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DISTORTION REDUCTION IN CHANNEL SWITCHING

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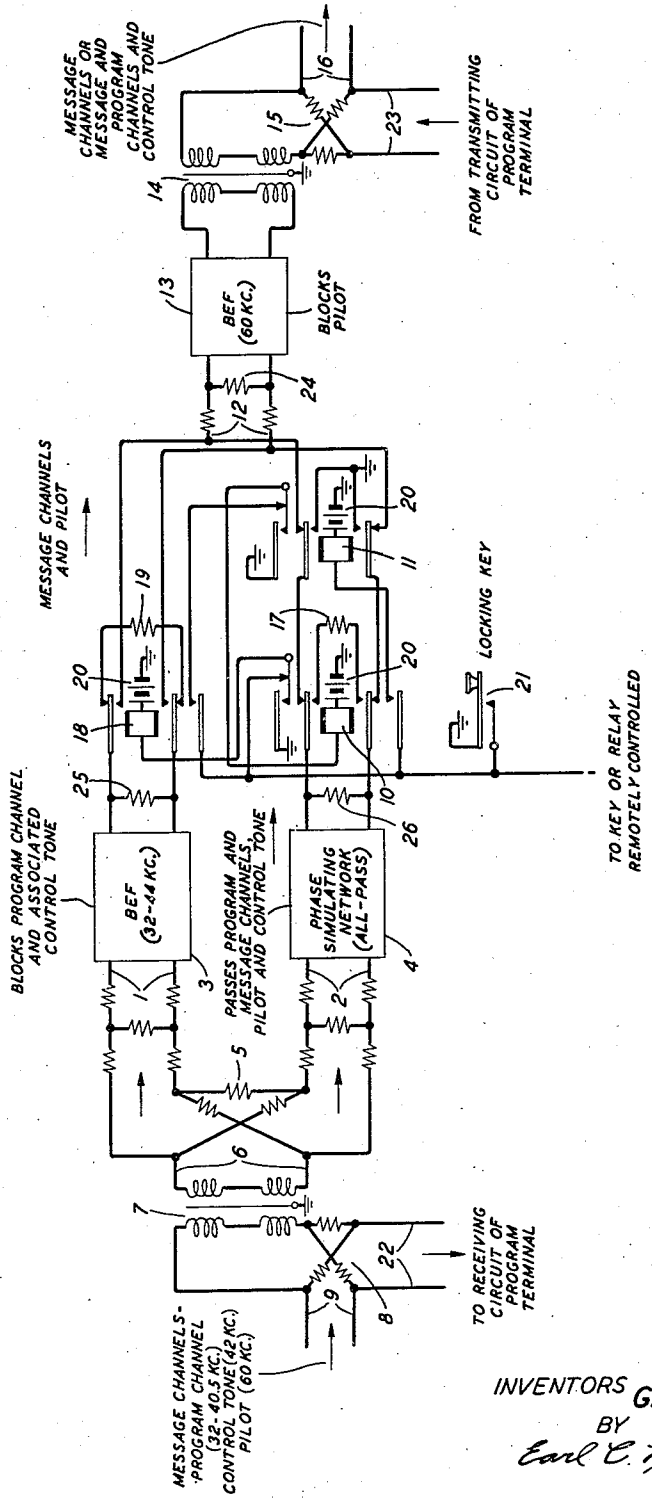

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DISTORTION REDUCTION IN CHANNEL SWITCHING

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The invention relates to a system for transmitting a plurality of signals comprising different frequencies or frequency bands for communication, entertainment or control purposes over common transmission paths between stations, and particularly to branching arrangements for providing a desired distribution of the different types of signals at the stations of such a system.

It is specifically applicable to, although not limited to, a broad-band carrier transmission system utilized for transmitting a broadcast program channel as well as telephone and telegraph message channels and single frequency tones for regulating, switching or other control purposes by means of carrier waves over common wire transmission paths between stations in each direction; and in which a program branching arrangement including two alternate paths of transmission for the carrier signals and relay means for switching from one path to the other are provided for each direction of transmission at certain intermediate stations. One of these paths is utilized to provide through transmission of the program and message channels and all control tones at carrier frequencies between the incoming and outgoing carrier lines, and the other to block transmission of the program channel and its associated control tone so that a new program channel can be introduced for transmission beyond the branching point, while allowing through transmission of the message channels and other control tones between the incoming and outgoing carrier lines.

