

Aug. 19, 1930.

H. A. AFFEL

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TRANSMISSION SYSTEM

Filed May 31, 1929

2 Sheets-Sheet 1

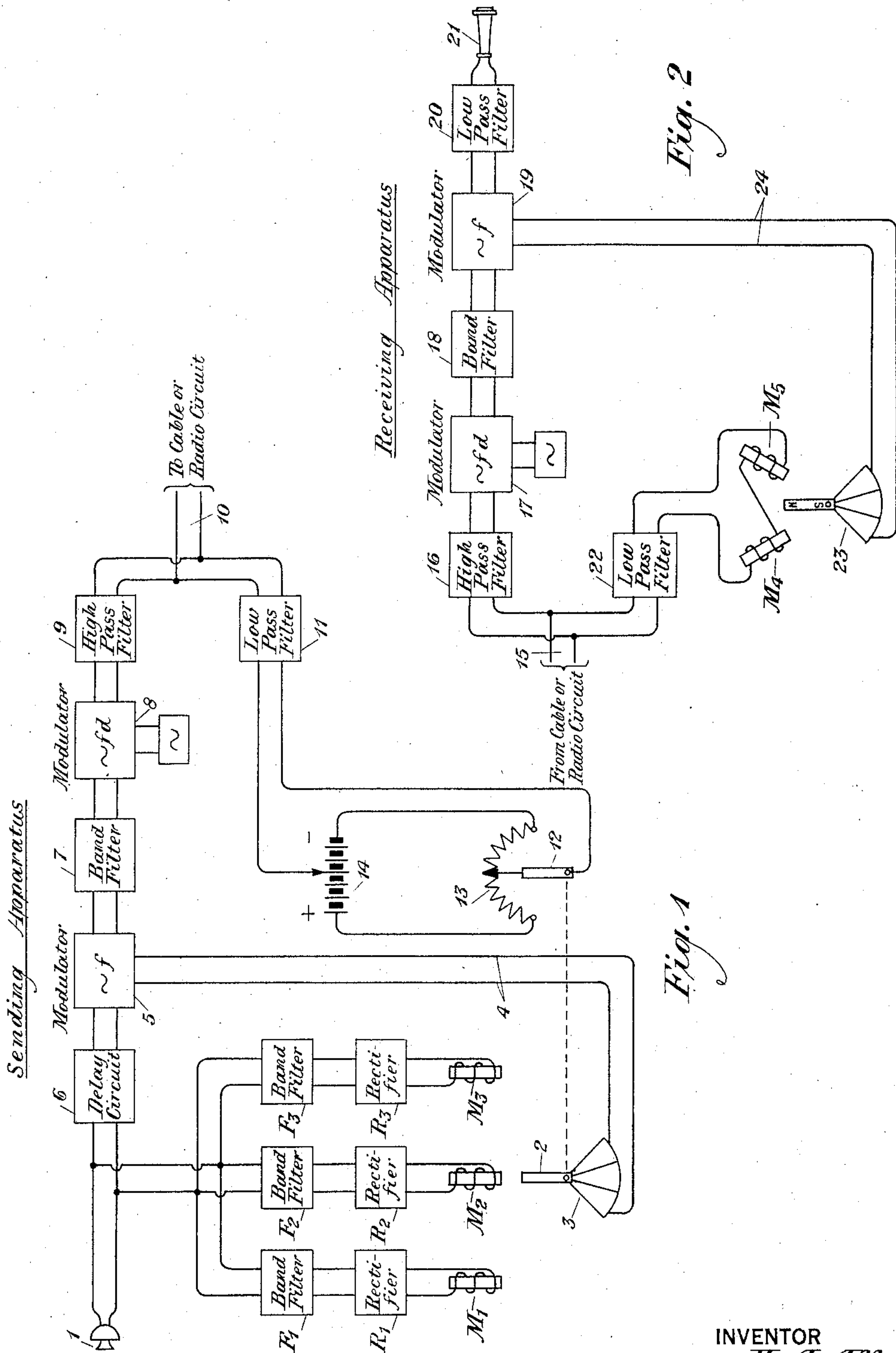


Fig. 2

Fig. 1

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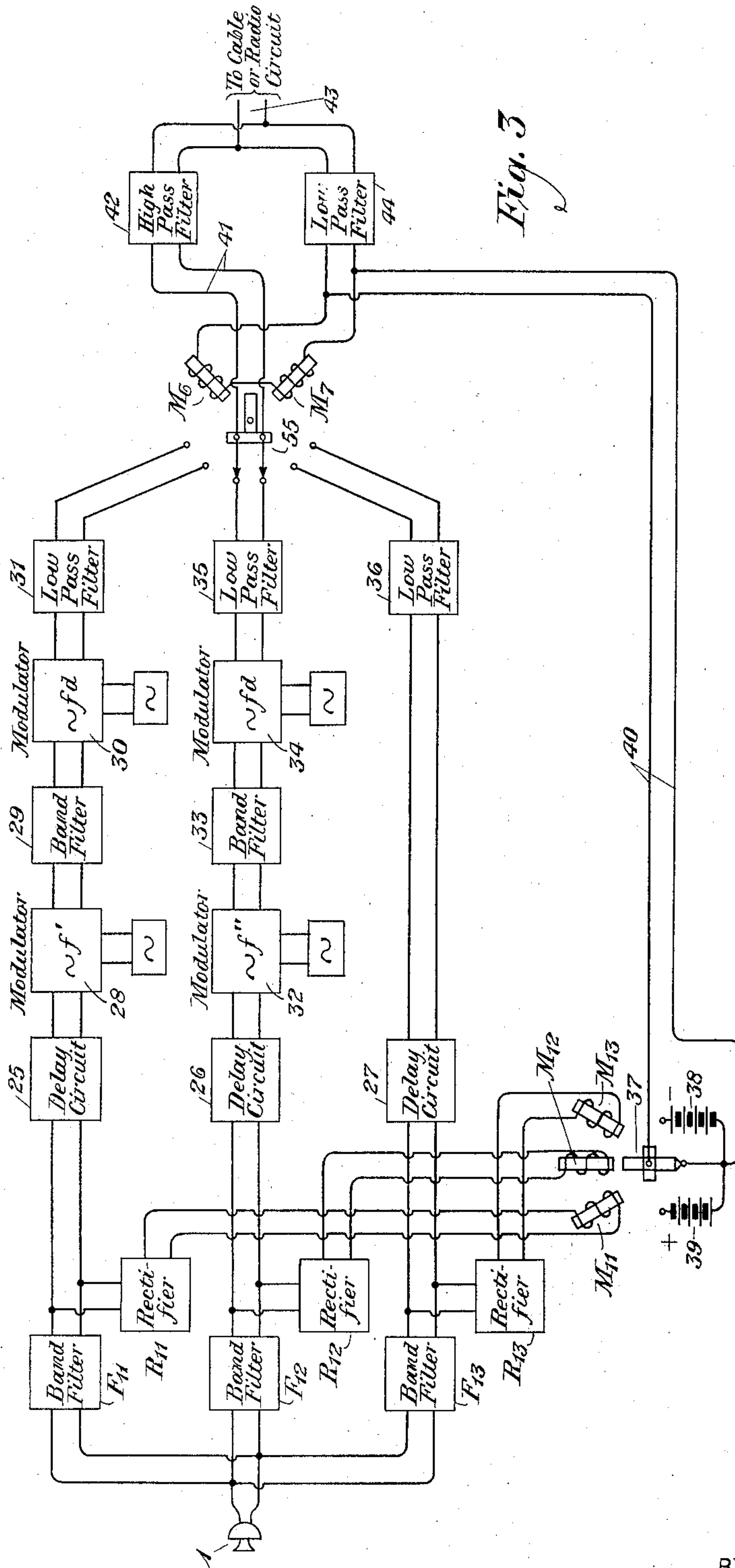


