June 15, 1943. M. K. ZINN 2,321,723

SPEECH TRANSMISSION SYSTEM

Filed June 26, 1942

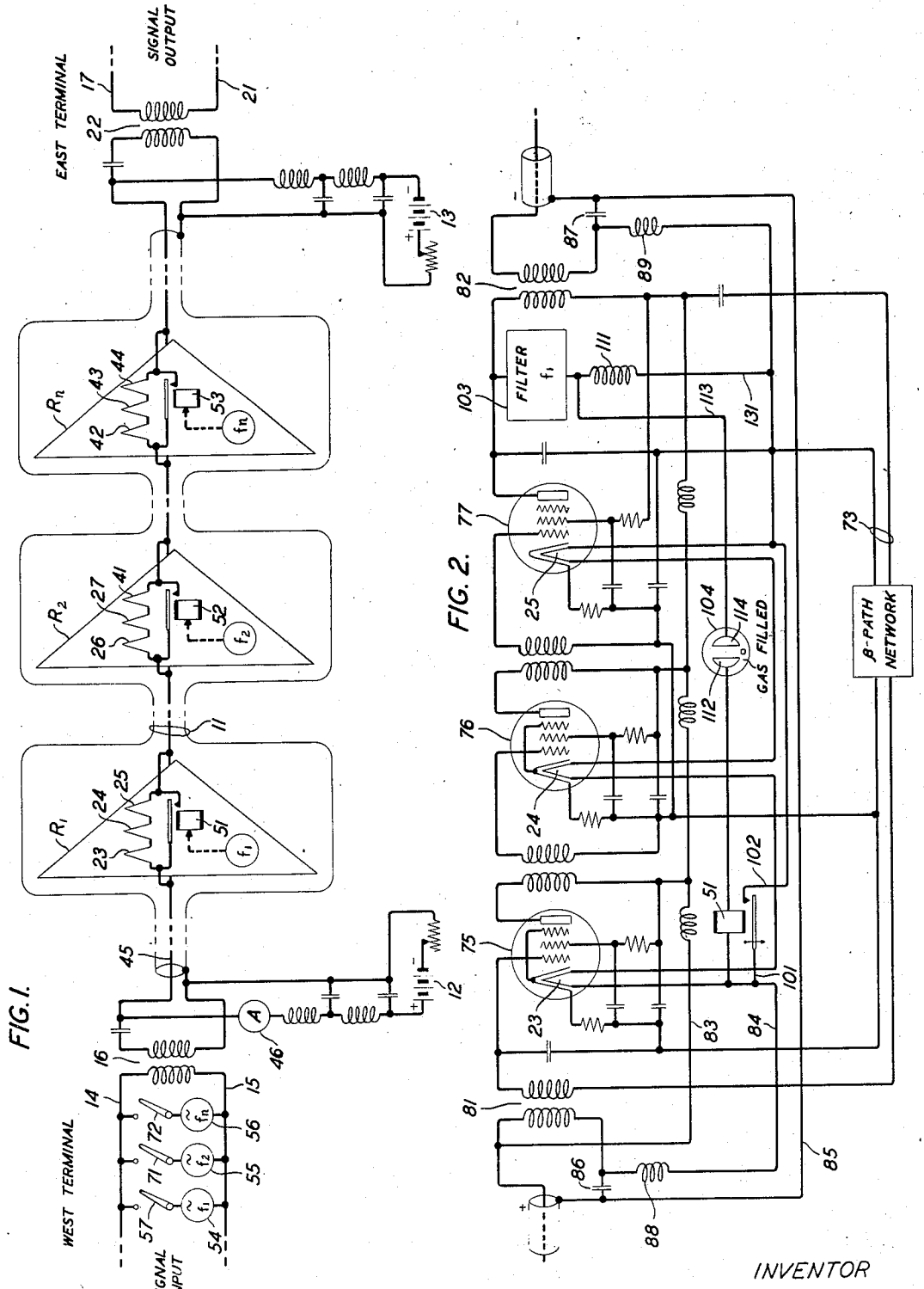

FIG. 1.

FIG. 2.

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Patented June 15, 1943 2,321,723

UNITED STATES PATENT OFFICE

2,321,723

SPEECH TRANSMISSION SYSTEM

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Application June 26, 1942, Serial No. 448,547

5 Claims. (Cl. 179—1)

This invention relates to a speech transmission system utilizing unattended repeaters and more particularly to such a system wherein the unattended repeaters are not readily accessible such, for example, as a submarine cable telephone system.