During the process of switching from either of these alternate paths to the other, the two paths are connected in parallel between the incoming and outgoing carrier lines for a short interval of time, resulting in a temporary increase in transmission to the outgoing carrier line during this time interval. This causes distortion in the transmitted signals at the branching point which is particularly objectionable in the case of voice frequency telegraph signals superposed on the message channels.

An object of the invention is to reduce signal distortion in systems of the above type.

A more specific object is to reduce signal distortion at program branching points of a carrier system of the above-described type, and particularly to reduce "hits" in telegraph signals transmitted over the audio frequency channels of such a system during the process of switching transmission from one alternate transmission path to the other.

These objects are attained in accordance with

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the invention by the provision of means for inserting compensating attenuation in the path of the signal channels transmitted to the outgoing carrier line during the short time intervals in which the alternate paths are connected in parallel by operation or release of the relay means, this attenuation being such that the combined current output of the two alternate paths transmitted to the ougoing carrier line during each of these time intervals is not appreciably greater than the current output of either one of the two paths after a transfer has been made. In one embodiment of the invention this is accomplished efficiently and economically by slightly modifying an attenuation network normally provided at the branching point for fixing the amplitude level of the carrier signals transmitted to the outgoing carrier line through either of the alternate transmission paths at a desired value, and locating the switching contacts of the relay means for switching transmission from either of these paths to the other at an intermediate point in the network. This involves replacing a shunt resistor of the attenuation network with two resistors of approximately the same value as the resistor they replace, which resistors are respectively permanently connected in shunt with a different one of the two alternate paths near its output end, and locating the contacts of the switching relay means at points intermediate these resistors and the other portions of the attenuation network located in a common circuit feeding the outgoing carrier line. During the short time intervals in which the two alternate transmission paths are connected in parallel between the incoming and outgoing carrier by operation or release of the switching relay means, the two resistors will be effectively connected in parallel with the outgoing carrier line and one or the other resistor only will be effective in the level controlling attenuation network at other times.

The various objects and features of the invention will be better understood from the following detailed description thereof when read in conjunction with the single figure of the drawing showing a portion of a branching repeater station of a broad-band carrier transmission embodying the invention.

The arrangements of the invention will be described and applied to a particular commercial broad-band carrier system utilizing particular frequency values for the message, program and control signals transmitted at carrier frequencies over the line to intermediate branching points, for which they were devised, but it is to be under-

stood that they may be applied equally well to carrier systems utilizing other frequency values for the carrier signals at these points. This particular carrier system was utilized for transmitting in each direction at carrier frequencies a high quality radio broadcast program channel initially comprising a frequency band extending from about 40 to 8,000 cycles and nine message channels initially in the audio frequency range as well as single frequency tones respectively utilized for conditioning program terminals connected to the line system at intermediate branching points for receiving the program signals, and for assisting in the regulation of the gain of the line amplifiers at repeater points to compensate for variations in line attenuation. In this system, the audio frequency program and message channels for each direction of transmission are modulated at the carrier terminal or other signal generating stations to adjacent single sideband positions in the high frequency range 60 to 108 kilocycles, and are then remodulated as a group with a suitable carrier to relocate them in adjacent positions within the frequency band 12 to 60 kilocycles in which the program channel occupies the frequency range 32 to 40.5 kilocycles, for transmission over common line circuits between stations.

The program channel may be utilized for transmitting studio material to various radio broadcast transmitters or other program reproducers connected to the line system at certain intermediate stations, and the message channels for transmitting telephone messages and voice frequency telegraph signals to a distant point. If a nationwide program network were built up of short links interconnecting a large number of radio broadcast transmitters or other program transmitting means to form continually changing combinations of studios and transmitting stations for different periods of time, changing from carrier frequencies to voice frequencies and back again to carrier frequencies at each point where the program circuit may be split would introduce more than allowable signal distortion because of the large number of program band filters through which the program signals might have to pass. To reduce this distortion without decreasing the flexibility of the system, program branching equipment has been provided for each direction of transmission to permit the program to pass through a branching point at carrier frequencies when a break is not required at that point, or alternatively to block off the incoming program channel at that point so that a new program channel may be added for transmission over the system beyond the branching point.

