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2,229,158

SWITCHING OF SPARE REPEATER SECTIONS

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FIG. 1

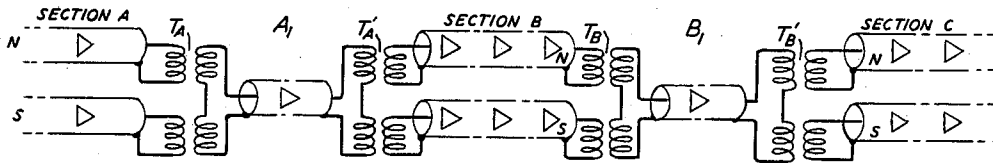


FIG. 2

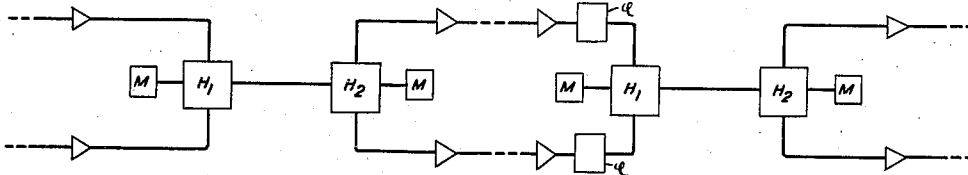


FIG. 3

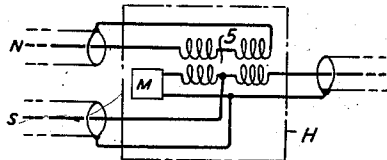


FIG. 4

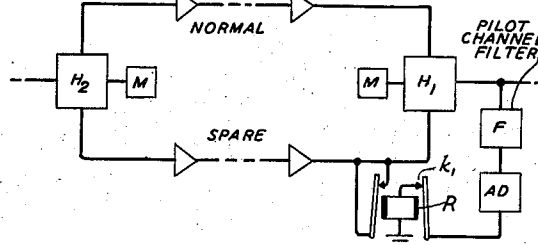


FIG. 8

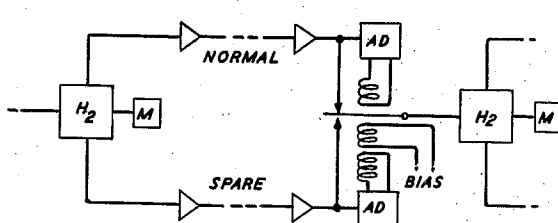


FIG. 7

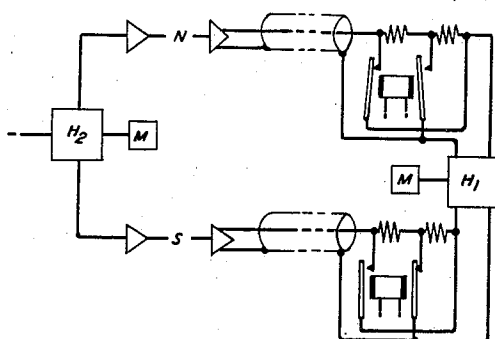


FIG. 6

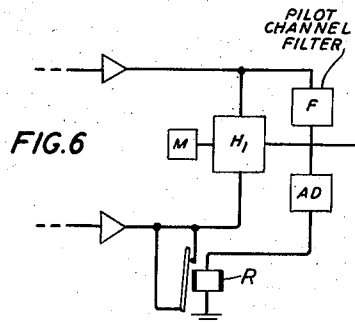
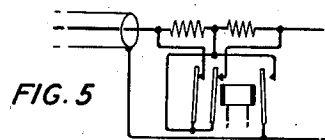


FIG. 5



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SWITCHING OF SPARE REPEATER
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12 Claims. (Cl. 178-44)

This invention relates particularly to broad-band transmission systems such as multichannel carrier current signaling systems.

Although the invention is applicable to open-wire circuits, wire cable and coaxial cable circuits, it relates to problems which become especially significant in circuits carrying a large number of signal channels, such as a coaxial cable. In such circuits it is customary to use a large number of line repeaters in tandem spaced at intervals which may be as short as five miles, or even less, with several unattended repeaters between attended repeater points. The section between such attended points may be perhaps fifty or one hundred miles long. If certain types of failure or a degradation in the operation of any one of the large number of elements in the circuit occurs, such as a tube failure, it means that the whole circuit fails or is degraded and this may involve several hundred signal channels in the circuit. Thus, in certain coaxial systems it is proposed to transmit as many as 400 or 500 channels on a single coaxial conductor. While with great precautions the likelihood of failures or degradation may be very small the number of channels involved renders it of the greater importance to make suitable provision in the event that they do occur.

