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CARRIER WAVE TRANSMISSION SYSTEM

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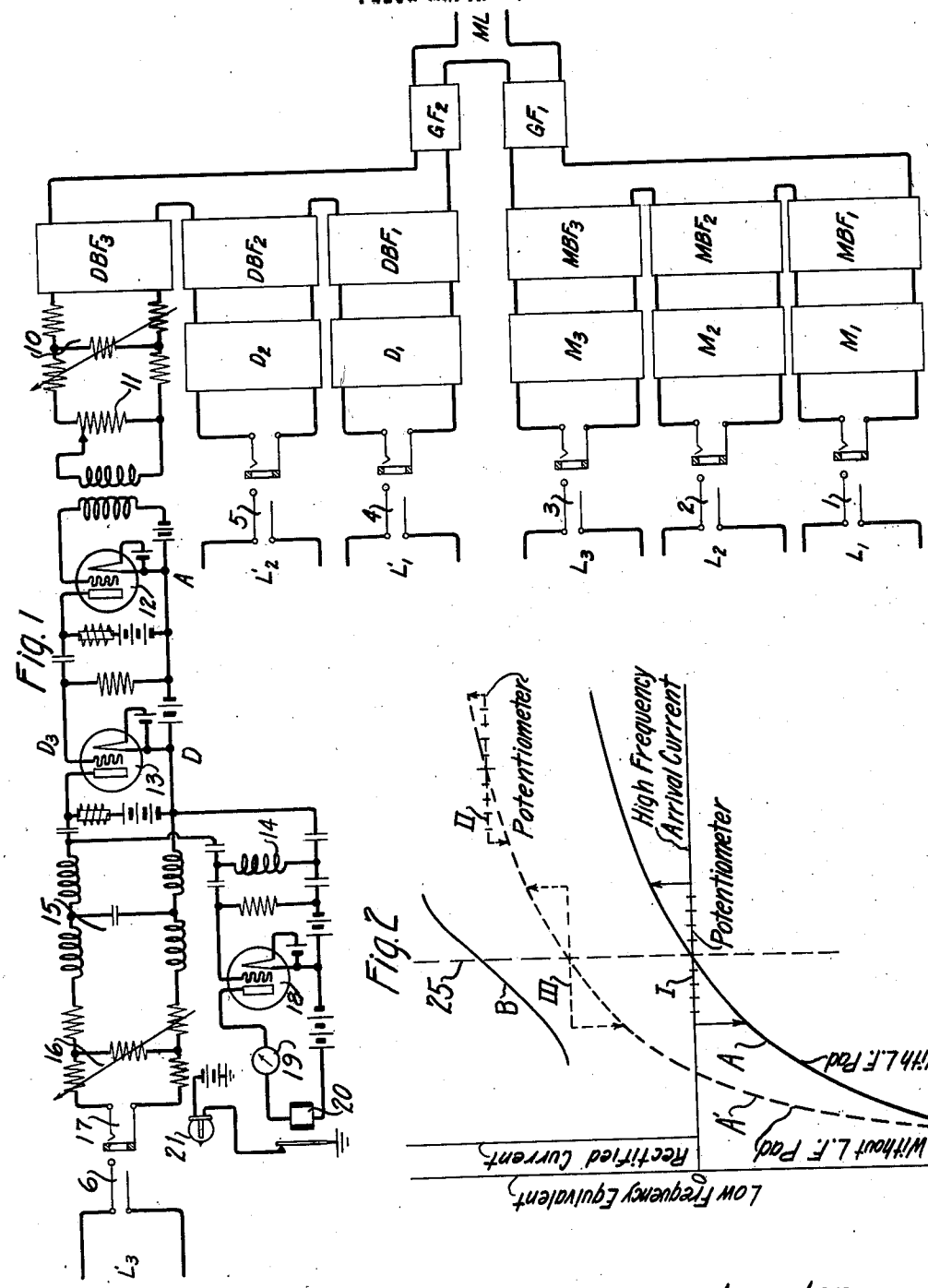


Fig. 1

Fig. 2

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CARRIER-WAVE-TRANSMISSION SYSTEM.

