H. A. AFFEL.

MEANS FOR AND METHOD OF TESTING UNBALANCE.

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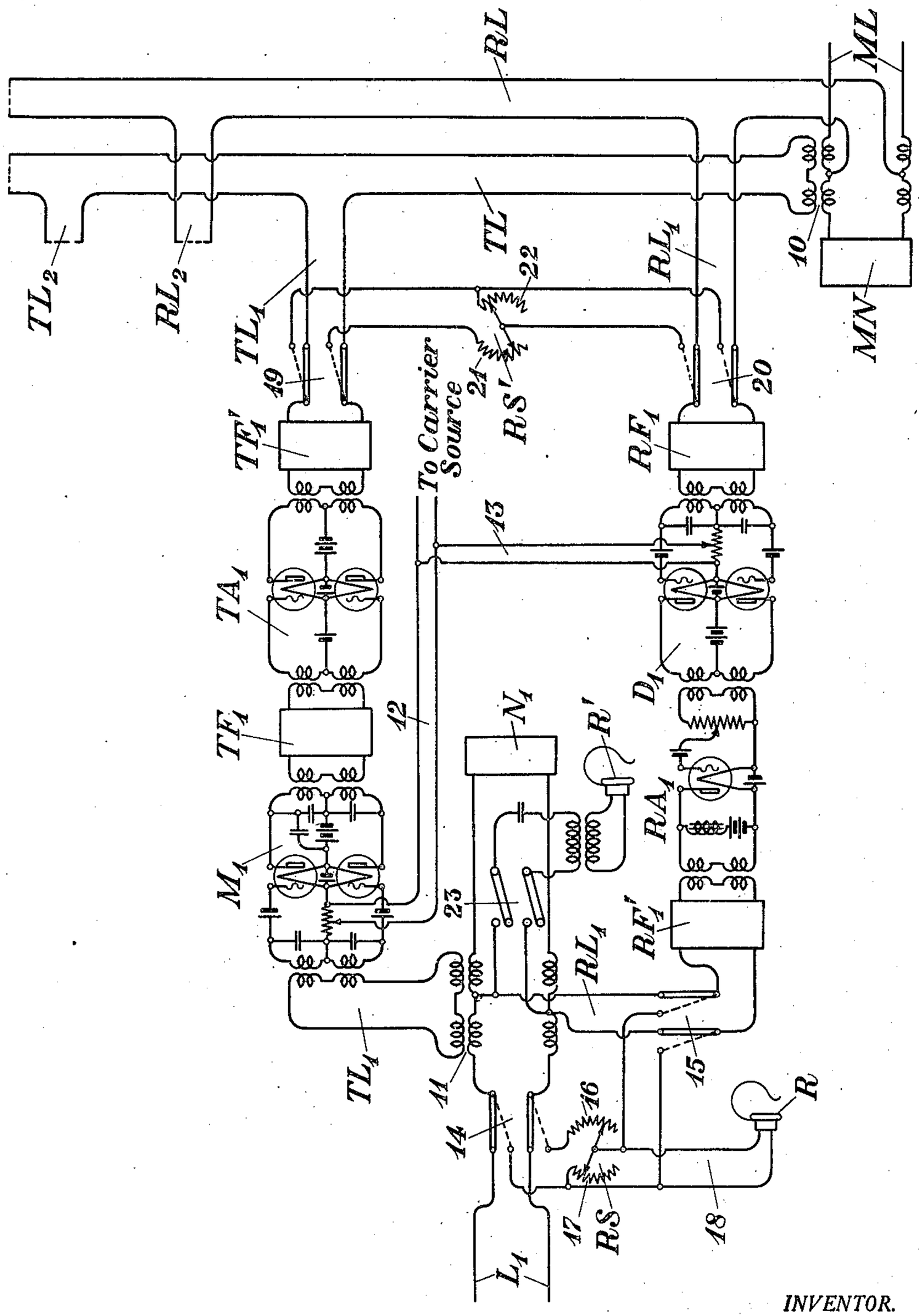

INVENTOR.

H.A. Affel

BY

ATTORNEY.

UNITED STATES PATENT OFFICE.

HERMAN A. AFFEL, OF BROOKLYN, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

MEANS FOR AND METHOD OF TESTING UNBALANCE.

1,414,391. Specification of Letters Patent. Patented May 2, 1922.

Application filed September 23, 1919. Serial No. 325,750.

To all whom it may concern:

Be it known that I, HERMAN A. AFFEL, residing at Brooklyn, in the county of Kings and State of New York, have invented certain Improvements in Means for and Methods of Testing Unbalance, of which the following is a specification.

The invention relates to multiplex carrier transmission circuits and more particularly to apparatus for and methods of testing the transmission conditions of such circuits.

