

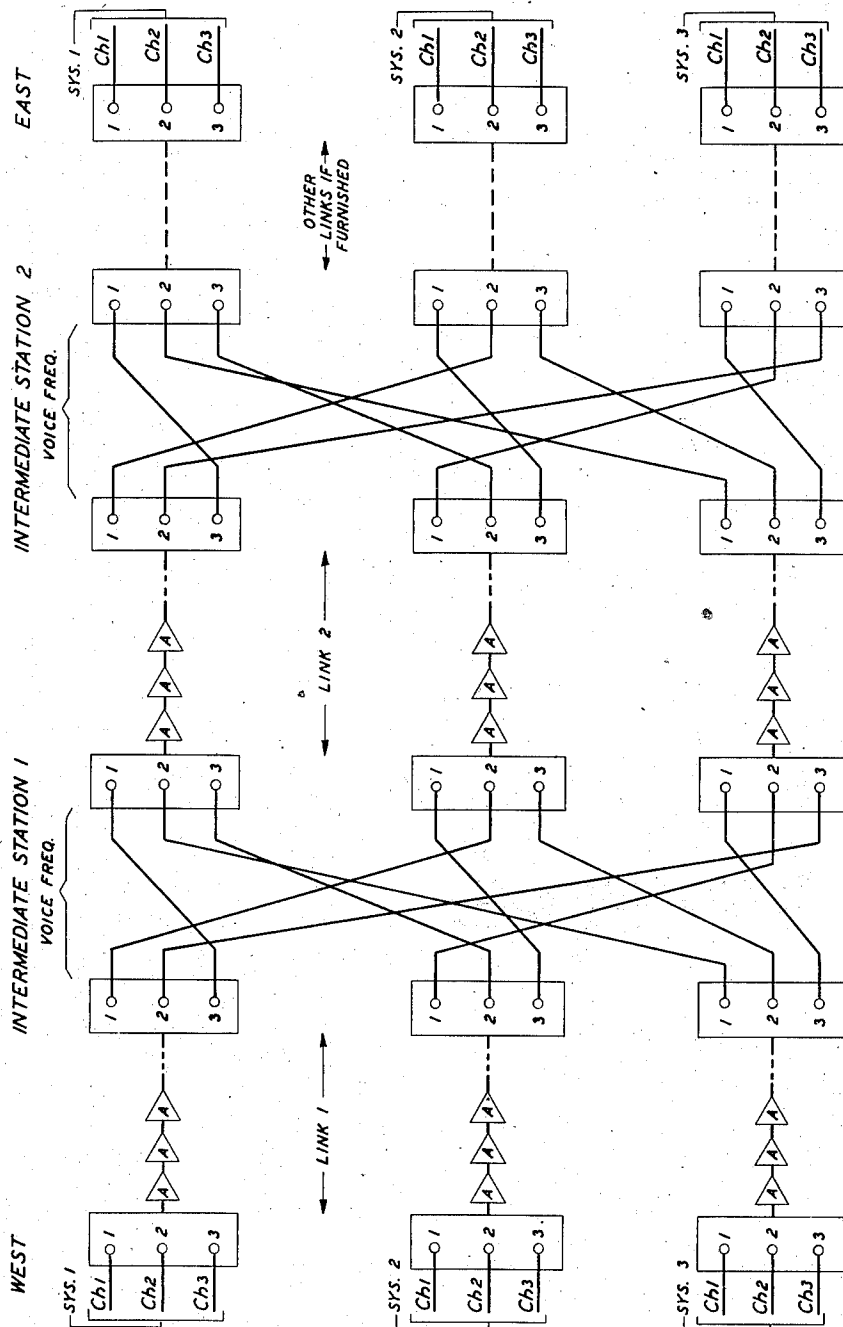
Oct. 30, 1945.

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2,387,712

TRANSMISSION SYSTEM

Filed April 4, 1944



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2,387,712

TRANSMISSION SYSTEM

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Application April 4, 1944, Serial No. 529,498

5 Claims. (Cl. 179-78)

This invention relates to a system for the transmission of intelligence and more particularly to a long multiplex carrier system.

An object of the invention is the lessening of impairment of signals transmitted over a multiplex carrier system.

