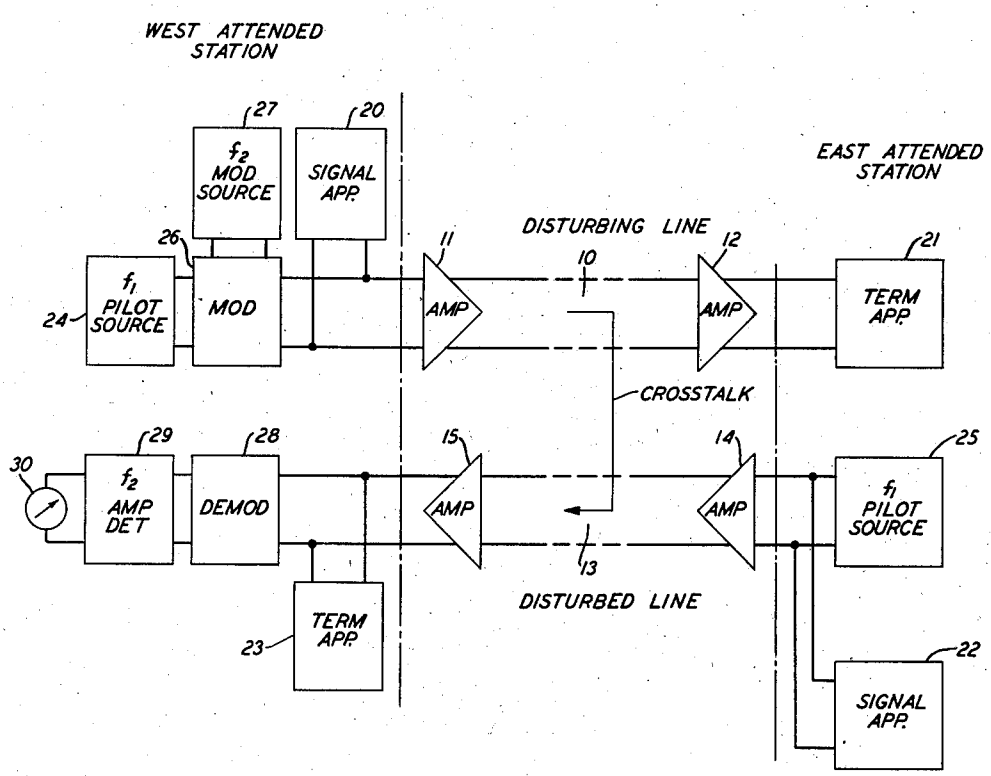
Aug. 15, 1944. H. H. BENNING 2,355,776

METHOD OF AND APPARATUS FOR MEASURING CROSS-TALK

Filed July 4, 1942



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Patented Aug. 15, 1944 2,355,776

UNITED STATES PATENT OFFICE

2,355,776

METHOD OF AND APPARATUS FOR MEASURING CROSS TALK

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Application July 4, 1942, Serial No. 449,819

7 Claims. (Cl. 179—175.3)

This invention relates to electrical measurements in intelligence transmission systems, and more particularly to a method of and apparatus for expeditiously measuring cross-talk between two conductor pairs extending together and embodied in a carrier current system.

Heretofore, various arrangements have been employed to measure cross-talk on intelligence transmission systems including both the audible and carrier current type. In accordance with such prior arrangements normal signal transmission was simultaneously interrupted on both the conductors involved so that the cross-talk measurements would be accomplished independently of the maintenance of normal signal transmission. However, in certain carrier transmission systems developed recently and embodying a plurality of repeaters in the individual conductor pairs, it is not practical to interrupt normal signal transmission on both the conductor pairs so that cross-talk measurement had to be made during normal signal transmission. Moreover, it was found in the recently developed carrier systems that pilot waves utilized to regulate the gain characteristic of the repeaters in one conductor pair tended, when present in the other conductor as cross-talk, to affect deleteriously the same regulation of the repeaters in the other conductor pair. This was so for the reason that the cross-talk pilot waves present in the other conductor pair possessed a varying phase angle with respect to the phase angle of the pilot waves individual to the other conductor pair.

The present invention contemplates an arrangement for measuring cross-talk between two parallel conductor pairs on which normal signal transmission is taking place.

The object of the invention is to measure the cross-talk of two alternating waves of identical frequency being simultaneously transmitted on two parallel conductor pairs.