It has been proposed to provide for multiplex transmission over a common path adapted to transmit carrier currents, by associating such path or transmission circuit with each of a plurality of low frequency signaling circuits through oppositely directed carrier transmission channels, the one of which is adapted to translate signaling currents from the low frequency signaling line into high frequency carrier currents for transmission over the carrier circuit and the other of which is adapted to translate the incoming carrier currents from said carrier circuit into low frequency signaling currents for transmission over said signaling circuit. In order to prevent singing over the oppositely directed carrier channels these channels are connected with the low frequency signaling circuit and carrier transmission circuit respectively, by balancing arrangements of such character that the oppositely directed carrier channels will be conjugate, that is, they will be so related that electrical disturbances in one will be without substantial effect upon the other.

Since this balanced condition is essential to the proper operation of the circuits, it is desirable that tests be made from time to time to indicate the degree of balance existing between the oppositely directed carrier channels with respect to both the low frequency signaling circuit and the carrier transmission circuit. In accordance with the present invention it is proposed to test the circuits with regard to their condition of balance, by disconnecting the oppositely directed channels from the carrier transmission circuit or low frequency signaling circuit as the case may be, without disturbing the connection with the other circuit, and then interconnecting the disconnected ends through a variable transmission element by adjusting the transmission element to the critical point at which singing just begins or ceases. The adjustment of the variable transmission element will be a measure of the degree of unbalance existing at the point of interconnection between the carrier channels and the transmission circuit whose connection was undisturbed.

The invention will be more fully understood from the following description when read in connection with the accompanying drawing, the figure of which constitutes a simplified diagram of one embodiment of the invention.

Referring to the drawing, ML designates a main transmission line over which carrier currents may be transmitted. In order to superpose a plurality of carrier channels upon the line ML, said line is associated through the balanced transformer 10 with a common carrier transmitting circuit TL and a common carrier receiving circuit RL. In order to render the circuits TL and RL conjugate, so that electrical disturbances in the one will be without effect upon the other, the line ML is balanced by an artificial line or network MN.

L_1 designates a low frequency signaling circuit such as an ordinary telephone transmission circuit, said line L_1 being associated through a balanced transformer 11 with a carrier transmitting channel TL_1 and a carrier receiving channel RL_1. The channels TL_1 and RL_1 are connected with the common carrier circuits TL and RL respectively. Another low frequency signaling circuit (not shown) may be associated with the common circuits TL and RL through transmitting and receiving channels indicated at TL_2 and RL_2 respectively, it being understood that these channels will be in general similar to the channels TL_1 and RL_1. In practice additional channels may also be associated with the circuits TL and RL in order that other low frequency transmission lines may be associated with the main line ML.

The transmitting channel TL_1 includes a modulator M_1, filters TF_1 and TF_1' and an amplifier TA_1. The modulator M_1 may be of any well-known type, but is preferably a duplex vacuum tube modulator of the type illustrated in the U. S. application of John R. Carson, Serial No. 157,413, filed March 26, 1917. The modulator is supplied

with carrier currents from a suitable source over a circuit 12 and the circuit of the modulator is so arranged that normally no oscillations from the circuit 12 are transmitted by the modulator, but when the circuit of the modulator is unbalanced by the application of low frequency signaling currents, such as voice currents to the channel TL_1, modulated carrier currents are transmitted from the modulator, said currents having amplitudes directly proportional to the modulating voice currents.

The amplifier TA_1 may be of any well-known type, but is preferably a duplex vacuum tube amplifier of the so-called "push-pull" type. The use of this type of amplifier is advantageous for the reason that the distortion of high frequency currents is much reduced by the balanced arrangement of the circuit.

The filter TF_1, which is introduced between the modulator M_1 and the amplifier TA_1, is preferably a broad band filter of the type disclosed in the U. S. patents to George A. Campbell, Nos. 1,227,113 and 1,227,114, dated May 22, 1917. The function of the filter TF_1 is to prevent unmodulated low frequency voice currents from being applied to the amplifier TA_1, thereby preventing any possibility of overloading the amplifier and causing it to still further modulate the high frequency currents transmitted thereto in accordance with the low frequency voice currents. The filter TF_1 is therefore so proportioned and constructed in accordance with the Campbell patents above referred to as to freely transmit frequencies lying above the voice range, while suppressing frequencies within the voice range.

The filter TF_1, which is included in the channel TL_1 and the amplifier TA_1, is more preferably a broad band filter of the type disclosed in the Campbell patents above referred to, and is preferably arranged to transmit a band of frequencies extending above or below the carrier frequency assigned to the channel by an amount substantially equal to the frequency range employed in the transmission of low frequency currents such as voice currents.