An object of the invention is to selectively indicate at an accessible point the operating condition of the several unattended repeaters of a transmission system.

A further object of the invention is to indicate at an accessible point a significant drop in the operating efficiency of any one of the unattended repeaters before its actual failure as a speech transmitting element of the system.

Patent 2,020,297 issued November 12, 1935, to Buckley and Jacobs discloses a submarine cable telephone system wherein repeaters of the vacuum tube type are provided at spaced intervals along the cable, and are incorporated as an integral part of the cable and, in the case of an armored cable, may actually be enclosed within the cable armor. The signal currents to be amplified and the energizing current for the vacuum tubes of the repeaters are transmitted over the line from one end thereof. As disclosed in the Buckley et al, patent the operation of the vacuum tubes at relatively low filament temperature and power output is contemplated in order to assure a greatly prolonged service period for the tubes. The present invention takes account of the possibility of failure of such a repeater and provides means whereby, in the event of such failure, it may be readily determined at a land terminal just which one of the several repeaters has failed.

Systems have previously been proposed for use on land lines for observing at an attended station the operating condition of the unattended repeaters, such a system is disclosed, for example, in Patent 2,208,417 issued July 16, 1940, to J. J. Gilbert. In general these prior systems utilize a cross connection between the East line and the West line at each unattended station and are not, therefore, readily adaptable to a submarine cable system as this cross connection between the two lines at each unattended station cannot be easily achieved.

In accordance with a feature of the present invention, indication of the operating condition of the unattended repeaters of a one-way line is obtained without recourse to interconnections between the two one-way lines of the system.

In accordance with a specific embodiment of the present invention all of the filament heater circuits of the amplifier elements of the various unattended repeaters are connected in series with the line whereby the resistance of each heater circuit is a contributing factor to the total resistance of the over-all system. Means, controlled from the observation point, are provided whereby the filament heater circuits of the various unattended repeaters may be selectively shorted out of the line (assuming, that is, that the various repeaters are in normal operative condition), each shorting action resulting, of course, in a decrease in the resistance of the over-all system. Further, each decrease in the resistance of the system will result in a proportional increase in current; means are provided at the terminals of the system for observing such changes in current. The arrangement is ineffective, however, to short out the heater circuit of an inoperative repeater from which it follows that when an attempt to actuate the means referred to from the observation point results in no discernible increase in the current, an inoperative repeater is indicated. The testing method is intended particularly for detecting faults which may develop in the high frequency transmission path through the amplifiers with a consequent reduction in their gain while the direct current power channels remain in normal operating condition. The usual testing procedure would involve starting with the repeater nearest to the observation point and testing each repeater in rotation until the inoperative element of the system is found.

A complete understanding of the operation of the arrangement contemplated by the present invention as well as appreciation of the various valuable features thereof may be gained from consideration of the detailed description and the annexed drawing in which:

Fig. 1 illustrates in simplified diagrammatic form and in general outline, a one-way submarine telephone cable provided with unattended repeaters at spaced intervals and including means in accordance with the present invention whereby the operating condition of the various repeaters may be checked; and

Fig. 2 shows in detail the circuit configuration of one of the unattended repeaters of the system of Fig. 1.

Referring now to Fig. 1 there is represented submarine cable 11 connecting two land points designated respectively "West terminal" and "East terminal"; the cable may be of the general type disclosed in Buckley et al. Patent 2,020,297 in that a number of vacuum tube repeater ele-

ments, designated R_1, R_2 and R_n, are enclosed at spaced intervals within the protective sheath of the cable. The necessary power for the repeater elements may be supplied over the cable from suitable sources provided at the terminals such, for example, as batteries 12 and 13.

The intelligence conveying waves to be transmitted over the cable, which may be for example speech or carrier waves, are applied to lines 14 and 15 by suitable transmitting equipment at the West terminal and impressed on cable 11 by transformer 16. These waves while passing over cable 11 are amplified by repeater elements R_1, R_2, R_n, and upon reaching the East terminal are impressed on lines 17 and 21 by transformer 22. Suitable intelligence receiving equipment is associated with lines 17 and 21 at the East terminal.

As a specific example, adapted for purposes of detailed description, it will be assumed that each of the repeaters R_1, R_2 and R_n, includes three vacuum tubes. The three heaters of the vacuum tubes of repeater R_1 are designated 23, 24 and 25, the three heaters of the vacuum tubes of repeater R_2 are designated 26, 27 and 41 and the three heaters of the amplifiers of repeater R_n are designated 42, 43 and 44.