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The present invention relates to the regulation of transmission in an electrical system of distribution, and has particular application to carrier wave transmission systems.

It is an object of the invention to enable regulation of the transmission through such a system in an efficient and convenient manner.

A feature of the invention comprises transmission controlling devices arranged to give the desired transmission level for the entire channel or line and to permit changes in the transmission level to be readily made for regulation purposes such as to compensate for line changes.

This will be more clearly understood if it be assumed that a certain over-all transmission level is to be maintained between the two distantly separated low frequency terminals of a carrier wave channel. Such a channel, as is well known, includes a high frequency transmission section and portions over which low frequency currents, such as speech or other signal currents are transmitted. Variations in the transmission characteristics of the channel (due to weather or other conditions) are compensated for by potentiometers or other adjustable transmission control devices. These control devices are commonly situated at such a point in the system that they vary the high frequency load on the detecting and receiving circuit. Over a limited range of load values, changes in the high frequency load produce corresponding changes in the detected output current. For other loads, however, considerably outside such range, an altogether different relation exists between the changes in high frequency load and the detected output. For example, for a certain region of load, a change in the high frequency load corresponding to a change of one mile of standard cable in the transmission equivalent may produce a change in the detected output also corresponding to a one mile standard cable change in low frequency equivalent. With a different value of load, however, it has been found in practice that a one mile change in high frequency load produced as much as a thirty-mile change in the detected output, while at still other values of high frequency load, a thirty mile change in high frequency load was required to produce a one-mile change in detected output.

It is seen, therefore, to be advantageous to fix the high frequency load at such value that the potentiometer or other input control is enabled to control the detected output in a fairly uniform manner. Otherwise, the potentiometer setting, which is commonly taken by the attendant as an index of the transmission level, is practically meaningless. This is accomplished in accordance with the invention by introducing a transmission control element in the high frequency path between the high frequency line and the input potentiometer employed to regulate the detected output for compensating for variations in transmission and the like.

It is usual practice to regulate the over-all transmission equivalent of a system to some specific value. For instance, if a channel has a "zero equivalent", the low frequency detected arrival current has the same amplitude as the current which is put into the channel at the distant terminal. This means, of course, that the gain introduced by the various circuit elements of the channel just make up for the transmission losses. Since the transmission characteristics of lines differ widely among themselves and the characteristics of the same line may differ widely with conditions, and also the channel transmission characteristics differ widely among channels on the same line, it will often, if not generally, happen that the transmission level of a channel cannot be brought to the required value by changing the high frequency load on the receiver without carrying the load outside the relatively small region discussed above in which the desired relation exists between load change and change in detected output. This difficulty is overcome in accordance with the invention by providing a low frequency transmission control element which is adjustable to change the strength of the received detected current within relatively wide limits. This element, being in the low frequency circuit, does not disturb the high frequency portion of the circuit, so that with the arrangement provided by the invention, the desired fine adjustment can be effected by the high frequency input control means.

These and the other features and objects of the invention will be more clearly understood from the following detailed description in connection with the accompanying drawing.

Fig. 1 is a schematic circuit drawing of so much of a carrier wave system as is necessary to an understanding of the invention.

Fig. 2 shows curves illustrative of the action of the regulating devices of the invention.

In Fig. 1 there is shown the west terminal of a multiplex carrier transmission system. This system is of the general type shown in Fig. 42 of the paper by Colpitts and Blackwell on Carrier current telephony and telegraphy published in vol. 40 of the Journal of the American Institute of Electrical Engineers in a series of installments beginning in April, 1921, and reference may be had to that figure for a more detailed disclosure of the actual circuit arrangements of the various parts of the system. In Fig. 1 of the drawing, a carrier line ML is shown terminating in two grouping filters GF_1 and GF_2 which serve to separate the oppositely directed carrier waves. For example, all of the carrier waves employed for transmission from the station shown in Fig. 1 to the main line ML may be comprised in an upper frequency range and these are selectively transmitted by the filter GF_1. The carrier waves received at the station in Fig. 1 from the main line ML may be comprised in a lower range to which the filter GF_2 is made selective. If preferred, the separation between transmitted and received waves may be effected by the used of a hybrid coil as shown in Fig. 42 of the Colpitts and Blackwell paper.

