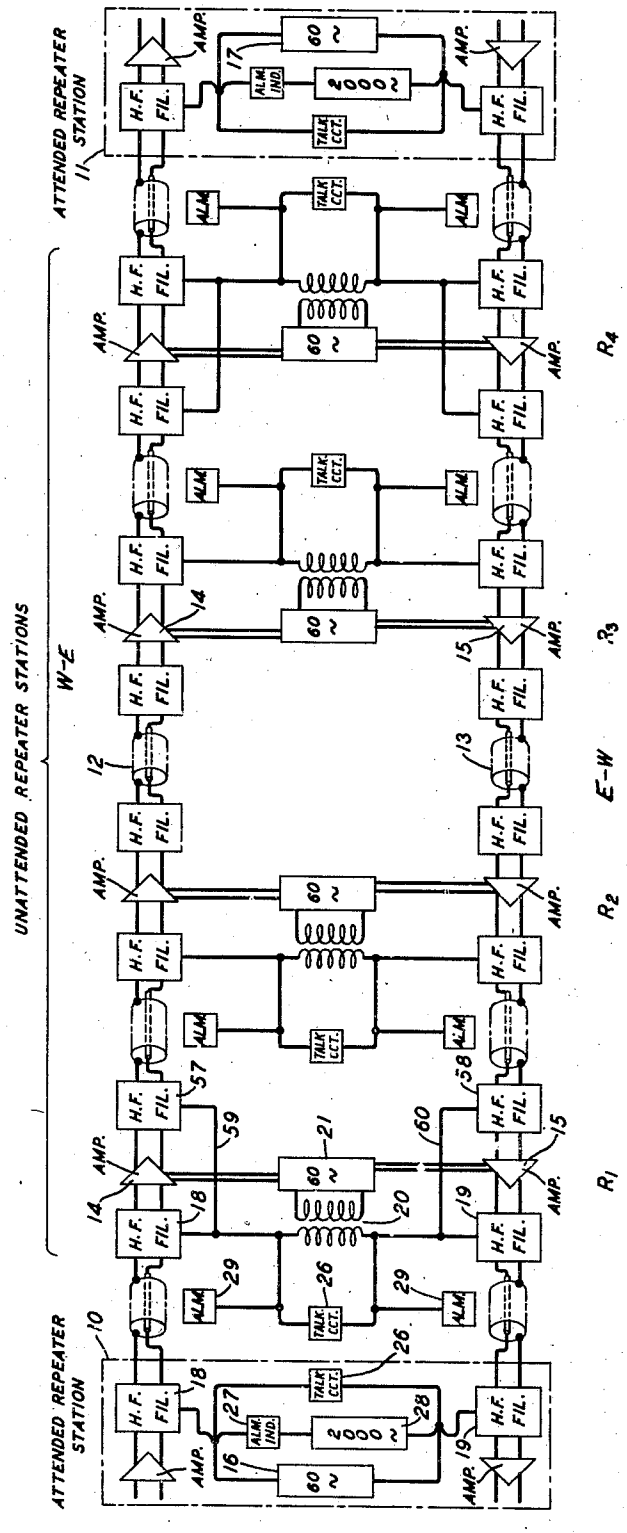
Aug. 10, 1937. K. C. BLACK 2,089,179

COAXIAL TRANSMISSION SYSTEM

