

April 24, 1945.

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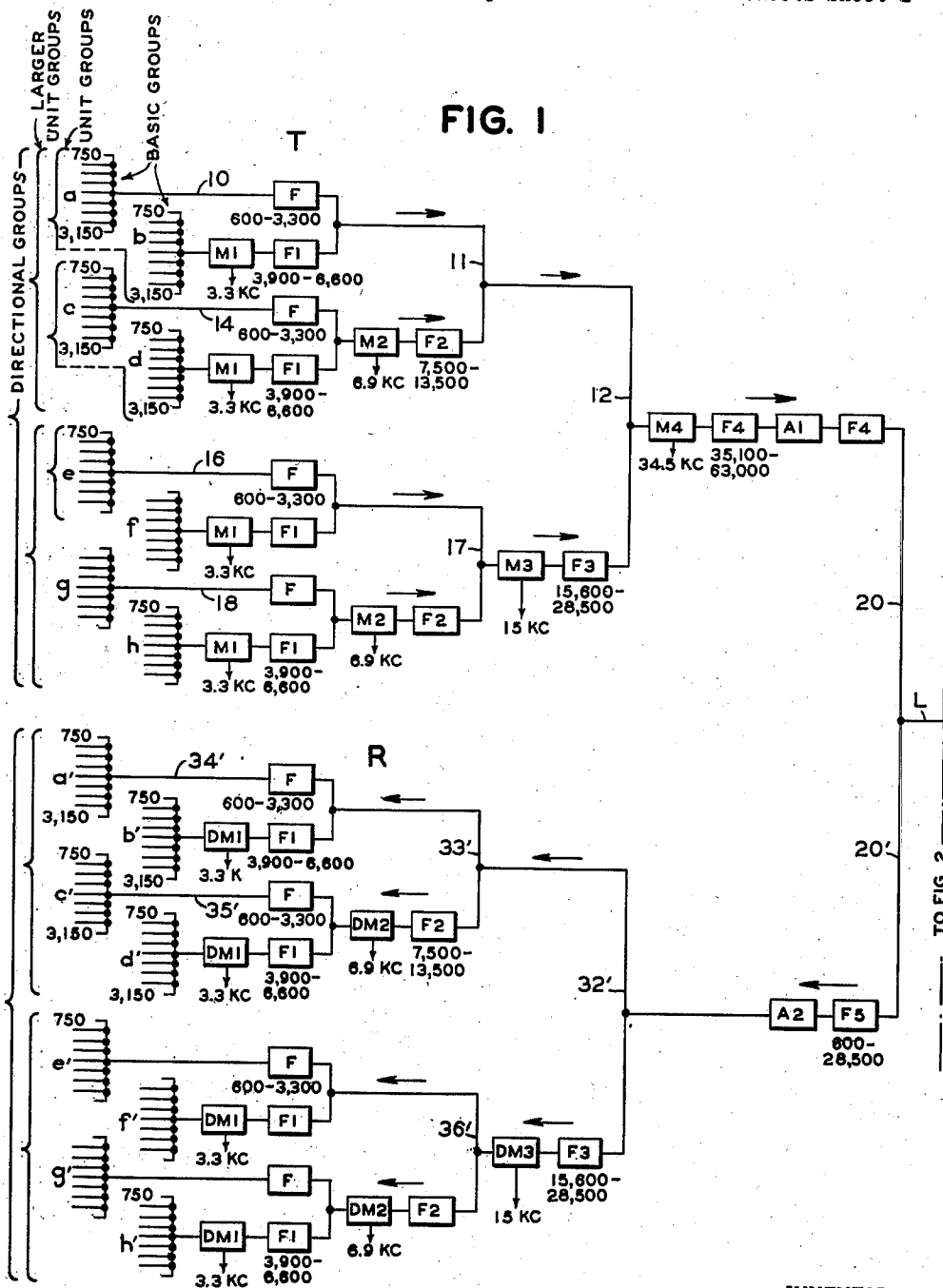
2,374,567