Fig. 3

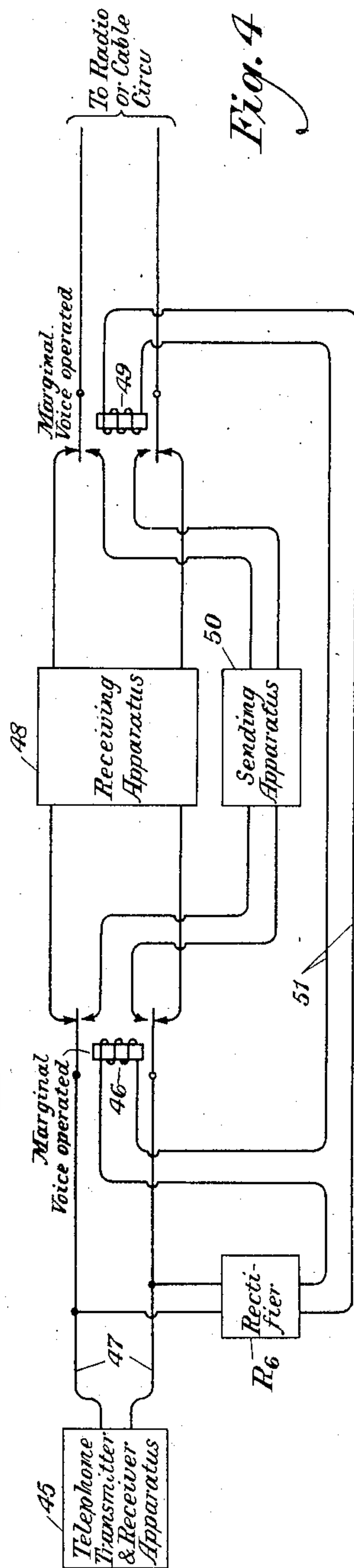


Fig. 4

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TRANSMISSION SYSTEM

Application filed May 31, 1929. Serial No. 367,471.

This invention relates to transmission systems and more particularly to arrangements for reducing the frequency band width required for telephone transmission over such systems.

The requirements for transmission over a telephone circuit are ordinarily set to embrace a band width which includes all the frequencies required for speech transmission at any instant. It has been found that a band width of about 3,000 cycles gives a very fair articulation reproduction for all speech sounds, except certain of the sibilant and fricative consonants which require frequencies several thousands of cycles higher for entirely adequate reproduction. In certain services, such as transatlantic radio and very long under sea cables, an adequate band width of even 3,000 cycles may be difficult and expensive to obtain. When a band width of only 2,000 or 1,500 cycles is available, transmission may be carried on only with certain sacrifices in articulation.

It is one of the primary objects of this invention to provide arrangements for improving the transmission situation when only a narrow band width of, for example, 1,000 cycles or 1,500 cycles can be economically obtained. In accordance with the arrangements of the invention, provision is made so that, in the utilization of such narrow band width, the voice range which is transmitted is varied upward or downward in frequency in accordance with the predominant frequencies present in the speech at the particular instant. For example, if a band width of 1,000 cycles were available for transmission over a long cable circuit, and if the speech at an instant required the transmission of a vowel sound embracing chiefly frequencies from zero to 1,000 cycles, the available band width would be employed to transmit in its normal position the speech frequency from zero to 1,000 cycles. If, on the other hand, the transmitted speech required a particular consonant reproduction, having a predominance of high frequencies, such, for example, as the letter S, the voice band would be shifted so that frequencies of say from 2,000 to 3,000 cycles would pass through the zero to 1,000

cycle range provided by the cable. The arrangements of the invention would operate in an automatic manner and in accordance with the speech requirements each instant. Further objects and features of the invention will appear more fully from the detailed description thereof hereinafter given.

