May 13, 1924. 1,493,019

L. ESPENSCHIED

CARRIER TRANSMISSION SYSTEM

Filed June 13, 1919

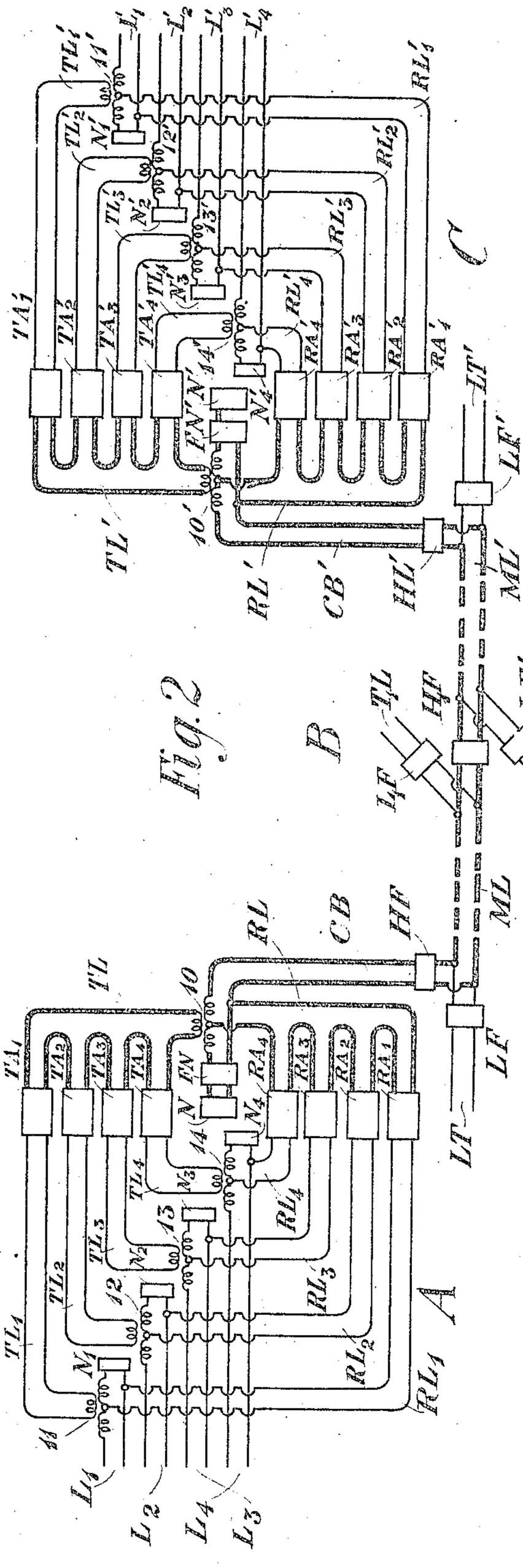

Fig. 2

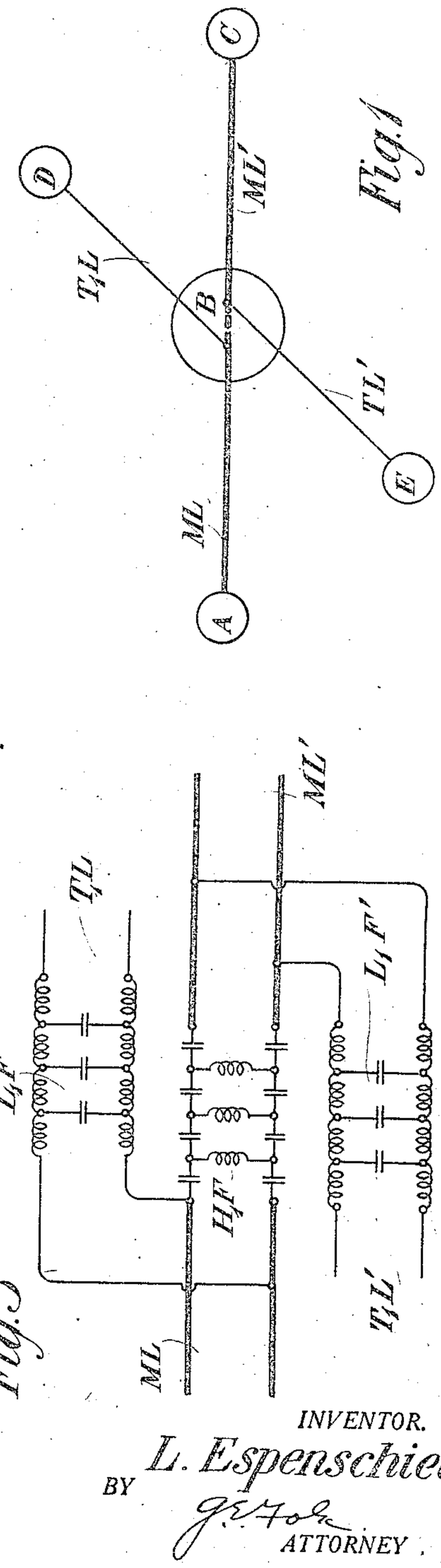

Fig. 1

Fig. 3

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UNITED STATES PATENT OFFICE.

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CARRIER-TRANSMISSION SYSTEM.

Application filed June 18, 1919. Serial No. 303,342.

To all whom it may concern:

Be it known that I, LLOYD ESPENSCHIED, residing at Hollis, Long Island, in the county of Queens and State of New York, have invented certain Improvements in Carrier-Transmission Systems, of which the following is a specification.

This invention relates to transmission systems in which carrier currents are employed for the transmission of low frequency signals such as telegraph or telephone signals.

This invention provides means whereby a plurality of low frequency circuits may be interconnected for the transmission of carrier frequencies from one to the other, while maintaining the two systems electrically distinct with regard to low frequencies.

It further comprises means whereby the carrier currents of one or more carrier channels may be superposed on a low frequency circuit, and after being transmitted over a desired section of the circuit may be transferred to another low frequency circuit for transmission over the latter, without necessitating any reorganization of the low frequency circuits involved.

It also comprises an arrangement whereby a plurality of transmission circuits adapted for the transmission of a plurality of frequencies (among which may be included carrier frequencies for a plurality of communication channels) may be interconnected for the transmission of certain frequencies in tandem over the circuits, at the same time maintaining the circuits electrically distinct with reference to other frequencies, so that such other frequencies are not transmitted from one circuit to the other.

These aims, as well as other objects more fully hereinafter appearing are secured in accordance with the present invention by providing a system of filters so arranged that two transmission circuits are interconnected through a filter adapted to transmit the frequencies which it is desired to transfer from one circuit to the other while excluding other frequencies. As a further refinement, filters may also be arranged in those portions of the circuits over which it is desired that the transferred frequencies shall not be transmitted, said filters being so designed as to exclude the frequencies which are to be transferred from one circuit to the other while transmitting frequencies which are not to be so transferred.