Filed April 7, 1936 3 Sheets-Sheet 1

FIG. 1



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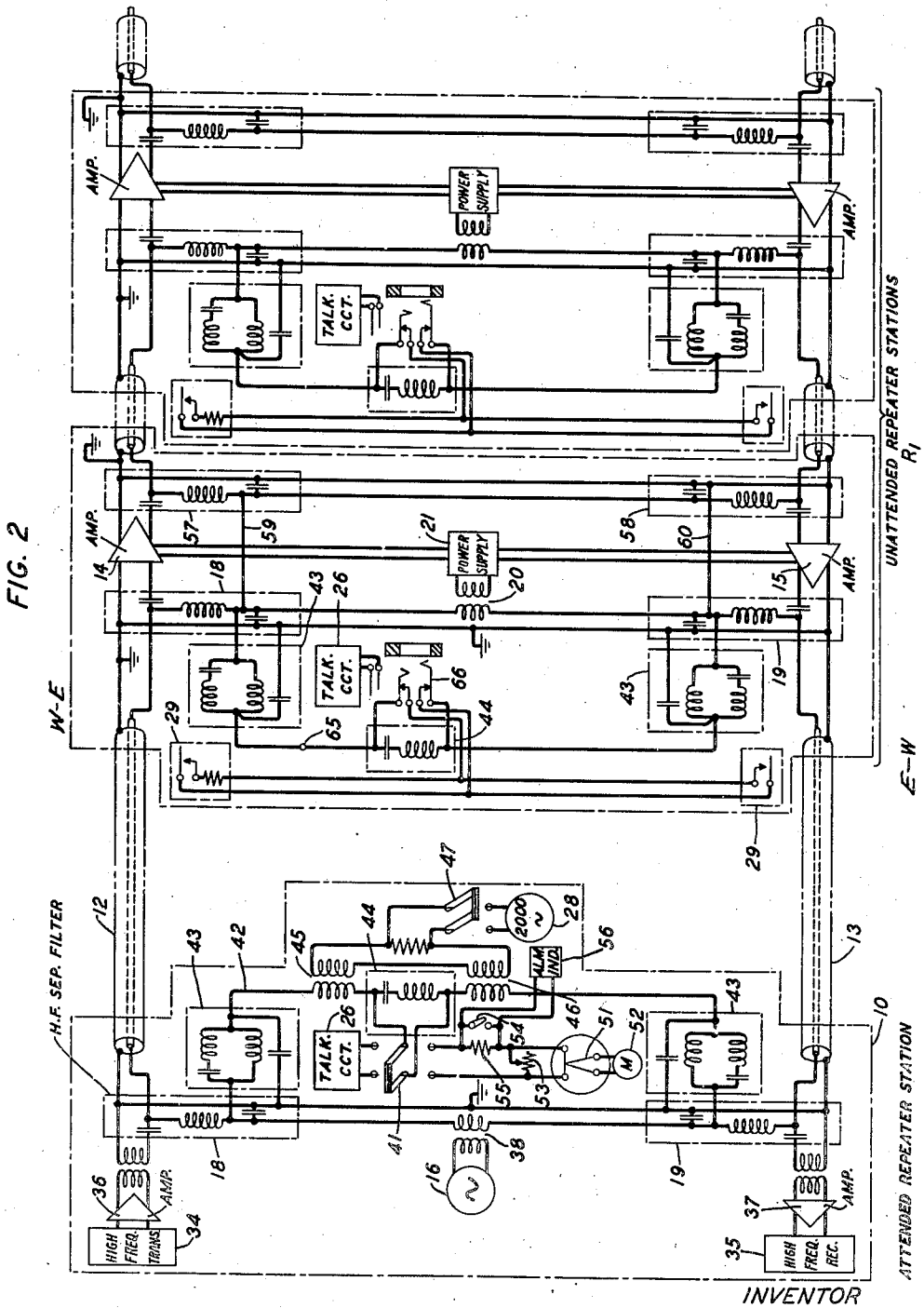

