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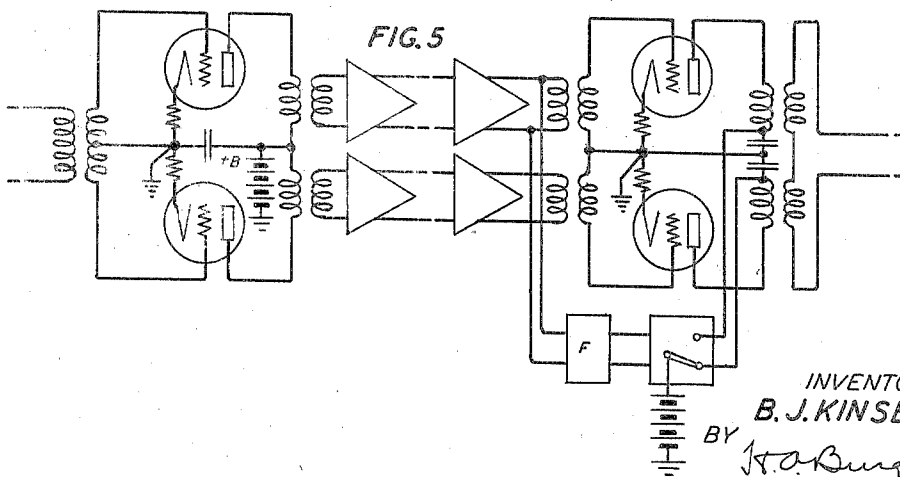
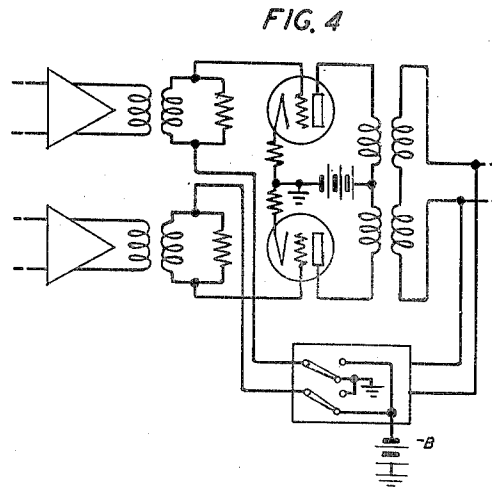
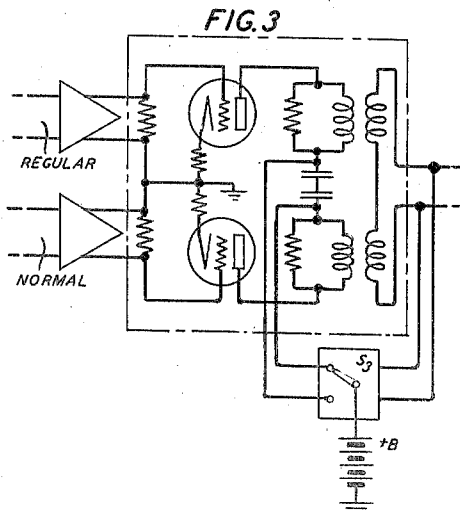
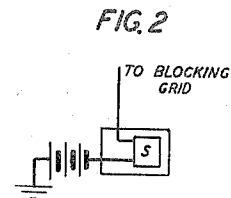
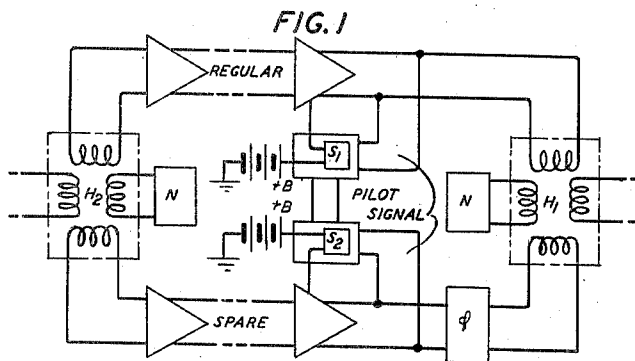
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2,229,089

