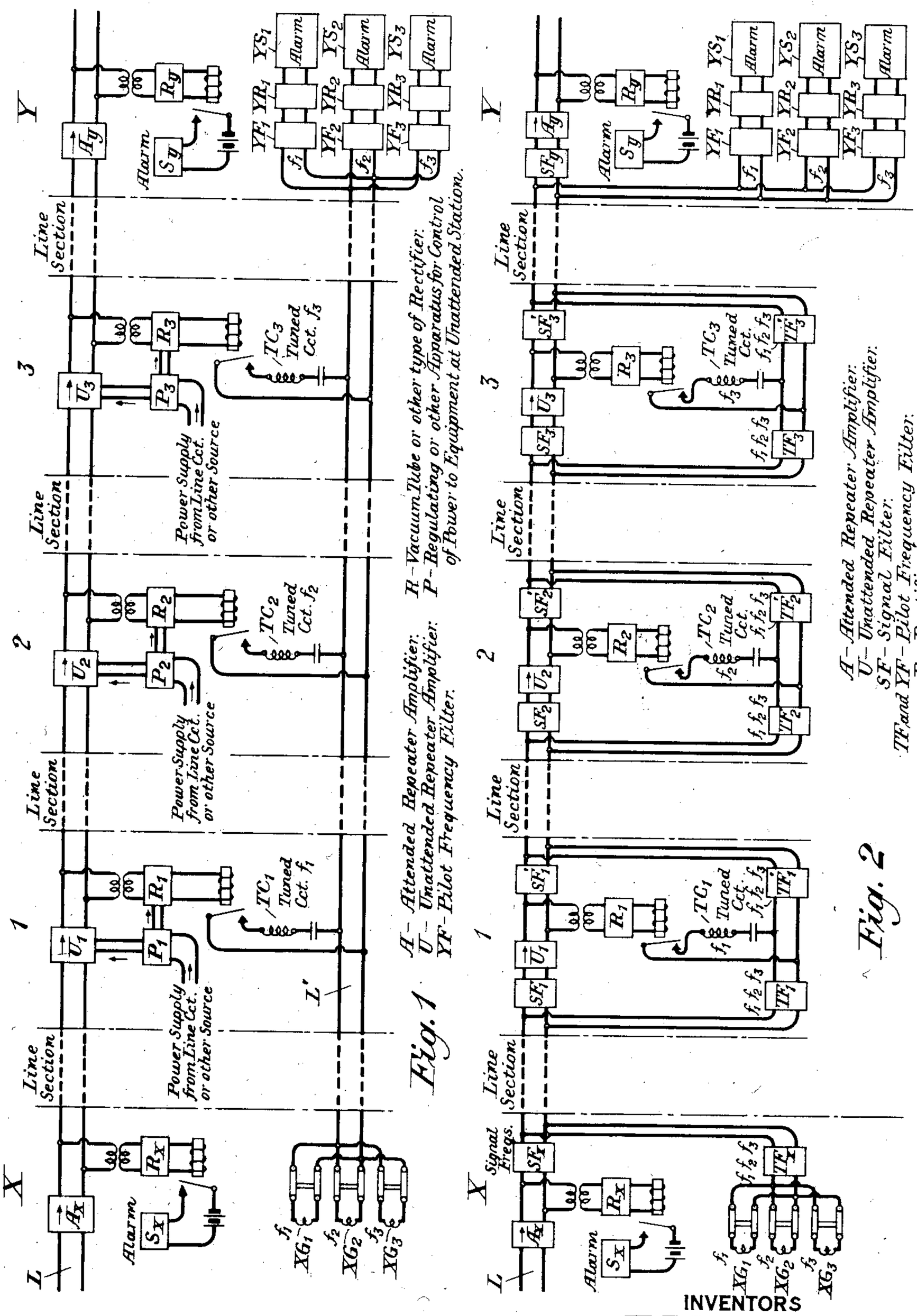
Oct. 29, 1935. E. I. GREEN ET AL 2,018,851

UNATTENDED REPEATER SYSTEM

Filed June 9, 1934 2 Sheets-Sheet 1



A- Attended Repeater Amplifier.
U- Unattended Repeater Amplifier.
YF- Pilot Frequency Filter.
R- Vacuum Tube or other type of Rectifier.
P- Regulating or other Apparatus for Control of Power to Equipment at Unattended Station.