In my invention I provide certain spare facilities and the purpose of the invention is to arrange for the simultaneous use of the spare facilities with the regular facilities or for the substitution of such spare facilities in place of the regular facilities to such extent as is needed in case of failure. Another purpose is to make any substitution in such manner as to reduce to a minimum any interruption or any irregularity in the transmission of the various signals or types of signals which are being transmitted.

The invention will be better understood by reference to the following specification and the accompanying drawing in which:

Fig. 1 shows an extended transmission circuit made up of several sections and installed in duplicate for simultaneous use;

Fig. 2 is a modification of the circuit of Fig. 1; Fig. 3 shows a detail of a portion of the circuit of Fig. 2;

Fig. 4 is a modification of Fig. 2; Fig. 5 shows a detail of a portion of Fig. 4; and Figs. 6, 7 and 8 are further modifications of Fig. 4.

Referring more specifically to Fig. 1 there is shown a transmission circuit in duplicate. While in this figure, as well as the subsequent ones, the

invention will be described in terms of a coaxial conductor, it is to be understood that this is for illustrative purposes only and that the invention applies equally well to other transmission circuits such as the ordinary cable circuits and is of particular use in any circuit transmitting a broad band of signals such as is required in television or multichannel signaling.

In many such circuits, especially in coaxial systems, it is necessary to have repeaters at frequent intervals along the transmission line and it is expedient that certain of these repeaters shall be unattended, the general control of these repeaters being from certain attended repeater points. In this description it will be convenient to refer to a portion of the line extending from one attended point to the next attended point as a section. In Fig. 1 there are shown several such sections comprising a portion of an extended transmission circuit. In view of the possibility of failure of some sort at any point in a section and in view of the large number of signal channels involved in any one circuit I provide two parallel and identical circuits for each section, it being evident that the likelihood of both sections failing at the same time is much less than that for one. Where Fig. 1 implies that within one section the two circuits will be running in close juxtaposition, and this would very probably be the case in common practice, it is evident that the two circuits may run by different routes thus reducing still further the likelihood of both circuits failing at the same time. In the figure, one circuit in each section is identified by the reference letter N signifying the normal circuit. The duplicate circuits are indicated by the letter S. These symbols, however, in this particular figure have no special significance for, in accordance with my invention, the two circuits in any one section are both normally in operation in parallel in identically the same manner. In each section there are a plurality of spaced repeaters indicated by the triangles, the pointing of the triangles indicating the direction of transmission, which is shown as the same in all the figures. At such points as A₁, B₁, etc. there will be an attended repeater and it will be convenient to bring the two circuits of a section together at these points, as is shown in passing from section A to the preferably short section of cable at the point A₁. Having passed through this repeater, the output is impressed on the parallel circuits of section B. If in any one of the sections a failure occurs in one of the circuits, the signal is then carried entirely by the other circuit with no great

effect or reaction on the preceding or following sections of line.

Fig. 2 is a circuit essentially the same as Fig. 1 in which, for simplicity, the equivalent of the two-wire circuit of the coaxial is represented by a single line. In Fig. 1 the connection from the receiving ends of section A to the common portion of the circuit at the repeater point A_1 is made by ordinary transformers. I find, however, that it is extremely useful to provide for conjugacy between such circuits as N and S in any section and at both ends of the section. This can be provided by means of suitable hybrid coil connections H_1 and H_2 at each attended repeater point. While a number of circuit arrangements can be used for establishing such conjugacy, one circuit which I find particularly simple is shown in Fig. 3, this being a circuit which is well known in the communication art. The four-coil winding has two of its coils connected to the terminals of one incoming circuit. A balancing network M with an impedance equal to that of the outgoing line is associated as shown. With the second incoming circuit connected in bridge as indicated, circuits N and S will be conjugate to each other. Such an arrangement of hybrid coil or its electrical equivalent will be assumed in the remaining figures. It will be apparent that with such an arrangement, if so violent a change as a short circuit should occur in a section N, such short circuit will have no effect upon the S section and vice versa.

