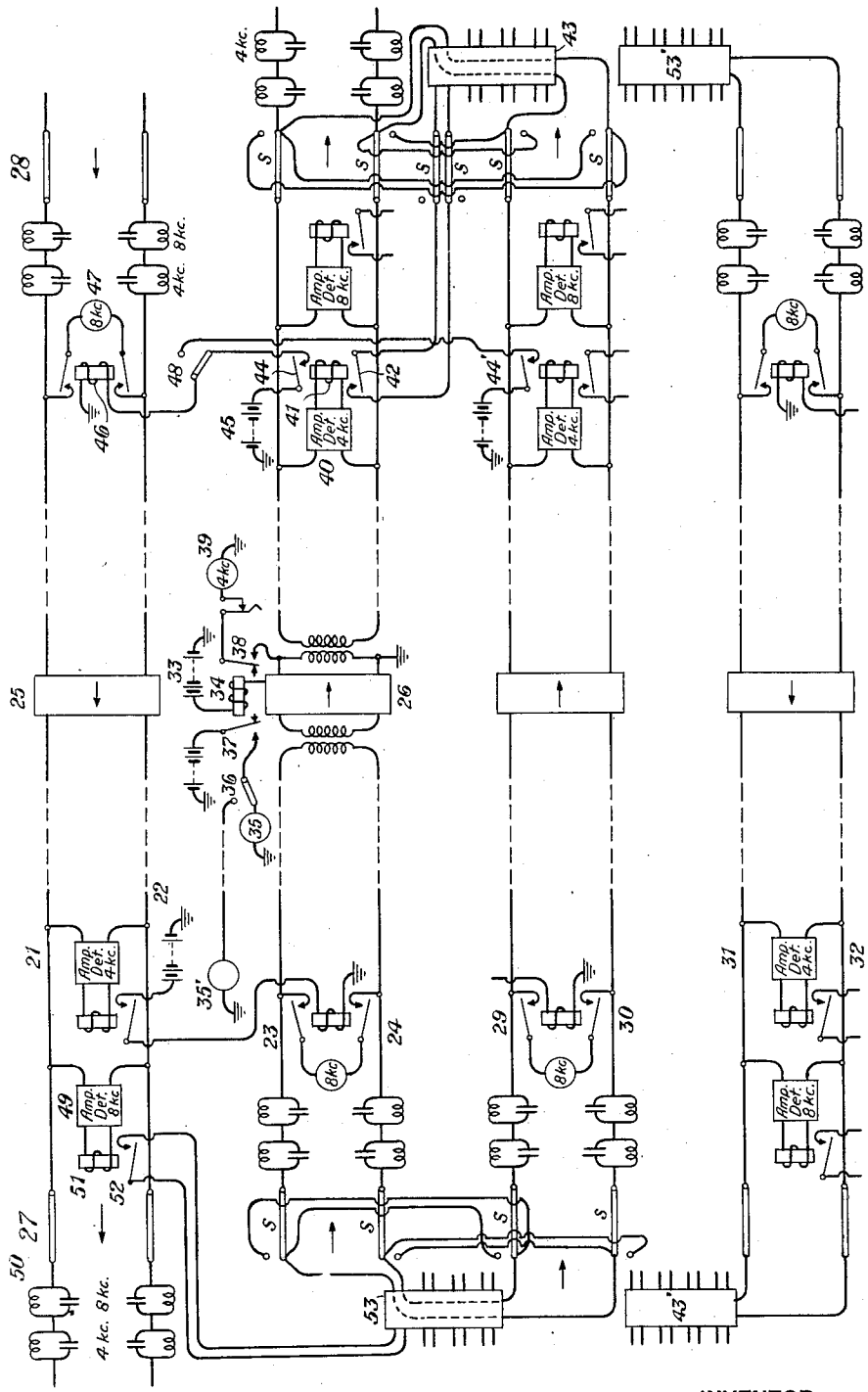
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SYSTEM FOR REPLACEMENT OF A DEFECTIVE CIRCUIT

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SYSTEM FOR REPLACEMENT OF A DEFECTIVE CIRCUIT

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It is among the objects of my invention to provide a new and improved system for replacing a defective signaling circuit by a reserve circuit in normal condition. Another object is to provide a plurality of signaling circuits extending side by side, one of them assigned as a reserve circuit, and to provide means to connect the reserve circuit in lieu of one of the others when such other circuit becomes defective. Another object of my invention is to provide for sending an impulse from the point of origin of a defect on a signaling circuit to one end thereof, and thereby to connect a reserve circuit at that end and to send an impulse the opposite way to make connection of the reserve circuit at the opposite end. All these objects, and various other objects and advantages of my invention will become apparent, on consideration of an example of practice according to the invention, which I will now proceed to disclose in this specification. It will be understood that the following description will relate principally to this particular example of my invention and that its scope will be indicated in the appended claims.

The drawing is a diagram of a system adapted for the practice of my invention.

