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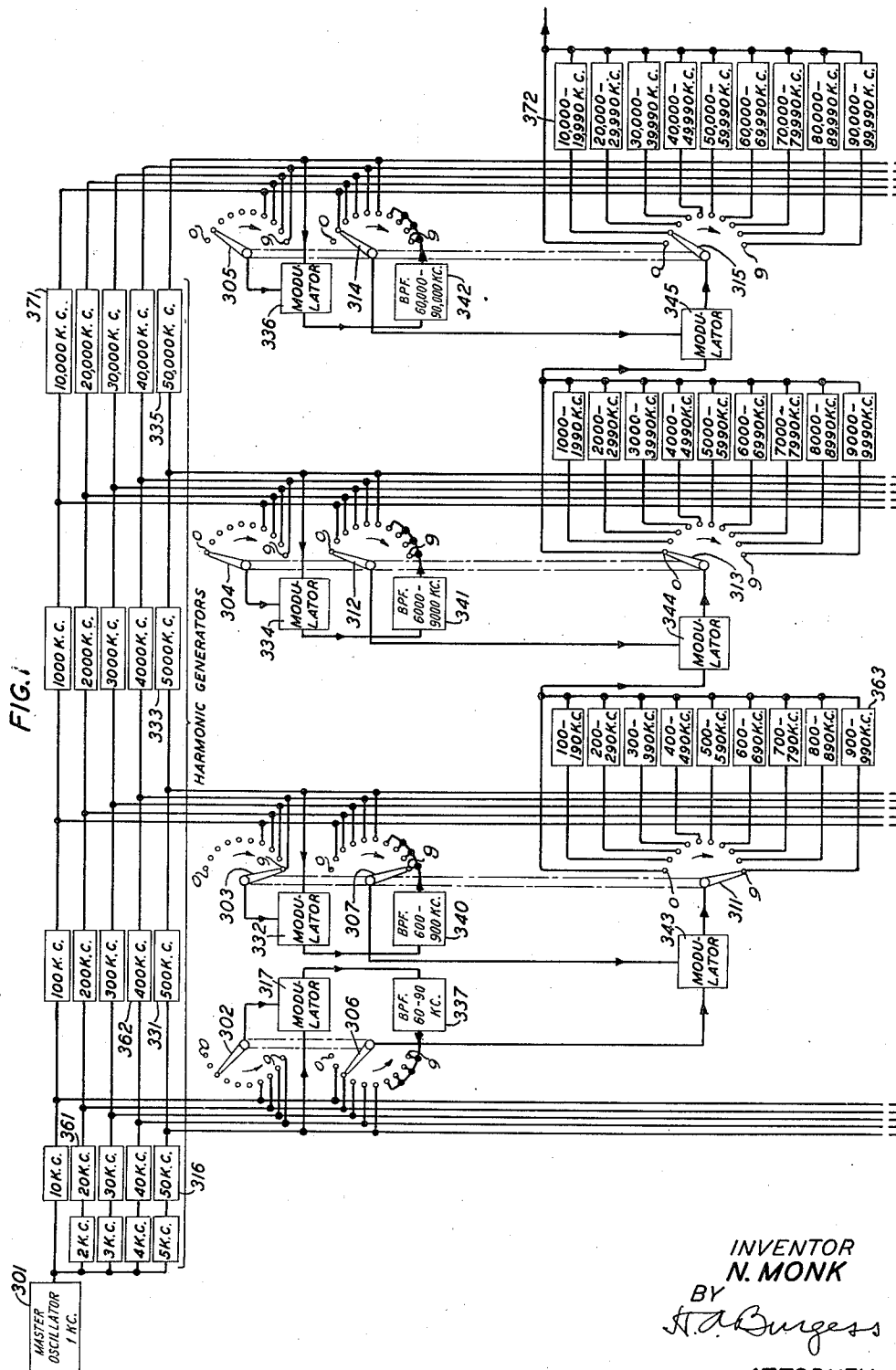
N. MONK