The invention may be more fully understood from the following description together with the accompanying drawing, in the Figures 1, 2, 3 and 4 of which the invention is illustrated. Fig. 1 is a circuit diagram showing apparatus utilized at a sending station. Fig. 2 is a circuit diagram showing receiving apparatus. Fig. 3 is a modification of the sending apparatus. Fig. 4 is a schematic showing of means for affording two-way operation with the apparatus of the invention. Similar reference characters have been utilized to denote like parts in all of the figures.

In Fig. 1 is shown a circuit diagram of apparatus for sending messages in accordance with the arrangements of this invention. Bridged across the circuit of the transmitter 1 is a group of selective circuits, which includes the band filters F_1 , F_2 and F_3 , the rectifiers R_1 , R_2 and R_3 and the magnets M_1 , M_2 and M_3 . Each of the filters F_1 , F_2 and F_3 may be selective for a different band of frequencies in the message frequency band. For example, F_1 may pass 0 to 1,000 cycles, F_2 may pass 1,000 to 2,000 cycles, and F_3 may pass 2,000 to 3,000 cycles. Networks for the purpose of weighting the different speech frequencies in any desired manner may be incorporated in these filters or elsewhere in the circuit. The electromagnets control the armature 2 and the movement of the rotating plates of the variable condenser 3, whereby the capacity of the circuit 4 may be controlled. This will control the variable frequency f of the modulator 5 in the transmitter circuit. In the transmitter circuit will be a delay circuit 6. In the output circuit of the modulator 5 will be a band filter 7 and a modulator 8 with an oscillator of fixed frequency fd attached thereto. A high pass filter 9 will be connected in the output of modulator 8 which will be connected to circuit 10 which may lead to ap-

paratus for transmitting signals, such as over a cable, radio or other circuit. Mounted on the same shaft as the armature 2 of variable condenser 3 and hence controlled by magnets M_1 , M_2 and M_3 , is the contact member 12 of a potentiometer device comprising resistance 13 and battery 14. This arrangement will transmit variations in current magnitude and direction through low pass filter 11 to the circuit 10 for causing apparatus at a receiving station to operate in synchronism with the sending apparatus as will be more fully described hereinafter.

The message currents originating in transmitter 1, depending on predominance of particular frequencies at an instant, will actuate most powerfully one of the three magnets M_1 , M_2 or M_3 , which by its pull on the armature 2 of the variable condenser 3 will determine the exact capacity introduced in circuit 4. This in turn will determine the frequency, termed f , of the oscillator associated with modulator 5 in the transmitter circuit. Modulator 5 acts to raise the frequency of the message after it has suffered a delay in circuit 6 in order to allow for the required operating time of the electromagnets and variable condenser 3. The modulated voice currents are then passed through the filter 7, which will cut off the lower side band and the other unwanted products of modulation, and the upper side band is applied to the modulator 8. This modulator will have a fixed frequency fd and operate to step down the frequency of the transmitted side band. If frequencies f and fd are identical, the voice band will pass through to the high pass filter 9 and thence to the cable or radio circuit 10 without shifting its position in the frequency range. However, if f is lower than fd , as determined by an increase of the capacity of the variable condenser 3, the voice band will be shifted downward in position in such a manner that the higher frequencies in the voice now appear as lower frequencies and are capable of transmission over the narrow band cable or radio channel.

For example, let it be assumed that at a given instant the predominant frequencies in the message band lie between zero and 1,000 cycles and that this band of frequencies is selected by filter F_1 and actuates most strongly the electromagnet M_1 to decrease the capacity in circuit 4 so that f will equal fd and that the value of each will equal 10,000 cycles. The predominant portion of the message band, such as zero to 1,000 cycles, will then be modulated by f , or 10,000 cycles, and the upper side band will be 10,000 to 11,000 cycles. This will be demodulated by fd , or 10,000 cycles, and the result will be a band occupying in the frequency scale a range of 0 to 1,000 cycles. Let it be assumed that at another given instant the predominant fre-

quencies in the message band lie between 1,000 and 2,000 cycles and that this band of frequencies is selected by filter F_2 and actuates most strongly the electromagnet M_2 and hence increases the capacity in circuit 4. This will tend to decrease f to, for example, 9,000 cycles. The message band of 1,000 to 2,000 cycles will be modulated by 9,000 cycles and the upper side band again will be 10,000 to 11,000 cycles. When this is demodulated by fd , or 10,000 cycles, the result will be a band occupying the same range in the frequency scale as heretofore, namely, from 0 to 1,000 cycles. Obviously, these values assumed for f and fd are only for purposes of illustration, and other values may be utilized.