SWITCHING OF SPARE CHANNEL

Filed Sept. 28, 1939

2 Sheets-Sheet 1



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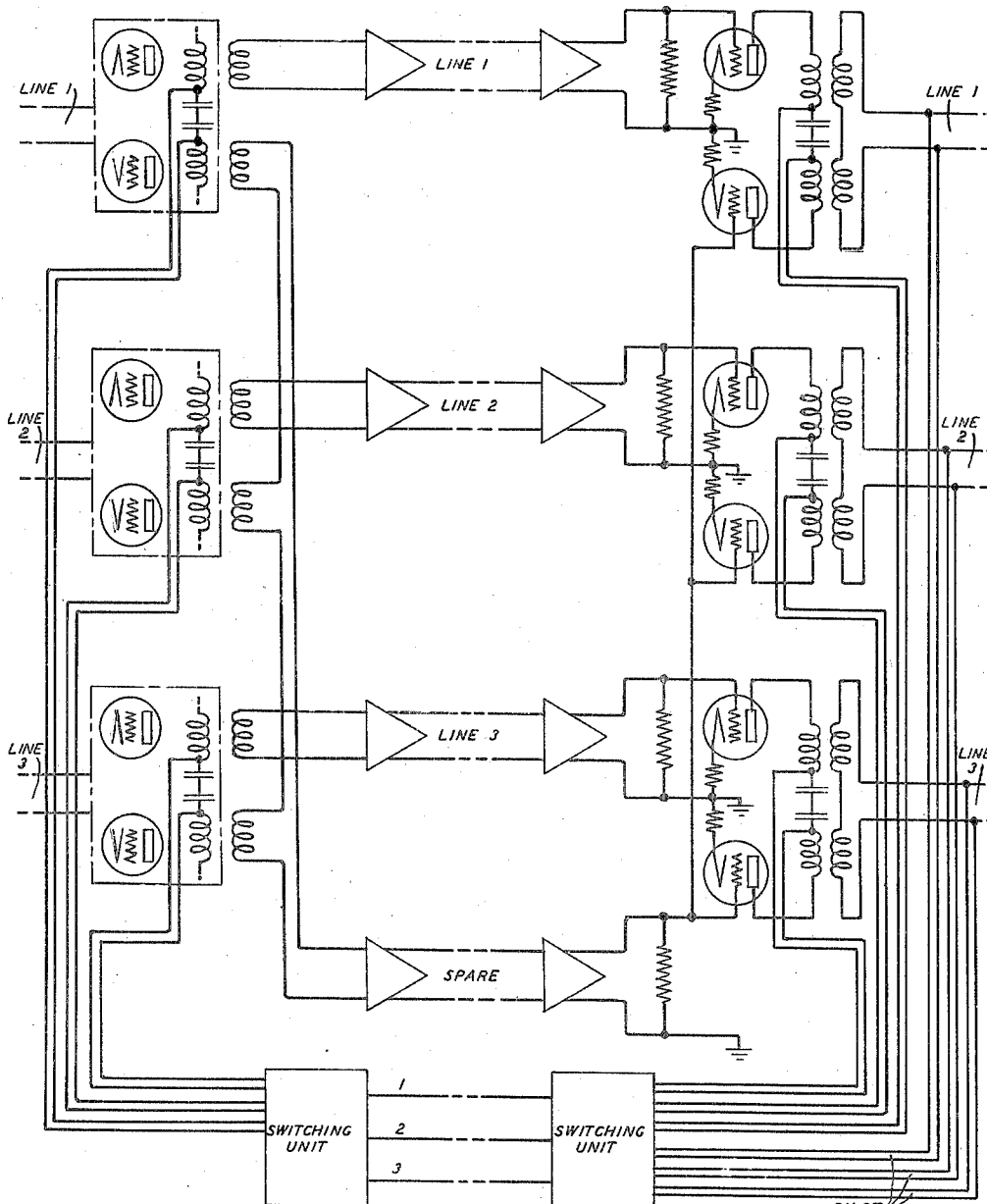
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FIG. 6



