with one end of this path, at the station X, for example, is a direct current relay whose armature controls an alarm signal S_x'. Each of the relays in the output of one of the rectifiers R_1, R_2 and R_3, by means of its contact controls a short circuit for the direct current path L'. Consequently, if one of the unattended repeaters as, for example, U_2, should fail, the rectifiers R_2 and R_3 will no longer be supplied with current to rectify, and, consequently, the relays will release and close short circuits across the path L' at stations 2 and 3. This causes a signal at station X, and also causes the alarm S_x' to operate. The attendant at station X upon observing this alarm, will then connect the testing equipment M_x to the path L' to locate the nearest point along the path L' at which the short circuit was applied. The testing equipment M_x may be of any known type, such as an ordinary Wheatstone bridge, for making a resistance measurement which will indicate the location of the short circuit. The attendant thus learns that the trouble is at station 2 and a maintenance man may be sent to station 2 to overcome the difficulty.

As already stated, the rectifiers and alarms such as S_x and S_y, associated with the attended repeaters, indicate to the attendant at such repeater that signal currents passing his station have been interrupted. This makes it possible for the attendant who receives the alarm produced by S_x' and which indicates repeater failure, to check with the next succeeding attended station and thereby single out those infrequent cases where the alarm produced by S_x' results merely from failure in the auxiliary rectifier circuit at the unattended repeater station, and not from failure in the main transmission path.

The arrangement above described provides for transmission in one direction only, and it will be understood that for the path transmitting in the opposite direction the equipment may be duplicated.

Fig. 2 shows an arrangement somewhat similar to that of Fig. 1, but in this case the direct current path is derived from the transmission circuit itself. Also, the transmission circuit is employed for transmitting the power supply to the various attended repeaters. In Fig. 2 two transmission paths LE and LW are shown for transmitting in opposite directions. Each of these paths is shown as comprising a concentric conductor type of transmission circuit in which an outer cylindrical conductor surrounds and acts as the return conductor for an inner conductor which may also be cylindrical. Attended repeaters WA_x and EA_x are associated with the lines LW and LE at station X, and, similarly, attended repeaters WA_y and EA_y are associated with the lines at station Y. Unattended repeaters WU_1 and EU_1 are associated with lines LW and LE, respectively, at station 1, and, similarly, unattended repeaters WU_2 and EU_2 are located at station 2. Likewise, unattended repeaters WU_3 and EU_3 are located at station 3.

In the system shown it is contemplated that a pilot frequency f_1 will be at all times transmitted over the circuit LE, for example, and, of course, a similar pilot frequency will be transmitted in the opposite direction over the circuit LW. At the station X the equipment ET_x is bridged across the output of the repeater EA_x for indicating failure. Some of the energy of the frequency f_1 is selected from the output of the repeater EA_x by means of the tuned circuit TC_x and rectified by means of a rectifier R_x to hold a relay operated. If any failure occurs in the repeater EA_x or in the line ahead of said repeater, the relay associated with the rectifier will release its armature and actuate the alarm S_x to notify the attendant. A similar equipment WT_x is associated with the output of the attended repeater WA_x.

Likewise, at the station Y an equipment ET_y comprising a tuned circuit TC_y, rectifier R_y and alarm signal S_y, is associated with the output of the attended repeater EA_y to indicate failure of said repeater or failure in the line ahead of said

repeater. Again, as at station X, similar equipment WT_y is associated with the output of the unattended repeater WA_y at station Y.

Unattended repeaters EU_1, EU_2 and EU_3 are included in the line LE at unattended stations 1, 2 and 3, respectively. Similar unattended repeaters WU_1, WU_2 and WU_3 are included in the line LW at the unattended stations 1, 2 and 3, respectively. The operating power current, such as the filament current, etc., of the repeaters at stations 1 and 2, is supplied from the attended station X over the inner conductors of lines LW and LE. Similarly, the operating power current for the repeaters at station 3 are supplied over the inner conductors of the lines from station Y.