The invention is of particular utility where it is desired to provide carrier transmission circuits between two points which are not interconnected by a single circuit which is adapted for the transmission of carrier frequencies. For instance, all of the circuits between the two points in question may contain sections near one of the points which are loaded for low frequency transmission, or which may be constructed of cable, in either of which cases the circuits considered in their entirety would not be adapted for transmission of carrier frequencies, although portions of the circuits would be available for this purpose. If then there should be another circuit or a section of another circuit adapted for the transmission of carrier frequencies extending from the distant point to an intermediate point which is connected to the first point by sections of the through circuits which are adapted for carrier transmission, a through carrier circuit may be provided by establishing a carrier connection between the available section of the line terminating at the distant station and an available section of some one of the lines extending from the first station.

In other instances it may be desired to provide carrier transmission between two points which are not interconnected by through circuits from one point to the other. In such a case, advantage may be taken of the fact that connections extend from the first point through an intermediate point to some third point while other connections extend from the second point through the intermediate point to a fourth point. By providing a carrier transmission connection between sections of the circuit extending from the first and second points through the intermediate point to other points, a carrier transmission circuit may be established between the first and second points.

The invention may now be more fully understood by reference to the following description when read in connection with the accompanying drawing, Figure 1 of which is a schematic diagram showing one situation to which the principles of the invention may be applied, Fig. 2 of which is a circuit

diagram, schematic in part, illustrating one form of the invention, and Fig. 3 is a diagram showing the arrangement of the filter organization employed in connection with the invention.

Referring to Fig. 1, A and C designate two distant stations between which it is desired to establish a carrier transmission circuit, and between which no complete through circuits adapted for carrier transmission are available. A transmission line ML—T_1L is illustrated as extending from station A through an intermediate station B to a third point D, the section ML of this line being of such character that the carrier frequencies may be transmitted thereover. Another line ML′—T_1L' is also shown as extending from station C through intermediate station B to another point of this line, being also adapted for the transmission of carrier frequencies. By interconnecting the two sections ML and ML′ by a carrier transmission path as indicated in dotted lines at B, a through carrier transmission circuit between stations A and C may be provided.