In Fig. 1, three transmitting channels and three receiving channels are indicated schematically. The transmitting filters comprise a modulator M and a band filter MBF for transmitting from the modulator to the line the desired components of the modulated wave such, for example, as the carrier and one of the side bands. Each receiving channel, likewise comprises a band filter DBF for selectively transmitting the components intended for the particular channel and a demodulating circuit D for deriving from the received waves the low frequency signal components such as speech. In the drawing, the apparatus belonging to each channel is designated by a suitable subscript.

The terminations of the low frequency lines adapted for connection with the carrier system are not shown in detail in Fig. 1 but are merely indicated by the jacks 1 to 6 inclusive and the respective line branches, such as L_1 to L_3 indicating the transmitting line branches and L_1' to L_3' indicating the receiving line branches. The association of these low frequency line branches with the low frequency telephone lines may be made in any suitable manner, such, for example, as that indicated in Fig. 42 of the Colpitts and Blackwell paper.

One of the receiving channels is illustrated more in detail in Fig. 1 and this will now be described in connection with the devices for regulating the transmission in the channel in accordance with the invention. The detecting circuit generally indicated at D_3 comprises the high frequency pad 10, a potentiometer 11, the amplifier 12, the detector 13 and selecting circuits 14 and 15 for separating the detected speech from the carrier frequency component for transmission to the low frequency pad 16 and receiving jack 17 on one hand, and to the rectifier 18 on the other hand. The pads 10 and 16 may be of any suitable type, preferably composed entirely of resistances and preferably made adjustable for convenience in use. A type which is suitable is the so-called H-type an example of which is shown in the U. S. Patent to Vennes, No. 1,472,507, issued October 30, 1923.

The operation of this portion of the circuit will be clear from the drawing and from the above designation of the various portions of the circuit. The high frequency waves selectively transmitted to the filter DBF_3 are impressed on the amplifier 12 and the detector 13 with a desired amplitude as determined by the settings of the high frequency pad 10 and the potentiometer 11. As explained hereinafter the high frequency pad 10 may be omitted in some cases. The detector 13 serves in well known manner to produce in its output circuit low frequency variations corresponding to the signal being transmitted over the channel, such, for example, as speech variations. These are selectively transmitted through the low pass filter 15 which is so designed as to prevent passage of currents of higher frequencies such as the carrier frequency. The speech currents after traversing the filter 15 pass through the low frequency pad 16 to the receiving jack 17 from which they may be impressed on the desired low frequency line by the insertion of the proper plug into the jack 17.

The currents of the carrier frequency appearing in the output of the detector 13 are selectively transmitted through the high pass filter 14 to the rectifier 18. This filter 14 is designed not to pass currents of speech frequencies. Only current of the carrier frequency is therefore impressed on the detector 18 and rectified high frequency current appearing in the output circuit is indicated by a suitable meter 19 and is utilized to actuate the relay 20. The relay 20 may be used in accordance with known practice to transmit a call signal to the operator at the receiving terminal at the station shown in Fig. 1 or may be relayed to a further point. For example, if the operator at the distant station interrupts the normally transmitted carrier wave, relay 20 becomes deenergized and closes a circuit through the

calling lamp 21 to indicate to the operator of the station in Fig. 1 that a call is incoming on channel 3.

It will be understood that each of the other receiving channels may be arranged in substantial duplicate of the channel 3 so that each receiving channel will have its individual high frequency and low frequency pads corresponding to 10 and 16, its individual amplifying, detecting and rectifying devices, calling relay and calling lamp. Each of the transmitting channels is adjusted and supervised either by an attendant or in any known manner so that the output current is maintained at a constant value. The only variations in the received current strength are therefore those due to variations in transmission characteristics of the system.