FIG. 2

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FIG. 4

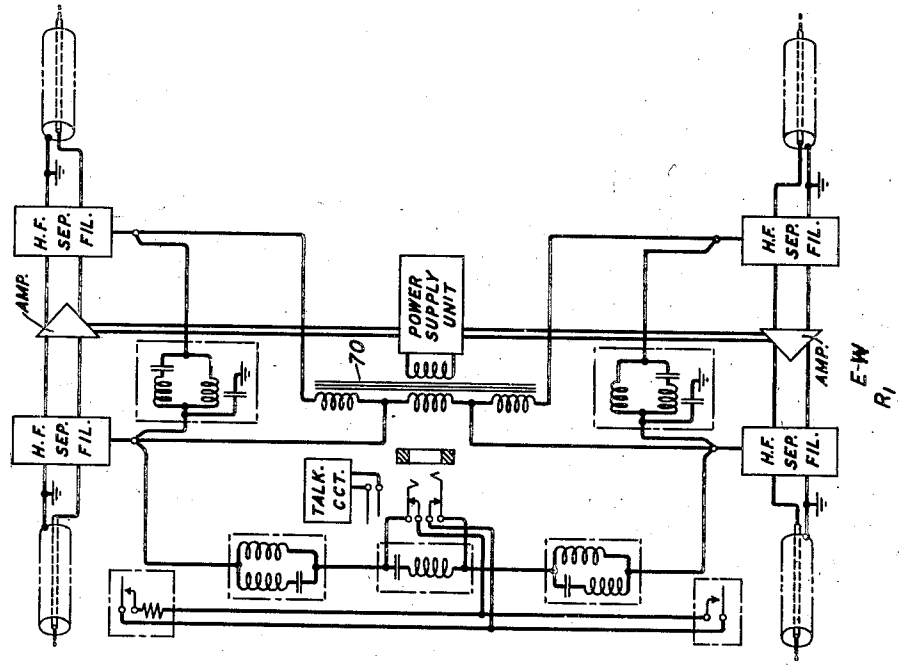
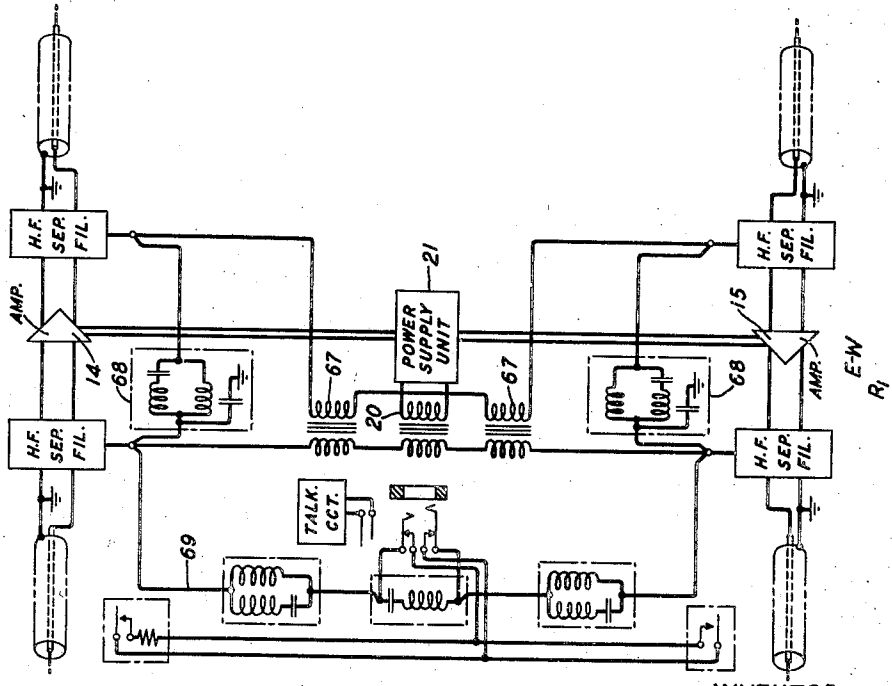


FIG. 3



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COAXIAL TRANSMISSION SYSTEM

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7 Claims. (Cl. 178—44)

This invention relates to a high frequency transmission system employing coaxial conductor lines, and more particularly to the simultaneous transmission of different frequency ranges over common portions of such lines.

One type of coaxial system comprises two coaxial conductor lines, one for transmitting exclusively in one direction and the other for transmitting similarly in an opposite direction. One-way attended repeater stations are spaced about fifty miles apart along the system while two one-way unattended repeater stations spaced about ten miles apart are positioned on one or both sides of each attended station. Once the coaxial system is placed in operation it is imperative that a failure along its unattended portion be instantaneously detected and reported so that repairs can be effected without undue interruption of transmission.

It is an object of the invention to transmit signals in one frequency range over a circuit comprising portions of other circuits used to transmit signals in another frequency range.

In the preferred construction to be described herein, the coaxial system is operated under gas pressure in a manner that an alarm indicator at an attended station is operated whenever a predetermined decrease in the gas pressure occurs. A suitable arrangement associated with the alarm indicator enables a quick location of the failure. To facilitate a clearance of the fault, a talking circuit is provided to enable communication between attended and unattended repeater stations. The talking and alarm circuits are provided by utilizing the central conductors of the coaxial conductor lines used to transmit the power for energizing the repeaters.