The branching equipment for accomplishing these purposes for the west-to-east direction of transmission at one intermediate station is illustrated in the drawing. As shown, this equipment includes two alternate transmission paths 1 and 2, respectively including a band elimination or blocking filter 3 and a phase simulating network 4, for the carrier signals. The inputs of the two paths 1 and 2 are permanently connected through the resistance hybrid 5 to a common two-wire circuit 6 which is connected through the repeating coil 7 and a second resistance hybrid 8 to a west carrier line 9 over which there is incoming in the west-east direction from a preceding carrier terminal or intermediate repeater station: a program channel at carrier frequencies in the range from 32 to 40.5 kilocycles; a control tone of 42 kilocycles to be utilized for locking program terminals connected to the line system at this and succeeding branching points in the receiving condition; a 60-kilocycle pilot tone for use in connection with the regulation of line amplifiers at intermediate repeater points to compensate for line attenuation variations; and nine message channels respectively carrying telephone messages and voice frequency telegraph signals, occupying other frequency positions in the line carrier frequency range of 12 to 60 kilocycles.

The band-elimination or blocking filter 3 in the transmission path 1 is designed to transmit with little attenuation wave of all frequencies within the line carrier frequency range 12 to 60 kilocycles except the frequency band 32 to 44 kilocycles utilized for the program channel and its associated control tone to which it presents high attenuation; and the phase simulating network 4 in the path 2 is designed to pass with little attenuation all frequencies within the line carrier frequency range 12 to 60 kilocycles and to simulate the phase characteristic of the blocking or band-elimination filter 3 in the path 1 over the frequency ranges of the message channels.

The output of the transmission path 2 including the phase simulating network 4 is normally disconnected from a terminating resistor 17 of a value, say 135 ohms, corresponding to the impedance of the incoming line circuit, because of the normally open condition of certain associated switching contacts of the normally unenergized electromagnetic relay 10, and is normally connected through normally closed switching contacts of the relays 10 and 11 to the two-wire circuit 12 including the band-elimination filter 13, which is connected through the repeating coil 14 and a third resistance hybrid 15 to the east carrier line 16 extending in the west-to-east direction to other branching and intermediate repeater stations or to an east carrier terminal station (not shown).

The output of the alternate transmission path 1 including the band-elimination or blocking filter 3, is normally disconnected from the two-wire circuit 12, and thus from the east carrier line 16, due to the normal open condition of certain switching contacts of the normally unenergized electromagnetic relay 18, and is normally connected through other normally closed switching contacts of that relay to the terminating resistor 19 having a value, say of 135 ohms, corresponding to the impedance of the input line which it faces. The relays 10, 11 and 18 are arranged to be operatively energized from a suitable power supply source, which may be a common battery 20, by the closing of the key 21 at the local program branching station by an attendant or, if this station is unattended, as indicated, by operation of a key-controlled relay or other means by remote control from a distant attended repeater or carrier terminal station, and are adapted to be deenergized by the opening of the local key 21 or release of the remote control mechanism. In any suitable manner, the relay circuits are arranged so that the three relays operate in the sequence order 18, 10 and 11 and release in the reverse order 11, 10 and 18 for reasons to be pointed out later in connection with a complete description of operation of the program branching arrangement.

The circuit 22 bridged by the resistance hybrid 8 across the output of the west carrier line 9 connects through suitable group demodulating, filtering and amplifying equipment (not shown) to the receiving circuit of a program terminal

feeding into a voice frequency program network, and the transmitting circuit of another program terminal fed from a voice frequency program network is connected through suitable group modulating and filtering equipment (not shown) to the circuit 23 bridged by the resistance hybrid 15 across the input of the east carrier line 16.

The program branching arrangement of the drawing operates in the following manner:

The energy of the program and message channels at carrier frequencies and the accompanying 42-kilocycle and 60-kilocycle control tones incoming over the west carrier line 9 is split into two energy portions by the resistance hybrid 8. One portion diverted into the circuit 22, after modification in the associated group demodulating, filtering and amplifying equipment enters the receiving circuit of a program terminal which is locked in the receiving condition in response to the 42-kilocycle control component, and the detected voice frequency program signals are fed to the associated program network.

