

Feb. 24, 1942.

J. T. DIXON

2,274,535

CARRIER WAVE SYSTEM

Filed Oct. 19, 1940

2 Sheets-Sheet 1

FIG. 1

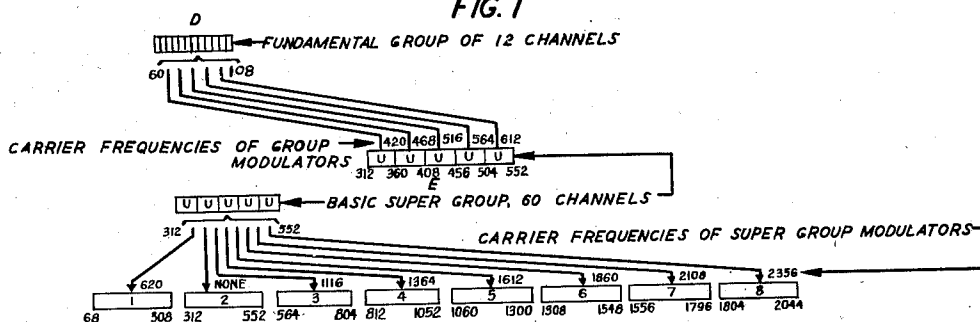


FIG. 2

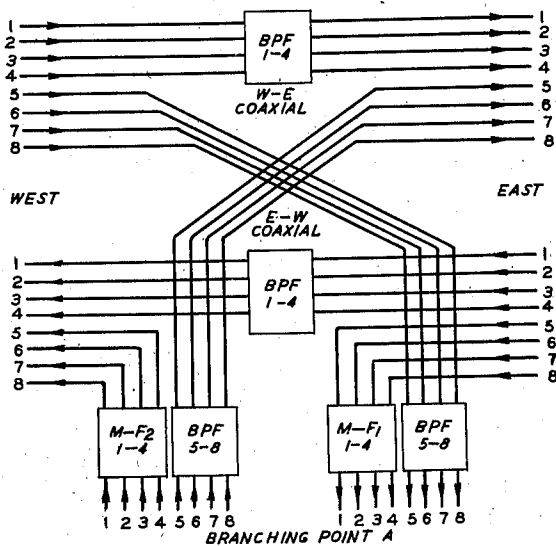
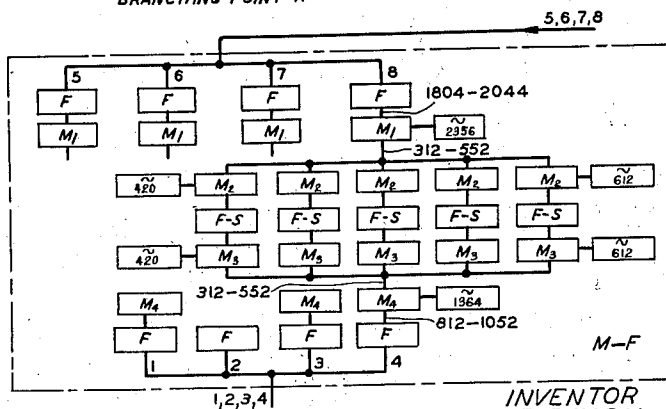


