

Feb. 25, 1936.

L. ESPENSCHIED ET AL

2,031,696

SWITCHING ARRANGEMENT FOR FOUR-WIRE CIRCUITS

Filed March 2, 1933

3 Sheets-Sheet 1

Physical Four-wire Circuit

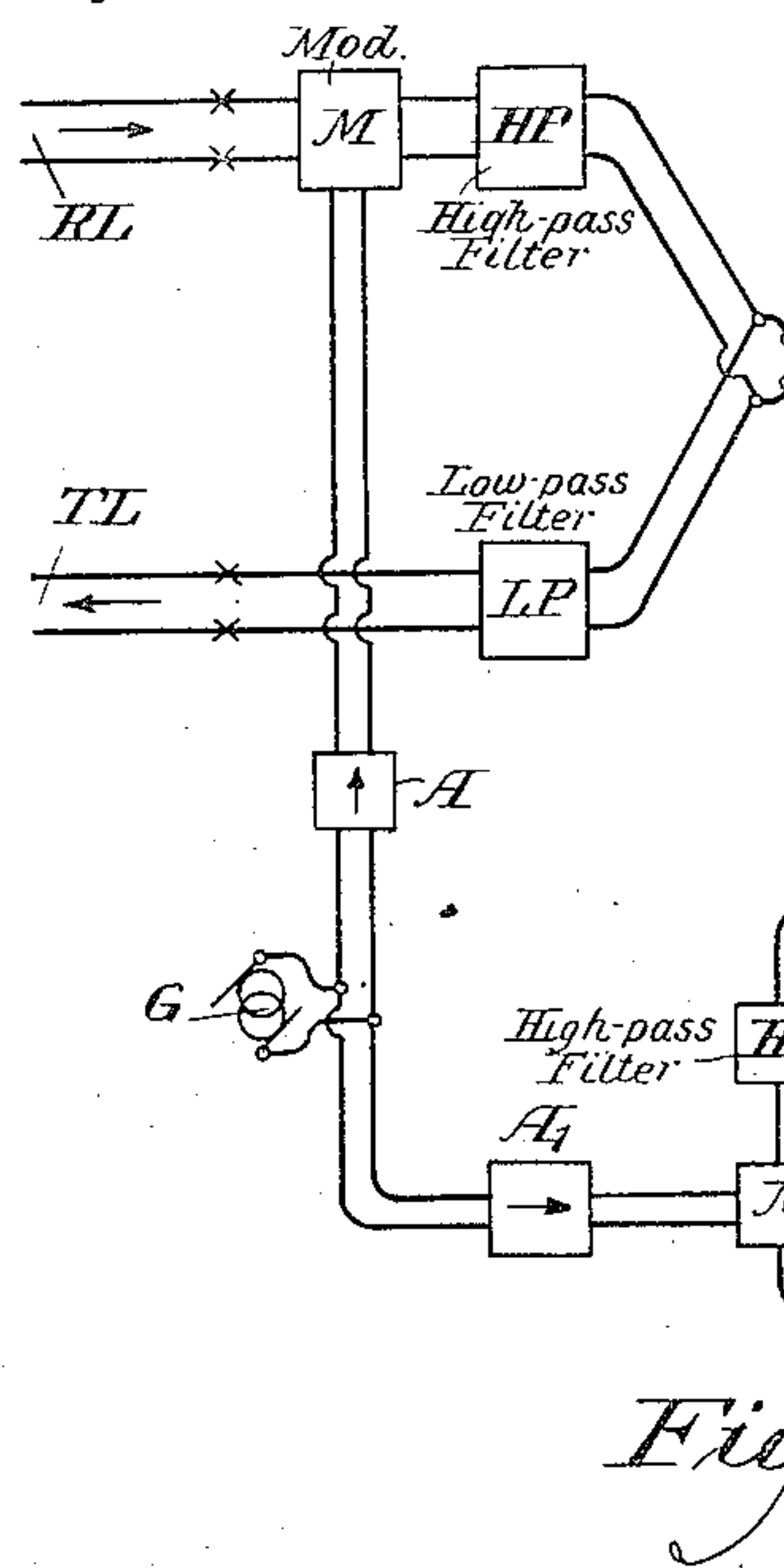


Fig. 1

Physical Four-wire Circuit

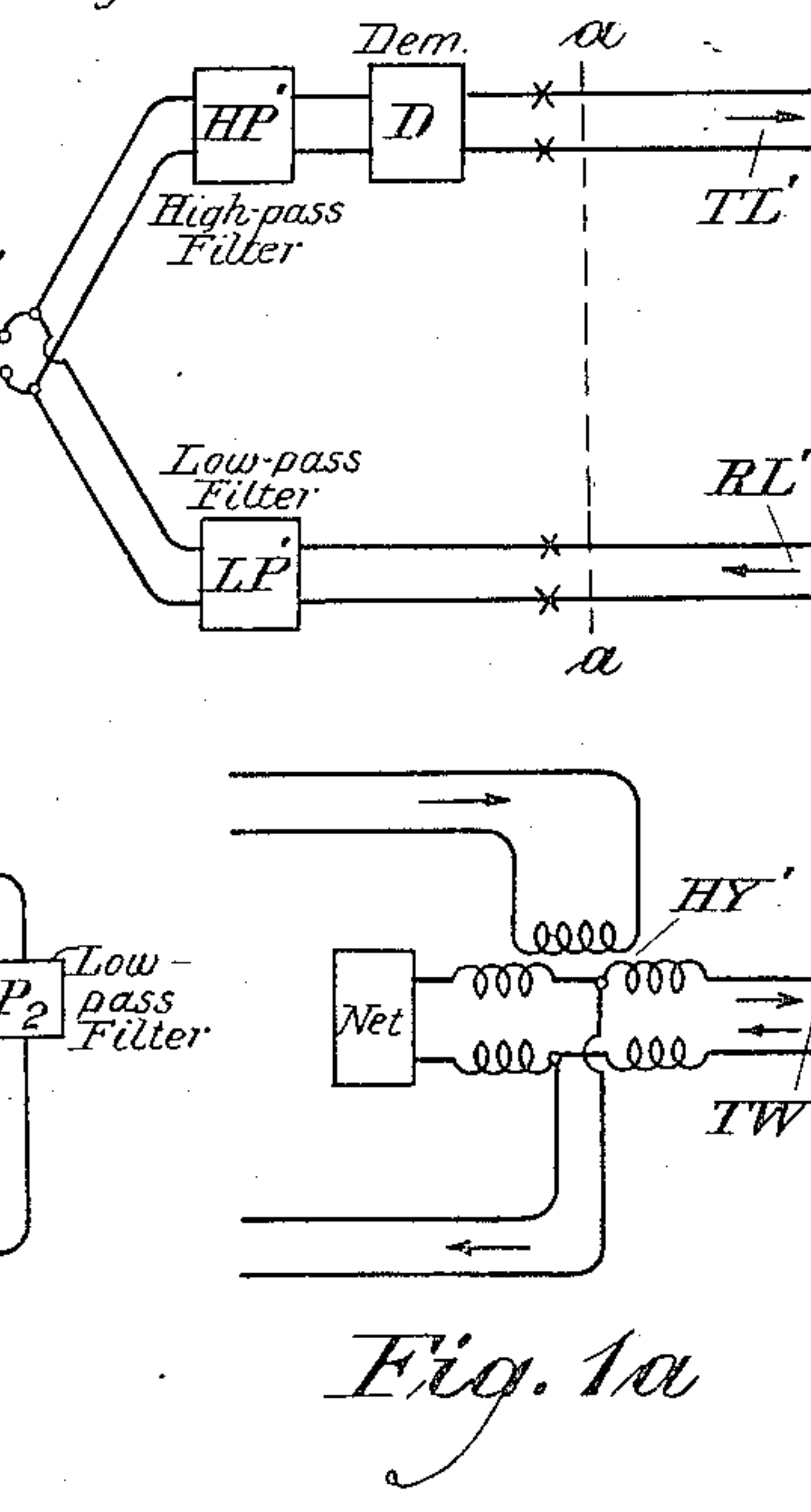