The above situation is typical of the general condition which it is proposed to meet by means of the present invention. The underlying idea is equally applicable to the case in which the line ML—T_1L, for instance, extends through from station A to C, but the section T_1L, by reason of being loaded for low frequency transmission, or by reason of the fact that it is constructed of cable, is unavailable for through carrier transmission. In such case the section ML may be extended over a carrier connection at the intermediate station B to a section such as ML′ of a line extending from station C to intermediate station B, or through said station to any other point, assuming, of course, that the section ML′ is adapted for the transmission of carrier currents.

Turning now to the circuit organization which is shown in more detail in Fig. 2, ML represents a section of an ordinary low frequency transmission line which is adapted for the transmission of carrier currents, said section extending between stations A and B. At station B the line which includes the section ML is extended over another section T_1L to some distant point which is not involved in the carrier transmission path which it is desired to establish. At station A the line which includes the section ML may be extended over a terminal section LT. In a similar manner ML′ designates a section of low frequency transmission line which section extends between stations B and C and is also adapted to transmit carrier frequencies. The line including the section ML′ is extended at station B over a section T_1L' and at station C over terminal section LT′. In order to establish a through carrier connection between stations A and C, the section ML and ML′ may be interconnected at intermediate station B through a high frequency filtering arrangement H_1F which is so arranged as to transmit the desired carrier frequencies while substantially suppressing other frequencies. In order to prevent the transmission of carrier frequencies over the line sections T_1L and T_1L', low frequency filters L_1F and L_1F' may be included in these sections, said filters being so designed as to substantially suppress carrier frequencies which it is desired to transfer from the section ML to the section ML′, while freely transmitting such frequencies as it is desired to transmit from the section ML to the section T_1L or from the section ML′ to the section T_1L'.

The filters which are used in the combination just described may be of any desired character, the only requirement being that they shall transmit the desired ranges of frequencies to the substantial exclusion of other frequencies. Preferably these filters should be of the general type disclosed in United States Patents granted to George A. Campbell, Nos. 1,227,113 and 1,227,114 dated May 22, 1917.

The arrangement of filters is shown in more detail in Fig. 3 in which the filter H_1F interconnecting the line sections ML and ML′ is illustrated as consisting of a plurality of sections having series capacity and shunt inductance so provided in accordance with the principles set forth in Campbell patents above referred to as to transmit a band of frequencies between whose limits are included the frequencies which it is desired to transfer from the section ML to the section ML′. If, for instance, the line including the sections ML and T_1L and the line including the sections ML′ and T_1L' are ordinary transmission lines, the filter H_1F would be so designed that its lower cut-off frequency would be at some point above the upper limit of the frequencies used in ordinary telephonic transmission, so that carrier frequencies above this limit would be freely transmitted, while frequencies below the upper limit of telephonic transmission would be suppressed.

The filters L_1F and L_1F' are each illustrated as comprising a plurality of sections, each including series inductance and shunt capacity so proportioned as set forth in the Campbell patents above referred to as to freely transmit a band of frequencies below an upper limiting frequency and substantially suppress frequencies lying aboye said limit. In the case already referred to, in which the lines are ordinary transmission lines, the filters L_1F and L_1F' would be arranged with a cut-off frequency at or above the highest frequency used in ordinary telephonic transmission.

It will be clear, therefore, that with the

arrangement so far described, frequencies lying within the limits of ordinary telephonic transmission may be transmitted from section ML over section T_1L without any substantial transmission loss due to the connection between sections ML and ML′ through the filter H_1F. So also frequencies within these limits may be transmitted from section ML′ over section T_1L'. Carrier frequencies or other frequencies above the limits of ordinary telephonic transmission may be transmitted from section ML to section ML′ or vice versa through the filter H_1F without involving any substantial transmission loss due to leakage through the filters L_1F or L_1F'.

The low frequency transmission lines may be of any character so far as their utility is concerned, that is, they may be either telephone lines, telegraph lines or any other form of signal transmission circuit. The carrier system superposed upon these lines may also be adapted for the transmission of any desired kind of signals, and, so far as principle of operation is concerned, may be of any type known in the art. For purposes of illustration, however, terminal carrier apparatus of the general type shown and described in the United States patent applications of B. W. Kendall, Serial No. 130,250, filed November 9, 1916 and 137,592 filed December 18, 1916, which has become Patent No. 1,445,141, dated Feb. 13, 1923, is schematically illustrated and will now be described.