The other energy portion of the incoming carrier signal passes through repeating coil 7 the function of which is to rebalance the signals to ground after passing through the preceding resistance hybrid 8, and the two-wire circuit 6 to the resistance hybrid 5 which splits this energy into two portions which are respectively transmitted into the inputs of the two alternate paths 1 and 2 for the carrier signals. With the relays 18, 10 and 11 in the normal unenergized condition shown, the energy portion passing through the blocking filter 3 in the path 1 is dissipated in the terminating resistor 19, whereas the other portion including all frequencies of the applied program and message channels, the 42-kilocycle control tone and the 60-kilocycle pilot passes through the "all-pass" phase simulating network 4 in path 2 to the circuit 12 in which the 60-kilocycle pilot tone is effectively suppressed by the band-elimination filter 13 having high discrimination in the neighborhood of 60 kilocycles, and the remaining nine message channels, the program channel and a portion of the 42-kilocycle control tone are transmitted through the repeating coil 14 having a function similar to that of repeating coil 7, and resistance hybrid 15 to the outgoing carrier line 16 at carrier frequencies.

When it is desired to introduce a new program at the branching point, the local key 21 or the remote control mechanism is operated so as to cause energizing current to be supplied to the three switching relays 18, 10 and 11 which operate in that sequence. The operation of relay 18 opens the normally closed contacts of that relay to remove the resistance termination 19 from the blocking filter 3 in path 1 and closes the normally open contacts to connect the output of that filter in parallel with the output of the simulating network 4 to the circuit 12. The operation of relay 10, next in sequence, in consequence of closure of its energizing circuit by an armature and contact of relay 18 opens the normally closed contacts of relay 10 to disconnect the output of the phase simulating network 4 in path 2 from the circuit 12, and thus from the east carrier line 16, and closes the normally open contacts of relay 10 to connect the terminating resistor 17 across network 4. The relay 11, the energizing circuit of which is closed upon energization of relay 10 to close its lower normally open contacts, then operates to open its normally closed contacts and close its normally open contacts to disconnect and ground the wiring from the relay

10 thus reducing cross-talk through relay 16 around the blocking filter 3. The relay 11 is not essential and may be eliminated in some cases.

The connection of the path 1 including the blocking filter 3 to circuit 12 in this manner, in place of the path 2 including phase simulating network 4, blocks the 32 to 40.5 kilocycle program channel and its associated 42-kilocycle program terminal controlling tone while permitting the nine message channels in the carrier frequency range 12 to 60 kilocycles to be transmitted between the west carrier line 9 through path 1, circuit 12, filter 13, repeating coil 14 and resistance hybrid 15 to the east carrier line 16.

The band-elimination filter 13 in the circuit 12 serves to block the 60-kilocycle pilot from the east carrier line 16. In this particular carrier system, the regulation of the line amplifier at repeater points is controlled by the total power transmitted over the preceding section of line, and this power is kept essentially constant by the 60-kilocycle pilot varying oppositely from the total signal. When the program channel is blocked at the branching point by the blocking filter 3 and a new program is not introduced at the branching point the sum of the original pilot and modified signal beyond the branching point would no longer be constant, and the regulation would be faulty. Therefore, the blocking of the original 60-kilocycle pilot and the introduction of a new pilot to regulate the remaining portion of the carrier line are necessary. At some branching points where no 60-kilocycle pilot is applied, the 60-kilocycle suppression filter would be omitted and the resistance pad at the point 24 in the input of circuit 12 would be designed to provide increase loss to keep the total loss at signal frequencies equal to that of the branching point illustrated.

When the local key 21 is opened or the remote control mechanism is released to cut off the supply of energizing current from the battery 20 or other power supply, the three relays will release in the reverse order, that is, first relay 11, then relay 10 and then relay 18, and the branching circuits will return to the normal condition shown in which the through transmission circuit includes the phase simulating network 4 in path 2 and the alternative circuit including blocking filter 3 is disconnected from the load circuit and terminated. The reverse order of relay release is required so that the through circuit for the carrier signals including the phase simulating "all-pass" network 4 is completed before the through circuit including blocking filter 3 is opened in order to prevent loss of signal transmission.