The receiving channel RL_1 includes a demodulator D_1, an amplifier RA, and band filters RF_1 and RF_1'. The demodulator D_1 may be of any well-known type, but is preferably a duplex vacuum tube modulator of the type disclosed in the U. S. application of John R. Carson, Serial No. 157,414, filed March 26, 1917. Since the demodulator of said Carson application operates upon the so-called homodyne principle of receiving, it is supplied with oscillations of the carrier frequency assigned to the channel over a circuit 13 and the unmodulated oscillations thus supplied react with the modulated oscillations received from the main line ML, so that the low frequency signaling currents such as telephone currents, in accordance with which the carrier currents were modulated at the distant station, will appear in the output circuit of said demodulator or detector D_1.

The amplifier RA_1 may be of any well-known type, but is preferably an ordinary vaccum tube amplifier such as is commonly used for the amplification of telephone currents. The filter RF_1 may be in all respects similar to the filter TF_1', and is arranged to transmit the same band of frequencies. The filter RF_1', however, is designed to transmit frequencies within the voice range, while suppressing frequencies above said range, thereby preventing the transmission of carrier currents to the line L_1.

In order to test the unbalance between the common carrier transmitting circuit TL and the common carrier receiving circuit RL, switches 14 and 15 are provided for disconnecting the ends of the channels TL_1 and RL_1 from the low frequency line L_1 and for interconnecting the ends of said channels through a variable transmission element such as receiver shunt RS. This receiver shunt is of well-known construction and includes series impedance 16 and shunt impedance 17, the effective values of which may be simultaneously varied so as to vary the transmission equivalent of the receiver shunt, while maintaining constant the impedance of the circuit as viewed from the contacts of the switch 14. A telephone receiver R may be bridged across the circuit beyond the receiver shunt RS, for the purpose of listening in on the circuit. In order that a relatively small amount of energy may be diverted through the receiver R, a resistance 18 may be included in circuit therewith, if desired.

In order to determine the low frequency unbalance, or in other words the unbalance between the transmitting channels TL_1 and RL_1 with respect to the line L_1, switches 19 and 20 are provided for disconnecting the ends of the channels TL_1 and RL_1 from the circuits TL and RL and for interconnecting the ends of said channels through receiver shunt RS'. This receiver shunt may be in all respects similar to the receiver shunt RS already described, and includes series and shunt impedance elements 21 and 22, respectively. In order to listen in upon the circuit during this test, a telephone receiver R' may be bridged across the midpoints of the primary winding of the transformer 11 through a switch 23. The bridged circuit of receiver R' should preferably be of high impedance in order to prevent undue transmission loss through said bridge.

Further details of the apparatus may now be more fully understood from the de-

tailed description of the operation which is as follows:

Telephone currents incoming from the line L_1 are transmitted through the transformer 11 to the modulator M_1 which modulates carrier currents from the circuit 12 in a well-known manner. The modulated carrier currents are then transmitted through the filter TF_1, amplified by the amplifier TA_1 and pass through the filter TF_1' to the common transmitting circuit TL, from whence they are transmitted through the transformer 10 to the main line ML. Incoming modulated carrier currents are transmitted from the line ML to the common receiving circuit RL and are passed through the filter RF_1 to the demodulator D_1. The incoming modulated carrier currents react in the demodulator with unmodulated carrier currents from the circuit 13, so that the low frequency currents in accordance with which the carrier currents were modulated appear in the output circuit of the detector D_1 and are impressed upon the amplifier RA_1. After amplification the low frequency voice currents are passed through the filter RF_1' and through the impedance of the windings of the transformer 11 to the low frequency line L_1 and the artificial line N_1 respectively.

Theoretically, the channels TL_1 and RL_1 should be perfectly balanced with regard to their association with the main line ML through the common circuits TL and RL and if this condition obtained singing over these channels would not occur. Since it is impossible to obtain a perfect balance, however, it is desirable from time to time to make a so-called high frequency balance test to determine the unbalance between the channels TL_1 and RL_1 with respect to the main line ML. In order to make such a test the switches 14 and 15 are thrown to their dotted line positions, so that the ends of the channels TL_1 and RL_1 are no longer associated with the line L_1, but are interconnected through the receiver shunt RS. This interconnection includes the transformer 11, so that the transmission efficiency of this element may be tested.

The condition of the circuit is now such that singing will occur provided the total amplification in the loop, including the channels TL_1 and RL_1, is greater than the loss due to the other elements in the circuit, of which the receiver shunt RS is one. Since the total net amplification in the loop may be previously determined by other tests, and the value of the variable transmission element noted when the circuit is just at the point of singing, the difference between these two factors will represent a criterion of the degree of balance or conjugacy of the respective low or high frequency terminal under test.

By listening in upon the receiver R it may be noted whether or not singing is taking place in the circuit and if the circuit is singing the receiver shunt element RS may be varied until singing just ceases. If, however, singing is not taking place in the circuit, the receiver shunt RS should be adjusted until singing just commences. In either case the adjustment will be substantially the same and will indicate the degree of unbalance existing between the channels TL_1 and RL_1 with respect to the main line ML. If desired, the receiver shunt may be calibrated in terms of some unit of balance.