Fig. 1

A- Attended Repeater Amplifier.
U- Unattended Repeater Amplifier.
SF- Signal Filter.
TF and YF- Pilot Frequency Filter.
R- Rectifier.

Fig. 2

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UNATTENDED REPEATER SYSTEM

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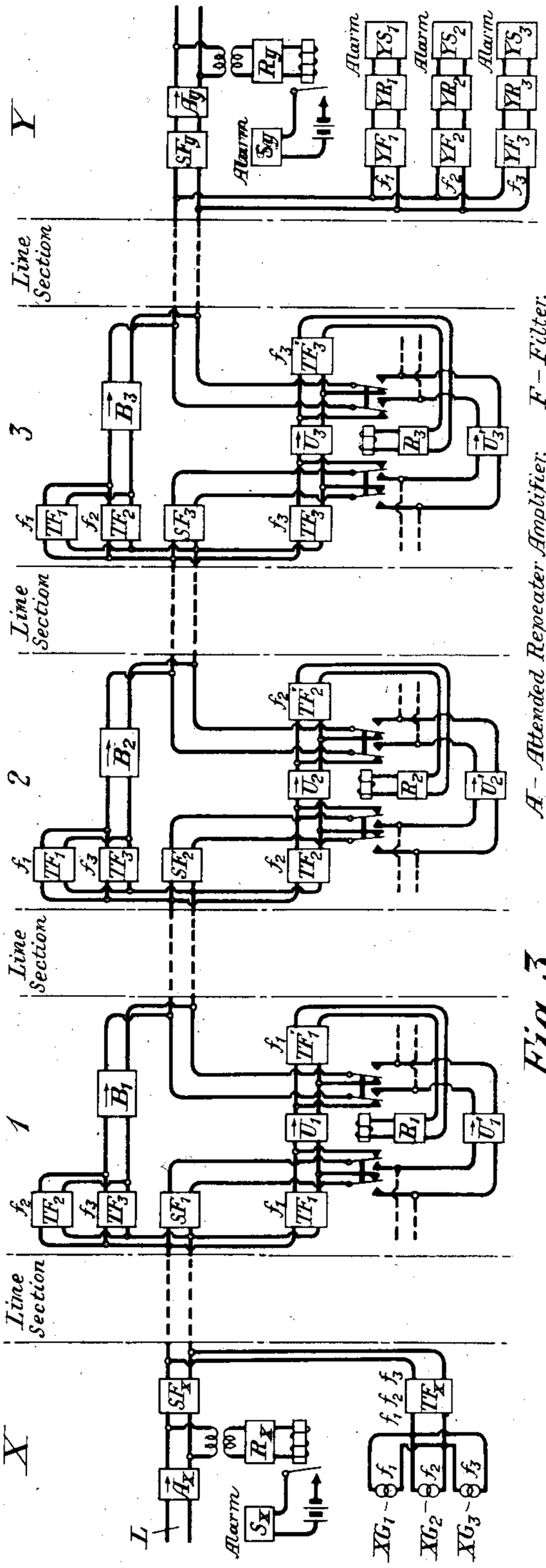
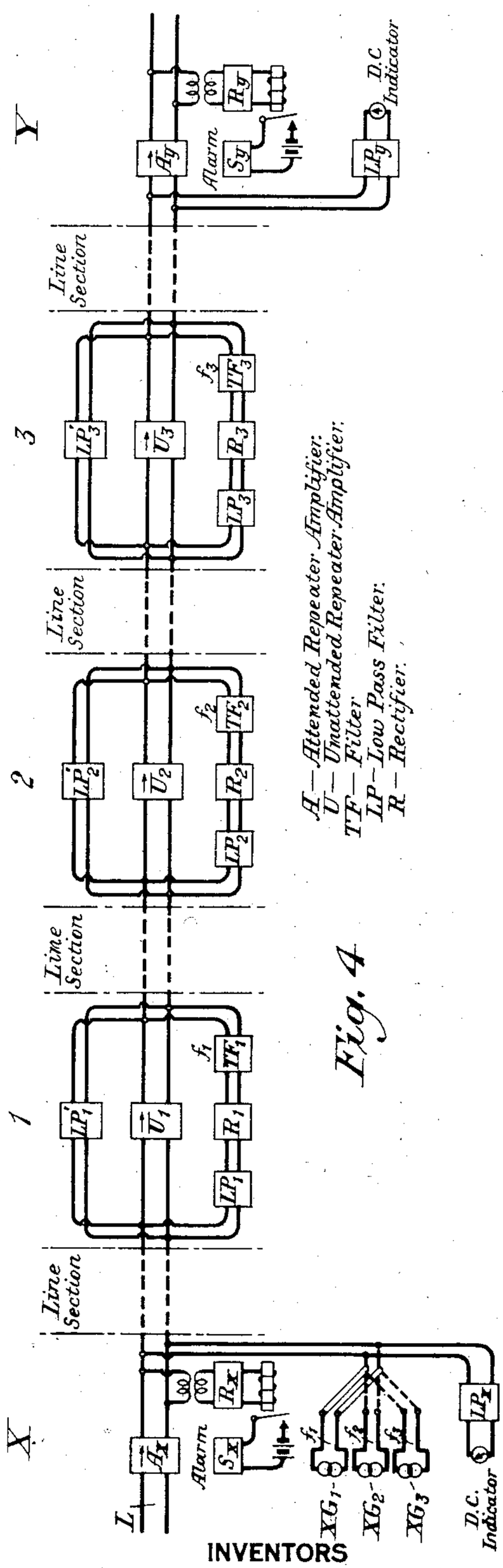