The terminal carrier current apparatus comprises a carrier branch CB which is associated with the main line section ML through a high frequency filter HF similar in character to the filter H_1F already described, the function of this filter being to suppress low frequency currents from the carrier apparatus. In order to prevent the transmission of carrier frequencies to the terminal portion of the line LT, a low frequency filter LF, similar to the filters L_1F and L_1F' already described, may be provided. The carrier branch CB is associated with a common carrier transmitting circuit TL and the common carrier receiving circuit RL through a transformer 10. The circuits TL and RL are so arranged as to be conjugate with respect to each other or, in other words so that electrical operations in the one circuit will be without effect upon the other. This result is secured by providing a circuit including a network FN for balancing the filter HF and another network N for balancing the main line and other apparatus connected to terminals of the carrier branch CB.

A plurality of carrier transmitting channels TL_1, TL_2, TL_3 and TL_4 may be associated with the common carrier transmitting circuit TL, and similarly carrier receiving channels RL_1, RL_2, RL_3 and RL_4 are associated with common carrier receiving circuit RL. Each corresponding transmitting and receiving channel is associated with a low frequency transmission line such as L_1, L_2, etc. through transformers 11, 12, 13 and 14 and corresponding transmitting and receiving channels are rendered conjugate with respect to each other by providing balancing networks such as N_1, N_2, N_3 and N_4 for the corresponding low frequency lines.

Each transmitting channel such as TL_1 is provided with translating apparatus for supplying the several carrier frequencies, modulating these frequencies in accordance with the low frequency signaling currents from the low frequency lines L_1, L_2, etc. and for impressing the modulated frequencies upon the common transmitting circuit TL. These arrangements may be of any desired character, such as, for instance, those shown in the applications of B. W. Kendall above referred to, and are schematically illustrated at TA_1, TA_2, TA_3 and TA_4.

In a similar manner the several receiving channels such as RL_1, RL_2, etc. are provided with means for selectively separating the received modulated carrier frequencies, for demodulating or detecting the received oscillations, and for impressing the resultant low frequency signaling currents upon the low frequency lines L_1, L_2, etc. These arrangements may also be of any well known character but are preferably of the general type illustrated and described in said applications of B. W. Kendall.

The carrier apparatus at the station C may be similar in character to that already described in connection with station A and need not be further discussed, it being sufficient to know that the various elements at station B are designated by the same reference character as those at station A, with the exception that the reference characters applied to the apparatus at station C are primed.

The operation is, briefly, as follows: Low frequency signals incoming from the lines L_1, L_2, L_3 and L_4 are transmitted through the transformers 11, 12, 13 and 14 to the transmitting channels TL_1, TL_2, etc. By means of the apparatus TA_1, TA_2, etc. carrier oscillations of different frequencies are suitably filtered, modulated by the low frequency currents and the modulated carrier currents of the several frequencies impressed upon the common transmitting circuit TL. From these circuits several modulated frequencies are transmitted over the transformer 10 to the carrier branch CB without producing any substantial reaction upon the receiving circuit RL. The filter HF freely transmits the several modulated carrier frequencies which are then transmitted over the line section ML and through the filter H_1F

to the line section ML′, the filters L_1F and L_1F' functioning to prevent the modulated carrier frequencies from entering the line sections T_1L and T_1L'. At the station C the filter LF′ prevents the modulated carrier frequencies transmitted over the line section ML′ from entering the terminal line TL′ while the high frequency filter HL′ permits the free passage of the modulated carrier currents to the carrier branch CB′. From this circuit the several frequencies are transmitted to the common receiving circuit RL′ without producing any substantial reaction upon the common transmitting circuit TL′. By means of receiving translating apparatus RA_1', RA_2' etc., the several modulated carrier frequencies are filtered into their respective channels, are modulated or detected and purified, the resultant low frequency signaling currents being impressed through the transformer arrangements 11′, 12′, 13′ and 14′ upon the outgoing low frequency lines L_1, L_2, L_3 and L_4.

The operations incident to transmission in the opposite direction will be in all respects similar to those already described and need not be further discussed.