In addition to these changes, Fig. 2 takes cognizance of the fact that the phase shift for the two circuits of a given section may not be identically the same. To provide for any desired adjustment of the phase of the signal of one circuit as compared with that in another, Fig. 2 is provided with phase shifting networks ϕ in each circuit. In some instances it may be desirable to so adjust the signals that they add up in phase at the output of the hybrid coil at the end of the section. More generally, however, I find it preferable to introduce a phase difference of 120 degrees between the message coming over the two circuits in a section. In that event, if the amplitude of a signal is represented by a then the vector sum of the two components will still be a and in case one of the circuits is completely disabled the amplitude of the signal impressed on the hybrid coil is still equal to a . In case of partial degradation of one of the circuits, the resultant of the two components will not differ very largely from the same value.

In accordance with the modification of my circuit as shown in Fig. 4 I propose to have the ends of the two circuits of a section associated permanently as already shown in connection with Figs. 1 and 2. In this case, however, one circuit only will be operating normally to supply a signal to succeeding sections and the other circuit will serve strictly as a spare facility. To this end the spare circuit is disabled by either an open circuit or a short circuit at some point in its path, preferably at the receive end as shown symbolically in Fig. 4. In this figure as well as in the previous ones it will be understood that in accordance with standard practice in such transmission circuit, a pilot frequency will be present on the circuit for continually and continuously regulating or adjusting the gain of the repeaters to values appropriate for the existing physical condition of the transmission circuit. It is assumed that such a pilot frequency

is present on both the normal and the spare circuits of Fig. 4 but with the arrangement as shown therein the spare circuit is shorted and therefore neither signal nor pilot frequency pass out from the spare circuit to the hybrid coil. Pilot signal will however be transmitted over the normal circuit. Such signal will be picked off from the line by a filter F and, through an amplifier detector, will then operate a relay R. As long as pilot signal arrives on the normal circuit the spare circuit will be shorted (or opened). In case of failure of the normal circuit or degradation below a certain specified point as indicated by a falling off of the pilot signal, the relay R will release thus enabling the spare circuit. It is evident, however, that as soon as the spare circuit is enabled pilot frequency will then again come through over the spare to operate the relay R which will then interrupt the spare circuit. To prevent such a contingency a lock-out contact k_1 is provided such that when the relay R has been once released it will not then operate by itself.

Since the normal and the spare circuits are conjugate with respect to each other, it is evident that one may now disconnect the normal circuit at any desired points to make any needed repairs or adjustments. Having been restored to action a manual closing of the contact k_1 will then lead to the disablement of the spare circuit as formerly.

While the short-circuiting arrangement for the spare circuit of Fig. 4 is shown as a make and break contact in the main transmission circuit of the spare, I find that for the very high frequencies used in coaxial cables such contacts usually possess sufficient capacity so that when physically open they do not introduce sufficient loss to be serviceable. On the other hand, I find a loss pad such as is shown in Fig. 5 to be effective. In this Fig. 5 there are shown two series resistance and a short-circuiting shunt in the main transmission line. When current is flowing through the relay winding R_1 a short across the line is removed and the series resistance is shorted so that no loss is introduced in the transmission circuit. When no current flows through the winding, however, the short around the series resistance is removed and a direct short across the line is inserted, the whole introducing a loss of sufficient magnitude to serve the purposes as desired. With this loss pad I find that even at frequencies as high as 2 megacycles a loss of 110 decibels is readily attained. It will be observed that there are no series contacts in the direct transmission path. It is also clear from Fig. 5 how this loss pad would be introduced into the circuit of the spare of Fig. 4.

Fig. 6 shows a modification of the circuit of Fig. 4 in that the pick-off point for the pilot channel filter is placed directly on the normal circuit in front of the hybrid coil. In this case it will be apparent that as long as pilot signal is coming over the normal circuit at normal level the spare circuit will be disabled. If the pilot signal fails and the relay R is released then the spare circuit is enabled. Furthermore, since the spare and the normal circuits are conjugate to each other, pilot signal coming over the spare circuit will not enter through the filter F to operate the relay R. As soon, however, as the normal circuit is restored to correct operating condition, the pilot signal coming thereover will disable the spare circuit and thus there is an auto-

matic restoration of normal operating conditions.