MULTICHANNEL CARRIER TRANSMISSION SYSTEM

Filed Sept. 6, 1944

3 Sheets-Sheet 1

FIG. 1



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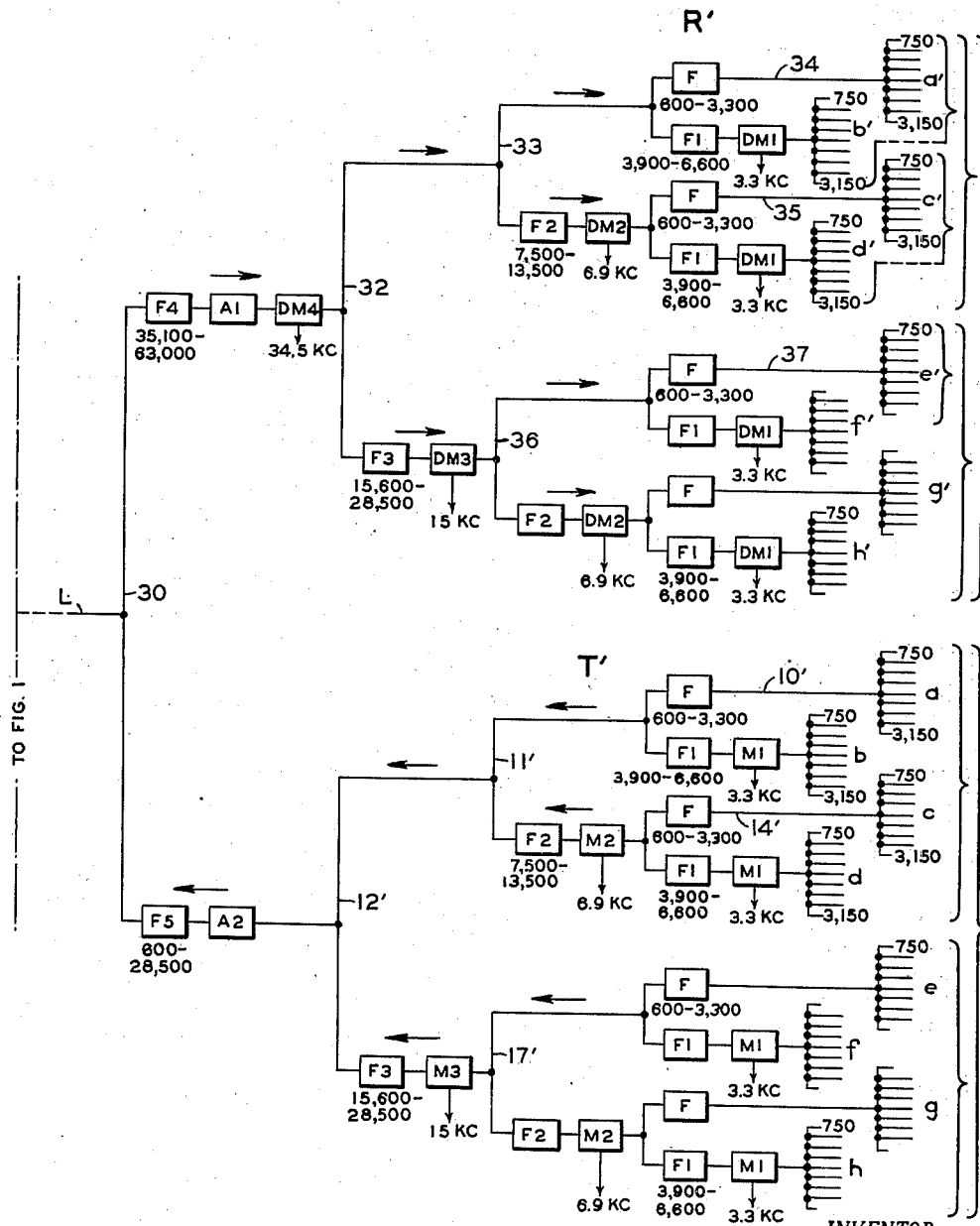
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FIG. 2