FIG. 3



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FIG. 4

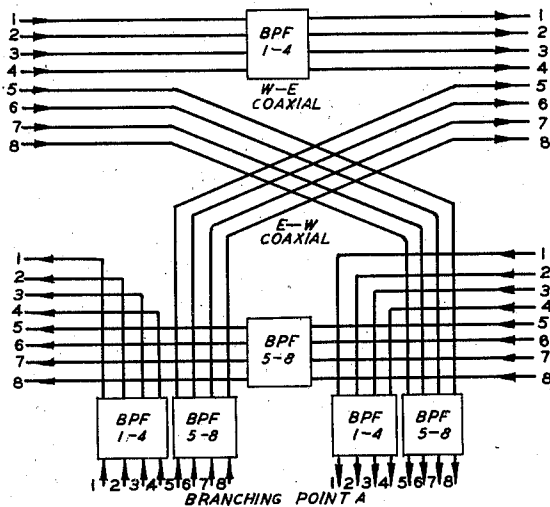


FIG. 5

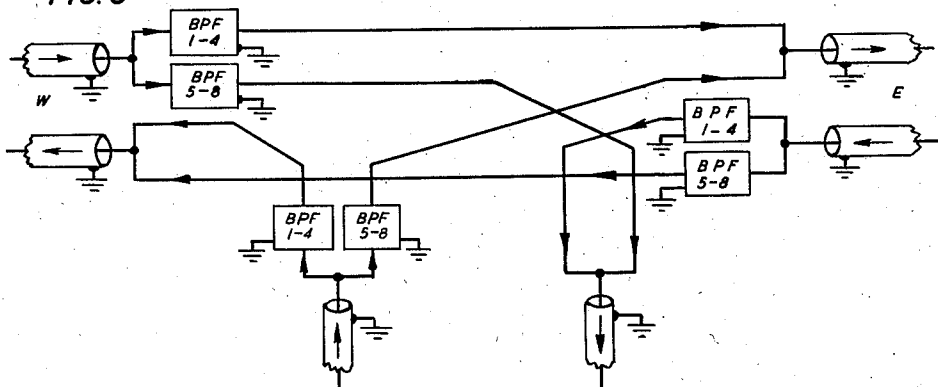
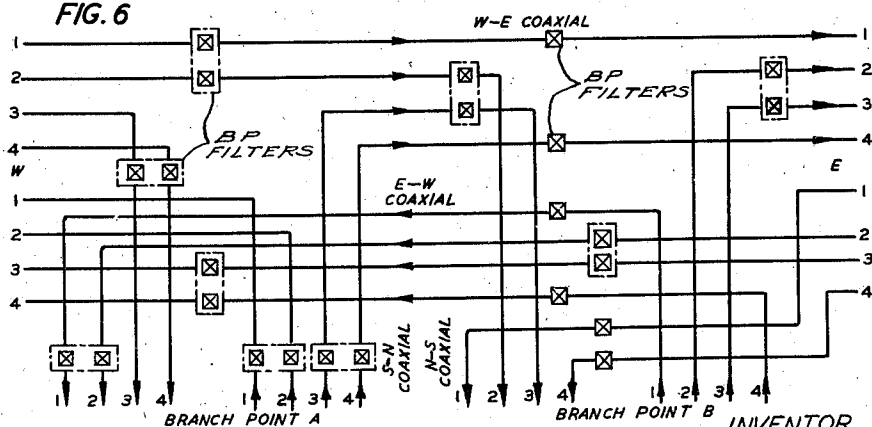


FIG. 6



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CARRIER WAVE SYSTEM

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Application October 19, 1940, Serial No. 361,852

5 Claims. (Cl. 179—15)

The present invention relates to a multiplex carrier wave transmission system and more particularly to a means of taking from, or adding to, the system at an intermediate point of the system a portion only of the total number of carrier waves or channels of the system.

An object of the invention is to permit the taking from, or adding to, the system at an intermediate point of the system a portion only of the total number of carrier waves or channels of the system at the same time permitting normal transmission through the remaining channels of the system.

In a multiplex carrier wave transmission system the channels must be placed as close together as possible if the most efficient use of the available frequency range is to be made. Complicated modulating and demodulating systems employing complex systems of frequency selective devices have sometimes proven advantageous economically as aids in achieving this end. With the advent of improved transmission mediums such as the concentric conductor and carrier cables and of improved carrier apparatus, the usable frequency range for wire transmission has been in some cases greatly extended.

A definite trend toward increasing the number of channels per system gives the problem of terminating or originating channels at intermediate points along the system an increased importance.

To solve the problem it is necessary to provide a means of effectively separating the channels that are to be diverted from, or added to, the through channels without interfering with normal transmission over the latter. It is also necessary to provide a means of isolating effectively one portion of the transmission system from the other at the frequencies utilized by the channels which are to be diverted or added, at the same time permitting normal transmission over the through channels.

The invention provides a solution of the above problems and makes possible the transmission not only of through channels between terminals but also of channels between a terminal and an intermediate point and of channels between two intermediate points along the route of a system. By means of extension systems connected with convenient intermediate points the main transmission system may be utilized to serve a broad area along its entire route.

In such a system as thus described it might be considered desirable that a channel corresponding to a given frequency band should be carried through without change of frequency allocation

between any two terminals whether these two terminals are on the main system or on branches thereof. Thus far it has not been found possible to do this and still retain the feature of connection between a side branch terminal and terminals in either direction on the main system. For some of the connections at least it has been necessary at a branching point to translate a signal band from one part of the frequency spectrum to another. This is illustrated in the patent to Weis 2,038,202, April 21, 1936. A reading of that patent will bring out effectively the very considerable amount of additional equipment required due to the fact that some of the signal bands must be translated to a different part of the frequency spectrum, involving in general elaborate demodulation and modulation steps calling for modulators and demodulators and numerous additional filtering arrangements.

In my invention it is the purpose to avoid such translation of frequency bands and to carry any band of frequencies directly from the one terminal to the other whether these terminals be on the through system or at branching points.

The invention will be better understood by reference to the following specification and the accompanying drawings in which:

Fig. 1 shows an illustrative frequency allocation for a 480 channel, broad band system such as might be used with a modern coaxial cable system;

Figs. 2 and 3 are illustrative of some present day practice and are explanatory of my improvements thereon; and

Figs. 4 to 6 are circuit arrangements illustrating directly my invention.