The several transmitting channels referred to in the preceding description whether low frequency channels or high frequency carrier channels may be employed for the transmission of telegraphic, telephonic or any other form of signals, the essential feature of the invention being the provision of arrangements whereby certain frequencies may be transferred from one transmission circuit to the other, while the transmission circuits are maintained electrically distinct with regard to other frequencies. Furthermore the filtering means employed for maintaining this relation between the circuits may be of other types than the broad band filters above described.

The arrangement above described is capable of a number of applications other than those above discussed. Thus, for instance by means of this invention a carrier circuit may be extended over a number of successive telephone circuits of shorter lengths. It is also possible to extend the carrier circuit over a point of disruption in the ordinary telephone circuit such as is occasioned by the insertion of a telephone repeater in the circuit, the carrier frequencies being filtered out and transmitted through a side branch around the repeater. In general, junctions between lines or line sections for transmitting carrier frequencies may be made at any points where the lines neighbor each other whether at the ends of the lines or at intermediate points.

While it has seemed desirable for the purpose of clearer understanding, to illustrate the invention as embodied in certain specific forms, 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. In a signaling system, a plurality of transmission lines adapted to transmit voice frequency signaling currents, each transmission line comprising a plurality of sections at least one of which is adapted to transmit high frequency currents of the order used for carrier transmission, and means to interconnect said lines for the transmission of carrier frequencies from a high frequency section of one line to a high frequency section of another line while maintaining the other sections of the lines electrically separate with regard to the transmission of voice frequency signaling currents, said means including an apparatus adapted to substantially suppress voice frequency signaling currents.

2. In a signaling system, a plurality of transmission lines adapted to transmit voice frequency signaling currents, each transmission line comprising a plurality of sections at least one of which is adapted to transmit high frequency currents of the order used for carrier transmission, and means to interconnect said lines for the transmission of carrier frequencies from a high frequency section of one line to a high frequency section of another line while maintaining the other sections of the lines electrically separate with regard to the transmission of voice frequency signaling currents, said means including an apparatus adapted to substantially suppress voice frequency signaling currents while freely transmitting frequencies above the upper limit of frequencies used in the transmission of low frequency signaling currents.

3. In a signaling system, a plurality of transmission lines adapted to transmit voice frequency signaling currents, each transmission line comprising a plurality of sections at least one of which is adapted to transmit high frequency currents of the order used for carrier transmission, and means to interconnect said lines for the transmission of carrier frequencies from a high frequency section of one line to a high frequency section of another line while maintaining the other sections of the lines electrically separate with regard to the transmission of voice frequency signaling currents, said means including an apparatus adapted to substantially suppress voice frequency signaling currents while freely transmitting a band of frequencies above the upper limit of frequencies used in the transmission of low frequency signaling currents and including frequencies used for carrier transmission.

4. In a signaling system, a plurality of transmission lines adapted to transmit voice frequency signaling currents, each transmission line comprising a plurality of sections at least one of which is adapted to transmit high frequency currents of the order used for carrier transmission, and means to interconnect said lines for the transmission of carrier frequencies from a high frequency section of one line to a high frequency section of another line while maintaining the other sections of the lines electrically separate with regard to the transmission of voice frequency signaling currents, said means including a broad band filter adapted to substantially suppress voice frequency signaling currents while freely transmitting frequencies above the upper limit of frequencies used in the transmission of low frequency signaling currents.

5. In a signaling system, a plurality of transmission lines adapted to transmit voice frequency signaling currents, each transmission line comprising a plurality of sections at least one of which is adapted to transmit high frequency currents of the order used for carrier transmission, and means to interconnect said lines for the transmission of carrier frequencies from a high frequency section of one line to a high frequency section of another line while maintaining the other sections of the lines electrically separate with regard to the transmission of voice frequency signaling currents, said means including a broad band filter adapted to substantially suppress voice frequency signaling currents while freely transmitting a band of frequencies above the upper limit of frequencies used in the transmission of low frequency signaling currents and including frequencies used for carrier transmission.

6. In a signaling system, a plurality of transmission lines adapted to transmit voice frequency signaling currents, each transmission line comprising a plurality of sections at least one of which is adapted to transmit high frequency currents of the order used for carrier transmission, and means to interconnect said lines for the transmission of carrier frequencies from a high frequency section of one line to a high frequency section of another line while maintaining the other sections of the lines electrically separate with regard to the transmission of voice frequency signaling currents, and means in sections adjacent to the interconnected sections for substantially suppressing the transmission over said adjacent sections of frequencies above the upper limit of frequencies used in the transmission of low frequency signaling currents.