A – Attended Repeater Amplifier. *F – Filter.*
U – Unattended Repeater Amplifier. *R – Rectifier.*

Fig. 3



A – Attended Repeater Amplifier.
U – Unattended Repeater Amplifier.
TF – Filter
LP – Low Pass Filter.
R – Rectifier.

Fig. 4

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2,018,851

UNATTENDED REPEATER SYSTEM

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Application June 9, 1934, Serial No. 729,923

16 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 second 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 first type above described, are disclosed and claimed in the joint application of E. I. Green and F. A. Leibe, Serial No. 729,922 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 understood 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 path for transmitting alternating current signals to the attended station for indicating the location of an unattended repeater which has failed; Fig. 2 illustrates a similar system in which the alternating path for indicating the location of the repeater which has failed is superimposed upon the main signal transmission circuit; Fig. 3 illustrates a modified arrangement in which the repeater which has failed at an unattended station exercises a different kind of control over the alternating current path, and in which the failure of the repeater is also used to cut in an alternate repeater automatically until an attendant has had time to go to the unattended station to rectify the trouble; and Fig. 4 illustrates an arrangement in which pilot frequencies individual to each unattended repeater station are provided for locating the repeater which has failed by successively applying said frequencies to the circuit after the failure has been indicated by an alarm located at the attended station and common to all of the unattended stations.

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 equipments P_2 and P_3 are provided at stations 2 and 3.

In order to indicate failure of an unattended station as well as to indicate the location of the repeater which has failed, an auxiliary path L′ is provided. Associated with one end of this path at the station X three generators XG_1, XG_2 and XG_3 are provided, and these generators may be connected through switches to the line L′ in order to apply thereto frequencies f_1, f_2, and f_3 corresponding to the three unattended stations 1, 2 and 3. At attended station Y three filters YF_1, YF_2 and YF_3 selective of frequencies f_1, f_2, and f_3, respectively, are connected to the line L′. The individual frequencies thus selected are applied to rectifiers YR_1, YR_2 and YR_3. Alarms YS_1, YS_2 and YS_3 are associated with the rectifiers and may be operated by the direct current in the output circuit of the rectifiers in the same manner as the alarms S_x and S_y are operated. However, in order to simplify the drawings the relays in the output circuits of the rectifiers and the contacts controlled thereby, for the alarm circuits, are not illustrated in detail.