The invention will be more fully understood from the following description when read in connection with the accompanying drawings, in which

Fig. 1 is a block diagram illustrating two attended repeater stations having interposed therebetween a plurality of unattended repeater stations;

Fig. 2 is a schematic diagram delineating one manner of communicatively connecting an attended repeater station with one unattended repeater station;

Fig. 3 is a schematic diagram showing a constant current arrangement for an unattended repeater station that may be used in the circuit of Fig. 2, and

Fig. 4 is a schematic diagram showing a constant voltage arrangement for an unattended repeater station that may be used in the circuit of Fig. 2.

In the following description, the same reference numerals are used whenever the identical elements appear throughout the several figures of the drawings.

In Fig. 1 attended repeater station 10 is connected with a remote attended repeater station 11 by a pair of coaxial conductor lines 12 and 13. Intermediate the attended repeaters 10 and 11 are positioned four unattended repeater stations R_1, R_2, R_3 and R_4, each of which includes an eastward one-way amplifier 14 and a westward amplifier 15. Attended repeater 10 controls unattended repeaters R_1 and R_2, while attended repeater 11 controls unattended repeaters R_3 and R_4. The attended repeater stations may be either terminating or intermediate repeater stations. In the latter event, two unattended repeater stations may be located on one or both sides of each thereof. The coaxial conductor lines are operated continuously under gas pressure by a method which is a common practice in the operation of multiconductor telephone cables.

Power from a 60-cycle source 16 is supplied from attended repeater 10 through high frequency filters 18 and 19 to unattended repeaters R_1 and R_2 over a two-wire circuit comprising the central conductors of the pair of coaxial conductor lines 12 and 13. In like manner, power from a 60-cycle source 17 is supplied from attended repeater 11 to unattended repeaters R_3 and R_4. At each unattended repeater, suitable transformers and power units similar to transformer 20 and unit 21 of unattended repeater R_1 are provided to take off power to energize the one-way amplifiers associated therewith. For a more detailed description of the distribution of 60-cycle power, reference may be had to the patent of M. E. Strieby, No. 2,037,183 issued April 14, 1936.

In the preferred form of the invention shown in Fig. 1 a conventional talking circuit 26, and alarm indicator 27 and its associated 2000-cycle supply 28 are connected in parallel with each other and with the 60-cycle power source 16. Therefore, the voice and alarm frequencies are transmitted through high frequency filters 18 and 19 to unattended repeaters R_1 and R_2 over the central conductors of the coaxial conductor lines 12 and 13, which as previously seen, are utilized to distribute the 60-cycle power supply between the same repeaters. In a similar manner, the voice and alarm frequencies are trans-

mitted from attended repeater 11 to unattended repeaters R_3 and R_4.

At each unattended repeater, a talking circuit and a pair of alarm contactors identical with talking circuit 26 and gas-pressure contactors 29, 29 of repeater R_1 are connected across the primary winding of the 60-cycle power transformer 20. The gas-pressure contactors 29, 29, well known in the operation of multiconductor telephone cables under gas pressure, are attached to the sheath of the coaxial cable so as to effect an alarm in the attended station in a manner that will be subsequently explained. They may be of any suitable type such, for example, as that disclosed in the patent of T. C. Henneberger et al. No. 1,936,194, issued November 21, 1933.

In Fig. 2, the circuit connections of attended repeater 10 and unattended repeater R_1 are shown in detail. Station 10 comprises a high frequency transmitting apparatus 34 and a high frequency receiving apparatus 35 both of which are preferably in the form of multiplex terminal circuits for respectively impressing on outgoing coaxial conductor line 12 and receiving from incoming coaxial conductor line 13 modulated carrier waves in a large number of channels extending over a frequency range of the order of 1000 kilocycles. Terminal amplifiers 36 and 37 may be energized in any satisfactory manner, not shown. The multiplex transmitting and receiving circuits may be of a suitable type such, for example, as that disclosed in the patent of L. Espenschied et al. No. 1,835,031, issued December 8, 1931.