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MULTICHANNEL CARRIER TRANSMISSION SYSTEM

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3 Sheets-Sheet 3

FIG. 3

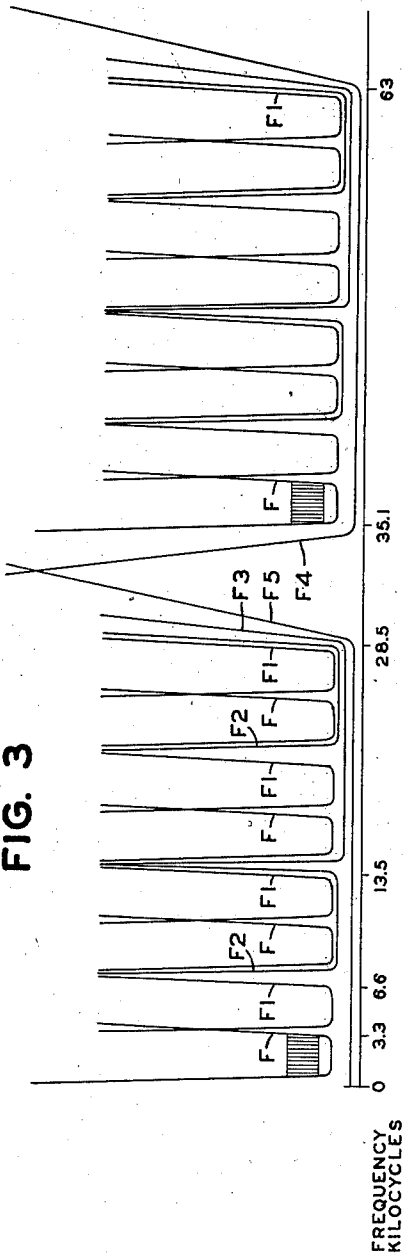
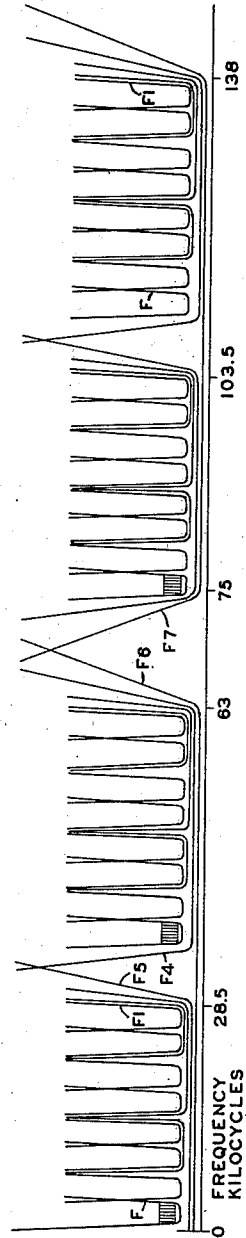


FIG. 4



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MULTICHANNEL CARRIER TRANSMISSION
SYSTEMRoland C. Taylor, Ridgewood, N. J., assignor to
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Application September 6, 1944, Serial No. 552,830

9 Claims. (Cl. 178—51)

This invention relates to a method and means for improving high frequency carrier systems suitable for the transmission of carrier telegraph, telephone or facsimile signals, and especially to such a multichannel system in which substantial advantages result from the mode of grouping the basic channels and the translation of these channels to and from the respective positions which they occupy in the available frequency spectrum of the transmission line.

The transmission space in the frequency spectrum which may be made available on a given transmission line is in general proportional to the expenditure invested in the line. For example, an ordinary pair of open line wires, which represents a minimum in line expenditure, will handle satisfactorily the voice range of frequencies; it requires only a relatively simple transposition system, and repeaters may be spaced at long intervals such as a few hundred miles. As the frequency range is extended, however, it becomes necessary to transpose the line more frequently in order to prevent cross talk and noise, and to space repeaters at smaller intervals because of the increased attenuation. Also, if intermediate cable sections occur, loading coils must be inserted at frequent intervals. Each of these measures expands in cost at a rate roughly proportional to the frequencies to be transmitted. It follows, therefore, that the efficient utilization of the frequency spectrum rendered available on a given transmission line through a given expenditure of money is a matter of considerable economic importance.

Another general rule applicable to high frequency carrier systems is that for a given type of quality of filter or selective circuit, the relative sharpness of cut-off is roughly proportional to the frequency, that is, if the characteristic curve of a filter cutting off at a frequency of 1000 cycles consumes a space 100 cycles wide in passing from minimum to maximum attenuation, 10% of the frequency space is therefore wasted. At higher frequencies, for example, 30,000 cycles, a 10% wastage amounts to a 3000 cycle band which is a frequency space of considerable economic value. Because of this ever increasing dissipation of useful frequency space, it is desirable to perform frequency selections, in so far as it is possible, in the low frequency range.

Band pass filters of very narrow range, such as are often used to accommodate carrier telegraph channels spaced, for example, 300 cycles apart, may be constructed with relatively good efficiency up to frequencies of 5000 or 6000 cycles.

Basic carrier telegraphic systems therefore usually comprise a group of from eight to twelve or more channels. Nine basic channels are frequently employed, as in the system illustrated herein, these channels comprising a total frequency band approximately 3000 cycles wide, and such a band is alternatively suitable for telephone transmission purposes. Such an arrangement fulfills the requirement of minimum original cost and convenience of handling in the process of operation. When greater message capacity is needed, and since it is uneconomical to construct channel filters along these lines for the higher frequencies, it has been the usual practice heretofore to bodily step upward the basic nine channel group into the next adjacent 3000 cycle band. If further channels were needed, they were obtained by a similar process of moving other nine channel basic groups into successive higher 3000 cycle spaces in the available frequency spectrum. However, even with these comparatively wide bands this process becomes very wasteful of frequency space as soon as the relatively higher range is reached, because the essential grouping filters which must be employed in various phases in the system consume a considerable frequency space at their cut-offs.