In describing this invention the explanation, for the sake of concreteness, will be in terms of a system in which it is assumed that there will be 480 speech channels, each channel having a band width of approximately 4000 cycles. In Fig. 1 at D there is represented a portion of the spectrum into which there has been brought by suitable modulation a group of twelve such channels constituting a band 48 kilocycles wide extending from 60 to 108 kilocycles and which may be referred to as a fundamental group. Five such groups are then shown as being brought together adjacent to each other in a frequency range from 312 to 552 kilocycles, the modulating frequency for each fundamental group being indicated in the figure. Such a group may be designated a supergroup and constitutes sixty channels. Eight such basic supergroups are then brought together adjacent to each other by

modulation against suitable carriers to constitute eight supergroups or the line group, as indicated in the lower part of Fig. 1.

It is such a group of 480 channels which it is proposed to impress on a suitable transmission line such as a coaxial cable, such cable comprising what would be termed a "through system." In such a system it is contemplated that one coaxial cable will be used for transmission from west to east and that a similar coaxial cable will be used for transmission from east to west. On this system it is also desired to take off or add to the through system certain groups of channels at one or more branching points.

Fig. 2 shows one assignment by which this may be accomplished. For one cable the numbers 1 to 8 designate the supergroups of 60 channels each referred to in Fig. 1. The arrows indicate the direction of transmission. It will be observed that in this assignment the channels 1, 2, 3 and 4 are used for transmission from west to east and from east to west, and at the branching point there are introduced suitable filters, BPF, which will pass the band of frequencies corresponding to the groups 1-4 and which will block the other groups. No frequency translation is required for the groups 1-4. The groups 5-8 on the west-east cable are shown as being diverted to a branching point A and again it will be observed that the band 5-8 goes through without need for frequency translation. Similarly from the branching point A the groups 5-8 go to the east terminal of the west-east cable without frequency translation. For the east-west cable it will be observed that groups 1-4 are used for through transmission. This leaves groups 5-8 to go to branching point A, but since the band from 5-8 on the incoming cable at A has already been assigned it becomes necessary to translate the group of frequencies from 5-8 to the unassigned portion 1-4 and this involves a frequency translation with the accompanying demodulators, modulators and filtering arrangements as indicated by the box M-F₁. For the outgoing cable at point A it will be observed that the groups 5-8 go directly to the east terminal of the west-east cable without frequency translation. This leaves the band 1-4 for connection to the west end of the east-west cable but it will be observed that the band 1-4 on the east-west cable has already been assigned and is therefore not available. The connection must be made through the remaining band 5-8 and this action calls for frequency translation as indicated by the box M-F₂.

A better appreciation of the equipment which is necessary for one of these frequency translation steps represented by the box M-F₁ of Fig. 2 is shown in Fig. 3. One may think of this as the translation of the frequency band 5-8 coming in from the east terminal of the east-west cable to be translated to the 1-4 band at the branching point A. The equipment connected with each one of the groups 5, 6, 7 and 8 is identical although for simplicity it is shown in block form for the group 8 only, all frequencies being expressed in terms of kilocycles. The band in this channel passes through a filter F passing the band 1804-2044. This passes into a supergroup demodulator M₁ supplied with the demodulating frequency 2356 kilocycles to yield a band of frequencies 312-552 corresponding to the group E of Fig. 1 made up of five fundamental groups. The 312-552 kilocycle band then passes into the five group demodulators M₂, each de-

modulator having a different carrier frequency starting at 420 kilocycles and increasing in 48 kilocycle steps to 612 kilocycles. Each group demodulator circuit M₂ also includes a band pass filter which precedes the demodulator proper and selects a group of 12 channels appropriate to the carrier frequency used. The output of each group demodulator M₂ comprises 12 channels in the frequency range 60-108 kilocycles. Filters F-S commonly designated "scrubbing filters" serve to increase the discrimination provided by the band filters associated with each group demodulator. Having passed through the scrubbing filters the five fundamental groups pass through group modulators M₃ and are recombined at the input of supergroup modulator M₄, the frequency range at this point being 312-552 kilocycles. In supergroup modulator M₄ the 60-channel supergroup is modulated against the carrier 1364 kilocycles to place it in the band 812-1052 kilocycles corresponding to the location of the supergroup on the line. A similar arrangement is required for each of the supergroups 5-8 translating them to supergroup locations 1-4. It is also possible to provide a frequency translation of this type by connecting the output of supergroup modulator M₁ to the input of supergroup modulator M₄ but this imposes severe requirements on the discrimination provided in scrubbing filters which have to be interposed between M₁ and M₄.