7. In a signaling system, a plurality of transmission lines adapted to transmit voice frequency signaling currents, each transmission line comprising a plurality of sections at least one of which is adapted to transmit high frequency currents of the order used for carrier transmission, and means to interconnect said lines for the transmission of carrier frequencies from a high frequency section of one line to a high frequency section of another line while maintaining the other sections of the lines electrically separate with regard to the transmission of voice frequency signaling currents, said means including an apparatus adapted to substantially suppress voice frequency signaling currents while freely transmitting frequencies above the upper limit of frequencies used in the transmission of low frequency signaling currents, and means in sections adjacent to the interconnected sections for substantially suppressing the transmission over said adjacent sections of frequencies above the upper limit of frequencies used in the transmission of low frequency signaling currents while freely transmitting frequencies below said limit.

8. In a signaling system, a plurality of transmission lines adapted to transmit voice frequency signaling currents, each transmission line comprising a plurality of sections at least one of which is adapted to transmit high frequency currents of the order used for carrier transmission, and means to interconnect said lines for the transmission of carrier frequencies from a high frequency section of one line to a high frequency section of another line while maintaining the other sections of the lines electrically separate with regard to the transmission of voice frequency signaling currents, and means in sections adjacent to the interconnected sections for substantially suppressing the transmission over said adjacent sections of frequencies above the upper limit of frequencies used in the transmission of low frequency signaling currents, while freely transmitting a band of frequencies below said limit.

9. In a signaling system, a plurality of transmission lines adapted to transmit voice frequency signaling currents, each transmission line comprising a plurality of sections at least one of which is adapted to transmit high frequency currents of the order used for carrier transmission, and means to interconnect said lines for the transmission of carrier frequencies from a high frequency section of one line to a high frequency section of another line while maintaining the other sections of the lines electrically separate with regard to the transmission of voice frequency signaling currents, said means including a broad band filter adapted to substantially suppress voice frequency signaling currents while freely trnasmitting frequencies above the upper limit of frequencies used in the transmission of low

frequency signaling currents, and means in sections adjacent to the interconnected sections comprising broad band filters adapted to substantially suppress frequencies above the upper limit of frequencies used in the transmission of low frequency signaling currents while freely transmitting a band of frequencies below said limit.

10. In a signaling system, a plurality of transmission lines adapted to transmit voice frequency signaling currents, each transmission line comprising a plurality of sections at least one of which is adapted to transmit high frequency currents of the order used for carrier transmission, and means to interconnect said lines for the transmission of carrier frequencies from a high frequency section of one line to a high frequency section of another line while maintaining the other sections of the lines electrically separate with regard to the transmission of voice frequency signaling currents, said means including a broad band filter adapted to substantially suppress frequencies below the upper limit of frequencies used in ordinary telephonic transmission while freely transmitting a band of frequencies above said limit.

11. In a signaling system, a plurality of transmission lines adapted to transmit voice frequency signaling currents, each transmission line comprising a plurality of sections at least one of which is adapted to transmit high frequency currents of the order used for carrier transmission, and means to interconnect said lines for the transmission of carrier frequencies from a high frequency section of one line to a high frequency section of another line while maintaining the other sections of the lines electrically separate with regard to the transmission of voice frequency signaling currents, said means including a broad band filter adapted to substantially suppress frequencies below the upper limit of frequencies used in ordinary telephonic transmission while freely transmitting a band of frequencies above said limit, and means in sections adjacent to the interconnected sections comprising broad band filters adapted to substantially suppress frequencies above the upper limit of telephonic transmission while freely transmitting a band of frequencies below said limit.

12. In a signaling system a plurality of lines adapted to transmit voice frequency signaling currents, means to superpose on said lines a plurality of high frequency carrier channels, means for interconnecting the lines so that high frequency currents will be transmitted from one line to the other while the lines are maintained electrically separate with regard to voice frequency currents, said last mentioned means including a connection between said lines, and means in said connection adapted to substantially suppress voice frequency signaling currents.

13. In a signaling system a plurality of lines adapted to transmit voice frequency signaling currents, means to superpose on said lines a plurality of high frequency carrier channels, means for interconnecting the lines so that high frequency currents will be transmitted from one line to the other while the lines are maintained electrically separate with regard to voice frequency currents, said last-mentioned means including a connection between said lines, and means in said connection adapted to substantially suppress voice frequency signaling currents while freely transmitting frequencies above the upper limit of frequencies used in the transmission of low frequency signaling currents.