As indicated in Fig. 1 all of the heater elements referred to above are normally conductively connected to line 45 of cable 11. Obviously, therefore, under normal operating conditions of the cable system, the resistance of each group of heaters will be an additive factor in the total resistance of the over-all system. Any variation in the total resistance of the system will, of course, result in a proportionate change in current. It follows therefore, that if the various heater groups were to be selectively shorted out of line 11, each such shorting action would result in an increase in the current; this current change could be indicated at the observation point by the use of a suitable current sensitive device such as ammeter 46. Means for obtaining this selective shorting action, in the instance of each operative repeater, is schematically indicated in Fig. 1.

As schematically indicated a relay is associated with the heater group of each repeater, relay 51 being associated with repeater R_1, relay 52 with repeater R_2 and relay 53 with repeater R_n. As also indicated in a schematic fashion, relay 51 is operated by application thereto of a wave of frequency f_1, relay 52 by a wave of frequency f_2 and relay 53 by a wave of frequency f_n. Operation of relay 51 is effective to complete through its armature and make contact a path which shunts heaters 23, 24 and 25 out of line 45; similarly operation of relay 52 is effective to shunt heaters 26, 27 and 41 out of line 45 and operation of relay 53 is effective to shunt heaters 42, 43 and 44 out of line 45.

Three wave sources 54, 55 and 56 are provided at the West terminal producing waves of respective frequency f_1, f_2 and f_n. Through operation of the respectively associated switches 57, 71 and 72, the outputs of these sources may be selectively applied to lines 14 and 15 and, through transformer 16 to cable 11. Through operation of certain frequency selective and switching means, not shown in Fig. 1 but shown in Fig. 2 and described in detail subsequently, waves of frequentcy f_1, when applied to cable 11 by closing switch 57, are applied in turn to circuits associated with relay 51 and cause the operation thereof; as pointed out above operation of relay 51 shunts heaters 23, 24 and 25 out of line 45. Similarly waves of frequency f_2, when applied to cable 11, are applied in turn to circuits associated with relay 52 causing the operation thereof and waves of frequency f_n, when applied to cable 11, are applied in turn to circuits associated with relay 53 causing the operation thereof.

In the description immediately above, it has been assumed, of course, that each of the repeaters tested is in operative condition. In the event of an inoperative repeater, the respective testing current would not be passed to cause operation of the respective relay and the associated heater group would not be shorted out of the line.

Let us assume now that in the operation of the system of Fig. 1 it becomes apparent that one of the repeater elements has failed and that it be desired to ascertain which one of the several repeaters is at fault. The value of the current flowing in the line would first be determined by device 46 after which switch 57 would be closed applying a wave of frequency f_1 to the cable. As pointed out above if repeater R_1 be in normal, operative condition application of a wave of frequency f_1 to the line will cause operation of relay 51 which operation, in turn, completes a path shunting heaters 23, 24 and 25 out of line 45. On the other hand, if repeater R_1 be inoperative to pass the testing current, the application of the testing current f_1 will not result in the shunting action. It is only necessary, therefore, to observe whether application of the testing current f_1 to the line results in a discernible increase in the current as indicated by device 46 in order to obtain an indication of the operativeness or failure of repeater R_1.

If it be found that repeater R_1 is inoperative, plans may then be undertaken for the necessary repairs or replacement. However, if repeater R_1 be shown to be operative, repeater R_2 and the other repeaters of the system are then tested in turn until the inoperative element is located.

Referring now to Fig. 2 there is shown in detail the amplifying circuit of repeater R_1; the amplifying circuits of all the repeaters are similar and only that of repeater R_1 will be described in detail. The amplifier circuit illustrated may be of the type that utilizes a stabilizing negative feedback connection or path 73 of the general type disclosed in H. S. Black Patent 2,102,671 issued December 21, 1937, and includes three vacuum tubes 75, 76 and 77 connected in tandem. Each of these vacuum tubes is provided with an indirectly heated cathode, a heater (23, 24 and 25, respectively), an input grid, a screen grid, a suppressor grid and an anode. The different stages of the amplifier are coupled by transformers in the usual way and the input and output paths are connected to the amplifier by input transformer 81 and output transformer 82, respectively.