It will be apparent that the avoidance of such frequency translations would result in a very substantial economy for the over-all system and it is the purpose of this invention to so arrange the connections as to avoid such frequency translations. The arrangement by which this is accomplished is shown in Fig. 4 in which it will be observed that suitable filters to pass certain bands and to eliminate certain others are provided but that no frequency translating arrangements are provided.

More specifically, it will be observed that the band 1-4 is used in the west-east cable for through transmission and that a different frequency band, namely band 5-8, is used for transmission in the opposite direction. Transmission from the west to the point A is carried on over the band 5-8 and in the reverse direction is carried on over the band 1-4. Communication from each to point A is carried on over the band 1-4 and in the reverse direction on the band 5-8.

It is to be borne in mind that Figs. 2 and 4 do not well represent the physical structure of the transmission system but are representative rather of signaling bands only. A better representation of the physical arrangement of Fig. 4 is shown in Fig. 5 where two cables are shown at each of the points west, east and A, one cable for out signaling and one for in signaling. Thus, the outgoing cable at west is divided into two portions by two band filters, one group of channels going directly to east and the other group going directly to A and so for each of the other cables.

In Figs. 4 and 5 the circuit arrangement and allocation of frequencies is on the basis of dividing the total signaling band into two equal portions, an upper and a lower portion. Thus, the band filters become relatively simple in that one of them is virtually a low pass filter and the other a high pass filter. It is, of course, to be understood that the division may be on a some-

what different basis. For example, bands 1, 2, 7 and 8 might be assigned to one grouping and 3, 4, 5 and 6 to another. In this case appropriate filters to permit the desired grouping would be provided.

Also in Figs. 4 and 5 the description is in terms of one branching point A. In some cases it would be desirable to have more than one branching point such as branching points A and B with provision for connection between any two of the points, either terminal or branch points.

Such an arrangement is shown in Fig. 6 which provides two branch points. For simplicity, in this Fig. 6 the total band width is shown as divided into four supergroups instead of eight supergroups, being designated by the numbers 1-4. Here again the arrangement is such that no frequency translation is necessary. A reading of the figure shows that the supergroup assignments between the various points west, east, A and B are as follows, the arrow indicating the direction of transmission:

W-E→1	E-A→2
←3	←4
W-A→3,4	E-B→1,4
←1,2	←2,3
W-B→2	A-B→3
←4	←1

By this arrangement it becomes possible to eliminate eight points of frequency translation which would otherwise be necessary under such a system as shown in the patent to Weis. In the figure the blocking or band-pass filters are indicated by the squares with diagonal lines. Where such a square stands singly it indicates the need of a filter which will separate the one supergroup from the others with sufficient sharpness of cut-off. In some cases two supergroup bands do not require separation but pass through together. Such points are shown by a dotted rectangle enclosing two filters and it is apparent then that these two filters would ordinarily be combined into a single filter of double pass-width, thus bringing about further economy of equipment.

What is claimed is:

1. A broad band multiplex communication system including a main or through long distance line system comprising separate physical circuits for the two directions of transmission between its terminals and at least one line system branching from a point along the said through system, said branching line system comprising separate physical circuits for the two directions of trans-

mission between said branching point and the other terminal of said branching line system, and multiplex signal transmission means including said line systems establishing between each pair of said terminals two-way carrier communication channels that are of constant frequency position throughout said line systems.

2. A combination in accordance with claim 1 in which more particularly the oppositely directed channels between any two of said terminals lie in different frequency ranges.

3. In a multiplex carrier signaling system comprising a four-wire through transmission line system interconnecting two terminal stations E and W and a four-wire transmission line system branching from an intermediate point of said through system to a station X, the method of effecting two-way transmission over said line systems between each pair of said stations without frequency translation at the branching point, which comprises transmitting signals from W to E in a first line frequency range A, from W to X in a second line frequency range B, from E to X in a range C that is non-overlapping with respect to range B, from E to W in a range D that is non-overlapping with respect to range C, from X to W in a range other than D, from X to E in a range other than A, and maintaining each of the signals so transmitted in the same frequency range throughout its transmission between said stations.

4. A method in accordance with claim 3 in which more particularly ranges A and C coincide and ranges B and D coincide.

5. In a broad band multiplex communication system comprising a main or through four-wire long distance line system interconnecting a pair of stations E and W, and two separate four-wire line systems branching from different points along said through system to respective branch stations X and Y, the method of establishing two-way communication between each pair of said stations which comprises transmitting signals without change in frequency position from one station to another in accordance with the following: from W to E in a frequency band A, from W to Y in a band B, from W to X in a band C, from E to Y in a band D that is other than B, from E to X in a band F that is other than C, from E to W in a band G, from X to W in a band H that is other than G, from Y to W in a band that is other than G and H, from X to E in a band I that is other than A, and from Y to E in a band that is other than A and I.

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