The invention provides means to insure a synchronous frequency shift in the reverse direction at the receiving station so that no net frequency shift is apparent at the receiver. For this purpose, a small portion of the available frequency range is reserved for a synchronizing or control channel and a circuit including a low pass filter 11 is connected to circuit 10. In the case where a cable circuit is utilized for the transmission of the message, the control channel will be transmitted by variations of current direction and magnitude from a source such as battery 14. The varying battery potentials will be applied to the low pass filter circuit and circuit 10 as determined by the potentiometer 12, 13, which, as has been pointed out, is connected to the same shaft as the armature 2 of the variable condenser 3 and is controlled by the operation of the electromagnets M_1 , M_2 and M_3 . Any other desirable means for control or synchronism might be utilized if the messages were to be sent over a radio or other circuit.

In Fig. 2 is shown receiving apparatus suitable for use with the arrangements of the invention. A circuit 15 is shown which may be connected to an incoming cable or radio circuit. Two branch circuits are connected to circuit 15. One of these circuits includes a low pass filter 22 and is for the control or synchronizing channel. The other circuit includes a high pass filter 16 and is for the message channel. The circuit for the control channel includes the two magnets M_4 and M_5 which control the armature of a variable condenser 23. The armature of the variable condenser 23 in this case is polarized and its position and consequently the capacity of condenser 23 are determined by the direction and magnitude of the control current transmitted over the cable circuit from the battery-potentiometer arrangement 13—14. The movable plates of condenser 23 should accordingly follow those of the condenser 3 at the sending station. In the message receiver circuit is a double modulator arrangement comprising modulator 17 having the fixed frequency fd , similar to frequency fd of modulator 8 at the

sending station, a band filter 18, and the modulator 19 having a variable frequency f . The oscillator circuit 24 of modulator 19 will have its frequency f varied by the condenser 23. By this double modulator arrangement, the voice band will be returned to its normal position in the frequency scale for transmittal through the low pass filter 20 to receiver 21. For example, let it be assumed that at a given instant the predominant frequencies in the voice band originating in transmitter 1 were from 1,000 to 2,000 cycles. It has been pointed out that this band would be shifted so as to occupy during transmission a range of from 0 to 1,000 cycles. At the receiving station, this band would be modulated in modulator 17 by the frequency fd , or 10,000 cycles, and the upper side band would be 10,000 to 11,000 cycles. The control channel would cause condenser 23 to make the frequency f the same as at the sending station at this instant, and hence f would equal 9,000 cycles. The result of the modulation in modulator 19 would be a band occupying the range of 1,000 to 2,000 cycles. In other words, the voice band would be reshifted to its original position in the frequency scale for transmission to the receiver 21.