A more specific object of the invention is the lessening of impairment of signals transmitted over a multiplex carrier system due to interference factors of a type that are not variable with frequency, i. e., that are non-frequency dependent.

A troublesome factor in the operation of a multiplex carrier system is the occurrence of various types of interference which are functions of frequency, i. e., which vary in intensity with changes in frequency. Among such types of interference are static and cross-talk. It is apparent that as signals are transmitted over such a system in a multiplicity of respective frequency bands some signals will be subjected to interference factors of greater intensity than others. Certain circuits accordingly may be excessively noisy whereas others may be unnecessarily quiet; it is the condition of the noisiest circuit that is the limiting factor in the design of the system.

In order to reduce the effects of such frequency-dependent types of interference factors, it has previously been proposed, as disclosed for example in Patent 2,154,594 issued April 18, 1939, to M. A. Weaver, to systematically assign each signal to successively different frequency channels as it progresses through the system. The system of successive assignments is such that the intensity of cross-talk or other frequency-dependent interference factor is substantially the same for all circuits and is substantially less than it would be in the noisiest circuit if the signals were confined to respective frequency channels.

Interconnecting or mixing different transmission element sections in the general manner discussed above is commonly referred to as "frogging" and the specific type disclosed in the Weaver patent as "channel frogging."

In addition to the impairment by frequency-dependent interference factors, signals transmitted over a multiplex carrier system may also be subjected to impairment by an additional factor of a type that is not frequency-dependent. The impairment referred to is that resulting from the effect upon the transmission regulators of certain high volume pulses originating in the speech channels for example such pulses as result from ringing.

It is customary, of course, in the operation of

long multiplex carrier systems to provide means for automatically maintaining the speech level substantially constant in spite of various unstable factors tending to cause changes in the level. For example, so-called "flat gain regulators" are ordinarily provided at intermediate points in the system for control of amplifier gain with respect to input variations of the type in which the change in gain is substantially uniform for all frequencies over the transmitted range. These flat gain regulators are designed to hold practically constant the output power of talking volumes over the working range of input levels. However, the high volume pulses of the type referred to above often considerably exceed the average power level for which the system is set up and with regard to which the flat gain regulators are designed. The initial flat gain regulator affected by the pulse is not able to fully compensate for it therefor, as it would if the change were within the working range of the system, so that subsequent regulators are affected in decreasing degrees until the pulse is finally fully compensated for.

The high volume pulses of the type referred to are usually very short in duration, of the order of one second, and the net effect on regulation where only a few repeaters are involved is not severe. In the instance of a long system where many repeaters are involved, however, the cumulative effect on many repeaters may result in serious impairment of transmission. Where many regulators in tandem are involved the result of the action of the pulse thereon is the production of a transient in the approximate form of a damped sine wave (decreasing in amplitude with each regulation). The frequency of this damped sine wave is a function of the number of repeaters and the over-all magnitude of the effect is a function of the length of the circuit. Such a transient effect is harmful to transmission over the line affected, particularly with respect to telegraph channels carrying telegraph signals which, in the instance of a long multiplex carrier system are usually superimposed upon one or more speech channels; the reduction in gain at the successive repeaters of course, tends to upset the normal level of the speech transmission. The telegraph, however, is more sensitive to these upsets. In fact, it has been discovered that spurious transmission variations of this nature which are insufficient to affect or seriously impair the performance of message or high quality program circuits are, nevertheless, large enough in magnitude to seriously interfere with the commercial transmission of ordinary telegraph messages.

In view of the fact that the disturbance of the type referred to is not frequency-dependent and as the transient disturbance set up in one channel of the system affects all other channels of the system similarly, transposition of channels of a single system, as set forth in the Weaver patent referred to above, is ineffective with respect to this type of transmission impairment.

In accordance with a feature of the present invention frequency channels of one system are interconnected to frequency channels of a different system whereby to reduce the non-frequency-dependent transmission impairment.

In accordance with another feature of the invention the order of the frequency channels is changed as they are interconnected whereby to reduce the effects of frequency-dependent impairment as well as non-frequency-dependent impairment.