In the operation of carrier current cable conductor pairs, there will ordinarily be a large number of repeaters; for example, in a stretch of cable extending 400 miles, there may be repeaters at intervals of 25 miles, thus making sixteen repeater sections for that stretch. In such a system the conductor pairs will each be operated one way, and telephone transmission will be on the "four-wire" system. Each of these one-way repeaters at 25-mile intervals may have three stages of amplification, which means three vacuum tubes. Thus in a 400-mile stretch such as suggested, excluding repeaters at the ends of the stretch, there will be fifteen repeaters each with three tubes, making forty-five tubes along any one conductor pair. The failure of a filament in any one of these tubes will throw that conductor pair entirely out of service and, obviously, at the same time render useless the conductor pair serving in the opposite direction to complete the four-wire system. By the application of my invention, such a tube failure will lead to a prompt replacement of the conductor pair involved by a reserve pair held in condition for normal operation.

In the drawing, one normal conductor pair serving for transmission from east to west is shown at 21—22 and the complementary pair for service from west to east is shown at 23—24. These are two pairs out of many in a single cable extending, say, 400 miles from station 27 to station 28, and with fifteen one-way repeaters distributed along each pair such as the repeater 25 in 21—22 and the repeater 26 in 23—24.

A reserve pair 29—30 is in readiness for service from west to east but is normally not connected at 27 and 28. There is a similar reserve pair 31—32 for service from east to west.

Further details of the structural arrangement of the apparatus involved will be readily gathered from the drawing and from the following description of operation. The filaments of the repeater tubes in the repeater 26 are in series, energized by the 24-volt battery 33, and the filament-heating current energizes the series relay 34, holding its armatures 37 and 38 against their front contacts. Suppose a filament fails in one of the tubes of the repeater 26, interrupting the circuit of the battery 33. Thereupon the armatures 37 and 38 move to their back contacts and the armature 37 closes the circuit of a local alarm or indicator 35. If the station of the repeater 26 is an unattended station, the switch 36 can be set so that the alarm or indication will be given at a moderately distant place 35′ where there is an attendant.

When the armature 38 drops back it applies a source 39 of 4 kilocycle current across the line 23—24 on the output side of the repeater 26 in which the defect has occurred. This being a carrier current system there will be several channels on each conductor pair having consecutive frequency ranges and the 4 kc. frequency will be midway between two such ranges so that it will be almost if not entirely excluded by the band filters which separate the channels at the end, or ends, of the line.

The 4 kc. current goes to the right through the remaining repeaters to the right, and at the end of the section at 28 it energizes the amplifier-detector 40, which in turn operates the relay 41 to close the armature 42. The anti-resonant circuits marked "4 kc." at the right on line 23—24 stop the 4 kc. current from going into the next section on the right.

The closing of the contacts at 42 closes a circuit to the line finder 43 which has been connected all the time with the ends of the reserve conductor pair 29—30. At once upon the closure of the circuit from 42 into the line finder 43, the latter connects the ends of conductor pair 29—30 across the line 23—24 as indicated by the dotted lines within the line finder 43. Thus the reserve

circuit 29—30 is connected across defective circuit 23—24 at the right.

At the same time that the amplfier-detector 40 and its relay 41 close the armature 42, they also close the armature 44, applying battery 45 to the circuit of relay 46, which in turn operates to put the 8 kc. source 47 across the line 21—22. The anti-resonant circuits marked "8 kc." keep this 8 kc. current from going to the right on line 21—22 and it goes to the left over the whole stretch from 28 to 27 through all the repeaters such as 25 on the line 21—22 to the end 27 where it actuates the amplifier-detector 49. This in turn energizes the relay 51 and operates its armature 52 to close a circuit into the line finder 53. This line finder 53 is already normally connected to the corresponding end of the reserve conductor pair 29—30 and at once it operates to connect the reserve pair 29—30 across the defective pair 23—24 as indicated by the dotted lines within the line finder 53. The 8 kc. current coming into 27 from the right is stopped by the 8 kc. anti-resonant circuits 50 from going into the section at the left of 27.

The reserve pair 29—30 is now connected at both ends, bridging across the defective pair 23—24. This connection will be effected in a time of the order of 1 second from the failure at the repeater 26, and the interference with conversations over the four-wire system comprising the pairs 21—22 and 23—24 will be negligible.

There will be some loss due to the fact that the defective pair is bridging the reserve pair that has been put in service, and to a limited extent the currents of 4 kc. and 8 kc. frequency may be audible to those persons using these lines. But these disadvantages will not be serious and they will soon be removed, as will now be explained.

The attendant who gets the alarm at 35 or 35', due to the failure in repeater 26, notifies the terminal office at 28, telling where the burn-out has occurred and giving an estimate of the time when it will be remedied. If the attendant at 28 should get no such report within a short time after the 4 kc. current has come in there, he should start inquiries to locate the office of the burn-out. This should be easy because all stations at the right of the place of the burn-out will be getting the 4 kc. tone while those at the left will not be getting it.