In Fig. 3 is shown a modification of the sending apparatus of the invention. In this modification, instead of providing for a smooth variation of frequency as determined by the position of a variable condenser as in Fig. 1 three distinct band shifts are provided by three independent circuits. Connected to the transmitter 1 would be three independent circuits including the band filters F_{11} , F_{12} and F_{13} each of which would select a different band of frequencies in the message band. For example, F_{11} might pass a band of 2,000 to 3,000 cycles, F_{12} a band of 1,000 to 2,000, and F_{13} a band of zero to 1,000 cycles. Rectifiers R_{11} , R_{12} and R_{13} are connected to each of these independent selective circuits and in turn are connected to the electromagnets M_{11} , M_{12} and M_{13} . These magnets will control the pivoted switch 37 whereby the circuit 40 may be completed through either battery 38 or battery 39 or without either of said batteries. Accordingly, the predominant frequencies in the original message band at a given instant will control the polarity and magnitude of the current in circuit 40. The magnitude and polarity of the current in circuit 40 will control the operation of magnets M_6 and M_7 , which in turn will connect the rotary switch 55 to either of the three selective circuits connected to the transmitter 1. In other words, the predominance of certain frequencies at a given instant in the message band will determine which of the three selective circuits is to be utilized. Each of these circuits will include a delay circuit, such as 25, 26 and 27. Connected in the circuit including filter F_{11} would be a modulator 28 having a frequency

f' , a filter 29 for selecting the upper side band of the product of modulation, a second modulator 30 having a fixed frequency fd , and a low pass filter 31. The values of f' and fd would be chosen so that the band of frequencies selected by filter F_{11} would be shifted to a predetermined position in the frequency scale, as heretofore explained. Connected in the circuit with filter F_{12} would be a modulator 32 having a frequency f'' , a filter 33 for selecting the upper side band of the product of modulation, a second modulator 34 having a fixed frequency fd , and a low pass filter 35. The values of f'' and fd would be chosen so that the band of frequencies selected by filter F_{12} would be shifted in the frequency scale to the same predetermined position as the band selected by the previously mentioned circuit. The frequencies selected by filter F_{13} would be transmitted in their normal position in the frequency scale which would be the desired and available band. The frequency bands would be transmitted through the high pass filter 42 to a cable or radio circuit 43. The variations of potential and magnitude of the current in circuit 40 would be transmitted through the low pass filter 44 and transmitted over the circuit 43 to synchronously control receiving apparatus operated in a corresponding manner.

In Fig. 4, there is shown schematically arrangements for permitting two-way conversation with the apparatus of this invention. The apparatus at one station only is shown. The telephone transmitting and receiving apparatus 45 is shown connected to a circuit 47. This circuit would normally be connected over the contacts of relays 46 and 49 through the receiving apparatus 48 to the cable or radio circuit. The receiving apparatus 48 might be similar to that shown in Fig. 2. Bridged across circuit 47 is the circuit 51 including the rectifier R_6 and the relays 46 and 49. These relays may be voice-operated and marginal. When speech starts, they will operate to connect circuit 47 through transmitting apparatus, such as that shown in Fig. 1, to the cable or radio circuit. By making relays 46 and 49 marginal, they will not operate falsely on incoming currents.

While the invention has been disclosed as embodied in certain specific forms which are deemed desirable, it is pointed out that these specific forms may be varied. For example, the message band might be split into more parts and the frequency range covered be much wider than indicated. Accordingly, the invention is capable of embodiment in many other forms than those illustrated without departing from the spirit of the invention as defined by the appended claims.

What is claimed is:

1. The method of reducing the frequency band width required for a communication channel, which comprises selecting a portion

of the band originated at a given instant in accordance with the predominant frequencies thereof, and shifting the selected portion of said band to a predetermined position in the frequency scale.

2. The method of telephone transmission, which comprises successively selecting portions of the message band in accordance with the frequencies predominant therein at successive instants, and successively shifting the selected portions of said message band to a predetermined position in the frequency scale.

3. The method of message transmission, which comprises selecting a portion of the message band in accordance with the frequencies predominant therein at a given instant, shifting the selected portion of said band to a predetermined position in the frequency scale, transmitting said selected portion of the band as shifted, reshifted to its original position in the frequency scale said transmitted portion of the message band, and receiving said portion of the band.

4. The method of message transmission, which comprises successively selecting portions of the message band in accordance with the frequencies predominant therein at successive instants, successively shifting the selected portions of said message band to the same position in the frequency scale, successively transmitting said portions of the band as shifted, successively reshifted to their original positions in the frequency scale said transmitted portions of the message band, and successively receiving said reshifted portions of the band.