In order to control the frequencies transmitted over the line L′ to indicate repeater failure, tuned circuits are arranged to be bridged across the line L′ at each of the stations 1, 2, and 3. For example, at station 1 tuned circuit TC_1, tuned to the frequency f_1, is controlled by the relay of the rectifier R_1 so that when the relay fails the tuned circuit TC_1 is bridged across the line L′, thus providing a short circuit for the frequency f_1 so that this frequency will be substantially suppressed at the station Y and the rectifier YR_1 will actuate the alarm YS_1. Similarly, tuned circuit TC_2, tuned to the frequency f_2, may be bridged across the line L′ by the relay associated with the rectifier R_2 at station 2, and at station 3 the relay associated with the rectifier R_3 is arranged to connect tuned circuit TC_3, tuned to the frequency f_3, across the line L′.

Upon failure of one of the attended repeaters, as, for example, repeater U_2, the rectifier R_y will no longer receive current and, consequently, the alarm S_y will be actuated. Likewise, the rectifiers R_2 and R_3 at stations 2 and 3 no longer receive current and the relays in their outputs become deenergized thereby bridging the short circuits TC_2 and TC_3 across the line L′. This provides short circuit paths for frequencies f_2 and f_3 so that these frequencies are no longer transmitted to the station Y and the rectifiers YR_2 and YR_3 cause the alarms YS_2 and YS_3 to be actuated. This indicates at once to the attendant at station Y that the repeater U_2 has failed.

If a rectifier such as rectifier R_2 should fail while the repeater U_2 is still functioning properly, the tuned circuit TC_2 would be closed thereby causing the alarm YS_2 to indicate a failure of the repeater U_2. In this case, however, current will still be transmitted over the line L to the station Y and therefore the alarm S_y would not be operated. The attendant at station Y noting this fact would at once be informed that the trouble was not in the repeater U_2, but in the rectifier equipment.

The arrangement, as above described, is intended to provide a continuous circuit for indicating the location of a repeater failure. If it is desired, however, to save the expense of transmitting the frequencies f_1, f_2, and f_3 over the line L′ at all times, the switches associated with the

generators of those frequencies at the station X may be opened. In this case the failure of a repeater such as U_2 will be indicated at Y by the alarm S_y. The attendant at station Y can then communicate with the attended station X and have the attendant at such station connect the generators XG_1, XG_2 and XG_3 to the line L'. The fact that frequency f_1 is then received and frequencies f_2 and f_3 are not received, will indicate that the repeater U_2 is the one which has failed.

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, in general, illustrates an arrangement somewhat similar to Fig. 1, except that the test frequencies f_1, f_2, and f_3 are transmitted over the line L itself, instead of over an auxiliary circuit. In this case the rectifiers R_x and R_y with their corresponding alarms S_x and S_y are connected as in Fig. 1. Also, the rectifiers R_1, R_2, and R_3, together with their relays at stations 1, 2, and 3, are connected as in Fig. 1. The generators XG_1, XG_2 and XG_3 at station X are connected to the line L through a filter TF_x which passes frequencies f_1, f_2, and f_3 while discriminating against signaling or pilot frequencies transmitted over the line L. A filter SF_x is connected to the line L between the connection for the generators and the connection for the rectifier R_x, this filter serving to pass the various signal bands and the pilot frequency, if any, transmitted over the line L. Filter SF_x serves to prevent the frequencies f_1, f_2, and f_3 from being transmitted into the rectifier R_x and interfering with the proper functioning thereof.

At station 1 a by-pass for the pilot frequencies f_1, f_2, and f_3 is provided through filters TF_1 and TF_1' which pass the testing frequencies but discriminate against the signal bands and pilot frequency, if any, normally transmitted over the line L. Filters SF_1 and SF_1' are connected in the line L on either side of the repeater U_1 within the points at which the by-pass is connected in order to prevent the test frequencies f_1, f_2, and f_3 from transmitting through the repeater U_1. The relay in the output of the rectifier R_1 at station 1 is arranged to bridge a tuned circuit TC_1, tuned to the frequency f_1, across the by-pass between the filters TF_1 and TF_1', in a manner similar to that shown in Fig. 1.