2,231,634

VARIABLE FREQUENCY WAVE PRODUCING MEANS

Filed April 21, 1939

3 Sheets-Sheet 1



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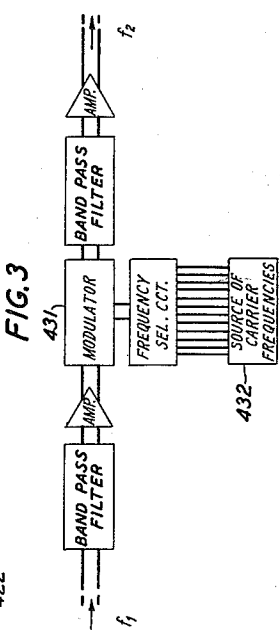
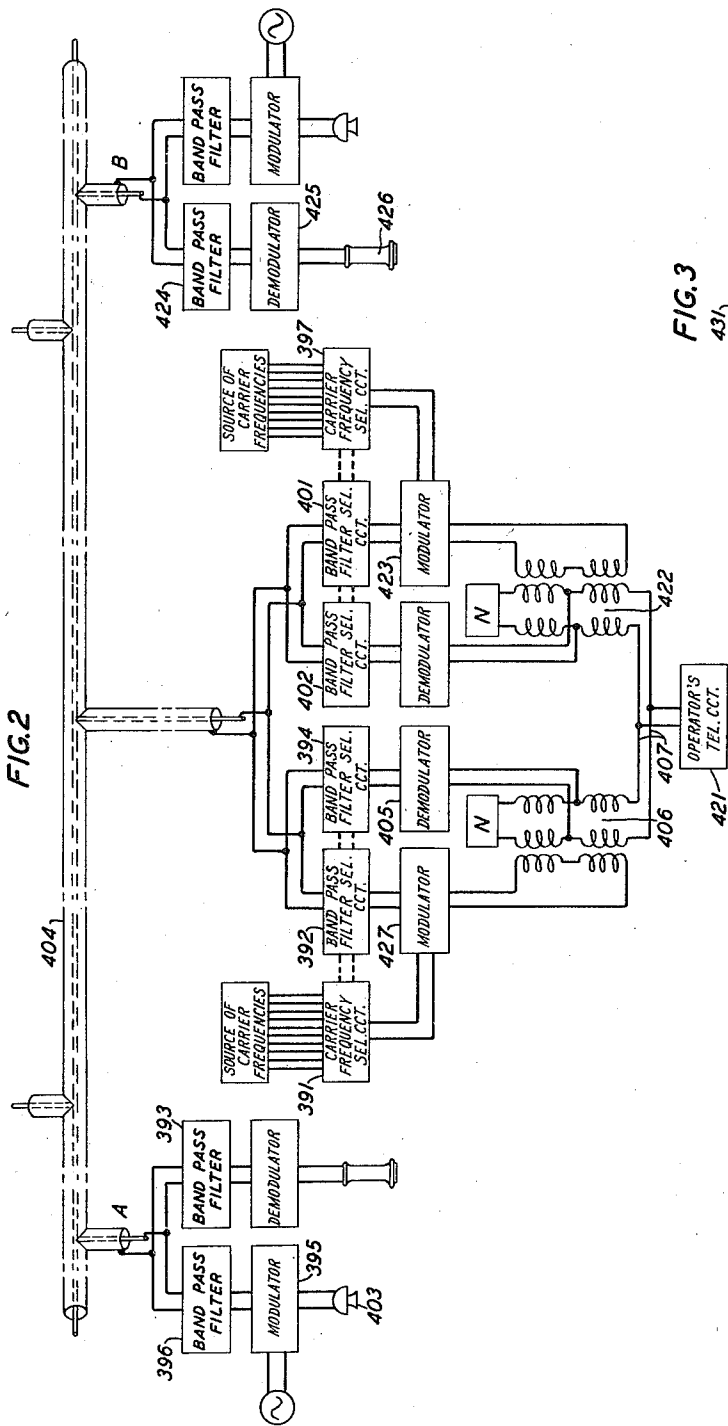
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VARIABLE FREQUENCY WAVE PRODUCING MEANS