5. The method of message transmission, which comprises successively selecting portions of the message band in accordance with the frequencies predominant therein at successive instants, successively shifting the selected portions of said message band to the same position in the frequency scale, successively transmitting said portions of the band as shifted, successively reshifted to their original positions in the frequency scale said transmitted portions of the message band, synchronizing the shifting and reshifted of said portions of the message band, and successively receiving said reshifted portions of the band.

6. The method of telephone transmission, which comprises selecting a portion of the band originated at a given instant in accordance with the predominant frequencies thereof, and utilizing the selected portion of the band to shift the message band to a predetermined position in the frequency scale.

7. The method of message transmission, which comprises selecting a portion of the message band in accordance with the frequencies predominant therein at a given instant, utilizing the selected portion of the band to shift the message band to a pre-

terminated position in the frequency scale, transmitting said message band as shifted, utilizing said selected portion of the band to reshift the message band to its original position in the frequency scale, and receiving said message band.

8. A circuit including a transmitter and a modulator for shifting the frequency of the original message band, a second modulator for reshifted the frequency of said shifted band, a combination of selective circuits connected to said transmitter circuit each adapted to select different portions of the original message band, and means under the control of said selective circuits for controlling the oscillator frequency of said first modulator.

9. A circuit including a transmitter, and a modulator for shifting the frequency of the original message band, a second modulator for reshifted the frequency of said shifted band, a combination of selective circuits connected to said transmitter circuit each adapted to select different portions of the original message band, a delay network in said transmitter circuit between said selective circuits and said first modulator, a variable condenser under the control of said selective circuits, and a circuit controlled by said variable condenser and controlling the oscillator frequency of said first modulator.

10. A circuit including a transmitter and a modulator for shifting the frequency of the original message band, a second modulator for reshifted the frequency of said shifted band, an output circuit for transmitting said reshifted band, a combination of selective circuits connected to said transmitter circuit each adapted to select different portions of the original message band, means under the control of said selective circuits for controlling the oscillator frequency of said first modulator, a control channel connected to said output circuit, and means under the control of said selective circuits for varying the characteristics of said control channel.

11. A transmission system comprising sending apparatus and receiving apparatus, said sending apparatus comprising means for shifting the frequency of the original message band in accordance with the frequencies predominant therein at a given instant, means for reshifted the frequency of said shifted band, and means for transmitting said reshifted band, said receiving apparatus comprising means for shifting the frequency of the received band, means for reshifted the frequency of the shifted received band in accordance with the frequencies predominant in the original message band at said given instant, and receiving means.

12. A transmission system comprising sending apparatus and receiving apparatus, said sending apparatus comprising means for shifting the frequency of the original message band in accordance with the frequencies

predominant therein at a given instant, means for reshifting the frequency of said shifted band, and means for transmitting said reshifted band, said receiving apparatus comprising means for shifting the frequency of the received band, means for reshifting the frequency of the shifted received band in accordance with the frequencies predominant in the original message band at said given instant, and receiving means, and means for synchronizing the shifting at the sending apparatus with the reshifting at the receiving apparatus.

13. A transmission system comprising sending apparatus and receiving apparatus, said sending apparatus comprising a circuit including a transmitter and a modulator for shifting the frequency of the original message band, a second modulator for reshifting the frequency of said shifting band, an output circuit for transmitting said reshifted band, a combination of selective circuits connected to said transmitter circuit each adapted to select different portions of the original message band, means under the control of said selective circuits for controlling the oscillator frequency of said first modulator, a control channel connected to said output circuit, and means under the control of said selective circuits for varying the characteristics of said control channel, said receiving apparatus comprising an input circuit including a modulator for shifting the frequency of the received band, a second modulator for reshifting said received shifted band, a receiver, and means connected to said input circuit and responsive to said control channel for controlling the oscillator frequency of said second modulator.

In testimony whereof I have signed my name to this specification this 29th day of May, 1929.

HERMAN A. AFFEL.

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