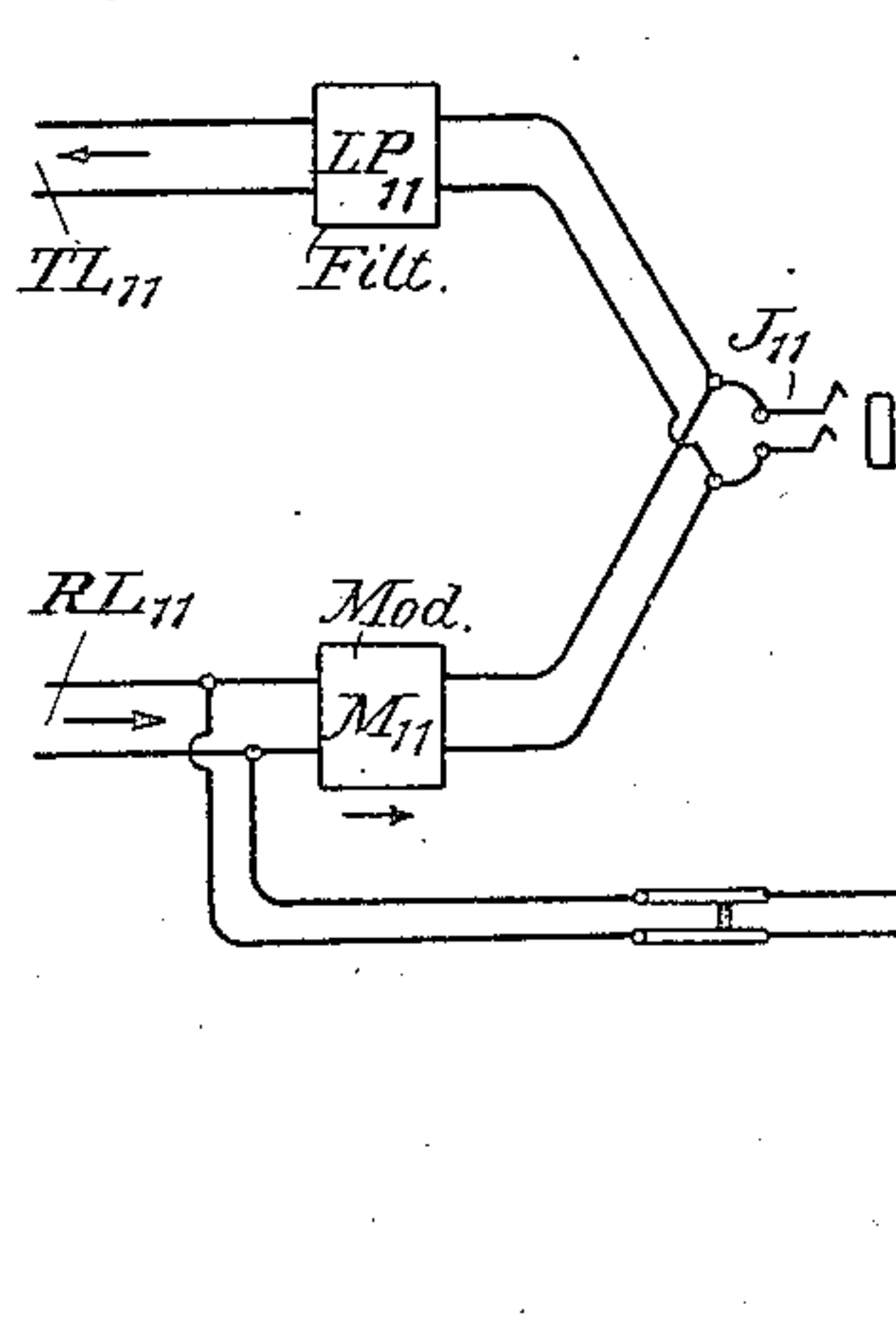
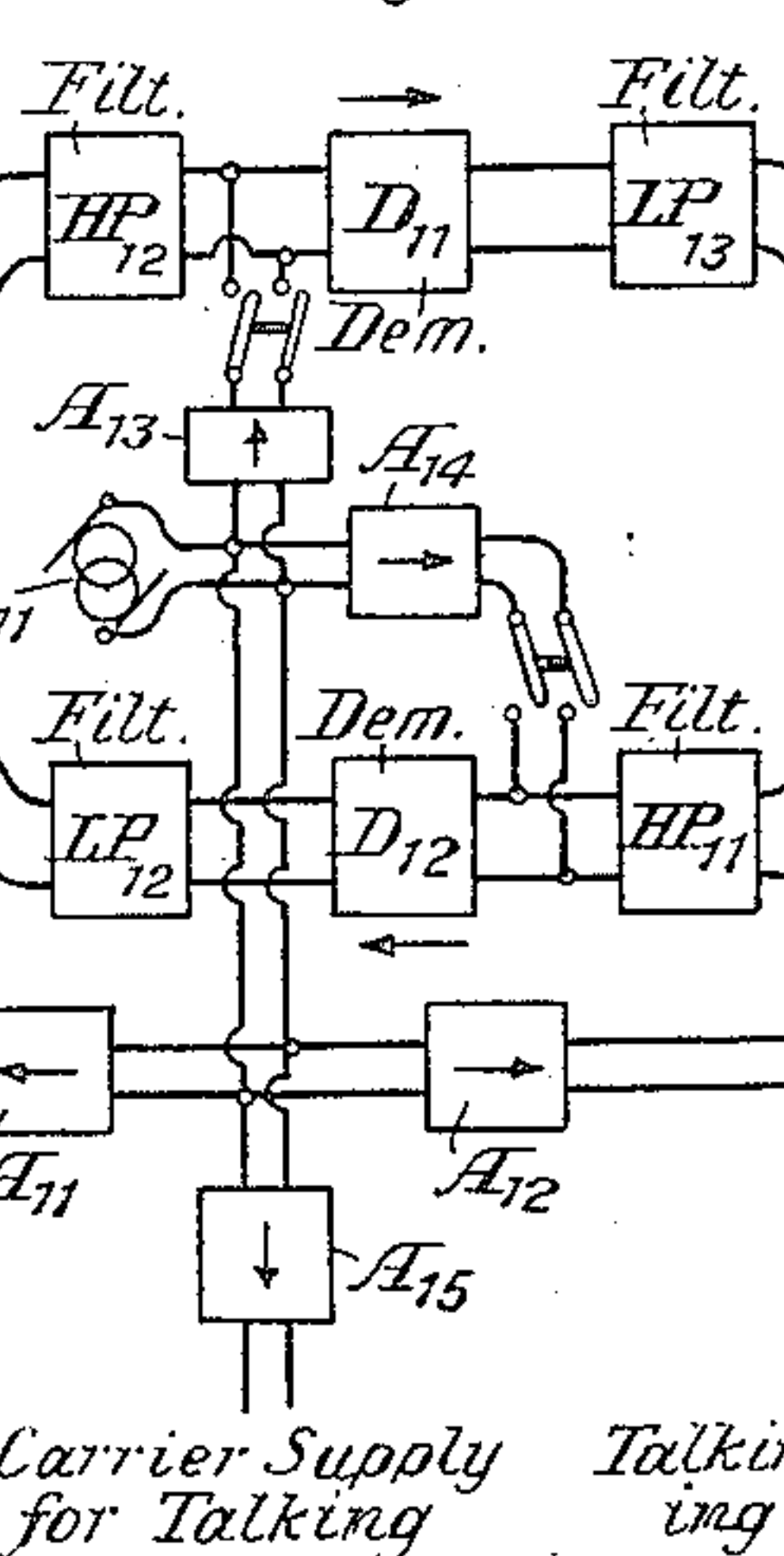