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3 Sheets-Sheet 2



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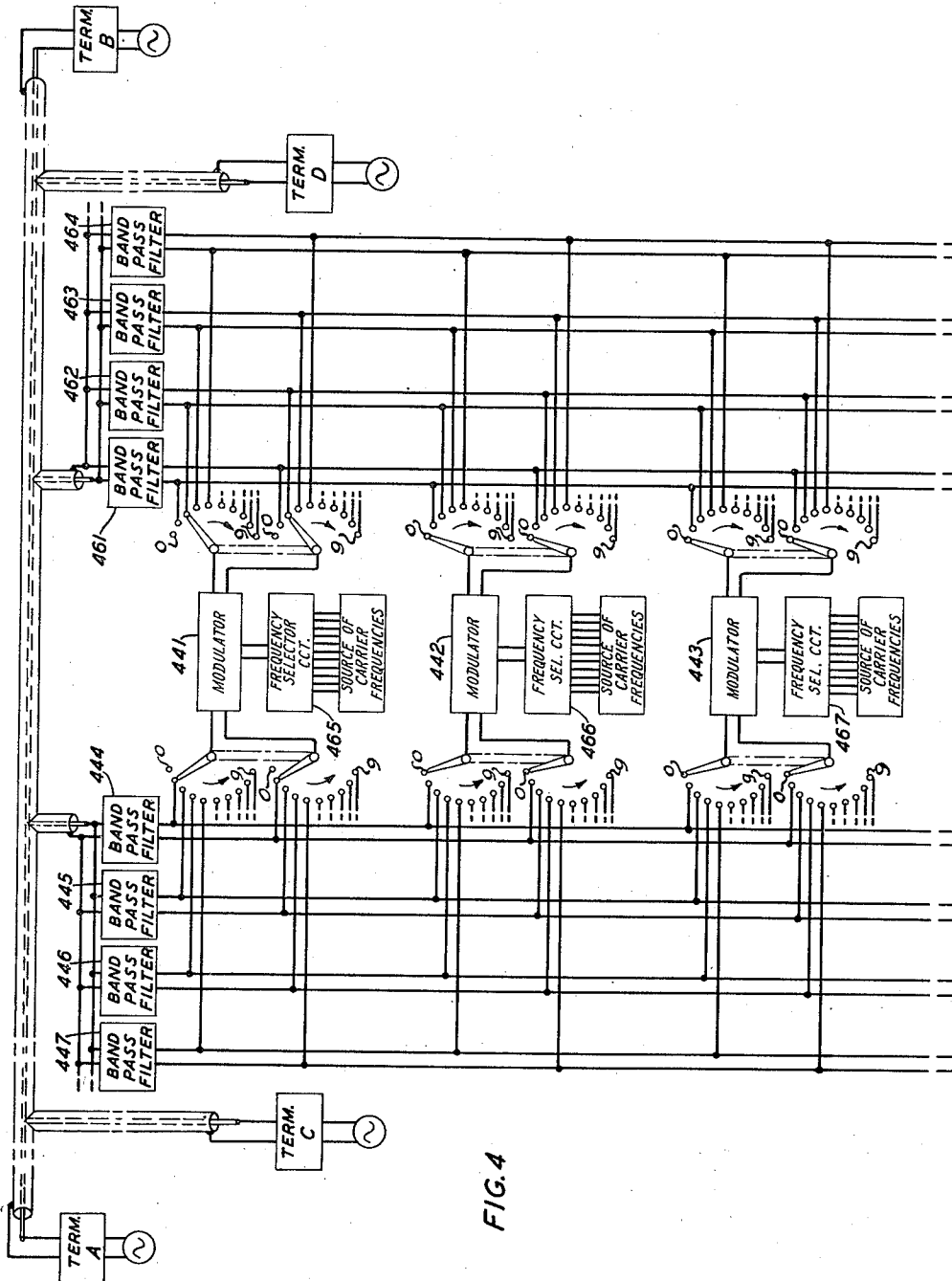
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VARIABLE FREQUENCY WAVE PRODUCING MEANS

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3 Sheets-Sheet 3



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2,231,634

VARIABLE FREQUENCY WAVE PRODUCING
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Application April 21, 1939, Serial No. 269,092

7 Claims. (Cl. 250—36)

This invention relates to a frequency producing system.

An object of the invention is to facilitate the production of any desired frequency within a wide frequency range.

A feature of the invention is means whereby any desired frequency within a wide frequency range may be quickly and easily obtained from a relatively small number of primary frequency sources.

A further feature of the arrangement is means whereby all of the primary frequencies are in harmonic relation to the output of a common master oscillator.