In accordance with a specific embodiment of the invention, which is applied to a group of multiplex carrier systems each of which comprises a plurality of different frequency channels and includes a plurality of intermediate stations, frequency channels of one of said systems are systematically interconnected to frequency channels of others of said systems at the intermediate stations. These interconnections between channels of different systems are made as part of the permanent installation. While this results in a long through circuit being affected more frequently by high volume pulses, such as those caused by rings on other channels, the magnitude of the transmission variation on any of the circuits is perceptibly less due to the fact that the pulses affect the channels over a shorter distance, for example, between two intermediate stations only rather than over an entire system. An improvement in the over-all transmission results, therefore.

A full understanding of the arrangement contemplated by the present invention as well as appreciation of the several novel and valuable features thereof may be gained from consideration of the following detailed description and the annexed drawing, in which the single figure is a schematic diagram of a group of three multiplex carrier transmission systems arranged in accordance with features contemplated by the present invention.

Referring now to the drawing there is schematically illustrated a group of three multiplex carrier systems numbered No. 1, No. 2 and No. 3 each of which includes three separate frequency channels and each of which is provided with a west terminal, an east terminal and two intermediate stations. A plurality of repeaters or amplifiers are included in each link of each system, i. e., the line section connecting the terminals and the intermediate stations. As indicated schematically each channel is "brought down to voice" i. e., the modulated carrier wave is demodulated to give the voice frequency wave at the intermediate station, before the channels are frogged; after interconnection the channels are again raised to carrier frequency by modulation for transmission over the next subsequent link. It will be understood that automatic transmission regulators are provided at each repeater point or at other suitable locations in the system; these regulators may for example, be of the type disclosed in Patent 2,179,915, issued November 14, 1939, to R. R. Blair. It will be understood also that the group may, and usually does, comprise more than three different systems and that each

system may include more than three different frequency channels. Further, in a long transmission system of the type in connection with which the present invention is particularly applicable, more than two intermediate stations may be provided. Specific application of the invention to a group of 12 systems each of which comprises 12 separate frequency channels will be outlined subsequently.

As illustrated, frequency channel No. 1 of system No. 1 is transmitted over link No. 1 to the first intermediate station. Here it is brought down to voice frequency and, in accordance with the features of the present invention, is then transferred, interconnected or frogged to frequency channel No. 2 of system No. 2. After being restored to carrier-frequency it passes over link No. 2 of system No. 2. Similarly, channel No. 1 of system No. 2 is transferred at the first intermediate station to frequency channel No. 2 of system No. 3. The manner of interconnecting the other frequency channels at the first intermediate station as well as the interconnections at the second station will be apparent from the figure.

In order to clearly disclose the improvement in transmission which results from this novel plan of frogging systems, let it be supposed that a high volume pulse is produced, for example, by a ring in channel 1 of system 1 at the west terminal. Assuming, first, that the systems are not frogged or interconnected, i. e., that features of the present invention are not provided, the pulse would traverse both links 1 and 2 of system 1 (as well as subsequent links, if any) affecting the regulators of both links. Channels 1, 2 and 3 of system No. 1 would all be affected in the same manner and the transitory fluctuations in net loss resulting in system No. 1 would be in accordance with the cumulative effect resulting from the dynamic response of the regulators of both links. Now let us suppose that the systems are transposed or frogged in the manner contemplated by the present invention and as illustrated in the drawing. In this case the occurrence of the high volume pulse in channel No. 1 of system No. 1 will affect transmission over channels No. 2 and No. 3 of system No. 1 only so far as the regulators of link No. 1 are concerned and will have no effect on the regulators of system No. 1 over link No. 2, i. e., the effect upon the over-all transmission over system No. 1 will be only a fraction of that prevailing without the arrangement of the present invention. Transfer of the pulse to channel No. 2 of system No. 2 will result in affecting transmission over channels No. 1 and No. 3 of system No. 2 but only with respect to the regulators of link No. 2 and will have no effect on the regulators of system No. 2 over link No. 1.

While, as will be apparent from the above, the arrangement of the invention results in each long distance circuit being affected more frequently by rings and the like than would be the case otherwise, this is more than offset by the improvement in over-all transmission which results from the fact that in each instance the number of regulators affected is materially lessened.

It is contemplated by the invention that both frequency-dependent impairment of transmission and non-frequency-dependent impairment of transmission may be reduced by changing the order of the frequency channels in the general manner taught by the Weaver patent referred to

above at the time the channels are interconnected among different systems in the manner described above. It is also contemplated that either system frogging alone or the combination of system frogging and frequency frogging may be applied to groups of any number of carrier systems each of which systems comprises any number of frequency channels.