Fig. 1a

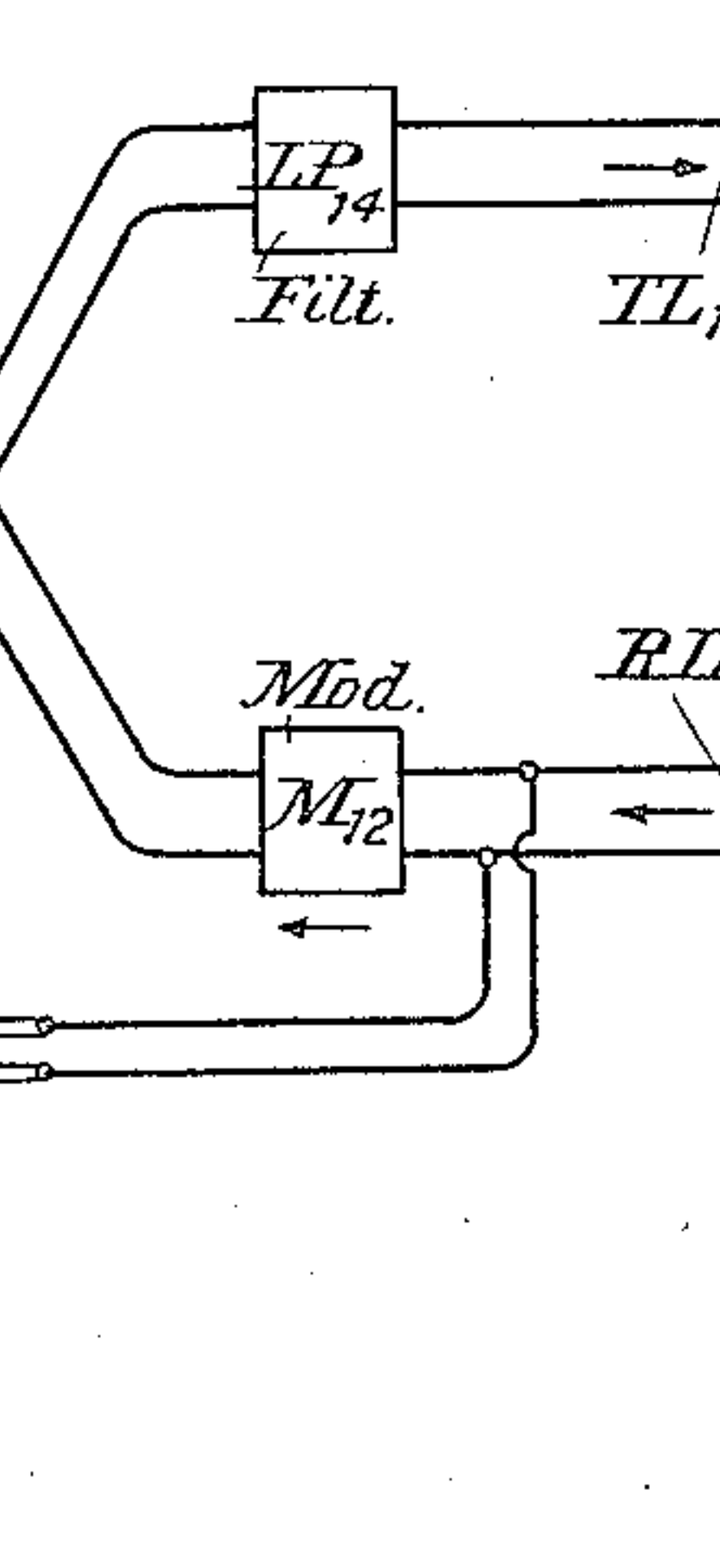
Terminal of Physical Four-wire Circuit



Switching Circuit



Terminal of Physical Four-wire Circuit