The power supply at station X is connected through a filter PF_x adapted to pass the 60 cycle power current to the two inner conductors, respectively, of the lines LW and LE. Filters WSF_x and ESF_x are included in the lines ahead of the power connections. These filters serve to pass the signal frequencies and the pilot frequencies, such as frequency f_1, but discriminate against the power currents and direct currents, which may be transmitted over the line as described later. At station 1 the power currents are bypassed around the repeaters WU_1 and EU_1 by bypass connections from the inner conductors through power filters PF_1 and PF_1' to connections leading, respectively, to the two inner conductors of the next section of each of the lines LW and LE. Between the filters PF_1 and PF_1' connections lead to the power regulating apparatus P_1 which may include transforming and rectifying equipment for supplying power to the amplifier WU_1. Similarly, connections lead to the power regulating equipment P_1' for repeater EU_1. Filters WSF_1 and WSF_1' are arranged on either side of the repeater WU_1 to pass the signal and pilot frequencies, but to discriminate against 60 cycle power current and against direct current. Likewise, filters ESF_1 and ESF_1' are arranged on either side of the repeater EU_1 for the same purpose.

At station 2 the power connections lead from the inner conductors of each of the transmission lines through a power filter PF_2 to power regulating apparatus P_2 and P_2' for supplying power to the repeaters WU_2 and EU_2. No connections are provided at station 2 for carrying the power up to the next sections of the lines LW and LE beyond station 2, as the power for station 3 is supplied from the other end of the system. Filters WSF_2 and WSF_2' are connected in the line LW on either side of the repeater WU_2 for discriminating against 60 cycle power and direct current while passing the signal and power frequencies. Likewise, filters ESF_2 and ESF_2' are connected in the line LE on either side of the repeater EU_2 for a similar purpose.

For supplying power to station 3, 60 cycle power is connected through the filter PF_y at station Y to the inner conductors of the lines LW and LE, and is transmitted over said inner conductors to station 3 where taps are taken off from the inner conductor and led through the power filter PF_3' to the power regulating equipment P_3 and P_3' which is used for supplying the power to the repeaters WU_3 and EU_3, respectively. Here, also, the power is not passed beyond station 3 to the conductors leading to station 2 because station 2 is supplied with power from station X. Filters WSF_y and ESF_y are provided in the lines LW and LE at station Y for passing signal and pilot frequencies while discriminating against 60 cycle current and direct current. Also, filters WSF_3 and WSF_3' are inserted on either side of the repeater WU_3, and filters ESF_3 and ESF_3' are inserted on either side of the repeater EU_3 in a manner similar to that described in connection with station 1 for the same purpose.

In order to signal the failure of an unattended repeater and to determine the location of said repeater by testing over a direct current path, equipment ET_x' is bridged across the conductors of the line LE at station X. This equipment includes a filter DCF_x for passing direct current, but discriminating against alternating current, the filter being connected by means of a switch to a direct current relay and source of current for operating an alarm S_x' or to the testing equipment M_x for making resistance measurements to determine the location of the fault. This testing equipment may be, for example, a Wheatstone bridge arrangement as already stated in connection with Fig. 1. Equipment similar to ET_x' is bridged across the line LW at station Y, as shown at WT_y', for signaling the failure of a repeater in the line LW and for locating the repeater which has failed.

Apparatus is provided at each of the stations 1, 2, and 3, for segregating the direct current path from the line conductors, and for short-circuiting or otherwise controlling the path in response to failure of the repeater. For example, at station 1 there are associated with the line LE bridge connections which lead through direct current filters DCF_1 and DCF_1' to bridge connections across the next section of the concentric conductor. The two sets of bridge connections are made on either side of the filters ESF_1 and ESF_1' of the main line, so that direct current may flow over the concentric conductors and around the repeater EU_1, through the bridge or by-pass just described. On the output side of the repeater EU_1 a tuned circuit TC_1 is connected for selecting the pilot frequency f_1, and this tuned circuit is connected to a rectifier R_1 for rectifying the pilot frequency, the rectified current operating a relay which controls a short-circuit which may be applied to the by-pass between filters DCF_1 and DCF_1'. The equipment ET_2 at station 2, and the equipment ET_3 at station 3, is similar to the equipment ET_1, in detail, and need not be further described. Similar equipment WT_1, WT_2 and WT_3 is connected to the line LW at stations 1, 2, and 3 for signaling and testing in connection with the unattended repeaters of line LW.