On December 22, 1936, a number of U. S. patents, to wit: 2,064,894, L. Espenschied; 2,064,895 and 2,064,896, L. Espenschied et al; 2,064,904, 2,064,905 and 2,064,907, E. I. Green; 2,064,906, E. I. Green et al; 2,064,938, issued to applicant; and 2,064,961, W. H. Tidd; were issued, all of which describe common medium multichannel telephone exchange systems. An exchange system of this type is one in which the individual subscribers are interconnected over a common medium such as space or a conducting network; for example, a network of coaxial conductor circuits in which the subscribers are reached over individual frequency channels. It is apparent that a system of this nature utilizes a large number of individual frequencies in order to provide all of the frequency channels; for efficient operation all of the frequencies employed should be readily available.

The system of the present invention, providing as it does means for rapidly and easily producing any desired frequency within a wide frequency range, is particularly adaptable to use in connection with a common medium multichannel telephone exchange system.

In an application of L. Espenschied, Serial No. 269,274, filed April 21, 1939 and now abandoned, a frequency producing arrangement is described in accordance with a specific embodiment of which invention, a plurality of series of primary frequency sources are provided together with switching means whereby one source from each series may be selected. The frequencies of the selected sources are then combined through a series of modulators to form the desired frequency. The action is essentially that of throwing into a succession of modulators the appropriate primary frequencies and at the same time selecting and connecting in series with the respective modulators band filters of proper value to pass the particular frequency sought to be

produced by the modulators. Each filter is so selected in relation to the respective primary frequency as to be effective to block out the unmodulated components and other unwanted frequencies. By proper selection of the primary frequency supply, an arrangement of the nature described in the Espenschied application may be made effective, within practical limits, to cover any frequency range desired.

The arrangement of the present invention is a modification of the Espenschied arrangement and, in a sense, an improvement thereover in that the arrangement is such that the number of primary frequency sources utilized is only slightly more than one-half the number utilized by the Espenschied system. The desirable reduction is made possible by a novel scheme of combining the frequencies from a relatively small number of primary frequency sources in order to produce the desired primary frequency. The process of building up to any desired frequency from a number of series of lower frequencies may be reversed to beat down an incoming high frequency to a frequency lower in value; the frequency building-up arrangement and the frequency building-down arrangement may be advantageously combined to form one composite system.

Complete understanding of the arrangements contemplated by the present invention and appreciation of the various desirable features thereof may be gained from consideration of the following detailed description together with the drawings in which:

Fig. 1 is a schematic showing of a frequency producing system which embodies features of the present invention; and

Figs. 2, 3 and 4 are schematics illustrating practical applications of the frequency producing system of the present invention to multichannel exchange systems of the types disclosed in the patents referred to above.

Referring now to the drawings, there is illustrated in Fig. 1 a master oscillator 301 the output of which is supplied to a series of harmonic generators which serve as primary frequency sources. It will be observed that there are but five frequency sources in each group although, as will be brought out subsequently, any one of the nine different primary frequencies may be obtained from each group. A plurality of rotary switches are also provided, switch 302 being associated with the 10-50 kilocycle sources, switch 303 with the 100-500 kilocycle sources, switch 304 with the 1000-5000 kilocycle sources and switch 305

with the 10,000-50,000 kilocycle sources. Switch 306 is mechanically coupled to switch 302 and operates in step therewith; in like manner switches 307 and 311 are associated with switch 303, switches 312 and 313 with switch 304 and switches 314 and 315 with switch 305.

Primary frequency source 316 (50 kilocycles) is permanently connected to modulator 317, primary frequency source 331 (500 kilocycles) to modulator 332, primary frequency source 333 (5000 kilocycles) to modulator 334, and primary frequency source 335 (50,000 kilocycles) to modulator 336. The output of modulator 317 is connected through filter 337 to the last four contacts of switch 306, the output of modulator 332 is connected through filter 340 to the last four contacts of switch 307, the output of modulator 334 is connected through filter 341 to the last four contacts of switch 312 and the output of modulator 336 is connected through filter 342 to the last four contacts of switch 314.

The brushes of switches 306 and 307 are connected to the input of modulator 343, the brush of switch 312 is connected to the input of modulator 344 and the brush of switch 314 is connected to the input of modulator 345. A group of nine band-pass filters is associated with contacts of switch 311, a second group of nine filters is associated with contact of switch 313 and a third group of nine filters is associated with contacts of switch 315.