An alternating source 16 of 60-cycle power is connected to the primary winding of a transformer 38 that has its secondary winding connected through the filters 18 and 19 to the central conductors of the pair of coaxial conductor lines 12 and 13. By means of the filters 18 and 19, the high frequency signaling currents are precluded from entering the 60-cycle power circuit, and the power currents are prevented from traversing the circuits utilized by the signaling currents.

Also, the talking circuit 26 is connected to one side of a D. P. D. T. switch 41 which has its central poles connected to a series circuit 42 comprising parallel networks 43, 43, series network 44, and the secondary windings of inductances 45 and 46. The series circuit 42 shunts the secondary winding of the transformer 38. The networks 43, 43 are designed to provide a relatively high impedance to the 60-cycle power voltage, hence the latter is precluded from endangering the safety of a speaker using the talking circuit 26. The networks 43, 43 are designed also to provide a relatively low impedance to voice and the 2000-cycle frequencies as well as serving as high frequency filters to prevent cross-talk between the coaxial conductor lines 12 and 13 during the transmission of high frequencies. The network 44 is designed to provide a relatively high impedance to voice and 2000-cycle frequencies, and a low impedance to the 60-cycle power voltage. Accordingly, when the switch 41 connects the talking circuit 26 to the series circuit 42, voice currents may be transmitted from attended repeater 10 through networks 43, 43 and filters 18 and 19 along the central conductors of the coaxial conductor lines 12 and 13 to the unattended repeaters R_1 and R_2.

Since the alarm circuit is normally conditioned for operation, a D. P. S. T. switch 47 is closed to connect the 2000-cycle alarm supply 28 to the primary windings of the inductances 45 and 46. This impresses continuously a 2000-cycle voltage across the central conductors of the pair of coaxial conductor lines extending between the attended repeater 10 and unattended repeaters R_1 and R_2. The transmission is effected in a manner that will be subsequently described. In addition, the switch 41 is normally closed across thermocouple 51 connected to an ammeter 52. During normal circuit conditions, a variable resistance 53 is set at zero, and an S. P. S. T. switch 54 is open to connect a fixed resistance 55 across the network 44. The resistance 55 determines the voltage to an alarm indicator 56 whose function and operation will be subsequently explained. The alarm indicator may be of a suitable type such, for example, as either a single rectifier tube and an ordinary direct current relay, or a rectifier tube operating a gas tube that in turn operates a direct current relay.

In unattended repeater R_1 of Fig. 2, filters 18 and 19, which are connected similarly to filters 18 and 19 in attended repeater 10, allow the relatively high frequency currents to be impressed on amplifiers 14 and 15, respectively, while at the same time separating the relatively low frequency currents originating in the talking, 60-cycle power, and 2000-cycle alarm circuits to be impressed on their associated apparatus without causing any interference between the high and low frequencies. After passing the amplifiers 14 and 15, the high frequency currents are impressed on high frequency filters 57 and 58 for transmission to the next unattended repeater. The filters 57 and 58 have circuit connections similar to the filters 18 and 19. The 60-cycle power transmitted from attended repeater 10 over the central conductors of the two coaxial conductor lines 12 and 13 is impressed on the primary winding of transformer 20 having its secondary winding connected to power unit 21. The latter serves to energize the tubes of the one-way amplifiers 14 and 15. In addition, 60-cycle power is shunted around amplifiers 14 and 15 by leads 59 and 60 which connect filters 18 and 57, and 19 and 58, respectively. These connections make the 60-cycle power available at the next unattended repeater for energizing the amplifiers associated therewith.

Also in unattended repeater R_1 of Fig. 2, a series circuit 65 comprising networks 43, 43 and 44 is connected in shunt with the primary winding of transformer 20. The networks of this repeater serve the same purpose for which the similarly identified networks are utilized in attended repeater 10. Across the network 44 is a telephone jack 66 that normally connects each contactor of the pair of gas-pressure contactors 29, 29 to the two central conductors employed to transmit the 60-cycle power between repeater stations. When talking circuit 26 is plugged into the jack 66, the pair of gas-pressure contactors 29, 29 are disconnected and a talking circuit is provided between unattended repeater R_1 and attended repeater 10 over the two central conductors of the pair of coaxial conductor lines 12 and 13. To complete this talking circuit, it is, of course, necessary to close the switch 41 across the talking circuit 26 located in attended repeater 10.