14. In a signaling system a plurality of lines adapted to transmit voice frequency signaling currents, means to superpose on said lines a plurality of high frequency carrier channels, means for interconnecting the lines so that high frequency currents will be transmitted from one line to the other while the lines are maintained electrically separate with regard to voice frequency currents, said last mentioned means including a connection between said lines, and means in said connection including a broad band filter adapted to substantially suppress voice frequency signaling currents while freely transmitting frequencies above the upper limit of frequencies used in the transmission of low frequency signaling currents.

15. In a signaling system a plurality of lines adapted to transmit voice frequency signaling currents, means to superpose on said lines a plurality of high frequency carrier channels, means for interconnecting the lines so that high frequency currents will be transmitted from one line to the other while the lines are maintained electrically separate with regard to voice frequency currents, said last mentioned means including a connection between said lines, and means in said connection including a broad band filter adapted to substantially suppress voice frequency signaling currents while freely transmitting a band of frequencies above the upper limit of frequencies used in the transmission of low frequency signaling currents and including frequencies used for carrier transmission.

16. In a signaling system, a plurality of lines each adapted to transmit a plurality of frequencies, means to interconnect said lines for the transmission of a definite range of frequencies from one to the other while maintaining them electrically separate with regard to other frequencies, said means comprising a conductive connection between the lines, and a broad band filter in said connection adapted to transmit with uniform neg-

ligible attenuation a band of frequencies from one line to another while substantially suppressing other frequencies.

17. In a signalling system a plurality of lines each adapted to transmit a plurality of frequencies, means to interconnect said lines for the transmission of certain of said frequencies from one to the other while maintaining them electrically separate with regard to the other frequencies, said means comprising a conductive connection between the lines, and means in said connection adapted to transmit certain frequencies with uniform negligible attenuation while substantially suppressing other frequencies.

18. In a signaling system, a plurality of transmission lines adapted to transmit voice frequency signaling currents, each transmission line comprising a plurality of sections at least one of which is adapted to transmit high frequency currents of the order used for carrier transmission and another section of which is incapable of effectively transmitting frequencies substantially higher than voice frequencies, and means to interconnect said lines at stations intermediate the terminal stations thereof for the transmission of carrier frequencies from a high frequency section of one line to a high frequency section of another line while maintaining the other sections of the lines electrically separate with regard to the transmission of voice frequency signaling currents, said means including an apparatus adapted to substantially suppress voice frequency signaling currents.

19. In a signaling system, a plurality of transmission lines adapted to transmit voice frequency signaling currents, each transmission line comprising a plurality of sections at least one of which is adapted to transmit high frequency currents of the order used for carrier transmission and another section of which is incapable of effectively transmitting frequencies substantially higher than voice frequencies, and means to interconnect said lines at stations intermediate the terminal stations thereof for the transmission of carrier frequencies from a high frequency section of one line to a high frequency section of another line while maintaining the other sections of the lines electrically separate with regard to the transmission of voice frequency signaling currents, said means including apparatus adapted to substantially suppress voice frequency signaling currents while freely transmitting frequencies above the upper limit of frequencies used in the transmission of voice frequency signaling currents.

20. In a signaling system, a plurality of transmission lines adapted to transmit voice frequency signaling currents, each transmission line comprising a plurality of sections at least one of which is adapted to transmit high frequency currents of the order used for carrier transmission and another section which is incapable of effectively transmitting frequencies substantially higher than voice frequencies, and means to interconnect said lines at stations intermediate the terminal stations thereof for the transmission of carrier frequencies from a high frequency section of one line to a high frequency section of another line while maintaining the other sections of the lines electrically separate with regard to the transmission of voice frequency signaling currents, said means including a broad band filter adapted to substantially suppress voice frequency signaling currents while freely transmitting frequencies above the upper limit of frequencies used in the transmission of voice frequency signaling currents.

21. In a signaling system, a plurality of transmission lines adapted to transmit voice frequency signaling currents, each transmission line comprising a plurality of sections at least one of which is adapted to transmit high frequency currents of the order used for carrier transmission and another section of which is incapable of effectively transmitting frequencies substantially higher than voice frequencies, and means to interconnect said lines at stations intermediate the terminal stations thereof for the transmission of carrier frequencies from a high frequency section of one line to a high frequency section of another line while maintaining the other sections of the lines electrically separate with regard to the transmission of voice frequency signaling currents, and means in sections adjacent to the interconnected sections for substantially suppressing the transmission over said adjacent section of frequencies above the upper limit of frequencies used in the transmission of low frequency signaling currents.