The instant invention eliminates a large part of the foregoing waste in frequency space. Consider, for example, a thirty-six channel, two-wire, 30 kc. carrier telegraph system designed according to prior practice. This means that each of the frequency bands which accommodates a basic group of nine 300 cycle spaced carrier telegraph channels consumes altogether a useful range of 2700 cycles. With a second group of nine channels located in a position just above and with a necessary separation of approximately 600 cycles between the adjacent channels of the two groups, the separation occurs at approximately 3600 cycles, and a wastage in frequency space of 600/3600 or 17% occurs. At the same rate, at 30,000 cycles a band 5100 cycles wide would be wasted. Proportionately large bands would be wasted at junctions between frequency bands located at still higher frequencies. Thus, a two-way four band 36 channel system of the type heretofore employed would require a frequency space of approximately 50.5 kc., whereas in accordance with the instant invention in a system of this size only 31 kc. would be required. This added space would more than accommodate two additional groups of two-way channels, and at higher frequencies many more additional groups of two-way channels may be obtained.

One of the objects of the invention is to reduce waste of frequency space in a high frequency carrier system and to enable a larger number of useful channels to be employed in a given frequency spectrum.

Another object is a system of the character described which effects substantial economies in the filter equipment and oscillator frequencies required.

A further object is to enable band widths to be employed in convenient multiples whereby a variety of services, such as telephone, telegraph, program broadcast channel, facsimile groups, and the like, may readily be accommodated.

A still further object is a multichannel system in which any impairments are concentrated on certain channels only of the system.

These and other objects and advantages will be apparent from the following detailed description, taken in connection with the accompanying drawings, in which:

Figs. 1 and 2 illustrate schematically a 72 channel two-way carrier sending and receiving system embodying the principles of the invention;

Fig. 3 shows diagrammatically the cut-off values and arrangement of basic channel group filters, unit group filters and directional separation filters employed for effecting transmission over the system of Figs. 1 and 2; and

Fig. 4 shows diagrammatically the filter arrangement employed for effecting two-way communication over a 144 channel carrier circuit.

Referring to Figs. 1 and 2, which together comprise a one-line diagram of a 72 channel, two-way carrier system, Fig. 1 shows the transmitting and receiving equipment T and R at one terminal, and Fig. 2 shows similar transmitting and receiving equipment T' and R'. It will be understood that a full metallic circuit is employed for such carrier systems, and that each circuit shown represents a pair of conductors. The two terminals may be connected by a line L, it being understood that suitable repeater points are interposed at various intervals in the line, the number and kind of such repeaters depending upon the length, attenuation and other characteristics of the line.

Referring to the transmitting side T of the terminal shown in the upper half of Fig. 1, it will be seen that there are eight basic groups *a* to *h* of transmitting channels. Each of the basic channel groups provides nine transmitting channels, the frequencies of which range from 750 cycles to 3150 cycles, the various channels being spaced 300 cycles apart. The eight basic groups of channels are arranged to form four identical unit pairs by the process of stepping one group above the other by a single modulation, as by a modulator M1 using a 3.3 kc. carrier, with selection of the upper side band for transmission. The first basic group *a* of nine channels is connected by a circuit 10 to a band pass filter F which passes the frequency range of 600 to 3300 cycles. The other basic group *b* of nine channels is translated upward by the modulator M1, the output of which passes to a band pass filter F' which passes the frequency range of 3900 to 6600 cycles produced by the modulation step. The output of filters F and F', which comprise a unit group of frequencies from 600 cycles to 6600 cycles, are passed through circuits 11 and 12 to a modulator M4, hereinafter described. The unit group thus formed from the basic groups is indicated by the bracket which encloses the two basic groups *a* and *b*. Immediately below this

first unit group is a second unit group which similarly is composed of two basic groups *c* and *d*. The frequencies of the basic group *c* are applied by means of the circuit 14 to the band pass filter F, which is like the first-named filter F, and which passes a frequency range from 600 to 3300 cycles. The second basic group *d* of frequencies of the second unit group is translated upward to the position just above group *c*, as by a modulator M1 using a 3.3 kc. carrier, the output of which is passed through a band pass filter F'. The output of filters F and F' of the second unit group is moved upward, as by a modulator M2 using a 6.9 kc. carrier, so that the channels of the second unit group are in a frequency range from 7500 to 13,500 cycles, this latter range lying just above the frequency range of the first unit group. The output of the modulator M2 is passed through a band pass filter F2 which passes frequencies from 7500 to 13,500 and thence through circuits 11 and 12 to the modulator M4.