Applicant has worked out as a general guide for combined system and frequency frogging in accordance with his invention the formula that channel N of system M should be interconnected to channel $N+1$ on system $M+N$ where N and M are any real numbers. Applying this to a group of systems in which channel N is No. 3 and system M is No. 4 then channel N , (3) of system M , (4), would be interconnected at the intermediate station in question to channel No. 4, ($N+1$), of system No. 7, ($M+N$).

Applying the above formula in the instance of a group of 12 carrier systems each of which systems comprises 12 different frequency channels, we may set up the following general guidance table:

Table

A table showing the general manner in which the 144 circuits from 12 terminals of 12 systems may be interconnected to the 144 voice frequency circuits associated with the corresponding 12 terminals of the 12 outgoing systems, each system having 12 separate frequency channels. The plan of interconnecting is the same at all frogging points. (M is the number of the incoming system and N is the number of the channel that is frogged to channel $N+1$ on outgoing system $N+M$.)

Channel		System					
N	$N+1$	M $N+M$	1 $N+M$	2 $N+M$	3 $N+M$	4 $N+M$	12 $N+M$
1	2	2	3	4	5	6	1
2	3	3	4	5	6	7	2
3	4	4	5	6	7	8	3
4	5	5	6	7	8	9	4
5	6	6	7	8	9	10	5
6	7	7	8	9	10	11	6
7	8	8	9	10	11	12	7
8	9	9	10	11	12	1	8
9	10	10	11	12	1	2	9
10	11	11	12	1	2	3	10
11	12	12	1	2	3	4	11
12	1	1	2	3	4	5	12

As an example of the application of the above table, let us assume we wish to determine the proper frogging of channel 2 of system 3. In accordance with the governing formula of the table, channel 2 of system 3 should be frogged to channel 3 ($N+1$) of system 5 ($N+M$). Again let us consider the frogging of channel 8 of system 7; here we will go to channel 9 ($N+1$) of system 3 ($N+M=15$ or $15-12=3$).

The above plan of frogging or interconnecting may be applied to a group of any number of systems each of which systems is made up of any number of separate frequency channels. When applied, substantial improvement in transmission is achieved both with respect to frequency-dependent impairment and non-frequency-dependent impairment.

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

What is claimed is:

1. In a group of multiplex carrier systems each of which systems comprises a plurality of separate frequency channels and includes two terminals and an intermediate station, the method of reducing both frequency-dependent transmission impairment and non-frequency-dependent transmission impairment which comprises the steps of interconnecting frequency channels of one of said systems to frequency channels of another of said systems at said intermediate station and changing the order of the frequency channels as they are interconnected.

2. In a group of multiplex carrier systems wherein the number of systems included is greater than M and wherein each system includes a number of separate frequency channels greater than N , M and N being any real numbers, and wherein each system includes two terminals and an intermediate station, the method of reducing both non-frequency-dependent transmission impairment and frequency-dependent transmission impairment which comprises the step of interconnecting at the intermediate station frequency channels of one of said systems to frequency channels of others of said systems in accordance with the plan whereby channel N of system M is interconnected to channel $N+1$ of system $M+N$.

3. A transmission medium comprising a plurality of multiplex carrier systems each of which comprises a plurality of separate frequency channels, an east terminal, a west terminal and an intermediate station for each of said systems, and means at said intermediate station for permanently interconnecting frequency channels of one of said systems each to a frequency channel of a different other of said systems.

4. A transmission medium comprising a plurality of multiplex carrier systems each of which comprises a plurality of separate frequency channels, an east terminal, a west terminal and an intermediate station for each of said systems and means at said intermediate station for distributing frequency channels of one of said systems among frequency channels of others of said systems and for changing the order of said frequency channels as they are distributed over said other systems.

5. A transmission medium comprising a greater number than M of multiplex carrier systems, each of which systems comprises a greater number than N of separate frequency channels, M and N being any real numbers, an east terminal, a west terminal and an intermediate station for each of said systems, and means at said intermediate station for distributing frequency channels of one of said systems among frequency channels of others of said systems in accordance with a plan of distribution whereby channel N of system M is interconnected to channel $N+1$ of system $M+N$.

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