In order to further describe the arrangement of Fig. 1 let us assume that we wish to produce a final frequency of 10,920 kilocycles. The frequencies of the 10,000-50,000 kilocycle series correspond to the first digit of the desired final frequency, the frequencies of the 1000-5000 kilocycle series to the second digit, etc. As the first step in building up the desired frequency of 10,920 kilocycles, therefore, we first set switch 302 and switch 306 controlled thereby on contact 2 of the associated brushes, thereby connecting primary frequency source 361 (20 kilocycles) to the input of modulator 343. It will be noticed that for this position of switch 306, the output of modulator 317 is not connected to modulator 343.

Now to obtain the next digit of the desired final frequency we move switch 303, and switches 307 and 311 controlled thereby, to contact 9 of the associated banks. As a result we now have connected to the input of modulator 332, primary frequency source 362 (400 kilocycles) and primary frequency source 331 (500 kilocycles). These frequencies when combined in the modulator produce in the output thereof, among other frequencies, the frequency 900 kilocycles. The frequency 900 kilocycles is now passed by filter 340, which is designed to pass the frequency band 600-900 kilocycles, and is connected through the brush of switch 307 to the input of modulator 343.

Combination of the two frequencies, 20 kilocycles and 900 kilocycles, in modulator 343 produces in the output thereof, among other frequencies, the frequency 920 kilocycles. This frequency is connected through the brush of switch 311 to filter 363 and as this filter is designed to pass the frequency band 900-990 kilocycles, is passed thereby to the input of modulator 344.

Now as the next digit of the desired frequency is 0, switch 304 and switches 312 and 313 controlled thereby, are set on the zero contact of the associated banks. No additional frequency is connected to modulator 344, therefore, and the

frequency 920 kilocycles is connected directly to the input of modulator 345.

Now in order to obtain 10,000 kilocycles, corresponding to the last digit of the desired frequency, switch 305 and switches 314 and 315 controlled thereby, are moved to contact 1 of the associated banks. This results in connection of primary frequency source 371 (10,000 kilocycles) to the input of modulator 345. It will be apparent that for this position of switch 314 the output of modulator 336 is not connected through to modulator 345.

Combination of the two frequencies, 920 kilocycles and 10,000 kilocycles in modulator 345 produces in the output thereof, among other frequencies, the desired final frequency of 10,920 kilocycles. This frequency is connected through switch 315 to band-pass filter 372 and, as this filter is designed to pass the frequency band 10,000-19,990 kilocycles, is passed therethrough to the output circuit.

It will be apparent, of course, that other desired final frequencies may be built up in a similar manner. It will be apparent further that by use of the novel combining arrangement provided only five primary frequency sources are necessary in each series for the production of frequencies corresponding to nine digits.

It is to be noted that this process of combining the lower of a series of primary frequencies to produce the higher primary frequencies of the same series may be employed to further reduce the total number of required frequencies for each series to 4. A second modulator similar to 317 is required and a slightly more complicated switching mechanism. The method of operation will, however, be evident to those skilled in the art.

Figs. 2, 3 and 4 illustrate various applications of the proposed arrangement in a common medium multichannel exchange system. Fig. 2 shows in schematic form a common medium telephone exchange system in which a number of subscribers may be interconnected through a central office, connection between each subscriber and the central office being accomplished over a coaxial conductor system which extends to all stations and to the central office. In this system each subscriber utilizes one frequency for talking to the central office and a different frequency for receiving transmission from the central office, the frequencies assigned to each subscriber in the system being different from those assigned to any other subscriber.

Each subscriber, such as the two illustrated, is provided with transmitting apparatus including an oscillator-modulator and receiving apparatus including a demodulator together with the necessary selecting circuits. At the central office a plurality of circuits such as the one shown are provided for interconnecting between subscribers. Each connecting circuit includes two separate sets of apparatus, each of which comprises variable frequency transmitting and receiving apparatus and a connection to which the operator has access between the two sets of apparatus.

When using the central office apparatus of Fig. 2 to interconnect, for example, stations A and B the frequencies of the variable frequency source 391 and the variable frequency selecting circuit 392 are adjusted to the frequency of the selecting circuit 393 and the variable frequency selecting circuit 394 to the frequency of the oscillator-modulator 395 and the selecting circuit 396. The variable frequency source 397 and the

variable frequency selecting circuits 401 and 402 are similarly adjusted to the frequencies of station B.