In carrier transmission systems of recent development as mentioned previously, the separate conductor pairs are arranged for opposite directions of transmission by embodying therein a plurality of one-way repeaters such that at one terminal of each of the conductor pairs is located suitable signal transmitting apparatus together with a pilot wave source while at the opposite terminal of each of the conductor pairs is located an appropriate signal translating mechanism. As the ranges of frequencies of the signal waves transmitted on the individual conductor pairs are identical, the pilot waves individual to each conductor pair for regulating the gain characteristics of the repeaters therein are provided with corresponding individual frequencies.

In a specific embodiment of the present invention, cross-talk measurements are made at the frequencies of individual pilot waves while normal signal transmission is being effected on the two parallel conductor pairs. At one terminal of one conductor pair the source of pilot waves having a frequency f_1 and a source of audible waves having a fixed frequency f_2 are applied to a modulating apparatus whose output, including a component having a frequency equivalent to the frequency f_1 and upper and lower side-band components whose frequencies differ by the frequency f_2 from the frequency f_1 of the pilot wave, is applied to the one terminal of the one conductor pair. The component f_1 serves to regulate the gain characteristic of the individual repeaters embodied in the one conductor pair.

To the other conductor pair at a terminal corresponding to the opposite terminal of the one conductor pair is applied a source of a further pilot wave having the frequency f_1 while at the opposite terminal of the other conductor pair is disposed a demodulating device for demodulating the pilot wave f_1 individual to the other conductor pair and the upper and lower side-band components present therein as cross-talk. As a consequence, the output of the demodulating device is supplied to an amplifier-detector device arranged to select a component f_2 whose frequency is equivalent to the frequency f_2 of the modulating wave. The magnitude of the component f_2 indicated on a suitable meter represents cross-talk at the frequency f_1 from the one to the other conductor pair. This procedure is repeated to measure cross-talk at the frequencies of the remaining pilot waves individual to the one pair and passing from the latter to the other pair. The same procedure is employed to measure cross-talk at all frequencies of the pilot waves individual to the other pair and passing from the latter to the one pair. In the latter procedure the audible source and modulating apparatus are connected to the other pair while the demodulating and associated apparatus are connected to the one pair.

The invention will be readily understood by reference to the following description taken together with the accompanying drawing which is a schematic circuit illustrating the specific embodiment of the invention.

Referring to the drawing, a disturbing conductor pair 10 embodying spaced one-way amplifiers 11 and 12 arranged for W—E signal trans-

mission extends along together with a disturbed conductor pair 13 embodying spaced one-way amplifiers 14 and 15 arranged for E—W signal transmission. The amplifiers 11 and 15 constitute one unattended station while amplifiers 12 and 14 comprise another unattended station. At the west attended station suitable signaling apparatus 20 connected to the W—E pair 10 serves to supply thereto signal waves which are received by suitable signal translating apparatus 21 located at the east attended station. At the latter station suitable signaling apparatus 22 connected to the E—W line 13 supplies thereto signal waves which are received by suitable signal translating terminal apparatus 23 located at the west terminal thereof. The broken lines indicate that additional unattended stations may be interposed between the west and east attended stations. Signal transmission may be effected, for example, over a frequency range extending from audibility up to at least 4 megacycles.

As both the conductor pairs 10 and 13 transmit identical frequency ranges of signal waves, the gain characteristics of the respective amplifiers 11 and 12 and 14 and 15 may be regulated in the usual manner by identical pluralities of pilot waves having corresponding individual frequencies. Depending on the frequency of the signal waves, one or more pilot waves of individual frequencies may be simultaneously employed for such regulation. Thus, for example, the several pilot waves individual to each conductor pair may comprise frequencies of the order of 64, 556, 2064 and 3096 kilocycles. Hence, the pilot sources 24 and 25 located at the respective west and east attended stations will be understood to generate simultaneously and continuously the frequency at which cross-talk measurements are to be made for a purpose that will now be explained.

In accordance with the present invention, the pilot source 24 at the west attended station is applied to a modulator 26 of a type to be explained subsequently and to which is also applied a source 27 of alternating waves of fixed frequency. The output of the modulator 26 is supplied to the west terminal of the W—E conductor pair 10. At the east terminal of the E—W conductor pair 13 the pilot source 25 is directly applied thereto. To the west terminal of the E—W conductor pair 13 is connected a demodulator 28 whose output is supplied to a selective amplifier-detector 29 which supplies its output to a meter 30.