The remaining four basic channel groups *e* to *h* which are immediately below the first four channel groups are similar thereto. The channels of the fifth basic group *e* are connected by circuit 16 through a filter F; the sixth basic group *f* is translated upward by a modulator M1, and the combined fifth and sixth basic groups are applied by circuit 17 to a modulator M3. At the same time the seventh and eighth basic channel groups *g* and *h* are stepped upward by an arrangement like that above described with respect to the third and fourth basic groups, the output of modulator M2 and band pass filter F2 being applied by means of the circuit 17 to the modulator M3. In the latter modulator the frequencies of the last four basic channel groups are moved upwardly by a single modulation using a 15 kc. carrier, the output of which comprises a frequency range from 15,600 to 28,500 cycles that passes through a band pass filter F3 and circuit 12 to the modulator M4. With these four sets of pairs combined in the manner set forth, the original seventy-two telegraph channels are all now lying adjacent to each other in the frequency space 35,100 to 63,000 cycles.

In the particular system shown, the lower portion of the available frequency range reaching to approximately 28,500 cycles is to be used for transmission from the station of Fig. 2 to the station of Fig. 1, and therefore the previously assembled group of seventy-two channels of Fig. 1 is relocated by the modulator M4 using a 34.5 kc. carrier so that the combined channels will lie within the band of 35,100 cycles to 63,000 cycles, which band is passed by a filter F4. From this band pass filter the frequency band is amplified by a terminal amplifier A1 and thence passes through another band pass filter F4 and circuit 20 to the outgoing line L.

At the receiving station R' of Fig. 2, the band of frequencies transmitted is received from the line L and applied by means of a conductor 30 to a band pass filter F4, the output of which is amplified by the receiving amplifier A1, and the transmitted band of frequencies 35,100 to 63,000 cycles is stepped downward by a first demodulator DM4 using a 34.5 kc. carrier. Frequencies within the range 600-13,500 in the output of the first demodulator are applied by means of conductors 32 and 33 to receiving band pass filters F, F' and F2 of the upper pair of unit groups but are rejected by F3. From filter F the frequencies 750 to 3150 cycles originally transmitted by group *a* of Fig. 1 are applied by means of a circuit 34 to

the first receiving basic group a' of channels. From the receiving filter F1 the frequencies 3900 to 6600 are applied to a demodulator DM1 where they are stepped downward by a frequency of 3.3 kc. and thereby are relocated in the frequency range of 750 to 3150 and applied to receiving group b' . From the filter F2 the band of frequencies 7500 to 13,500 are applied to a demodulator DM2 and demodulated by a frequency of 6.9 kc. The band 600 to 3300 cycles in the output of this demodulator is applied to a band pass filter F and by means of a circuit 35 to the third basic channel group c' . The band 3900 to 6600 cycles in the output of DM2 is applied to a receiving filter F1 and a demodulator DM1 where they are demodulated by a frequency of 3.3 kc. to produce the original frequencies 750 to 3150 in the fourth basic channel group d' .

The band 15,600 to 28,500 cycles in the output of the demodulator DM4 is applied by means of the circuit 32 to a receiving band pass filter F3, the output of which is applied to a demodulator DM3 and demodulated by a frequency of 15 kc., the relocated frequencies thus lying within the band from 600 to 13,500 cycles. The band 600 to 3300 cycles in the output of DM3 is applied by means of a circuit 36 to a filter F and thence to the fifth basic receiving channel group e' . The band of frequencies from 3900 to 6600 cycles is applied from circuit 36 through a filter F1 to a demodulator DM1 where it is demodulated by a frequency of 3.3 kc. to give the sixth receiving basic channel group f' . The band from 7500 to 13,500 cycles in the output of DM3 is applied through a filter F2 to a demodulator DM2 to produce a band of 600 to 6600 cycles, of which 600 to 3300 cycles are passed through a filter F to the seventh basic receiving channel group g' , the band 3900 to 6600 cycles passing through a filter F1 and demodulated by a demodulator DM1 to give the eighth receiving basic channel group h' .

Transmission of the basic groups of channels a to b from the transmitting portion T' of the station shown in Fig. 2 proceeds in generally the same manner as transmission from the portion T of the station of Fig. 1, the circuits which interconnect the filters and modulators being designated by the same reference numerals as in Fig. 1, with a prime mark added. The station of Fig. 2 differs, however, in that from a circuit 12' the transmitted band of frequencies from 600 to 28,500 cycles is not stepped up as in the case of the transmitting circuit of Fig. 1, but instead the band is passed through an amplifier A2 and filter F5 and thence by the circuit 30 to the line L. In the receiving side R of the station of Fig. 1 the band 600 to 29,500 cycles is applied to a filter F5 and a terminal amplifier A2. By means of circuits 32' and 33' a band 600 to 6600 cycles is applied to filters F and F1. From filter F the band 600 to 3300 cycles is applied to the first receiving basic group of channels a' , and the band 3900 to 6600 is relocated by the demodulator M1 and applied to the second receiving group b' . In a manner similar to that heretofore described with respect to the receiving equipment R' of Fig. 2, the remaining frequencies from 7500 to 28,500 cycles are relocated and applied to the remaining receiving basic groups c' to h' .