Fig. 7 is similar to Fig. 4 except that either circuit may be disabled at will. In this case provision therefor is made by the introduction in each circuit of some suitable switching device, here shown as similar to that in Fig. 5 but somewhat simplified. In Fig. 7 the schematic form of circuit of Fig. 2 is used in part but in order to more fully illustrate the manner of connection, the one-line showing is extended into the two-line showing. Means for exciting the relays in Fig. 7 are omitted but it is evident that they may be operated from any desired points and from any desired source such as direct current batteries or pilot signal or otherwise.

In Fig. 8 a further modification of the circuit of Fig. 2, is shown, this circuit calling for but one hybrid coil. The regular and the spare sections are connected at the transmit end in the same manner as indicated in connection with the previous figures. Instead, however, of bringing them together through a hybrid coil at the receive end, provisions are made for direct switching in the transmission path. Thus in Fig. 8 it will be observed that, through a suitable relay, contact is normally made for transmission over the regular path to the hybrid coil of the next section. The relay for maintaining this connection is controlled by pilot signals coming over the two circuits, these pilot signals being selected by amplifier-detectors to energize two windings of a biased relay. The relay, however, is so biased by direct current or otherwise that connection is normally made from the regular circuit to the next section, the pilot signal over the two circuits virtually neutralizing each other. If, however, pilot signal fails or is degraded over the regular circuit, then pilot signal over the spare takes control and switches the relay contacts so that transmission now takes place to the next section over the spare circuit.

What is claimed is:

1. A communication system comprising a section of broad-band signal transmission line subject to impairment of service, a substantially identical section serving as a spare, normal connections from the receive end of the previous section to the transmit end of the regular and the spare sections for continuously activating both by signals, and means at the receive end of said regular and spare sections for connecting them alternatively to activate the next section.

2. The combination of claim 1 characterized by the fact that the regular and spare sections are so associated with the previous section that they are conjugate with respect to each other.

3. In a communication system comprising a section of broad band signal transmission line subject to impairment of service, a substantially identical section serving as a spare, means for concurrently activating the transmit ends of said sections with signals from the previous section, means for concurrently activating the next section with signals from the receive ends of both said regular and said spare sections, and phase adjusting means in one of the two first-mentioned sections to bring the respective outputs of said two sections into a desired phase relationship such that if one of said two sections

is disabled the vectorially combined output will remain approximately the same.

4. In a communication system comprising a section of signaling circuit subject to impairment of service, a substantially identical section serving as a spare, a six-terminal network connecting the transmit ends of the regular and spare sections in conjugate relation with each other for normally concurrent activation by signal from the receive end of the previous section, and another six-terminal network connecting the receive ends of the regular and spare sections in conjugate relation with each other and to the transmit end of the next section.

5. The combination of claim 4 characterized by the fact that there is a phase adjusting network in at least one of the circuits to bring the output of the two parallel sections into desired phase relationship.

6. The combination of claim 1 characterized by the fact that there are means for normally disabling the spare circuit but for enabling it when the regular circuit is impaired.

7. The combination of claim 1 characterized by means for normally disabling the spare circuit at its receive end but for enabling it when the normal circuit is impaired.

8. In a communication system comprising a section of coaxial circuit subject to impairment of service, a substantially identical section serving as a spare, a hybrid coil connection from the receive end of the previous section to the transmit end of the regular and the spare sections whereby both the regular and the spare sections are normally activated by signal in parallel, a hybrid coil connection from the receive ends of the regular and spare sections to the transmit end of the next section, a pad connection at the receive end of the spare section and means controlled by the pilot signal in the normal circuit to control the pad whereby when pilot signal is normal the losses due to the pad are high and when pilot signal is below normal the losses due to the pad are low.

9. The combination of claim 4 characterized by the fact that there are means for normally disabling the spare circuit but for enabling it when the regular circuit is impaired.

10. The combination of claim 4 characterized by means for normally disabling the spare circuit at its receive end but for enabling it when the normal circuit is impaired.

11. In a communication system comprising a section of coaxial circuit subject to impairment of service, a substantially identical section serving as a spare, a hybrid coil connection from the receive end of the previous section to the transmit end of the regular and the spare sections whereby both the regular and the spare sections are normally activated by signal in parallel, and means for normally disabling the spare circuit but for enabling it when the regular circuit is impaired.

12. The combination of claim 4 characterized by the fact that there are means for normally disabling the spare circuit but for enabling it when the regular circuit is impaired, the said means being subject to pilot signal.

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