At station 2 the by-pass is provided through filters TF_2 and TF_2' similar to the corresponding filters at station 1, and likewise, filters SF_2 and SF_2' are arranged on either side of the repeater U_2 to prevent the passage of the testing frequencies. The relay in the output circuit of the rectifier R_2 also controls a tuned circuit TC_2 adapted to provide a short circuit for the frequency f_2 in connection with the by-pass. Also, at station 3, a by-pass, including filters TF_3 and TF_3' similar to the corresponding filters at station 2, is provided in the line circuit on either side of the repeater U_3, these latter filters being similar to and performing the same function as the corresponding filters in stations 1 and 2. Also, the relay associated with rectifier R_3 controls a circuit tuned to the frequency f_3 and adapted to be bridged across the by-pass.

At station Y a filter SF_y is inserted in the line ahead of the repeater A_y and ahead of the filter a bridged connection is made which leads to filters YF_1, YF_2, and YF_3 and associated rectifiers and alarms similar to those bearing the same reference characters in Fig. 1.

If a repeater such as U_2 fails, no signal bands or pilot frequency will be transmitted to rectifier R_y, and the alarm S_y will be actuated indicating the failure of some repeater in the line L. Likewise, the rectifiers R_2 and R_3 will receive no current and their relays will permit their armatures to fall off causing the tuned circuits TC_2 and TC_3 to be bridged across the by-passes at stations 2 and 3. This provides short circuits for frequencies f_2 and f_3 which are no longer transmitted to station Y. Consequently, the alarm YS_2 and YS_3 will be actuated, indicating that repeater U_2 has failed.

As in Fig. 1, if merely the rectifier R_2 should fail, thereby causing the alarm YS_2 to be actuated at station Y, the attendant will know that the repeater U_2 is still functioning by reason of the fact that the alarms S_y and YS_3 will not be actuated. Also, as in Fig. 1, the frequencies f_1, f_2 and f_3 need not be applied to the circuit at all times, but merely switched to the circuit. When an alarm such as S_y is actuated to indicate a failure, as soon as the testing frequencies f_1, f_2 and f_3 are applied to the line after the fact of failure has been noted, the location of the repeater which has failed will be indicated by the proper alarms YS_1, YS_2 or YS_3 at station Y.

Fig. 3 shows an arrangement which is similar to that of Fig. 2, in that the line circuit L acts as a transmission path for the testing frequencies f_1, f_2, and f_3. In this case, however, the control over the test frequencies at the unattended repeater station is not effected by means of bridged tuned circuits, but, on the contrary, at each unattended repeater station one of the testing frequencies is passed through the unattended repeater while the other two are by-passed around it. Therefore, when the unattended repeater fails, the particular testing frequency which is permitted to pass through it is no longer transmitted over the line and this causes the operation of an alarm at the attended station. Fig. 3 also differs from Fig. 2 in that an arrangement is provided at each unattended station so that when the repeater fails an auxiliary or substitute repeater is connected in the line automatically.

In Fig. 3 the apparatus at stations X and Y is identical with that of Fig. 2. At station 1 a filter TF_1' passing frequency f_1 is bridged across the output of the repeater U_1 and the filter is connected to a rectifier R_1 having a relay in its output circuit which is normally energized, so long as the repeater U_1 remains operated, to connect the input and output terminals of the repeater in the line circuit L. When the repeater fails, however, the relay is released and its contacts disconnect the repeater U_1 and substitute the repeater U_1' in the line connections. A filter SF_1 is connected in the input line connection to pass the normal signaling bands to the repeater, this filter serving to prevent the passage of the testing frequencies f_1, f_2, and f_3.

The testing frequencies are taken off the line circuit through filters TF_1, TF_2 and TF_3, selective of the frequencies f_1, f_2, and f_3, respectively. The filter TF_1 which selects the frequency f_1 is connected to the input of the amplifier U_1 in parallel with the filter SF_1. The filters TF_2 and TF_3 are selective of frequencies f_2 and f_3, and are connected in the by-pass circuit around the repeater U_1. This by-pass circuit may include,

if desired, amplifier B_1 for amplifying the frequencies f_2 and f_3.