As indicated above, the strength of the detected speech currents will vary in some non-linear relation with the high frequency load impressed on the detecting circuit. Referring to Fig. 2, for example, the full line curve A may indicate the relation between the high frequency arrival current at the terminals of the band filter DBF_3 and the strength of the detected speech currents at the terminals of jack 17 as compared with the strength of the speech currents impressed on the transmitting jack at the distant terminal of this station. That is, values of low frequency equivalent above the zero axis indicate a gain in over-all transmission between the transmitting jack at the distant station and the receiving jack 17 at the station of Fig. 1, while values of low frequency equivalent below the zero axis indicate an over-all loss. As the high frequency load impressed on the detector is varied in any manner due to the high frequency line pad 10 or the potentiometer 11 or the transmission line ML, the low frequency equivalent of the system is changed by the relation shown by the curve A.

The main function of the potentiometer 11 is to secure a fine adjustment of the low frequency output detecting circuit to compensate for the variations in the transmission characteristics of the line ML which occur from time to time and which are in general relatively small. It is convenient in practice to set the potentiometer 11 at about its midpoint for an average condition of the line ML so that the potentiometer will give a substantially equal variation in either direction from the average condition to compensate for corresponding variations in the transmission characteristics of the main line. If it be assumed that a zero transmission equivalent is desired between the low frequency terminals of the channel 3, the high frequency load impressed on the receiving terminal when the main line ML has its normal characteristics should be that indicated by the dotted line 25 in Fig. 2. If the system is adjusted to have a zero low frequency equivalent for this normal characteristic of the main line and with the potentiometer adjusted to its midpoint, the conditions will be as indicated in Fig. 2 with the potentiometer in position I. The range of variation of the high frequency load by the potentiometer is indicated in this figure by the length of the horizontal line marked potentiometer. The amount of variation in the low frequency output produced by varying the potentiometer setting from its midpoint in either direction to the left or to the right is shown by the corresponding ordinates of the curve A. Within the range of the potentiometer, therefore, the low frequency equivalent may be either increased or decreased in a substantially linear manner as shown by the curve A within these limits.

In setting up a system or in adjusting a system to proper working conditions it may be found that varying the potentiometer 11 from one end of its scale to the other produces practically no effect in the detected speech currents. It may also happen that the detected speech currents are much stronger than is desired, that is, the over-all gain between the transmitting low frequency jack and the receiving low frequency jack is too great. This condition may be as represented in Fig. 2 by position II of the potentiometer 11 and by the curve A'. On account of the small slope which the curve A' has in its upper right hand portion, no amount of adjusting the potentiometer is effective in producing any substantial change in the detected output. This is due to the fact that the high frequency load impressed on the detecting circuit is too great. By inserting a high frequency artificial line or pad 10 such as to introduce a loss in the high frequency channel, the effect of the potentiometer in controlling the low frequency output may be changed from that indicated in position II to that indicated in position III. In position III, the potentiometer gives a substantially linear regulation in the detected low frequency output. If still greater losses are introduced in the high frequency arrival currents, the effect of the potentiometer 11 may be still further increased since its position with respect to the curve A' will be moved further to the left. However, no amount of change in the high frequency pad 10 will bring about the relations indicated by curve A and by the potentiometer in position I, and it will be impossible, therefore, by the use of the high frequency pad alone to adjust the system to give a zero low frequency equivalent and at the same time give a fairly linear

relation between the potentiometer setting and the output current with the desired sensitivity of the potentiometer settings.

In accordance with the invention, the desired regulation is effected by introducing enough losses by the high frequency pad 10 to reduce the mean high frequency load on the amplifier to the value indicated by line 25 of Fig. 2. The required low frequency equivalent is then secured by introducing a low frequency pad 16 which produces the required loss between the detector output and the jack 17 to reduce the strength of the detected speech currents to the value indicated by the zero axis in Fig. 2. By means of the high frequency pad 10 and the low frequency pad 16, therefore, the regulation may be readily changed from that indicated by the potentiometer at position II and curve A′ to that indicated by position I and curve A.