It will be noted that only a very small number of different types of filters, modulators, demodulators and carrier frequencies are required, and that such devices are relatively few in number. This economy in types and numbers of equipment items permits a considerable saving in the cost

of the design, installation and maintenance of such carrier systems. Since all the channels which are being transmitted in the same direction are at substantially the same level, the problem of separating the various groups and suppressing unwanted frequencies is greatly facilitated. At the line terminals and at the input and output of repeaters (not shown) directional grouping filters having frequency ranges of approximately 600–28,500 kc. and 35,100–63,000 kc. separate the transmissions in both directions. At these points a considerable divergence in level may exist between the received frequency and the amplified transmitted frequencies, and the requirements for these filters is accordingly more critical. For this reason a wider spacing is necessary between the directional groups than at the division points between groups which are being transmitted in the same direction. Also, the band widths are in convenient multiples, as appears from Figs. 1 and 2, so that a variety of services may readily be accommodated in which bands of widths most suitable to such services may be employed, such as a telegraph and telephone band from 0 to 3300 cycles, program broadcast channels or facsimile groups of double band width extending from 0 to 7500, and the like. The relatively few types of filters required and the economy in frequency space are readily seen from Fig. 3 of the drawings, which outlines the positions of the bands of frequencies in the seventy-two channel system illustrated in Figs. 1 and 2, the boundary frequencies of the various grouping and directional separation filters also being indicated. Each of the filters F passes a basic group of nine carrier telegraph channels spaced 300 cycles apart. From any basic group of nine channels in one direction, the next group of nine channels is located in a position just above and with a separation of approximately 600 cycles between the adjacent channels of the adjacent basic groups. The separation between the directional filters F4 and F5 of 28,500 to 35,100 cycles constitutes a 6600 cycle loss of useful signaling frequency space, or 20% of the mean frequency at the point of separation. It will be noted that this frequency space is the only one occurring in the entire system in which a substantial waste of frequencies occurs. If a multi-channel system were constructed according to any of the usual methods, the necessary separation between the adjacent basic groups would progressively increase as these groups were shifted one above the other in the frequency spectrum. Such wastage of frequency space becomes increasingly severe in the higher portions of the spectrum. The cumulative effect of such wastage means that a great many signaling channels must be omitted which otherwise could be used with a given frequency spectrum. In the instant arrangement, on the contrary, the spacing between adjacent basic groups is uniform and is required to be no greater in the upper portions of the spectrum than in the lower portions thereof, and thus an important saving in frequency space is effected.

In the foregoing description it has been assumed that the upper side bands of each channel were selected for transmission in each case. With such an arrangement the basic channels retain their original order in the group throughout; for example, the 750 cycle telegraph channel remains always at the low frequency end of its group while the 3150 channel lies at the upper frequency end. As is well known, the characteristics of band filters, such as attenuation, im-

pedance and phase shift, make marked departures from the linear ideal at the edges of the filter pass band. Therefore the 750 and 3150 channels only will consistently encounter these filter defects and thus suffer impairment to the exclusion of the channels located near the center of the band, and circuit layout engineers and traffic dispatchers must keep these characteristics in mind in making certain assignments. It may be preferable in many instances to cause these cumulative impairments to transmission to be concentrated upon the lowest frequency channels rather than be divided between the upper and lower channels, and in this case circuit assignments may be made upon the premise that only the lower frequency channels are markedly inferior. The channels in the instant system may therefore be rearranged so that only the basic low frequency channels would lie in most cases near the edge of the group by employing instead of the 3.3 kc. carrier indicated in the first modulators M1, a 7.2 kc. carrier along with selection of the lower side band. Since selection of the lower side band causes inversion of the signaling frequencies, it follows then that in each pair of basic groups, the two 3150 cycle channels would be adjacent to each other at the center of the unit group band while the 750 cycle channels would lie at the outer edge of the unit group. At the receiving side the demodulators DM1 would likewise employ a 7.2 kc. frequency to relocate the channels 750 to 3150 so that they would be received in their initial order. The value of 7.2 kc. is chosen in the instance given in order that the basic group 750 to 3150 cycles would be stepped up to the same band 3900-6600 obtained when the upper side bands are chosen as in the case first described, and thus no other changes in the remainder of the system need be made. The upper frequency channels will then be free of the impairments to transmission inflicted by the imperfections of the various band filters and so could be regarded always as preferred channels.