Transmission from subscriber A to subscriber B is effected by means of the telephone transmitter 403, the combined oscillator-modulator 395, the selecting circuit 396, the coaxial circuit 404, the variable frequency selecting circuit 394, the demodulator 405, the hybrid coil 406, the connecting circuit 407 (across which is bridged the operator's set 421), the hybrid coil 422, the modulator 423 which is supplied with a source of carrier frequency 397, the variable frequency selecting circuit 401, the coaxial conductor 404, the selecting circuit 424, the demodulator 425 and the telephone receiver 426. Transmission in the opposite direction is accomplished in an analogous manner.

In order that the connecting circuit at the central office may be employed for the interconnection of any pair of subscribers it is essential that the frequencies applied to the modulators 427 and 423 from the sources 391 and 397, respectively, be variable. Furthermore, it is desirable that each of these frequency sources may be readily and quickly adjusted to the desired frequencies. The proposed arrangement illustrated in Fig. 1 may be used in this connection. Furthermore, there will be required a plurality of such frequency sources in any one central office. This makes it possible to supply each of the variable frequency sources from one set of primary frequencies as is illustrated in Fig. 1. Thus, there are provided adjustable frequency supplies for each central office modulator utilizing a minimum of apparatus.

It is desirable although not essential that the variable frequency source 391 and the variable frequency selecting circuits 392 and 394 be operated together from a common control and that the variable frequency source 397 and the selecting circuits 392 and 394 be similarly controlled together.

The arrangement of Fig. 3 shows how the invention may be applied in interconnecting two circuits of different frequencies. In this case it is necessary to connect the two circuits to the input and output of a modulator, such as 431, and to supply to the modulator the difference between the incoming frequency f_1 and the outgoing frequency f_2 . Such a frequency may be readily obtained from a variable frequency source 432 which may be of the type suggested in the arrangement of Fig. 1.

Fig. 4 is an extension of the principle of Fig. 1 to show how the proposed arrangement might be used in a central office of a common medium multichannel system in which interconnections are made at carrier frequencies. The wiring illustrated in this figure is merely schematic and not intended to show the details of a complete central office.

A number of modulators 441, 442, 443, etc., are arranged so that their inputs may be connected to any one of a number of filters 444, 445, 446, 447, etc., corresponding to the incoming frequency channels of the various subscribers' stations. At the same time the outputs of the modulators are arranged to be connected to any one of the filters 461, 462, 463, 464, etc., which correspond to the outgoing frequency channels of the subscribers' stations. The modulators 441, 442, 443, etc., are supplied by a number of variable frequency sources 465, 466 and 467 of the type disclosed above, each arranged to be

permanently connected to one of the modulators. Two stations may now be interconnected by supplying from the variable frequency source associated with the modulator to which they are connected a frequency equal to the difference between the frequencies associated with the two stations. Thus, interconnection is effected directly without reducing the transmission to voice frequencies.

The arrangement described herewith is not intended to be restricted to the various arrangements illustrated in Figs. 2, 3 and 4. For example, it may be employed wherever a variable source of frequencies is required in connection with various types of common medium multichannel telephone exchange systems. Examples of such systems are disclosed in the U. S. patents referred to above.

While specific embodiments of the invention have been selected for illustration and detailed description, the invention is not, of course, limited in its application to the embodiments disclosed. Those embodiments described should be taken as illustrative rather than as restrictive.

What is claimed is:

1. In a frequency producing system for obtaining any desired frequency within a given frequency range, a plurality of primary frequency sources arranged in groups, each of said groups comprising five primary frequency sources producing frequencies in the ratio 1, 2, 3, 4, 5, the frequency range covered by each of said groups being related in successive powers of 10, means for selecting from each of said groups a primary frequency the first digit of which corresponds to a significant digit of the desired frequency if said digit is less than 6, means for selecting from each of said groups a suitable combination of primary frequencies and means for combining said selected frequencies to obtain a frequency the first digit of which corresponds to a significant digit of a desired frequency if said significant digit be greater than 5, and means for combining the primary frequencies or combinations of primary frequencies selected from each group to produce a desired final frequency.