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SWITCHING OF SPARE CHANNEL

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Application September 28, 1939, Serial No. 296,890

6 Claims. (Cl. 178—44)

This invention relates to broad band transmission systems, such as multichannel carrier current signal 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, a section between such attended points being perhaps fifty or one hundred miles long. If a failure or a degradation in the operation of any element or elements in the circuit occurs, such as a tube failure, it usually means that the whole circuit fails or is degraded, and this may involve several hundred signal channels in the circuit. While with great precautions the likelihood of failures or degradation may be very small, the number of channels involved renders it of the greatest importance to make suitable provision in the event that they do occur.

My invention relates to such circuits as are described in patent application of I. G. Wilson, Serial No. 296,893, and in patent application of Maggio, Van Tassel and Wilson, Serial No. 296,892, both filed of even date herewith. In this invention I provide spare circuit facilities and the purpose of the invention is to arrange for the substitution of such spare facilities or circuits in place of the regular facilities or circuits 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 the interruption or irregularity in the transmission of the various signals or types of signals which are being transmitted. Still another purpose is to introduce in such circuits electronic switching which is rapid in its action and to do this in a manner which does not entail mechanical switching in the direct transmission path.

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

Fig. 1 is a circuit showing the use of a regular and a spare section with switching in an electronic path;

Fig. 2 is a modification of a portion of Fig. 1;

Figs. 3 and 4 are more detailed disclosures of circuits which may be used in carrying out my invention;

Fig. 5 is a further modification of Fig. 1; and

Fig. 6 shows the application of my electronic switching arrangements to a plurality of regular circuits which are to be serviced by one spare circuit.

Referring more specifically to Fig. 1, there is shown one section of a transmission system with a regular circuit and a spare circuit. The two are associated at their transmit end with the previous section of the system through a hybrid coil H_2 so connected that the regular and the spare both receive signal from the previous section but are conjugate with respect to each other and thus, in that respect, completely separate. The two circuits in the section are similarly joined at their receive end with a similar hybrid coil H_1 . Both the regular and the spare circuits receive signal from the previous section and are excited for their whole length. Provision is made, however, whereby the regular circuit is normally enabled and the spare circuit is normally disabled at the receive end, preferably at the output of the last amplifier. An important part of my invention resides in the fact that such enablement and disablement shall not involve switching in the direct transmission path and the method which I find particularly effective for carrying out my invention is to resort to electronic switching, that is, switching which involves the interrupting or establishing of an electronic path. Such electronic path may very conveniently comprise the stream of electrons flowing from a filament to a plate in a vacuum tube amplifier; thus in Fig. 1 switches S_1 and S_2 connect or disconnect B battery in the plate circuit of the last tube in the regular and in the spare circuit. During normal operation pilot signal from the regular circuit operating through suitable filter amplifier-detector circuits will maintain the switch S_1 closed, whereby B battery voltage is connected in the amplifier of the regular circuit. At the same time this pilot signal operating on switch S_2 will remove B battery from the corresponding repeater in the spare circuit, thus disabling the circuit. If pilot signal over the regular circuit fails, then operation of the switches will reverse the situation so that the regular circuit is completely disabled and the spare is enabled, the switching occurring in electronic paths.

While the switches S_1 and S_2 may take on a wide variety of forms, such as the usual mechanical switching relay, I find it useful in some cases to open or close the circuits of the B batteries by gas discharge devices. The presence of pilot signal of sufficient magnitude, after detection and amplification, may be used in any well-known

manner to trigger off such a gas discharge device placed in series in the B battery circuits.