The derived direct current path for the line LE may now be traced from the relay and battery of equipment ET_x' at station X, through the filter DCF_x, over the line section leading to station 1, thence over the by-pass including filters DCF_1 and DCF_1', over the line section leading to station 2, over the corresponding by-pass at that station, over the line section leading to station 3, and then over the by-pass around the repeater EU_3 at that station to the line section extending to station Y. Now let us suppose that the repeater EU_2 fails at station 2. The pilot frequency f_1 which has been received and which when rectified by the rectifier R_2 maintained the relay in the output circuit of the rectifier energized, will no longer be received. The relay therefore falls off and closes the circuit between the two filters DCF_2 and DCF_2', thus completing a direct current path from that point over the line section extending to station 1, over the by-pass at station 1, and through the filter DCF_x at station X to operate the relay which closes the cir-

cuit of alarm S_X', thereby notifying the attendant that a repeater has failed. Likewise, the relay at station 3 will be released, closing the circuit between the two filters DCF_3 and DCF_3'. The attendant then switches the current of the direct current path to the testing equipment M_X and by resistance measurements locates the nearest point at which the direct current path has been short-circuited, which will be at station 2, and thus ascertains that the repeater EU_2 has failed.

The equipment ET_X and ET_Y associated with the line LE at stations X and Y, respectively, indicates a failure in the circuit LE ahead of the point at which the respective pieces of equipment are bridged to the line. This makes it possible, as in connection with Fig. 1, for the attendant to check with the next succeeding attended station and determine whether the signal received by the equipment ET_X' has resulted merely from the failure of the auxiliary rectifying equipment associated with the unattended repeater stations.

The received indication of failure may represent either the failure of a repeater or the failure of the line section immediately preceding it. It would be possible to distinguish between these two conditions by tests made for failure of the line itself in the manner ordinarily employed for telephone cables.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated, without departing from the spirit of the invention as defined by the following claims.

What is claimed is:

1. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, means at each attended station to indicate a failure along the line one way therefrom, a plurality of auxiliary circuit paths extending the one way from each such attended station to said unattended repeater stations, means responsive to the failure of a repeater at an unattended repeater station to produce a circuit change characteristic of said station upon certain of said auxiliary circuit paths, and means at an attended station to indicate the repeater station at which the failure has occurred.

2. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, means at each attended station to indicate a failure along the line one way therefrom, a plurality of auxiliary circuit paths extending the one way from each such attended station to said unattended repeater stations, means responsive to the failure of a repeater at an unattended repeater station to produce a circuit change characteristic of said station upon certain of said auxiliary circuit paths, and means adapted to be associated with said auxiliary circuit paths at an attended station to indicate that an unattended repeater has failed and to indicate the repeater station at which the failure has occurred.

3. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, a plurality of auxiliary circuit paths extending from an attended station to said unattended repeater stations, means responsive to the failure of a repeater at an unattended repeater station to produce a circuit change characteristic of said station upon certain of said auxiliary circuit paths, means associated with the transmission line at an attended station to indicate that a failure has occurred ahead of the attended station, and means at an attended station to indicate the repeater station at which the failure has occurred.

4. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, a plurality of auxiliary circuit paths extending from an attended station to said unattended repeater stations, means responsive to the failure of a repeater at an unattended repeater station to produce a circuit change characteristic of said station upon certain of said auxiliary circuit paths, means associated with the transmission line at an attended station to indicate that a failure has occurred ahead of the attended station, and means adapted to be associated with said auxiliary circuit paths at an attended station to indicate that an unattended repeater has failed and to indicate the repeater station at which the failure has occurred.

5. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, a direct current circuit extending from an attended station to each of said unattended repeater stations, respective relays at the unattended stations, electrical circuit connections to each such relay from the output side of the corresponding repeater, means associated with each unattended repeater station and responsive to the operation of a relay thereat to produce a change in the condition of said direct current circuit at said station, and means associated with said direct current circuit at an attended station to indicate that a repeater has failed.

6. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, a direct current circuit extending from an attended station to each of said unattended repeater stations, respective relays at the unattended stations, electrical circuit connections to each such relay from the output side of the corresponding repeater, means associated with each unattended repeater station, and responsive to the operation of a relay thereat to produce a change in the condition of said direct current circuit at said station, means associated with said direct current circuit at an attended station to indicate that a repeater has failed, and means associated with said direct current circuit at an attended station to indicate the station at which the failure has occurred.

7. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, a direct current circuit extending from an attended station to each of said unattended repeater stations, means associated with each unattended repeater station and responsive to the failure of a repeater thereat to produce a change in the condition of said direct current circuit at said station, means associated with the transmission line at an attended station to indicate that a failure has occurred ahead of said attended station, and means associated with said direct current circuit at an attended station to indicate that a repeater has failed.

8. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, a direct current circuit extending from an attended station to each of said unattended repeater stations, means associated with each unattended repeater station and responsive to the failure of a repeater thereat to produce a change in the condition of said direct current circuit at said station, means associated

with the transmission line at an attended station to indicate that a failure has occurred ahead of said attended station, means associated with said direct current circuit at an attended station to indicate that a repeater has failed, and means associated with said direct current circuit at an attended station to indicate the station at which the failure has occurred.

9. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, an auxiliary line extending from an attended station to each of said unattended repeater stations, respective relays at the unattended stations, electrical circuit connections to each such relay from the output side of the corresponding repeater, means associated with each unattended repeater station and responsive to the operation of a relay thereat to produce a change in the condition of said auxiliary line at said station, and means associated with said auxiliary line at an attended station to indicate the unattended repeater station at which the failure has occurred.

10. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, an auxiliary line extending from an attended station to each of said unattended repeater stations, respective relays at the unattended stations, electrical circuit connections to each such relay from the output side of the corresponding repeater, means associated with each unattended repeater station and responsive to the operation of a relay thereat to produce a change in the condition of said auxiliary line at said station, and means adapted to be associated with said auxiliary line at an attended station to indicate that an unattended repeater has failed and to indicate the repeater station at which the failure has occurred.

11. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, an auxiliary direct current line extending from an attended station to each of said unattended repeater stations, respective relays at the unattended stations, electrical circuit connections to each such relay from the output side of the corresponding repeater, means associated with each unattended repeater station and responsive to the operation of a relay thereat to produce a change in the condition of said auxiliary direct current line at said station, and means associated with said auxiliary direct current line at an attended station to indicate in response to such change of condition that a repeater has failed.

12. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, an auxiliary direct current line extending from an attended station to each of said unattended repeater stations, respective relays at the unattended stations, electrical circuit connections to each such relay from the output side of the corresponding repeater, means associated with each unattended repeater station and responsive to the operation of a relay thereat to produce a change in the condition of said auxiliary direct current line at said station, means associated with said auxiliary direct current line at an attended station to indicate in response to such change of condition that a repeater has failed, and means associated with said auxiliary direct current line at an attended station to indicate the station at which the failure has occurred.

13. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, an auxiliary test circuit superposed on said transmission line and extending from an attended station to each of said unattended repeater stations, means associated with each unattended repeater station and responsive to the failure of a repeater thereat to produce a change in the condition of said superposed circuit without affecting other channels of said transmission line, and means associated with said superposed circuit at an attended station to indicate the unattended repeater station at which the failure has occurred.

14. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, an auxiliary test circuit superposed on said transmission line and extending from an attended station to each of said unattended repeater stations, means associated with each unattended repeater station and responsive to the failure of a repeater thereat to produce a change in the condition of said superposed circuit without affecting other channels of said transmission line, and means adapted to be associated with said superposed circuit at an attended station to indicate that an unattended repeater has failed and to indicate the repeater station at which the failure has occurred.

15. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, an auxiliary direct current test circuit superposed on said transmission line and extending from an attended station to each of said unattended repeater stations, means associated with each unattended repeater station and responsive to the failure of a repeater thereat to produce a change in the condition of said superposed circuit without affecting other channels of said transmission line, and means associated with said superposed direct current circuit at an attended station to indicate in response to such change of condition that a repeater has failed.

16. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, an auxiliary direct current test circuit superposed on said transmission line and extending from an attended station to each of said unattended repeater stations, means associated with each unattended repeater station and responsive to the failure of a repeater thereat to produce a change in the condition of said superposed circuit without affecting other channels of said transmission line, means associated with said superposed direct current circuit at an attended station to indicate in response to such change of condition that a repeater has failed, and means associated with said superposed direct current circuit at an attended station to indicate the station at which the failure has occurred.

17. In a signaling system, a transmission line extending both ways from an attended repeater station through a plurality of unattended repeater stations on each side, means responsive to the failure of a repeater one way from the attended station to indicate such failure, and means responsive to the failure of a repeater the other way to indicate such failure and to indicate the particular station at which the failure occurred.

18. In a signaling system, a one-way transmission line, an attended repeater station on that line, unattended repeater stations on the line on both sides of the attended station, means at the attended station to indicate the failure of a repeater on the incoming side, and means at the

attended station to indicate the failure of a repeater on the outgoing side.

19. In a signaling system, a one-way transmission line, an attended repeater station on that line, unattended repeater stations on the line on both sides of the attended station, means at the attended station to indicate the failure of a repeater on the incoming side, and means at the attended station to indicate the failure of a repeater on the outgoing side and further to indicate the particular repeater station at which such failure occurs.

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