In the system illustrated two basic channel groups, for example, groups *a* and *b*, are combined into a unit group, and two unit groups are translated into positions one above the other in the frequency spectrum, but it will be understood that the number of basic channel groups thus combined to form unit groups and the number of unit groups translated to form larger unit groups may be varied, depending upon the number of channels to be made available in the system. Thus, three, four or more basic channel groups could be combined to form unit groups, and three, four or more unit groups could be translated to form larger unit groups which would be translated into positions one above the other in the spectrum. Also, the particular range of frequencies employed may be varied within wide limits, depending upon the character or type of service with which the system is to be used.

Moreover, the cut-off values of the band pass filters employed may vary within considerable limits, depending upon the efficiency and type of filters employed. In the case of the basic group filters F these may, for example, be low pass filters 0-3300 cycles instead of band pass filters 600-3300 cycles, although the latter are preferred in order to eliminate possible interference present due to extraneous frequencies below 600 cycles. Similarly the directional filter F4 may be a high pass filter for 35,100 cycles and above.

Fig. 4 illustrates the advantages of the invention when applied to a 144 channel, two-way carrier system, and it will be noted that with the exception of the necessary separation between the wide band pass filters F4 and F5, and F6 and F7, there is no wastage in frequency space notwithstanding that sixteen basic group filters are employed in each direction and that these basic groups are translated one above the other into high regions in the frequency spectrum. In other words, the only substantial frequency space losses are those occasioned by the directional separation filters F6 and F7 and the wide band group filters F4 and F5.

In the foregoing description unit groups and successively larger unit groups were composed of pairs of the next smaller groups. This choice, however, was illustrated only since the number of groups used to build the next larger group may be any reasonable number and furthermore the numbers need not all be the same.

Various modifications of the circuit arrangement and apparatus shown, and various equivalents or substitutes in the devices illustrated, will readily occur to those versed in the art without departing from the spirit and scope of the present invention. The disclosure, therefore, is for the purpose of illustrating the principles of the invention which is not to be regarded as limited except as indicated by the scope of the appended claims.

What is claimed is:

1. In a high frequency carrier transmission system wherein a plurality of basic carrier channels may be transmitted over a single transmission path, the method of substantially reducing the idle frequency space required to avoid interference between the channels which comprises forming the carrier channels into a plurality of basic channel groups each of which comprises a plurality of carrier channels occupying the same frequency band in the lower portion of the available frequency spectrum of the transmission path, translating certain of the basic channel groups each to an adjacent position above another of said basic channel groups to form a plurality of unit groups each of which occupies the same portion of the frequency spectrum, translating certain of said unit groups to an adjacent position above another of said unit groups to form larger unit groups each of which occupies the same portion of the frequency spectrum, translating at least one of said larger unit groups into an adjacent position above another of the larger unit groups to form a still larger unit group and transmitting the last-named group over said transmission path.

2. In a high frequency carrier transmission system wherein a plurality of basic carrier channels may be transmitted over a single transmission path, the method of substantially reducing the idle frequency space required to avoid interference between the channels which comprises forming the carrier channels into a plurality of basic channel groups each of which comprises a plurality of carrier channels occupying the same frequency band in the lower portion of the available frequency spectrum of the transmission path, translating alternate ones of the basic channel groups to adjacent positions above the other basic channel groups to form a plurality of unit groups each of which occupies the same portion of the frequency spectrum, translating alternate ones of said unit groups to an adjacent position above the other unit groups to form larger unit groups

each occupying the same portion of the frequency spectrum, translating at least one of said larger unit groups into an adjacent position above another of the larger unit groups to form a still larger unit group and transmitting the last-named group over said transmission path.

3. In a high frequency carrier transmission system wherein a plurality of basic carrier channels may be transmitted over a single transmission path, the method of substantially reducing the idle frequency space required to avoid interference between the channels which comprises forming the carrier channels into a plurality of basic channel groups each of which comprises a plurality of carrier channels occupying the same frequency band in the lower portion of the available frequency spectrum of the transmission path, translating alternate ones of the basic channel groups to adjacent positions above the other basic channel groups to form a pair of unit groups each of which unit groups occupies the same portion of the frequency spectrum, translating one of said unit groups of each pair to an adjacent position above the other unit group of the pair to form a pair of larger unit groups each occupying the same portion of the frequency spectrum, translating one of said larger unit groups into an adjacent position above the other larger unit group of said pair to form a still larger unit group and transmitting the last-named group over said transmission path.