In the operation of the present invention, let it be assumed that cross-talk from the disturbing W—E conductor pair 10 to the disturbed E—W conductor pair 13 is to be measured at the frequency f_1. In such case, the wave sources 24 and 25 located at the respective west and east terminals of the conductor pairs 10 and 13 are understood to be generating simultaneously and continuously pilot waves having the frequency f_1. The source 27 also located at the west terminal of the conductor pair 10 is generating a wave of the frequency f_2 which, for the purpose of this illustration, is assumed to be in the audible range.

As the pilot wave f_1 (from the source 24) and audible wave f_2 are simultaneously and continuously applied to the modulator 26, the modulation components appearing in the output of the modulator 26 include a component having the frequency f_1 and other components whose frequencies constitute the upper and lower side-bands of the pilot wave f_1, that is, frequencies differing from the frequency f_1 of the pilot wave by an amount equivalent to the frequency f_2 of the audible wave. Thus, the modulator 26 transmits the modulation component whose frequency is equivalent to the frequency of the pilot wave f_1 and which serves to regulate the gain characteristic of the W—E amplifiers 11 and 12 in the well-known manner as previously pointed out. The modulation components comprising the upper and lower side-bands of the pilot wave f_1 are also transmitted on the W—E conductor pairs 13 but do not materially interfere with the aforementioned gain regulation of the W—E amplifiers 11 and 12 by the component f_1.

Portions of the upper and lower side-band components being transmitted on the disturbing W—E conductor pair 10 are also transmitted as cross-talk to the disturbed E—W conductor pair 13 and are further transmitted thereon together with the pilot wave f_1 supplied directly thereto by the source 25 as previously pointed out. Again, it is to be understood that while the pilot wave f_1 (from the source 25) serves to regulate the gain characteristic of the E—W amplifiers 14 and 15, the cross-talk upper and lower side-band components being transmitted on the disturbed E—W conductor pair 13 do not materially affect such regulation. The pilot wave f_1 (from the source 25) and the cross-talk upper and lower side-band components being transmitted on the E—W conductor pair 13 are supplied to the demodulator 28.

As a result of the demodulation action, the output of the demodulator 28 includes a component f_2 whose frequency is equivalent to the frequency f_2 of the modulating audible wave supplied by the source 27 to the modulator 26. The component f_2 is selected by the amplifier-detector 29 which applies the detected wave to the meter 30, the reading of which in response to the detected component f_2 serves to indicate the magnitude of the cross-talk at the frequency f_1. This procedure is repeated in like manner at the other individual frequencies of the pilot waves to measure the cross-talk thereat from the W—E conductor pair 10 to the E—W conductor pair 13.

A similar procedure is employed to measure cross-talk from the E—W conductor pair 13 to the W—E conductor pair 10 at all frequencies of the pilot waves individual to the E—W conductor pair 13. In accordance with this procedure, the modulator 26 and audible wave source 27 are operatively associated with the pilot wave source 25 located at the east terminal of the E—W conductor pair 13, and the demodulator 28, amplifier-detector 29 and meter 30 are operatively connected to the east terminal of the W—E conductor pair 10.

Obviously, the cross-talk measurements are not necessarily limited to pilot waves but may be also expeditiously accomplished at the frequency of any individual wave whose transmission cannot be interrupted without seriously impairing the fidelity of the transmission system.

What is claimed is:

1. The method of measuring cross-talk between two conductor pairs extending together and embodying one or more amplifiers in each thereof, which consists in continuously transmitting individual alternating waves of certain frequency on each of the two pairs at the same time for regulating a characteristic of the respective amplifiers, continuously transmitting also at the same time on one of the two pairs other alternating waves whose frequencies differ from the cer-

tain frequency by a predetermined amount, deriving from said certain wave being transmitted on the other of the two pairs and the portions of said other waves being transmitted on the other pair as cross-talk a component whose frequency is equivalent to the predetermined frequency difference between said certain and other waves on the one pair, and observing cross-talk represented by said component.

2. The method of measuring cross-talk between two conductor pairs extending together and embodying an amplifier in each thereof, which consists in generating an alternating wave having a certain frequency, translating said certain wave into one component whose frequency is equivalent to the certain frequency and other components whose frequencies differ from the certain frequency by a predetermined amount and continuously transmitting said one and other components on one of the pairs such that said one component controls the gain of the amplifier in the one pair, continuously transmitting on the other of the pairs at the same time a further alternating wave having the certain frequency for controlling the gain of the amplifier in the other pair, translating said further certain wave being transmitted on the other pair and the portions of said other components being transmitted thereon as cross-talk into a further component whose frequency is equivalent to the predetermined frequency difference between said one and other components on the one pair, and observing cross-talk represented by said further component.