The necessary anode and screen grid potential is supplied over line 83 while the energizing current for heaters 23, 24 and 25 is supplied over line 84 and return line 85. Low pass filters, comprising capacitances 86 and 87 and inductances 88 and 89, serve to segregate the direct current supply branch and the high frequency signaling branch. A shunting path, which includes lines 101 and 102, is provided; this path becomes effective upon operation of relay 51 to shunt heaters 23, 24 and 25 out of the heater energizing circuit.

Band-pass filter 103 is connected in the anode or output circuit of vacuum tube 77; this filter

is designed to pass only a narrow band of frequencies including f_1 but excluding f_2 and f_n. The output of filter **103** is connected to the energizing winding of relay **51** over a path which includes gaseous discharge device **104**. Retard coil **111** is connected in series with filter **103**.

Let us assume now that testing current of frequency f_1 be applied to the line at the attended station in order to ascertain the operating condition of repeater R_1 of Fig. 2. (It will be remembered that current of frequency f_1 is passed by filter **103**.) Under normal operating conditions discharge device **104** has an initial steady bias of a value equal to the voltage drop through heaters **23**, **24** and **25** due to the connection of electrode **112** to the positive side of the heater circuit and connection of electrode **114** to the negative side of the circuit. The value of this bias will depend upon the characteristics of the system; for purposes of description a bias of 60 volts will be assumed. Assuming first that the amplifier is operative and that the testing current of frequency f_1 is passed through filter **103**, a potential will be built up at the junction of line **113** and the upper terminal of retard coil **11** due to passage of the "peaks" of the testing current through the coil; this potential plus the steady bias of 60 volts is sufficient to cause discharge device **104** to "breakdown" and establish a conductive arc between electrodes **112** and **114**.

Breakdown of discharge device **104** completes an operating path for relay **51** which includes line **113**, discharge device **104**, operating winding of relay **51**, heaters **23**, **24** and **25**, line **131** and retard coil **111**. Sufficient current passes over this path at this time to cause relay **51** to operate.

Operation of relay **51** establishes a path including line **84**, line **101**, armature and make contact of relay **51** and line **102** which is effective to shunt heaters **23**, **24** and **25** out of the filament heater energizing circuit of the over-all system. This, of course, results in decrease of the resistance of the system by an amount equal to the sum of the resistance of heaters **23**, **24** and **25**. The value of this resistance will depend, of course, on the characteristics of the system; for purposes of description it is assumed that the resistance of each heater is 80 ohms while that of the over-all system is 16,000 ohms. Shorting out heaters **23**, **24** and **25** therefore causes a decrease of 240 ohms in the resistance of the system. This decrease in resistance, in turn, results in a proportional rise in current of the system

$$\left(\frac{240}{16000}=1.5\%\right)$$

Therefore, assuming as stated above that repeater R_1 is operating satifactorily, the application of testing current of frequency f_1 to the line will result in a definite increase in current; this change will be observable at the attended station as an indication that repeater R_1 is operating satisfactorily. On the other hand if the testing current f_1 were not passed by the amplifier, relay **51** would not operate and no appreciable change in current would result from application of testing current to the line; this would be an indication that repeater R_1 is not operating normally.

Upon operation of relay **51** and consequent shunting of the heaters, the amplifier of course ceases to be operative and current is no longer supplied over the energizing path of relay **51** to hold the relay operated. It is preferable therefore that relay **51** be of the slow-to-release type in order that it may remain in operated position for a sufficient period to allow the change in the circuit conditions to be observed.

After testing repeater R_1, the other repeaters may be tested in a similar manner by application of the other testing currents $f_2 \ldots f_n$ in turn.

In certain instances it may transpire that a repeater, while not incompletely inoperative so far as passage of intelligence conveying currents is concerned, is operating at such a reduced efficiency as to make repair or replacement desirable. Such cases may be detected by the testing method contemplated by the present invention as, if the operating efficiency of a particular repeater is dangerously low, sufficient testing current will not be passed to cause the associated gas-filled tube to trip when the repeater is tested. This means, of course, that no appreciable change in the total current of the system will be detected when that particular repeater is tested.

The selecting arrangement of the present invention may well be utilized in connection with a gain control arrangement of the general type disclosed in my copending application, Serial No. 412,916, filed September 30, 1941, "Electric wave circuit" to provide selective gain control for a plurality of separated amplifiers.

While certain specific embodiments of the invention have been selected for disclosure and detailed description the invention is not, of course, limited in its application to such embodiments. The embodiments disclosed should be taken as illustrative of the invention and not as restrictive thereof.