In unattended repeater R_2, which is not shown in detail in Fig. 2, the circuit arrangements required to make available the voice and 2000-cycle alarm currents therein are identical with those shown in detail in connection with its associated repeater R_1.

In Figs. 1 and 2 it will be noticed in unattended

repeaters R_2 and R_3 that there are no leads shunting the 60-cycle power supply around the two one-way amplifiers in a manner similar to that effected by leads **59** and **60** of unattended repeater R_1. The omission of these shunt connections is intended to eliminate the possibility of interconnection between the 60-cycle power sources **16** and **17** located at the remote repeaters **10** and **11**, respectively. In addition, the absence of the shunt connections also precludes an interconnection between the talking and alarm circuits of the same repeaters.

When the pressure in the coaxial conductor lines is normal, the gas-pressure contactors **29, 29** are open so as to interrupt the alarm circuit which is conditioned for operation as hereinbefore described. When, however, the gas pressure in close proximity to one of the four points covered by the contactors **29, 29** falls below a predetermined value, one of the gas-pressure contactors is closed thereby enabling a 2000-cycle current to flow over the two central conductors of the pair of coaxial conductor lines extending between the attended repeater **10** and either unattended repeater R_1 or R_2 depending on the location of the fault. The value of this current depends upon the distance of the operated contactor from the attended repeater **10**, and, to some extent, upon the line resistance which varies according to weather conditions. The 2000-cycle current flow develops a voltage across the fixed resistance **55** at attended repeater **10** whereby the alarm indicator **56** is actuated. The indicator **56** warns the operator that a cable failure has occurred somewhere along the unattended portion of the coaxial system, but, however, does not show the location of the failure.

To determine the position of the fault, the switch **54** is closed thereby short-circuiting the fixed resistance **55** to remove the voltage from the alarm indicator **56**. Thereafter, resistance **53** is varied to correspondingly increase the 2000-cycle current flowing through the thermocouple **51**. The value of the current indicated on the associated ammeter **52** enables the determination of the particular gas-pressure contactor that has operated to report the cable failure. To make this possible, a range of current values depending on the range of resistance values of this line circuit is predeterminedly assigned to each gas-pressure contactor so that a value of current falling within the range indicates immediately the closed gas-pressure contactor.

A constant current arrangement for 60-cycle power distribution for use in unattended repeater R_1 is shown in Fig. 3. The circuit connections for this arrangement differ from those of the same repeater in Fig. 2 only with reference to the feature of operation on a constant current basis. For this operation no change in the circuit connections at either attended repeater **10** or unattended repeater R_2 of Fig. 2 is required. In R_1, however, a constant 60-cycle current flows through the primary windings of two transformers **67, 67** used to transmit power to unattended repeater R_2 and through the primary winding of transformer **20** connected to a power unit **21** which is utilized to supply 60-cycle power to the one-way amplifiers **14** and **15**. It will be noted that the primary winding of transformers **67, 67** and **20** are connected in series. The secondary windings of the transformers **67, 67** are also connected in series so that for a constant current flowing through their associated primary windings, a constant current of a slightly smaller magnitude will be delivered to the sections of the coaxial conductor lines extending between unattended repeaters R_1 and R_2. Networks **68, 68** connected between the windings of the transformers **67, 67** are designed to present a high impedance to the 60-cycle power, and, in addition, a low impedance to the flow of voice and 2000-cycle currents from unattended repeater R_2. The transformers **67, 67** and **20** serve as high impedances to the voice and 2000-cycle currents. A series circuit **69** connected across the primary windings of transformers **67, 67** and **20** is identical with and performs the same function as the similar circuit **65** in unattended repeater R_1 of Fig. 2.