The low frequency pad 16 does not, of course, affect the high frequency load on the detecting circuits. The use of the separate high frequency pad and low frequency pad enables the high frequency load impressed on the detecting circuit to be adjusted to the point at which the detector operates most efficiently without regard to the actual strength of the detected currents. The latter may be regulated by means of the low frequency pad 16.

The curve B in Fig. 2 indicates the relation between the high frequency arrival current and the readings of the meter 19, that is, the rectified carrier component. With the high frequency load indicated by the curve A it is seen that curve B is practically symmetrical with respect to the line 25. For a considerable region each side of the line 25 both curve A and curve B have slopes of about 45°. This relation permits the attendant to judge of the transmission characteristics of the main line ML from time to time by observing the reading of the meter 19. If the regulation were that corresponding to the curve A′ with the potentiometer at position II, the attendant would not observe a substantial change in the reading of the meter 19 by any change in setting of the potentiometer 11. The variation in the meter reading with a change in setting of the potentiometer 11 may, therefore, be taken as a convenient indication of the proper regulation of the channel.

The use of the high frequency and low frequency pads, as described, not only permits the desired transmission level to be secured and maintained for an individual channel of the system, but enables a uniform adjustment to be made of all the channels on a line, and, as well, of all the systems entering, say, a given office, even under the changing conditions of service. It is well known that the attenuation is greatest in the highest frequency channels. The separate high frequency and low frequency regulating pads readily permit all channels regardless of length or frequency employed to be brought to the same over-all transmission level and still keep the potentiometer settings the same. A given change in the potentiometers, whether made manually or automatically, and separately or in common, will produce substantially the same change in detected output and will therefore serve to compensate in all channels for a given change in line attenuation.

What is claimed is:

1. In a system in which high frequency waves are transmitted between distantly separated stations and are detected to yield desired low frequency components, the method of regulating transmission comprising lowering the high frequency amplitude, regulating the high frequency amplitude before detection to obtain a required relation between changes in the high frequency amplitude and the detected low frequency current, and independently regulating the detected low frequency current to obtain the required low frequency amplitude.

2. In a carrier wave transmission system, a line the transmission level of which is subject to change, a receiving carrier wave channel, including a detector and a low frequency termination, means associated with said detector for regulating the high frequency load impressed on the detector to compensate for changes in the line transmission level, means to control the sensitivity of said regulating means, and means in the low frequency terminating circuit for independently regulating the detected output current.

3. In a regulating system for a carrier signaling channel having a detecting circuit, a low frequency output circuit, a high frequency input circuit and an adjustable potentiometer for varying the high frequency load impressed on the detecting circuit, the combination of an artificial line in the high frequency input circuit for controlling the sensitivity of the potentiometer, and an artificial line in the low frequency output circuit for determining the over-all transmission level of the channel.

4. In a multiplex carrier wave transmission system, a line, a plurality of carrier channels superposed on the line, a detector in each receiving channel for deriving low frequency signal currents from the transmitted high frequency waves, an adjustable potentiometer individual to each channel for controlling the high frequency load on the respective detector and the resultant low frequency output of the detector, an artificial line individual to each channel between the multiplex transmission line and the respective potentiometer for making the sen-

sitivity of all of the potentiometers substantially equal in their control of the detected low frequency output, and an artificial line in the output circuit of each detector for adjusting the low frequency output to the same level in all of the channels for a substantial mid-scale potentiometer setting.

5. In a regulating system for a carrier signaling channel having a detector and a high frequency input and low frequency output therefor, the combination of means in the high frequency input circuit for lowering the high frequency amplitude, means for regulating the high frequency amplitude in the input circuit, and means for independently regulating the low frequency amplitude in the low frequency circuit.

In witness whereof, I hereunto subscribe my name this 29th day of February A. D., 1924.

JACOB SUTER JAMMER.