It will be seen from the above description of operation that for a short time interval while relays 18, 10 and 11 are operating to switch through transmission from path 2 to path 1, and for a short time interval while relays 11, 10 and 18 are releasing to switch through transmission from path 1 to path 2, the two paths 1 and 2 will be connected in parallel to the output load including circuit 12 connected to the east carrier line 16. Each of these time intervals for the particular relays used was in the order of about 40 milliseconds, and it was found by tests that during these time intervals the increase in transmission to the load was in the order of 2.5 decibels more than that obtained when the output of only one of the paths was connected to the load after a transfer had been made from one path to the other, resulting in signal distortion. It was

found that these temporary increases in current transmission produced objectionable "hits" in the case of the voice frequency telegraph signals superposed on some of the message channels.

Consideration of the possibility of using extremely fast operating relays to alleviate these difficulties brought to light the following factors. Such relays must be of very special type. They tend to be very critical in their operation and they require special maintenance. Sometimes their necessary dimensions are such as to preclude their fitting into available space in the apparatus of the existing telephone plant. These facts lead to the conclusion that a solution of the problem based on the use of very fast relays is unlikely to be satisfactory from the standpoint of cost.

An analysis of this problem showed that the ratio of the current I transmitted to the load from the two equal sources, (outputs of paths 1 and 2) when both are connected in parallel to the load, to the current i transmitted by only one of the sources (output of path 1 or path 2) to the load is

$$\frac{I}{i}=\frac{2R_2/R_1+2}{2R_2R_1+1} \qquad (1)$$

where R_2 is the load resistance and R_1 is the resistance of either source. It will be seen that this ratio approaches unity as the resistance of the sources R_1 become small compared to the load resistance R_2.

In the present design of program branching equipment in the commercial carrier system above described, the effective load at the point 24 in circuit 12 is a square-type resistance pad of fairly large attenuation value (24.5 decibels) provided for fixing the amplitude level of the carrier signals transmitted to the east carrier line 16 through either of the alternate through transmission paths 1 and 2 at a desired operating value. If this resistance pad is opened at the first shunt resistor (nearest the alternate paths 1 and 2), the ratio of the load impedance including the series resistors of this resistance pad, to the source impedance in parallel with the shunt resistor is K, the current attenuation ratio of the pad.

In accordance with the invention, the temporary transmission variations produced at the branching point during the short time intervals when the two paths 1 and 2 are connected in parallel to the load circuit 12 during the process of switching from either one of these paths to the other, are reduced to values which will not cause objectionable distortion "hits" in the transmitted voice frequency signals superposed on the message channels in the following manner. The shunt resistor of the resistance pad normally connected at the point 24 in the load circuit 12, nearest the outputs of the alternate paths 1 and 2, is replaced with two resistors 25 and 26 each of approximately the same value as the shunt resistor which they replace, which resistors are permanently connected in shunt with the output of the paths 1 and 2, respectively, as shown, on the source side of the switching contacts of the relays 18 and 10 and 11, respectively, utilized for switching through transmission from one of these paths to the other. Thus, during the short time intervals during the operation or release of the relays 18, 10 and 11, in which the outputs of the two alternate paths 1 and 2 are connected in parallel between the west carrier line 9 and the east carrier line 16, the two resistors 25 and 26 will be connected in parallel with the load circuit (circuit 12), and effectively provide an increased loss in the connections to the load circuit such that the current transmitted to the load circuit from the two sources (outputs of paths 1 and 2) is not substantially greater than that transmitted to the load circuit through either of the paths 1 and 2 after a transfer of through transmission from one of these paths to the other has been completed. Then, the increased output with both sources over that of one source is

$$\frac{I}{i}=\frac{2K+2}{2K+1} \qquad (2)$$

or a function of the current attenuation of the attenuation pad.

Calculations show that the same result may be obtained by a similar modification of an H-type attenuation pad at the point 24.

The following table shows the effects of an arrangement in accordance with the invention on the transmission variations (hits) using loss pads of different loss value.

Pad Loss, Decibels	I/i	Hit, Decibels
0	1.33	2.5
6	1.2	1.58
12	1.125	1.1
18	1.059	0.5

The use of the arrangements of the invention in connection with program branching point equipments in a commercial broad-band carrier system was found to provide greatly improved telegraph performance, the telegraph errors caused by the switching hits being reduced to a satisfactory percentage value.

Various modifications of the arrangements of the invention shown in the drawing and described above within the spirit and scope of the invention will occur to persons skilled in the art.