2. In a broad band multichannel system, a group of five primary frequency sources varying in accordance with the series 1, 2, 3, 4, 5, a second group of five primary frequency sources also varying in accordance with the same series, the frequency ranges of the two groups being related by an integral power of 10, means for selecting from each of said groups a primary frequency corresponding to a significant digit of a desired final frequency, said last-mentioned means including means for combining appropriate frequencies of a respective group if the particular significant digit be greater than 5, and means for combining the selected frequencies or combinations of frequencies by modulation to produce a desired final frequency.

3. In a frequency producing system for producing a wave of any desired frequency within a given frequency range, a master oscillator for producing a wave of fixed frequency, a plurality of groups of harmonic generators electrically connected to the output of said master oscillator, each of said groups comprising five harmonic generators producing primary frequencies in the ratio 1, 2, 3, 4, 5, the frequency ranges of the groups being related in successive powers of 10, means for selecting from each group a single frequency corresponding to a significant digit of the desired frequency, the selected single fre-

quency in cases where the particular significant digit of the desired frequency is greater than 5 being obtained by suitable combination of selected frequencies of the appropriate group, and means for successively combining the selected primary frequencies or combinations of primary frequencies to produce the desired final frequency.

4. In a frequency producing system for producing a wave of any desired frequency within a given frequency range, a master oscillator for producing a wave of fixed frequency, a plurality of groups of harmonic generators electrically connected to the output of said master oscillator, each of said groups comprising five harmonic generators producing primary frequencies in the ratio 1, 2, 3, 4, 5, within a different portion of said given frequency range, the frequency range covered by the individual groups being related in successive powers of 10, means for selecting from each of said harmonic generator groups a primary frequency which corresponds to a significant digit of the desired frequency if said significant digit be less than 6, and means for selecting from each of said groups a suitable combination of primary frequencies if said significant digit be greater than 5, and means for combining the primary frequencies or combination of primary frequencies selected from each group to produce a desired final frequency.

5. In a frequency producing system for producing a wave of any desired frequency within a given frequency range, a master oscillator for producing a wave of fixed frequency, a plurality of groups of harmonic generators electrically connected to the output of said master oscillator, each of said groups producing primary frequencies in an arithmetical series, a plurality of modulators, the output of one of said harmonic generators of each group being permanently connected to the input of a respective one of said modulators, a plurality of other modulators included in a series circuit, means for selecting one primary frequency from each of said groups of harmonic generators, means for connecting said primary frequency to the input of one of said last-mentioned modulators, means for connecting the output of each of said first-mentioned modulators to the input of one of said last-mentioned modulators, said last-mentioned means being effective only when said selecting means be positioned to

select a frequency greater than a predetermined value, and means for combining the primary frequencies or combination of primary frequencies from each group to produce a final desired frequency.

6. In a frequency producing system for obtaining any desired frequency within a given frequency range, a plurality of primary frequency sources arranged in groups, each of said groups comprising a number of primary frequency sources having frequencies in accordance with an arithmetical series, the frequency ranges covered by each of said groups being related in successive powers of 10, means for selecting from each of said groups a single frequency, the first digit of which corresponds to a significant digit of the desired frequency if said digit is less than a predetermined value, means for selecting from each of said groups a suitable combination of primary frequencies and means for combining said selected frequencies to obtain a single frequency, the first digit of which corresponds to a significant digit of the desired frequency, if said significant digit be greater than said predetermined value, and means for combining the primary frequencies or combinations of primary frequencies selected from each group to produce the desired final frequency.

7. In a frequency producing system for producing any desired frequency within a given frequency range, a master oscillator for producing a fixed frequency, a plurality of groups of harmonic generators coupled with said master oscillator, each of said groups producing primary frequencies in accordance with an arithmetical series, the maximum frequency of each of said groups being in accordance with a predetermined value and the frequency ranges covered by each of said groups being related in successive powers of 10, means for selecting from each group a single frequency corresponding to a significant digit of the desired frequency, the selected single frequency being obtained by suitable combination of primary frequencies of the appropriate group in cases where the frequency is greater than any frequency produced by the group, and means for successively combining the selected primary frequency or combinations of primary frequencies to produce the desired final frequency.

NEWTON MONK.