In some cases I find it desirable to allow signal to come over both the regular and the spare circuits and be transmitted into the next section of the signaling system. Under these conditions both of the switches S_1 and S_2 would be operated to connect in their respective batteries. The switches in that case would be maintained in such operative condition by pilot signal over the two circuits. In such operation it would be desirable to have some phase adjusting device ϕ in one of the circuits to maintain the output of the two circuits substantially 120 degrees apart. The resultant of these two will then be equal to the magnitude of one of the components. If one of the circuits fails, the magnitude of the transmitted impulse into the following section is not appreciably altered.

While in Fig. 1 electronic switching has been shown as consisting of the connection and disconnection of the B battery, it is obvious that the electronic path may be interrupted in some other manner, such, for example, as a blocking bias introduced on an appropriate grid. Such an arrangement is indicated in Fig. 2 where the switch S may be controlled in a manner analogous to that described in connection with Fig. 1.

Fig. 3 shows a modification of the circuit arrangements for the receive end of the two circuits, a modification which still retains the advantages of electronic switching. In this figure the hybrid coil H_1 of Fig. 1 is replaced by a mixing circuit consisting essentially of two vacuum tube repeater units in parallel. The one circuit or the other is maintained in an enabled position by the application of B battery through the switch S_3 . This switch is operated by pilot signal in a manner already described in connection with Fig. 1. A sufficient change in the value of the pilot signal will bring about the switching operation. The switch is of such a form, as a gaseous discharge device, that having been operated it remains operated, even though pilot signal arrives from the spare circuit. In the circuit of this figure, as in that of Fig. 1, the regular and spare circuits may both be transmitting to the next section, preferably with the phase relationship already described. One of the advantages of the mixing circuit of Fig. 3 is the avoidance of the use of a hybrid coil with its attendant loss. Preferably, the mixing circuit should have a gain of zero decibels, in which case the line which is disabled can be repaired on an out-of-service basis. While the amplifiers of the mixing circuit are shown in a simple form, it is to be understood that actually they will include the usual precautions, such as feedback, which are desirable for broad band, high frequency amplifiers.

Fig. 4 is essentially the same as Fig. 3 with the exception that the interruption of the electronic path is obtained by the interruption of a biasing voltage on the grid of a tube. Also, it will be noted that the connection from the incoming line to the mixing circuit takes place through transformers.

Fig. 5 shows the replacement of a hybrid coil at the transmit end of the section by a mixing circuit. This connection still retains the feature of effective separation of the lines and without the loss normally characteristic of hybrid coils. Again, it will usually be desirable to operate the mixing circuit on the basis of zero decibel gain. The connections at the receive end are the same as for Fig. 3 with the exception that the pilot

signal to control the switching is taken off from the output of the regular circuit only.

Fig. 6 shows the application of my invention to a case where one spare circuit is provided for a plurality of regular circuits. Under these conditions it is necessary that switching of the spare shall occur at both ends of the section. For illustrative purposes, there is shown at the transmit end of the section the same type of mixing circuit as is shown in Fig. 5. Also, at the receive end there is associated with each regular circuit a mixing circuit of the type described in Fig. 3. The spare circuit at the receive end is connected to the tube in the spare position in each mixing circuit. Under normal conditions each tube in the spare position of these mixing circuits is disabled. If, however, pilot signal fails on one regular circuit, such as circuit No. 2, then the tube in spare position for that mixing circuit is enabled for operation of the switching unit at the receive end. A corresponding switch must be made at the transmit end and for this purpose a suitable signal is sent from the switching unit at the receive end to a corresponding switching unit at the transmit end which will so operate the elements in the switching unit as to enable the tube in the spare position in the mixing circuit of circuit No. 2. The connection from the switching unit at the receive end with that at the transmit end may very conveniently be carried out over special small conductor wires. In some cases, however, the speed of transmission over such a wire would not be high enough to complete the switching operation in the necessary short interval of time. In that event it may be desirable to use a circuit of higher velocity connecting the two ends of the section, and for this purpose the transmission line itself may be used. This is particularly suitable in some cases where the transmission line consists of a coaxial cable.