22. In a signaling system, a plurality of transmission lines adapted to transmit voice frequency signaling currents, each transmission line comprising a plurality of sections at least one of which is adapted to transmit high frequency currents of the order used for carrier transmission and another section of which is incapable of effectively transmitting frequencies substantially higher than voice frequencies, and means to interconnect said lines at stations intermediate the terminal stations thereof for the transmission of carrier frequencies from a high frequency section of one line to a high frequency section of another line while maintaining the other sections of the lines electrically separate with regard to the transmission of voice frequency signaling currents, said means including an apparatus adapted to substantially suppress voice frequency signaling currents while freely

transmitting frequencies above the upper limit of frequencies used in the transmission of voice frequency signaling currents, and means in sections adjacent to the interconnected sections for substantially suppressing the transmission over said adjacent sections of frequencies above the upper limit of frequencies used in the transmission of voice frequency signaling currents while freely transmitting frequencies below said limit.

23. In a signaling system, a plurality of transmission lines adapted to transmit voice frequency signaling currents, each transmission line comprising a plurality of sections at least one of which is adapted to transmit high frequency currents of the order used for carrier transmission and another section of which is incapable of effectively transmitting frequencies substantially higher than voice frequencies, and means to interconnect said lines at stations intermediate the terminal stations thereof for the transmission of carrier frequencies from a high frequency section of one line to a high frequency section of another line while maintaining the other sections of the lines electrically separate with regard to the transmission of voice frequency signaling currents, and means in sections adjacent to the interconnected sections for substantially suppressing the transmission over said adjacent sections of frequencies above the upper limit of frequencies used in the transmission of low frequency signaling currents while freely transmitting a band of frequencies below said limit.

24. In a signaling system, a plurality of transmission lines adapted to transmit voice frequency signaling currents, each transmission line comprising a plurality of sections at least one of which is adapted to transmit high frequency currents of the order used for carrier transmission and another section of which is incapable of effectively transmitting frequencies substantially higher than voice frequencies, and means to interconnect said lines at stations intermediate the terminal stations thereof for the transmission of carrier frequencies from a high frequency section of one line to a high frequency section of another line while maintaining the other sections of the lines electrically separate with regard to the transmission of voice frequency signaling currents, said means including a broad band filter adapted to suppress voice frequency signaling currents while freely transmitting frequencies above the upper limit of frequencies used in the transmission of low frequency signaling currents, and means in sections adjacent to the interconnected sections comprising broad band filters adapted to substantially suppress frequencies above the upper limit of frequencies used in the transmission of voice frequency signaling currents while freely transmitting a band of frequencies below said limit.

25. In a signaling system a plurality of transmission lines adapted to transmit voice frequency signaling currents, each transmission line comprising a plurality of sections at least one of which is adapted to transmit high frequency currents of the order used for carrier transmission and another section of which is incapable of effectively transmitting frequencies substantially higher than voice frequencies, and means to interconnect said lines at stations intermediate the terminal stations thereof for the transmission of carrier frequencies from a high frequency section of one line to a high frequency section of another line while maintaining the other sections of the lines electrically separate with regard to the transmission of voice frequency signaling currents, said means including a broad band filter adapted to substantially suppress frequencies below the upper limit of frequencies used in ordinary telephonic transmission while freely transmitting a band of frequencies above said limit.

26. In a signaling system, a plurality of transmission lines adapted to transmit voice frequency signaling currents, each transmission line comprising a plurality of sections at least one of which is adapted to transmit high frequency currents of the order used for carrier transmission and another section of which is incapable of effectively transmitting frequencies substantially higher than voice frequencies, and means to interconnect said lines at stations intermediate the terminal stations thereof for the transmission of carrier frequencies from a high frequency section of one line to a high frequency section of another line while maintaining the other sections of the lines electrically separate with regard to the transmission of voice frequency signaling currents, said means including a broad band filter adapted to substantially suppress frequencies below the upper limit of frequencies used in ordinary telephonic transmission while freely transmitting a band of frequencies below said limit, and means in sections adjacent to the interconnected sections comprising broad band filters adapted to substantially suppress frequencies above the upper limit of telephonic transmission while freely transmitting a band of frequencies below said limit.

In testimony whereof, I have signed my name to this specification this 12th day of June 1919.

LLOYD ESPENSCHIED.