What is claimed is:

1. In combination, a source supplying at least two different types of signals, two transmission paths fed in parallel from said source, one of said paths being adapted to effectively block transmission of signals of one of said types and to transmit the other types of supplied signals, the other transmission path being adapted to transmit all of the supplied signals including said one type, a third transmission path, relay switching means having make-before-break switching contacts associated with the outputs of said two transmission paths and said third transmission path, which contacts in one condition of operation of said relay switching means connect the output of said one path to said third path and effectively disconnect the output of said other path therefrom and in another condition of operation of said relay switching means connect the output of said other transmission path to said third path and effectively disconnect the output of said one transmission path therefrom, means for causing said relay switching means to be operated to said one condition or to said other condition and other means for reducing signal distortion due to the temporary increases in transmission to said third transmission path during the short time intervals in which said one and said other transmission paths are connected in parallel between said source and said third transmission path when said relay switching means is operated to said one or to said other condition comprising means for introducing a suitable compensating attenuation

in the signals transmitted from said one and said other transmission paths to said third transmission path during said short time intervals only.

2. The combination of claim 1, in which an attenuation network including a shunt resistor is utilized to fix at a desired operating value the amplitude level of the signals transmitted to said third transmission path through said one or said other path, and said other means comprises two resistances of selected approximately equal values respectively connected in shunt with the output of said one and said other path on the source side of the switching contacts of said relay means so that the two resistances are effectively connected in parallel with said third transmission path during said short time intervals, one or the other of said two resistances operating as said shunt resistor of said network at other times.

3. In combination, a transmission line, means to supply to said line for transmission in one direction thereover signal waves comprising a band of frequencies of which the frequency components in respectively different sub-bands thereof represent different signals and a signal distributing station at one or more points along said line including two alternate transmission paths supplied with the signal waves incoming over said line, respectively adapted to effectively block from transmission at least one sub-band of frequency components representing one signal of the supplied waves while transmitting all other supplied frequency components representing the other signals, and to transmit a wider frequency band including said one sub-band and other frequency sub-bands representing other signals, of the supplied waves, relay switching means having make-before-break switching contacts which in one condition of operation of said relay means connect one of said paths in transmission relation between the incoming and outgoing portions of said line and effectively disconnect the other of said alternate paths from said outgoing line portion, and in another condition of operation of said relay means connect said other of said paths in transmission relation between said incoming and outgoing line portions and effectively disconnect said one path from said outgoing line portion, means to cause operation of said relay means to said one or said other condition and means to reduce signal distortion due to temporary increases in transmission to said outgoing line portion, when in the process of changing said relay means for either operating condition to the other, said two alternate transmission paths are connected in parallel between said incoming and outgoing line portions for a short time interval, comprising means for inserting a loss of suitable value in the path of the signals transmitted to said outgoing line portion during said short time interval only.

4. In combination, a transmission line supplied with signal waves of a wide band of frequencies for transmission thereover in one direction, respectively different frequency sub-bands of said waves representing different signals, a signal branching station at one or more points along said line including two alternate transmission paths the inputs of which are permanently connected in parallel to the incoming portion of said line so as to be fed with different energy portions of the incoming signal waves, one of said paths being adapted to transmit all frequency components in said wide band of the applied signal wave and the other of said paths being adapted to effectively block transmission of

one frequency sub-band representing one signal and to transmit all other frequency components representing the other signals of the applied waves, relay switching means having make-before-break switching contacts associated with the outputs of said paths and the outgoing portion of said line, which in the normal unoperated condition of said relay means maintain the output of said one path connected to said outgoing portion of said line and the output of the other path disconnected therefrom and terminated, and in the operated condition of said relay means cause the output of said other path to be disconnected from its termination and connected in transmission relation with said outgoing line portion, and the output of said one path to be disconnected from said outgoing line portion and terminated, means for causing the operation or release of said relay means and means to reduce signal distortion due to the increase in transmission to said outgoing line portion during the short time intervals in which said two alternate paths are connected in parallel between said incoming and outgoing line portions by operation or release of said relay means comprising means for inserting a resistor of suitable value effectively in shunt with said outgoing line portion during said short time intervals only.