It is apparent, of course, in connection with Fig. 6 that provision must be made whereby if one of the regular lines has failed and has been replaced by the spare that no other regular line during that period shall be able to seize the said spare. To this end an interlocking arrangement would be necessary, such, for example, as the interlocking arrangement shown in the application of Maggio, Van Tassel and Wilson, referred to above.

The switching unit at the receive end has its operations controlled by the pilot signals in the plurality of regular circuits, and by the operation of any suitable relays or equivalent structure will perform the switching operation in the mixing circuit at the receive end as well as at the transmit end of a given section.

What is claimed is:

1. A communication system comprising a section of signaling circuit embracing at least one repeater span and subject to impairment of service, a substantially identical section serving as a spare, means connecting the sections together at the transmit end of the section to the preceding section of the system so that both are signal excited, an electron discharge path in each signaling circuit at the receive end for connecting said circuits to the succeeding section, and means controlled by a pilot signal on one of the circuits for interrupting the one electron discharge path or the other.

2. A communication system comprising a section of signaling circuit embracing at least one repeater span and subject to impairment of

service, a substantially identical section serving as a spare, means connecting the sections together at the transmit end of the section to the preceding section of the system so that both are signal excited, an electron discharge path in each signaling circuit at the receive end, and means to normally maintain the electron discharge path in the regular circuit but to interrupt the electron discharge path in the spare, said means being so controlled by a pilot signal on one of the circuits that when the regular circuit is impaired the electron discharge path therein is interrupted and that in the spare circuit is established.

3. A communication system comprising a section of signaling circuit subject to impairment of service, a substantially identical section serving as a spare, means connecting the sections together at the transmit end of the section to the preceding section of the system so that both are signal excited, a vacuum tube amplifier with a grid control in each path at the junction between the receive end of said section and the succeeding section, and means operating on the said grids to normally block the tube in the spare, said last-mentioned means operating on impairment of a regular circuit to unblock the tube of the spare and block the tube of the regular circuit.

4. A communication system comprising a section of signaling circuit subject to impairment of service, said section embracing at least one signal repeater span, a substantially identical section serving as a spare, means connecting the sections together at the transmit end of the section to the preceding section of the system so that both are signal excited, the said means comprising parallel repeater tube circuits of zero decibel gain, one for the regular and one for the spare circuit, and electronic switching means for alternatively connecting the receive ends of said regular and spare to the succeeding line section.

5. In a communication system, a geographically extended section thereof comprising a plurality of substantially identical circuits subject to im-

pairment and having an electron discharge path in each signaling circuit at both the transmit and the receive ends of the section, means for setting aside one circuit as a spare, and means for replacing an impaired circuit by the spare, said last means interrupting the electron discharge path of the impaired circuit and simultaneously establishing the electron discharge path of the spare circuit at both ends of the section.

6. In combination in a signaling system, a plurality of regular repeatered transmission lines for the long distance transmission of respectively different signals, said lines being divided into a plurality of tandem-connected sections with a signal amplifier in each line at the junctions of said sections, a spare transmission line associated with said regular lines and adapted for replacing any section of a regular line that may become impaired, switching means for connecting the transmit end of a section of spare line to the adjacent receive end of the preceding section of a regular line that may become impaired, signal repeaters, each comprising an electron discharge device and each fixedly connected between the receive end of said spare section and the respective transmit ends of the succeeding sections of said regular lines, means normally blocking the electron discharge in all of said discharge devices whereby said spare section is inoperative, means for transmitting pilot current through each of said regular lines, and means at each of said discharge devices responsive to an abnormal change in the pilot current in the respectively corresponding regular line for unblocking the corresponding discharge device, said responsive means simultaneously disabling the corresponding regular line section, and means actuated by said responsive means for operating said switching means, whereby transmission through one of said regular sections is immediately transferred to said spare section.

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