3. The method of measuring cross-talk between two conductor pairs extending together and embodying an amplifier in each thereof, which consists in generating an alternating wave having a certain frequency, generating an alternating wave having a different frequency, translating said certain and different waves into upper and lower side-band components of said certain wave and another component whose frequency is equivalent to the certain frequency and continuously transmitting said side-band and other components on the first pair such that said other component controls the gain of the amplifier of the first pair, continuously transmitting at the same time a further alternating wave having the certain frequency on the second pair for controlling the gain of the amplifier therein, translating said further wave being transmitted on the second pair and the portions of said side-band components being transmitted thereon as cross-talk into a further component whose frequency is equivalent to the different frequency, and observing cross-talk represented by said further component.

4. In combination, two conductor pairs extending together and embodying an amplifier in each thereof, means to apply continuously to one terminal of the first pair a plurality of alternating waves including a wave having a certain frequency and other waves whose frequencies differ by a predetermined amount from the certain frequency such that the certain wave controls a characteristic of the amplifier of the first pair, means to apply continuously to the second pair at the same time at a terminal adjacent the opposite terminal of the first pair a further alternating wave of the certain frequency for controlling a characteristic of the amplifier of the second pair, means at the opposite terminal of the second pair to derive from the further wave being transmitted thereon and the portions of the other waves being transmitted on the second pair as cross-talk an additional wave whose frequency is equivalent to the predetermined frequency difference between the certain and other waves on the first pair, and means to observe cross-talk at the certain frequency as represented by the additional wave.

5. In combination, two conductor pairs extending together and embodying an amplifier in each thereof, means at one terminal of the first pair to generate an alternating current having a certain frequency, means to translate said certain current into a plurality of components one of which has a frequency equivalent to the certain frequency and others of which have frequencies differeing from the certain frequency by a predetermined amount and to apply continuously said one and other components to said one terminal of the first pair such that the one component regulates the gain characteristic of the amplifier of the first pair, means to apply continuously to the second pair at the same time at a terminal adjacent the opposite terminal of the first pair a further alternating current having the certain frequency for regulating the gain characteristic of the amplifier of the second pair, means connected to the opposite terminal of the second pair to translate the further current being transmitted thereon and the portions of the other components being transmitted thereon as cross-talk into a further component whose frequency is equivalent to the predetermined frequency difference, and means to observe cross-talk represented by the further component.

6. A system for measuring cross-talk between two conductor pairs extending together, comprising one or more amplifiers embodied in individual pairs such that a characteristic of said amplifiers is regulated by an alternating wave having a certain frequency, at one terminal of the first pair a source of alternating current of the certain frequency, a source of an alternating wave of a different frequency and means to translate both the certain and different waves into components of which certain ones comprise frequencies constituting the upper and lower side-bands of the certain wave and a further one whose frequency is equivalent the certain frequency and to apply continuously the side-band and further components to the one terminal of the first pair such that the further component regulates the characteristic of the amplifier of the first pair, a further source of an alternating wave having the certain frequency and applied continuously at the same time to the second pair at a terminal adjacent the opposite terminal of the first pair for regulating the characteristic of the amplifier of the second pair, means connected to the second pair at the terminal adjacent the one terminal at the first pair for translating the further certain wave being transmitted on the second pair and the upper and lower side-band components being transmitted thereon as cross-talk into an additional component whose frequency is equivalent to the frequency of the different wave, selective means to detect the additional component, and means responsive to the detected additional component for indicating cross-talk represented thereby.

7. In combination, two conductor pairs extending together and embodying in each thereof an amplifier having a characteristic regulated by an alternating wave of certain frequency, means for continuously applying said certain wave to each of said pairs for regulating the characteristics of

the respective amplifiers, further means included in said wave applying means for continuously applying at the same time to one of said pairs other alternating waves having a predetermined frequency difference from said certain wave, means connected to the other of said pairs for translating said certain wave thereon and the portions of said other waves thereon as cross-talk, passing from said one to said other pair, into a component whose frequency is equivalent to the predetermined frequency difference between said certain and other waves on said one pair, and means for observing the magnitude of said component as a measure of the magnitude of the cross-talk at said certain frequency, passing from said one to said other pair.

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