5. In a carrier signaling system, a transmission line, means for supplying to said line for transmission thereover in one direction a signal wave comprising a program channel consisting of a band of low frequency signal components and one or more message channels each consisting of low frequency signal components representing a different message, modulated on a carrier wave to respectively different sideband positions within a single band of higher frequencies and a program signal branching station at one or more points along said line, each station including two alternate transmission paths for the carrier signals having their inputs connected in parallel to the incoming portion of said line, one of said paths being adapted to transmit the applied program and message channels at carrier frequencies and the other of said paths being adapted to effectively block from transmission the applied program channel at carrier frequencies and to transmit the applied message channels at carrier frequencies, relay switching means having make-before-break switching contacts associated with the outputs of said two paths and the outgoing portion of said line, two terminating resistors, means for supplying operating current to said relay means and for disconnecting it therefrom, certain switching contacts of said relay means in the unoperated condition of the latter being arranged to connect the output of said one path to said outgoing line portion so as to permit through transmission of said message and program channels at carrier frequencies thereto and to disconnect the output of said other path from said outgoing line portion and to connect it to one of said terminating resistors, other switching contacts of said relay means being arranged in the operated condition of the latter to disconnect the output of said other path from its terminating resistor and to connect it to said outgoing line portion, and to disconnect the output of said one path from said outgoing line portion and to connect it to the other of said terminating resistors and means to reduce signal distortion due to the temporary increase in transmission to said outgoing line during the

short time intervals in which the output of said one path and the output of said other path are connected in parallel thereto while said relay means is operating or releasing comprising other means for introducing a compensating loss in the path of the signals transmitted to said outgoing line portion during said short time intervals only.

6. The system of claim 5 in which at least one of said message channels comprises voice frequency telegraph signals and the compensating loss introduced in the path of the signals transmitted to said outgoing line portion during said short time intervals is made sufficient to reduce the distortion in the transmitted voice frequency telegraph signals to an unobjectionable amount.

7. The combination of claim 5, in which a network of suitable attenuation value is utilized to fix the amplitude level of the message channels transmitted to said outgoing line portion through either of said alternate paths at a desired value and said other means comprises two other resistors of suitable equal values associated with said network, respectively permanently connected in shunt with a different one of said alternate paths near its output end in front of the associated switching contacts of said relay means so that both resistors are effectively connected in parallel to said outgoing line portion during said short time intervals to provide said compensating loss and one or the other of said two resistors is connected in parallel therewith at other times to provide a shunt resistor for said network.

8. In combination, a signal transmission circuit transmitting waves of a wide band of frequencies different frequency sub-bands of which represent different signals, a second and a third transmission circuit both fed from the first circuit, said second transmission circuit being adapted to transmit all frequency components of the applied waves, said third transmission circuit being adapted to effectively block from transmission one frequency sub-band of the applied waves representing one of said different signals and to transmit all other frequency components thereof representing other signals, a fourth transmission circuit adapted for alternative connection to the output of said second or said third transmission circuit, relay means having make-before-break switching contacts which in the released condition of said relay means connect the output of said second circuit in transmission

relation with said fourth transmission circuit and maintain the output of said third circuit disconnected therefrom, and in the operated condition of said relay means connect the output of said third circuit in transmission relation with said fourth circuit, and disconnect the output of said second circuit from said fourth circuit, means for causing the operation or release of said relay means, an attenuation network of suitable value for fixing the amplitude level of the signals transmitted to said fourth circuit through said second circuit or said third circuit at a desired operating value, said attenuation network including two resistors of equivalent selected values connected in shunt of said second and said third transmission circuit, respectively, near its output but in front of the associated switching contacts of said relay means, said two resistors being connected in parallel to said output circuit and serving to introduce additional loss in the path of signals transmitted to said fourth transmission circuit only during the short intervals of time in which said second and said third transmission circuits are connected in parallel between said first and fourth transmission circuits by operation or release of said relay switching means, so as to reduce signal distortion during said intervals, only one or the other of said two shunt resistors being effective in said network at other times.

9. In combination, a source of signal energy, two transmission paths fed in parallel from said source, a common load circuit for the two paths, the connection of one of said paths to said load circuit being normally disabled and the connection of the other of said paths to said load circuit being normally enabled, switching means for enabling the normally disabled path and disabling the normally enabled path in such manner as to maintain continuity of transmission to said load circuit at all times, and means for reducing distortion in the transmitted signals during the operation or release of said switching means comprising means for restricting to a relatively small magnitude the difference in the amount of energy supplied to said load circuit when only one of said paths is connected to that circuit and that supplied thereto during the overlap period when both paths are connected to the load circuit.

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