The arrangement at station 2 is similar to that at station 1, except that at station 2 frequencies f_1 and f_3 are selected and transmitted over the by-pass circuit through the amplifier B_2, and frequency f_2 is selected by the filter TF_2 and applied to the repeater U_2. Also, in this case, the filter TF_2' bridged across the output of the repeater U_2, is selective of frequency f_2, and it is the failure of this frequency which causes the operation of the rectifier R_2 and its associated relay.

So, also, the arrangement at station 3 is similar to station 1, except that frequencies f_1 and f_2 are selected and transmitted over the by-pass, and frequency f_3 is selected and applied to the input of the repeater U_3. Also, the rectifier R_3 is, in this case, responsive to the frequency f_3 because of the filter TF_3' connected in its circuit.

If desired, a single spare amplifier may be arranged so that it may replace the normal amplifier for either direction of transmission. This is indicated by the dotted line connections of U_1, U_2 and U_3 in Fig. 3.

If in Fig. 3 the repeater U_2 should fail at station 2 the frequency f_2 which is selected out at that station and transmitted through the repeater U_2, exclusive of frequencies f_1 and f_3, will no longer be transmitted. Consequently, the frequency f_2 will no longer be transmitted through the filter TF_2' and the relay associated with said rectifier will release its armatures thereby disconnecting the repeater U_2 from the line, and substituting therefor the repeater U_2'. In making this substitution it will be noted that the frequency f_2 will not be applied to the repeater U_2' as the filter TF_2' is connected to the input of the amplifier U_2 beyond the switching point. Frequencies f_1 and f_3 will be transmitted over the line to station Y as before.

At the moment the repeater U_2 fails, so that transmission over the line L is interrupted, the alarm S_y at station Y will be actuated momentarily until the repeater U_2' is substituted for the repeater U_2 so that transmission again takes place. Also, as soon as the repeater U_2 fails, so that frequency f_2 is no longer transmitted to station Y, the alarm YS_2 will be actuated indicating that the failure has occurred in station 2.

Fig. 4 illustrates an arrangement in which, as in the other cases, failure of an unattended station is indicated at an attended station by an alarm common to the unattended stations. The three signaling frequencies individual to the three unattended stations may then be applied to the line circuit, one at a time, to determine which repeater has failed. These frequencies are individually selected at the unattended stations and rectified to produce direct currents which are transmitted over the line to indicate whether or not the alternating testing frequency has been transmitted through its repeater. Failure of the repeater is indicated by failure of the direct current indication when the proper test frequency is applied.

In Fig. 4 the attended repeaters A_x and A_y, their associated rectifiers R_x and R_y, and the alarms S_x and S_y are the same as in Figs. 1, 2, and 3.

At station X the generators XG_1 XG_2 and XG_3, generating frequencies f_1, f_2, and f_3, are arranged to be connected to the line, one at a time, by means of a switch. At station 1 the frequency f_1 is selected by means of a filter TF_1 connected across the output of the repeater U_1, the output of this filter being connected to a rectifier R_1 which rectifies the selected frequency and produces a direct current which may be transmitted back to the line L ahead of the repeater U_1 through a filter LP_1 which passes direct current but discriminates against alternating current. This causes the direct current to be transmitted back over the line L to the bridge circuit in which is connected a filter LP_x and a direct current indicator, the filter LP_x serving to pass direct current but to reject alternating current.

Similarly, at station 2, the frequency f_2 is selected by filter TF_2 and applied to rectifier R_2 which is connected through filter LP_2 to the line L ahead of the amplifier U_2 to permit the rectified direct current to be transmitted back to station X. So, also, at station 3, the frequency f_3 is selected from the output of the repeater U_3 by filter TF_3 rectified by the rectifier R_3 and passed through the direct current filter LP_3 to the line L ahead of the repeater U_3.

In order that the rectified direct current at any one of the three unattended stations may also be transmitted over the line to the attended station Y, by-passes, including filters LP_1', LP_2', and LP_3' are bridged about the repeaters U_1, U_2 and U_3, respectively, these filters serving to pass direct current but rejecting alternating current.