As soon as the defect in the repeater 26 has been remedied, the changes are made at the end stations 27 and 28, which are indicated symbolically, by throwing the switches marked S. Also switch 48 at the east station is thrown from the position shown in the drawing. The effect of these changes is to connect the conductor pair 29—30 between 27 and 28 exactly as the pair 23—24 was formerly connected and to make 23—24 the reserve pair connected with the line finders in the same way that 29—30 was formerly connected.

Whereas the pair 29—30 was provided as a reserve for the failures of any pair operating from west to east, the pair 31—32 is provided as a reserve in the opposite direction. However, its connections at the ends are not shown in the drawing because they would be reciprocally similar to the connections for the pair 29—30, and to put them in the drawing would somewhat reduce its clearness of disclosure.

I claim:

1. A plurality of conductor pairs extending between two places, at least one of them being a reserve pair, means operative at an intermediate point of failure on another pair to send a corresponding signal thereon to one of said places, and means actuated by said signal at that place to connect the reserve pair for service in lieu of such other pair.

2. A plurality of conductor pairs extending between two places, at least one of them being a reserve pair, means operative at an intermediate point of failure on another pair to send a corresponding signal thereon to one of said places, means actuated by said signal at that place to connect the reserve pair for service in lieu of such other pair, means to send a signal from that place on a normal pair to the other place, and means actuated by the signal at the other place to connect the reserve pair at that place in lieu of the pair on which the failure has occurred.

3. In a four-wire signaling system comprising two normal conductor pairs respectively for service in opposite directions, and a reserve pair, means operative at an intermediate point where a defect occurs on one of the normal pairs to put a special signal thereon to an end of the system, means there governed by said signal to connect the reserve pair in lieu of the pair in which the defect has occurred and also to put a special signal on the normal pair in the opposite direction to the opposite end of the line, and means there operated by the last mentioned signal to connect the reserve pair at that place in lieu of the defective pair.

4. In a carrier current cable signaling system operated on the four-wire plan with repeaters, means at each repeater to put a special signaling current on the corresponding conductor pair on the output side of the repeater when the repeater fails, means at the end of the line on the output side of the repeater to connect a reserve pair in lieu of the pair involved in the failure and to put a special signal on the complementary pair for service in the opposite direction, and means at the opposite end of the line actuated by the last mentioned signal to connect the reserve pair at that place in lieu of the pair involved in the failure.

5. In a carrier current cable system operated on the four-wire plan at a plurality of frequencies in bands, a plurality of conductor pairs, repeaters associated therewith, means actuated by the occurrence of a defect in a repeater to apply current of special frequency between the bands to the corresponding pair, and means operated by the presence of such current to connect a reserve conductor pair in lieu of the pair involved in the repeater defect.

6. The method of maintaining service in a four-wire system when one conductor pair fails at a certain point along its length, which consists in sending an impulse along such pair to one end and an impulse back therefrom along the other pair to the opposite end, and by these impulses at the ends connecting an alternative pair in lieu of the defective pair.

7. A plurality of conductor pairs extending between two places, means to originate an impulse at a point of failure on a pair and transmit it to both those places and means governed by said impulses as received at said places to connect an alternative pair at those places in lieu of the pair involved in the failure.

8. A plurality of four-wire carrier current multiple frequency band signaling circuits comprising conductor pairs side by side between two places, some for transmission one way and some the opposite way and each with numerous in-

terposed repeaters, tube filament heating circuits and batteries for the repeaters, relays in these last mentioned circuits, sources of current at a frequency between carrier current bands and controlled by said relays for application to the respective pairs on the output sides of the corresponding repeaters, appropriate tuned relays at said places, and switching means governed by said relays to connect an alternative pair in lieu of a pair from which such a tuned relay is operated.

9. A plurality of four-wire carrier current multiple frequency band signaling circuits comprising conductor pairs side by side between two places, some for transmission one way and some the opposite way and each with numerous interposed repeaters, tube filament heating circuits and batteries for the repeaters, relays in these last mentioned circuits, sources of current at a frequency between carrier current bands and controlled by said relays for application to the respective pairs on the output sides of the corresponding repeaters, appropriate tuned relays at said places, another source of current at another frequency between carrier current bands at each of said places, additional switching means governed by said last mentioned relays to apply such other source to a pair for transmission in the opposite direction, appropriate tuned relays at said places to be actuated by transmitted current of the last mentioned frequency, and switching means governed by said last mentioned relays likewise to connect said alternative pair.

10. A plurality of conductor pairs extending between two places, means to originate an impulse of a certain frequency at a point of failure on a pair and transmit it to those places, means governed by said impulses as received at said places to connect an alternative pair in lieu of the pair involved in the failure and anti-resonant circuits in said pairs to stop such impulses from going beyond said places.

11. A plurality of conductor pairs extending between two places, one of them being a reserve pair, means to originate an impulse at a point of failure on a normal pair and transmit it to one of those places, a line finder at such place connected with the reserve pair, and means governed by such an impulse received at such place to set the line finder to connect the reserve pair in lieu of the pair on which the impulse was received.

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