A constant voltage arrangement for 60-cycle power distribution for use in unattended repeater R_1 is shown in Fig. 4. The circuit connections for this arrangement differ from those of the same repeater shown in Figs. 2 and 3 only with respect to the feature of operation on a constant voltage basis. For this operation, no change in the circuit connections of either attended repeater **10** or unattended repeater R_2 of Fig. 2 is required. In R_1, however, a multiwinding unit **70** is designed to impress a slightly higher voltage on the coaxial sections extending between R_1 and R_2 than that impressed on the coaxial sections extending between repeaters **10** and R_1. In this way a constant voltage is provided for energizing the one-way amplifiers in unattended repeater R_2. The multiwinding unit serves as a high impedance to the voice and 2000-cycle alarm currents. In all other respects the circuits of unattended repeater R_1 shown in Fig. 3 and Fig. 4 are alike.

Accordingly, it is seen in Figs. 3 and 4 that voice and 2000-cycle alarm currents are transmitted over a power distributing circuit shown therein in a manner substantially identical with that described hereinbefore with respect to Figs. 1 and 2.

It will be understood that the invention is capable of modifications without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. In a high frequency carrier wave transmission system, a pair of attended stations, a plurality of unattended stations between the attended stations, two coaxial conductor lines connecting the attended and unattended stations, means for transmitting high frequency carrier waves through the unattended stations and between the attended stations in one direction over one coaxial conductor line and in an opposite direction over the other coaxial conductor line, a signaling circuit extending from one of the attended stations to a plurality of unattended stations and comprising the central conductor of one coaxial conductor line as one side and the central conductor of the other coaxial conductor line as the return side, means for impressing low frequency currents on the signaling circuit, filter networks connected in the coaxial conductor lines at each station for preventing interference between the high and low frequency transmission, and a local circuit at each station for deriving the low frequency currents from the signaling circuit to enable signaling communication between the attended and unattended stations.

2. A system according to claim 1 in which the local circuit includes networks for preventing cross-talk between the coaxial conductor lines during transmission.

3. In a high frequency carrier wave transmission system, a pair of attended repeater stations, a plurality of unattended repeater stations intermediate the attended stations, two coaxial conductor lines connecting the attended and unattended repeater stations, means for transmitting high frequency carrier waves between the attended stations in one direction over one coaxial conductor line and in an opposite direction over the other coaxial conductor line, a low frequency power supply at each attended station, a circuit comprising the central conductors of the two coaxial conductor lines for transmitting the power supply between the attended station and at least one unattended station, means for impressing other low frequency currents on the power transmitting circuit, filter networks connected in the coaxial conductor lines at each station for preventing interference between the high and low frequency transmission, means at the unattended stations for deriving power from the power circuit and rendering same available thereat, and a local circuit at each station for deriving the other low frequency currents from the power circuit to enable signaling communication between the attended and unattended repeater stations.

4. In a high frequency carrier wave system, a pair of attended stations, a plurality of unattended stations between the attended stations, a pair of coaxial conductor lines connecting the stations, means for transmitting high frequency carrier waves between the stations in one direction over one coaxial conductor line and in an opposite direction over the other coaxial conductor line, a signaling circuit extending from one of the attended stations to a plurality of unattended stations and comprising the central conductor of one coaxial conductor line as one side and the central conductor of the other coaxial conductor line as the return side, the coaxial conductor lines being operated under a predetermined gas pressure, means at the attended stations for continuously impressing a low frequency signaling current on the signaling circuit, a circuit at each station for deriving the signaling current from the signaling circuit, means attached to each coaxial conductor line passing through the unattended stations and operatively connected in the last-mentioned circuit for normally interrupting the signaling current under the predetermined gas pressure and closing the signaling circuit when the gas pressure falls below the predetermined amount due to a failure of the coaxial conductor lines, and an alarm indicator actuated in the attended station in response to the closed signaling circuit to report a failure along an unattended section of the coaxial conductor line.

5. A system according to claim 4 in which means is provided to locate the failure after the alarm indicator has reported the existence thereof.

6. A system according to claim 3 in which the local circuit includes networks for deriving low frequency currents from the power circuit at one unattended repeater arranged for a constant current operation.

7. A system according to claim 3 in which the local circuit includes networks for deriving low frequency currents from the power circuit at one unattended repeater arranged for a constant voltage operation.

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