In order to make a so-called low frequency balance test, that is a test to determine the degree of unbalance between the channels TL_1 and RL_1 with respect to the low frequency line L_1, the switches 15 and 14 should be restored to their full line positions and the switches 19 and 20 thrown to their dotted line positions. Channels TL_1 and RL_1 are now disconnected from the main line ML and are interconnected through a receiver shunt RS'. By operating the switch 23 the operator is enabled to "listen in" on the circuit through the receiver R' and if the circuit is singing the receiver shunt RS may be adjusted until singing just ceases. If the circuit is not singing the receiver shunt may be adjusted until singing just commences. In either case the adjustment of the receiver shunt RS' will indicate the degree of unbalance between the channels TL_1 and RL_1 with respect to the line L_1. By properly calibrating the receiver shunt RS' the setting of this instrument may indicate the degree of unbalance in terms of some suitable unit of unbalance.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated, without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. The method of determining the unbalance between oppositely directed channels of a multiplex carrier system in which each pair of oppositely directed channels is associated with a common transmission circuit and with an individual low frequency signalling circuit in such a manner that the channels will be conjugate with respect to each other, which consists in disconnecting a pair of oppositely directed channels from one of said circuits while maintaining the connection with the other circuit intact, interconnecting the disconnected ends of the channels through a variable transmission element and then adjusting the transmission of said element until singing in the circuit begins or ceases, the adjustment of said transmission thereby indicat-

ing the degree of unbalance between the oppositely directed channels with respect to the connection which was not disturbed.

2. The method of determining the unbalance between oppositely directed channels of a multiplex carrier system in which each pair of oppositely directed channels is associated with a common carrier transmission circuit and with an individual low frequency signaling circuit in such a manner that the channels will be conjugate with respect to each other, which consists in disconnecting a pair of oppositely directed channels from said carrier transmission circuit, while maintaining their connection with the corresponding signaling circuit intact, interconnecting the disconnected ends of said channels through a variable transmission element, and adjusting said transmission element to the point at which singing begins or ceases, the adjustment of said transmission element thereby indicating the unbalance of said channels with respect to the signaling circuit.

3. The method of determining the unbalance between oppositely directed channels of a multiplex carrier system in which each pair of oppositely directed channels is associated with a common carrier transmission circuit and with an individual low frequency signaling circuit in such a manner that the channels will be conjugate with respect to each other, which consists in disconnecting a pair of oppositely directed channels from the corresponding low frequency signaling circuit, while maintaining their connection with the carrier transmission circuit intact, interconnecting the disconnected ends of said channels through a variable transmission element, and adjusting said transmission element to the point at which singing begins or ceases, the adjustment of said transmision element thereby indicating the degree of unbalance between said channels with respect to said carrier transmission circuit.

4. In a testing system for multiplex carrier transmission apparatus, a carrier transmission circuit, a low frequency signaling circuit, oppositely directed carrier channels interconnected with said circuits in such a manner that the channels will be conjugate with respect to each other, means for disconnecting said channels from one of said circuits and directly interconnecting the disconnected ends of said channels while maintaining the connection of said channels with the other circuit intact, and means for adjusting the transmission in the resultant circuit to such a point that singing begins or ceases, the resulting adjustment indicating the unbalance of the channels with respect to the circuit the connection with which was undisturbed.

5. In a testing system for multiplex carrier apparatus, a carrier transmission circuit, a low frequency signaling circuit, oppositely directed carrier channels interconnected with said circuits in such a manner that the channels will be conjugate with respect to each other, means for disconnecting said channels from the carrier transmission circuit and directly connecting the disconnected ends of said channels, while maintaining the inter-connection of said channels with the low frequency signaling circuit intact, and means for adjusting the transmission of the circuit thus formed, to such a point that singing begins or ceases, the resultant adjustment thereby indicating the condition of unbalance between the oppositely directed channels with respect to the low frequency signaling circuit.

6. In a testing system for multiplex carrier apparatus, a carrier transmission circuit, a low frequency signaling circuit, oppositely directed carrier channels inter-connected with said circuits in such a manner that the carrier channels will be conjugate with respect to each other, means for disconnecting said oppositely directed channels from said low frequency signaling circuit and directly interconnecting the disconnected ends of said channels without disturbing the interconnection of said channels with said carrier transmission circuit, and means for adjusting the transmission of the resultant circuit to the point at which singing begins or ceases, the resultant adjustment indicating the degree of unbalance between said channels with respect to said carrier transmission circuit.

In testimony whereof, I have signed my name to this specification this 22nd day of September, 1919.

HERMAN A. AFFEL.