4. In a high frequency carrier transmission system wherein a plurality of basic groups each comprising a plurality of carrier channels may be transmitted over a single transmission path, the method of substantially reducing the idle frequency space required to avoid interference between the channel groups which comprises combining at least n basic channel groups into a unit group, translating at least $n1$ such unit groups into adjacent positions one above the other in the available frequency spectrum of said transmission path to form a larger unit group, and then translating at least $n2$ such larger unit groups into adjacent positions one above the other in said available frequency spectrum, where n , $n1$ and $n2$ represent integers each of which is an exact divisor of the total number of said carrier channels to be transmitted in one direction over said transmission path.

5. A high frequency carrier transmission system for the transmission of a plurality of basic carrier channels over a single transmission path, comprising means for connecting the basic carrier channels into a plurality of basic channel groups each of which comprises a plurality of basic channels occupying the same frequency band in the lower portion of the available frequency spectrum of the transmission path, means for modulating certain of said basic channel groups to translate them upward to an adjacent position above the remainder of said basic channel groups and form a plurality of unit groups each of which occupies the same portion of the frequency spectrum, means for modulating certain of said unit groups to translate them upward to an adjacent position above the remainder of said unit groups and form larger unit groups each of which comprises the same portion of the frequency spectrum, and means for modulating at least one of said larger unit groups to translate it upward to an adjacent position above the other larger unit groups and form a still larger unit group for transmission over said transmission path.

6. A high frequency carrier transmission system for the transmission of a plurality of basic carrier channels over a single transmission path, comprising means for connecting the basic carrier channels into a plurality of basic channel groups each of which comprises a plurality of basic channels occupying the same frequency band in the lower portion of the available frequency spectrum of the transmission path, means for modulating alternate ones of said basic channel groups to translate them upward to an adjacent position above the remainder of said basic channel groups and form a plurality of unit groups each of which occupies the same portion of the frequency spectrum, means for modulating alternate ones of said unit groups to translate them upward to an adjacent position above the remainder of said unit groups and form larger unit groups each of which comprises the same portion of the frequency spectrum, and means for modulating at least one of said larger unit groups to translate it upward to an adjacent position above the other larger unit groups and form a still larger unit group for transmission over said transmission path.

7. A high frequency carrier transmission system for the transmission of a plurality of basic carrier channels over a single transmission path, comprising means for connecting the basic carrier channels into a plurality of basic channel groups each of which comprises a plurality of basic channels occupying the same frequency band in the lower portion of the available frequency spectrum of the transmission path, means for modulating alternate ones of said basic channel groups to translate them upward to an adjacent position above the remainder of said basic channel groups and form a pair of unit groups each of which occupies the same portion of the frequency spectrum, means for modulating one of said unit groups of each pair to translate it upward to an adjacent position above the other unit group of the pair and form a pair of larger unit groups each of which comprises the same portion of the frequency spectrum, and means for modulating one of said larger unit groups to translate it upward to an adjacent position above the other larger unit group of said pair and form a still larger unit group for transmission over said transmission path.

8. A high frequency carrier transmission system for the transmission of a plurality of basic carrier channels over a single transmission path, comprising means for connecting the basic carrier channels into a plurality of basic channel groups each of which comprises a plurality of basic channels occupying the same frequency band in the lower portion of the available frequency spectrum of the transmission path, means for modulating at least n of said basic channel groups to translate them upward to an adjacent position above the remainder of said basic channel groups and form a plurality of unit groups each of which occupies the same portion of the frequency spectrum, means for modulating at least $n1$ of said unit groups to translate them upward to an adjacent position above the remainder of said unit groups and form larger unit groups each of which comprises the same portion of the frequency spectrum, and means for modulating at least $n2$ of said larger unit groups to translate it to an adjacent position above the other larger unit groups and form a still larger unit group for transmission over said transmission path, where n , $n1$ and $n2$ represent integers

each of which is an exact divisor of the total number of said carrier channels to be transmitted in one direction over said transmission path.

9. A high frequency carrier transmission system for the transmission of a plurality of basic carrier channels over a single transmission path, comprising means for connecting the basic carrier channels into a plurality of basic channel groups each of which comprises a plurality of basic channels occupying the same frequency band in the lower portion of the available frequency spectrum of the transmission path, each of said basic channel groups having a band width of the order of 2500 cycles to 3300 cycles, means for modulating certain of said basic channel groups to translate them upward to an adjacent

position above the remainder of said basic channel groups and form a plurality of unit groups each of which occupies the same portion of the frequency spectrum, means for modulating certain of said unit groups to translate them upward to an adjacent position above the remainder of said unit groups and form larger unit groups each of which comprises the same portion of the frequency spectrum, and means for modulating at least one of said larger unit groups to translate it upward to an adjacent position above the other larger unit groups and form a still larger unit group for transmission over said transmission path.

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