What is claimed is:

1. In a signaling system comprising an attended repeater station and a plurality of unattended repeater stations geographically separated from the attended station and from each other and having a transmission line joining the attended station and the unattended stations and including an amplifier in said line at each of said unattended stations, each of said amplifiers including a filament heater circuit, an energizing source for said heater circuits, means at each of said unattended stations operative if the respective amplifier be in operative conditon and effective when operated to short-circuit the filament heater circuit of the respective amplifier so far as said energizing source is concerned, means at said attended station for selectively operating said short-circuiting means one at a time and means at said attended station for observing changes in the current flow of the line, said shorting means being ineffective with respect to inoperative amplifiers.

2. In a signaling system comprising an attended station and a plurality of unattended repeater stations geographically separated from said attended station and from each other and having a transmission line joining said attended station and said unattended stations and including an amplifier at each of said unattended stations, each of said amplifiers including a filament heater circuit, an energizing source for said heater circuits connected to said line at said attended station, all of said filament heater circuits normally being connected in series with said line whereby the respective resistance of each heater circuit is a contributing factor to the total resistance of said line, means at each of said unattended stations operative only if the respective amplifier be in operative condition and effective when operated to short out from said line the filament heater circuit of the respective

amplifier, means at said attended station for selectively operating said shorting means one at a time and means at said attended station for indicating changes in the total resistance of said line as each respective filament heater circuit is shorted out of said line.

3. In a signaling system comprising an attended station and a plurality of unattended repeater stations geographically separated from said attended station and from each other and having a transmission line joining said attended station and said unattended stations and including an amplifier at each of said unattended stations, each of said amplifiers including a filament heater circuit, an energizing source for said heater circuits connected to said line at said attended station, all of said filament heater circuits normally being connected in series with said line whereby the respective resistance of each heater circuit is a contributing factor to the total resistance of said line, frequency responsive means at each of said unattended stations operative only when the respective amplifier is in operation condition and effective when operated to short out from said line the filament heater circuit of the respective amplifier, each of said means being responsive to a different distinctive frequency when applied to said line, a plurality of sources of distinctive frequencies at said attended station corresponding to the various distinctive frequencies to which said means are respectively responsive, means at said attended station for selectively applying frequencies from said sources to said line one at a time, and means at said attended station for indicating changes in the current flow of said line as each respective filament heater circuit is shorted out of said line.

4. In a signaling system comprising an attended station and a plurality of unattended repeater stations geographically separated from said attended station and from each other and having a transmission line joining said attended station and said unattended stations and including an amplifier at each of said unattended stations, each of said amplifiers including a filament heater circuit, an energizing source for said heater circuits connected to said line at said attended station, all of said filament heater circuits normally being connected in series with said line whereby the respective resistance of each heater circuit is a contributing factor to the total resistance of said line, a relay at each of said unattended stations effective when operated to short out from said line the filament heater circuit of the respectively associated amplifier, an operating path for each of said relays, each of said operating paths including a gaseous discharge device effective normally to prevent passage of sufficient current in said operating paths to cause operation of the respective relay, frequency selective means connected in the output circuit of each of said amplifiers and in the operating path of a respective one of said relays, each of said frequency selective means passing a different distinctive frequency when applied to said line and passed by the respectively associated amplifier, a plurality of sources of distinctive frequencies at said attended station corresponding to the various distinctive frequencies to which said frequency responsive means are respectively responsive, means at said attended station for selectively applying frequencies from said sources to said line one at a time, passage of current by one of said frequency selective means being effective to render the gaseous discharge device of the respectively associated relay operating path conductive to current whereby the respectively associated relay is operated, and means at said attended station for indicating changes in the total resistance of said line as each respective relay is operated.

5. In a signaling system comprising an attended station and a plurality of unattended repeater stations geographically separated from said attended station and from each other and having a transmission line joining said attended station and said unattended station and including an amplifier at each of said unattended stations, each of said amplifiers including a filament heater circuit, and also including an energizing source for said heater circuits connected to said line at said attended station, all of said filament heater circuits normally being connected in series with said line whereby the respective resistance of each heater circuit is a contributing factor to the total resistance of the line, the method of observing at the attended station the operating condition of the amplifier of each of said unattended repeaters which includes the step of selectively shorting out of said line the filament heater circuits of each of said amplifiers which is operative, one at a time, and observing at the attended station the change resulting in the current flow of the line as each filament heater circuit is shorted out of said line.

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