Assuming that the repeater U_2 has failed, the signaling band or pilot frequency normally transmitted over the line L is no longer received at station Y and, consequently, the alarm S_y is actuated at said station. The attendant at said station will then inform the attendant at station X who proceeds to apply frequencies f_1, f_2, and f_3 to the line, one at a time, by means of the switch. When frequency f_1 is applied to the line the rectifier R_1 at station 1 rectifies it and causes a direct current to flow back over the line L to operate the direct current indicator at station X, and direct current also flows over the three by-passes to operate the direct current indicator at station Y. When, however, the frequencies f_2 or f_3 are applied to the line this frequency will not be received by the rectifiers R_2 or R_3 because of the failure of the repeater U_2, and hence, no rectified current will flow over the line to either attended station to operate the direct current indicator. Consequently, the attendant will know that the repeater U_2 has failed.

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 in the claims appended hereto.

What is claimed is:

1. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, means to transmit a plurality of alternating currents of different frequencies from an attended station to said unattended repeater stations, means whereby the failure of a repeater at an unattended repeater station produces an effect upon at least one of said alternating currents distinguishable from the effect produced by the failure of the repeaters at other unattended stations, and means at an attended station controlled by said alternating

currents to indicate the repeater station at which the failure has taken place.

2. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, means to transmit a plurality of alternating currents of different frequencies from an attended station to said unattended repeater stations, means whereby the failure of a repeater at an unattended repeater station produces an effect upon at least one of said alternating currents distinguishable from the effect produced by the failure of the repeaters at other unattended stations, and means at an attended station controlled by said alternating currents 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, means to transmit a plurality of alternating currents of different frequencies from an attended station to said unattended repeater stations, means whereby the failure of a repeater at an unattended repeater station produces an effect upon at least one of said alternating currents distinguishable from the effect produced by the failure of the repeaters at other unattended stations, 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 controlled by said alternating currents to indicate the repeater station at which the failure has taken place.

4. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, means to transmit a plurality of alternating currents of different frequencies from an attended station to said unattended repeater stations, means whereby the failure of a repeater at an unattended repeater station produces an effect upon at least one of said alternating currents distinguishable from the effect produced by the failure of the repeaters at other unattended stations, 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 controlled by said alternating currents to indicate the repeater station at which the failure has taken place.

5. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, means to transmit from an attended station alternating currents of different frequencies to said unattended repeater stations, there being one frequency corresponding to each unattended repeater station, means whereby the failure of a repeater at an unattended repeater station produces an effect upon the alternating current of frequency corresponding to that station, and means at an attended station responsive to such effect to indicate the repeater station at which the failure takes place.

6. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, means to transmit from an attended station alternating currents of different frequencies to said unattended repeater stations, there being one frequency corresponding to each unattended repeater station, means whereby the failure of a repeater at an unattended repeater station produces an effect upon the alternating current of frequency corresponding to that station, 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 responsive to such effect to indicate the repeater station at which the failure takes place.

7. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, means to transmit a plurality of alternating currents of different frequencies from an attended station to said unattended repeater stations, means whereby the failure of a repeater at an unattended repeater station produces an effect upon at least one of said alternating currents distinguishable from the effect produced by the failure of the repeaters at other unattended stations, 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 each unattended repeater station operating upon the failure of a repeater thereat to produce a change in the transmission of the alternating current whose frequency corresponds to that station without changing the transmission of the alternating currents corresponding to other stations, and means at an attended station responsive to such change to indicate the repeater station at which failure takes place.

8. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, means to transmit a plurality of alternating currents of different frequencies from an attended station to said unattended repeater stations, means whereby the failure of a repeater at an unattended repeater station produces an effect upon at least one of said alternating currents distinguishable from the effect produced by the failure of the repeaters at other unattended stations, means associated with the transmission line at an attended station to indicate that a failure has occurred ahead of the attended station, means at each unattended repeater station operating upon the failure of a repeater thereat to produce a change in the transmission of the alternating current whose frequency corresponds to that station without changing the transmission of the alternating currents corresponding to other stations, 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 responsive to such change to indicate the repeater station at which failure takes place.

9. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, means to superpose on said transmission line test channels for the transmission of alternating currents of different frequencies to said unattended repeater stations, there being one frequency corresponding to each unattended repeater station, means at each unattended repeater station to separate said test channels from the line circuit, selective means responsive to failure of a repeater at an unattended station to change the transmission of the frequency of the test channel corresponding to that station without affecting the frequencies corresponding to other repeater stations, and means at an attended station responsive to such change to indicate the repeater station at which failure takes place.

10. In a signaling system, a transmission line having a plurality of unattended repeater sta-

tions between attended stations, means to superpose on said transmission line test channels for the transmission of alternating currents of different frequencies to said unattended repeater stations, there being one frequency corresponding to each unattended repeater station, means at each unattended repeater station to separate said test channels from the line circuit, selective means responsive to failure of a repeater at an unattended station to change the transmission of the frequency of the test channel corresponding to that station without affecting the frequencies corresponding to other repeater stations, 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 responsive to such change to indicate the repeater station at which failure takes place.

11. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, means to superpose on said transmission line test channels for the transmission of alternating currents of different frequencies to said unattended repeater stations, there being one frequency corresponding to each unattended repeater station, means at each unattended repeater station to by-pass around the repeater thereat frequencies of test channels corresponding to other unattended repeater stations so that the failure of any unattended repeater will cause failure of the alternating current whose frequency corresponds to that station, and means at an attended station responsive to the failure of the frequency corresponding to an unattended repeater station to indicate that a repeater has failed at such unattended station.

12. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, means to superpose on said transmission line test channels for the transmission of alternating currents of different frequencies to said unattended repeater stations, there being one frequency corresponding to each unattended repeater station, means at each unattended repeater station to by-pass around the repeaters thereat frequencies of test channels corresponding to other unattended repeater stations so that the failure of any unattended repeater will cause failure of the alternating current whose frequency corresponds to that station, 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 responsive to the failure of the frequency corresponding to an unattended repeater station to indicate that a repeater has failed at such unattended station.

13. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, means to superpose on said transmission line test channels for the transmission of alternating currents of different frequencies to said unattended repeater stations, there being one frequency corresponding to each unattended repeater station, means at each unattended repeater station to by-pass around the repeaters thereat frequencies of test channels corresponding to other unattended repeater stations so that the failure of any unattended repeater will cause failure of the alternating current whose frequency corresponds to that station, means associated with the transmission line at an attended station to indicate that a failure has occurred ahead of the attended station, means at an attended station responsive to the failure of the frequency corresponding to an unattended repeater station to indicate that a repeater has failed at such unattended station, and means at each unattended repeater station operating in response to the failure of the frequency corresponding thereto to substitute an alternative repeater at such station.

14. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, means at an attended station to supply alternating test currents of frequencies corresponding to each unattended repeater station, means to apply an alternating current of frequency corresponding to any unattended repeater station to said transmission line, means at each unattended repeater station to change an alternating test current received thereat into a direct current, means to transmit such direct current to an attended station, and indicating means at such attended station to indicate the transmission of direct current thereto, whereby failure of direct current when an alternating test current corresponding to a particular unattended repeater has been applied to said transmission line will indicate failure of a repeater at such unattended station.

15. In a signaling system, a transmission line having a plurality of unattended repeater stations between attended stations, means at an attended station to supply alternating test currents of frequencies corresponding to each unattended repeater station, means to apply an alternating current of frequency corresponding to any unattended repeater station to said transmission line, means at each unattended repeater station to change an alternating test current received thereat into a direct current, means to transmit such direct current to an attended station, means associated with the transmission line at an attended station to indicate that a failure has occurred ahead of the attended station, and indicating means at such attended station to indicate the transmission of direct current thereto, whereby failure of direct current when an alternating test current corresponding to a particular unattended repeater has been applied to said transmission line will indicate failure of a repeater at such unattended station.

16. In a signaling system, a transmission line extending between two attended stations through a plurality of unattended repeater stations, means at each unattended station for automatically switching in a spare amplifier to replace an amplifier which fails, means common to several unattended stations to indicate at an attended station when an amplifier has failed, and means further to indicate the unattended station at which such failure has occurred.

ESTILL I. GREEN.
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