Carrier Supply for Talking Talking & Monitoring Circuit

Fig. 2

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3 Sheets-Sheet 2

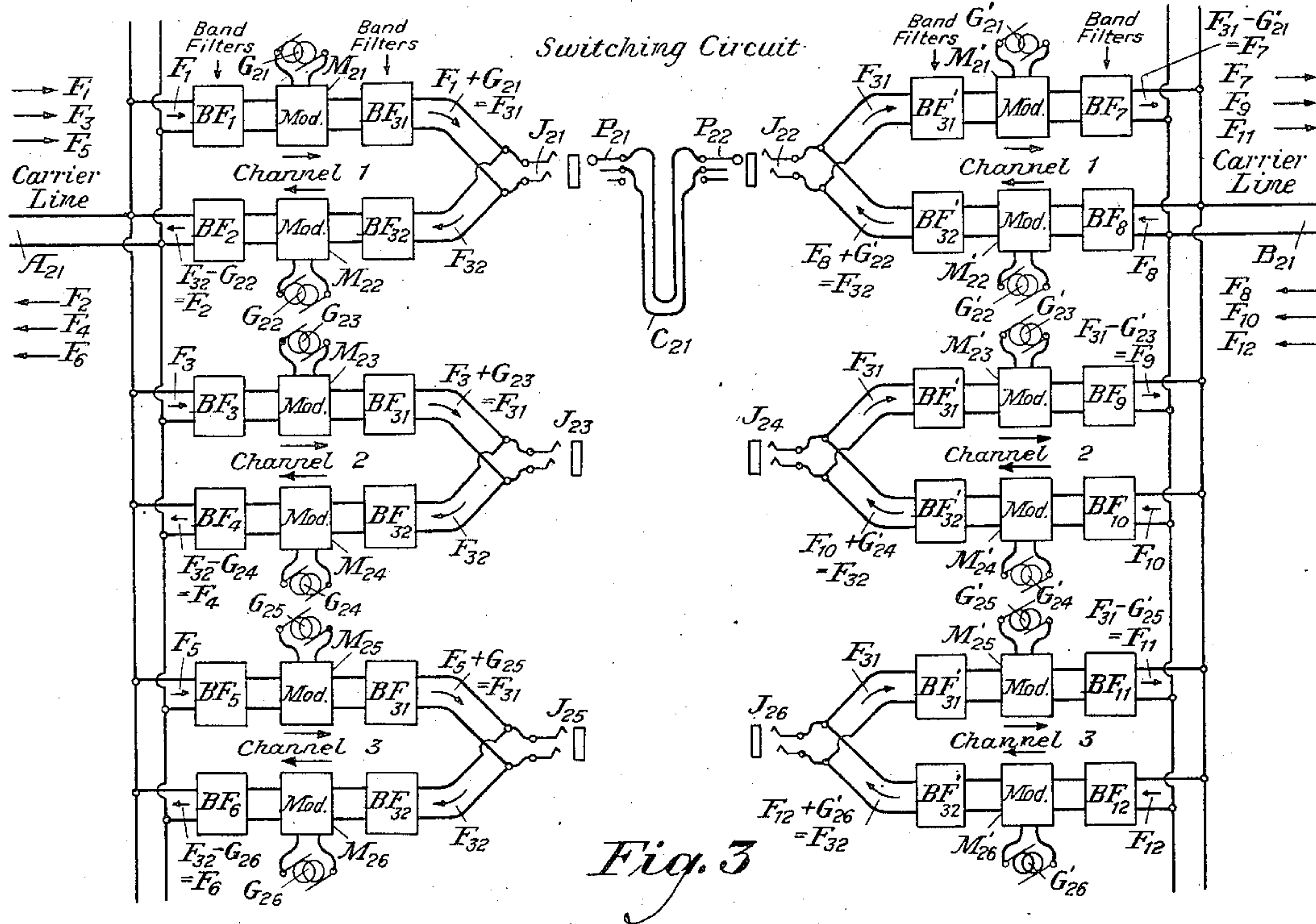


Fig. 3

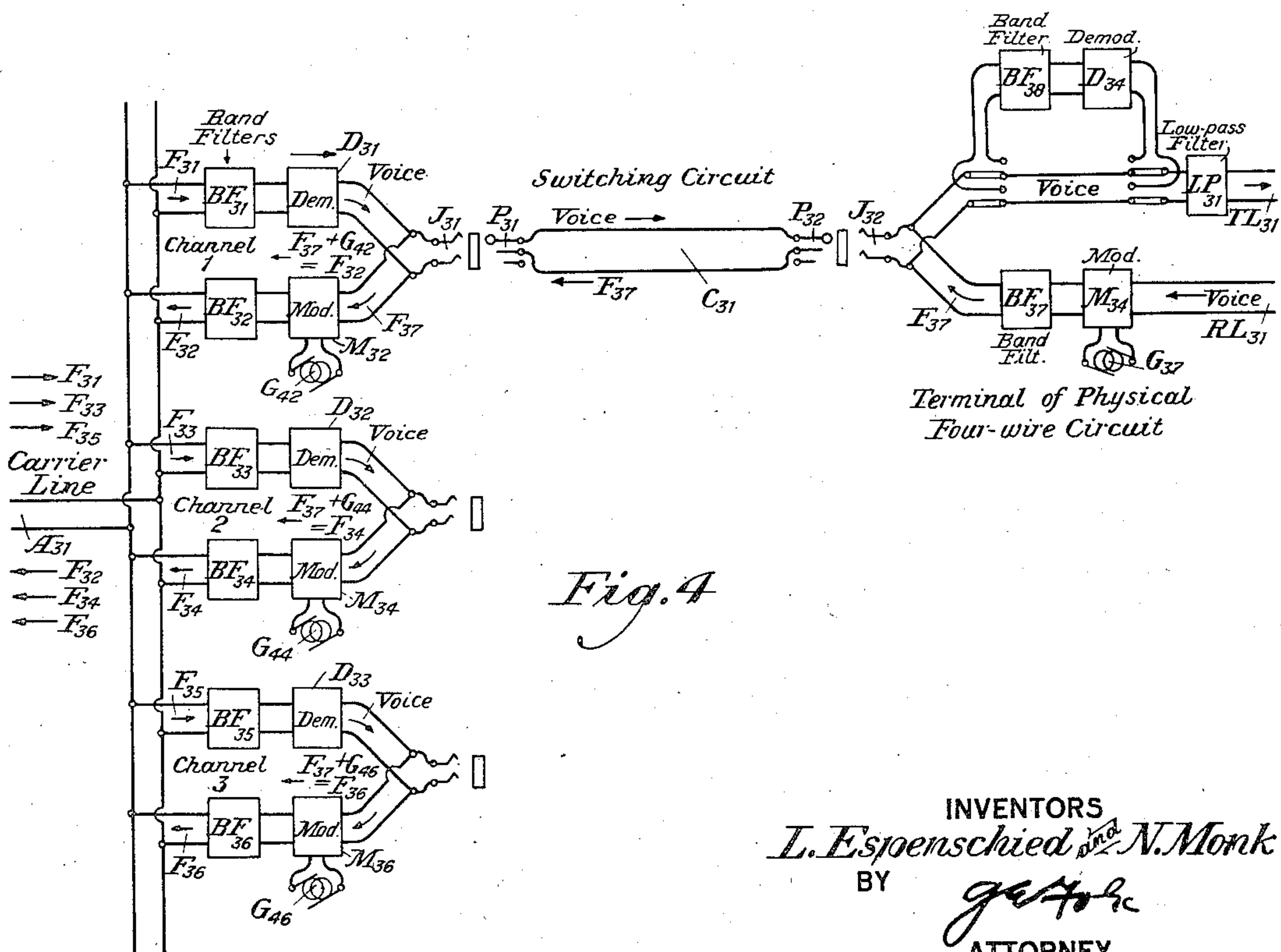


Fig. 4

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3 Sheets-Sheet 3

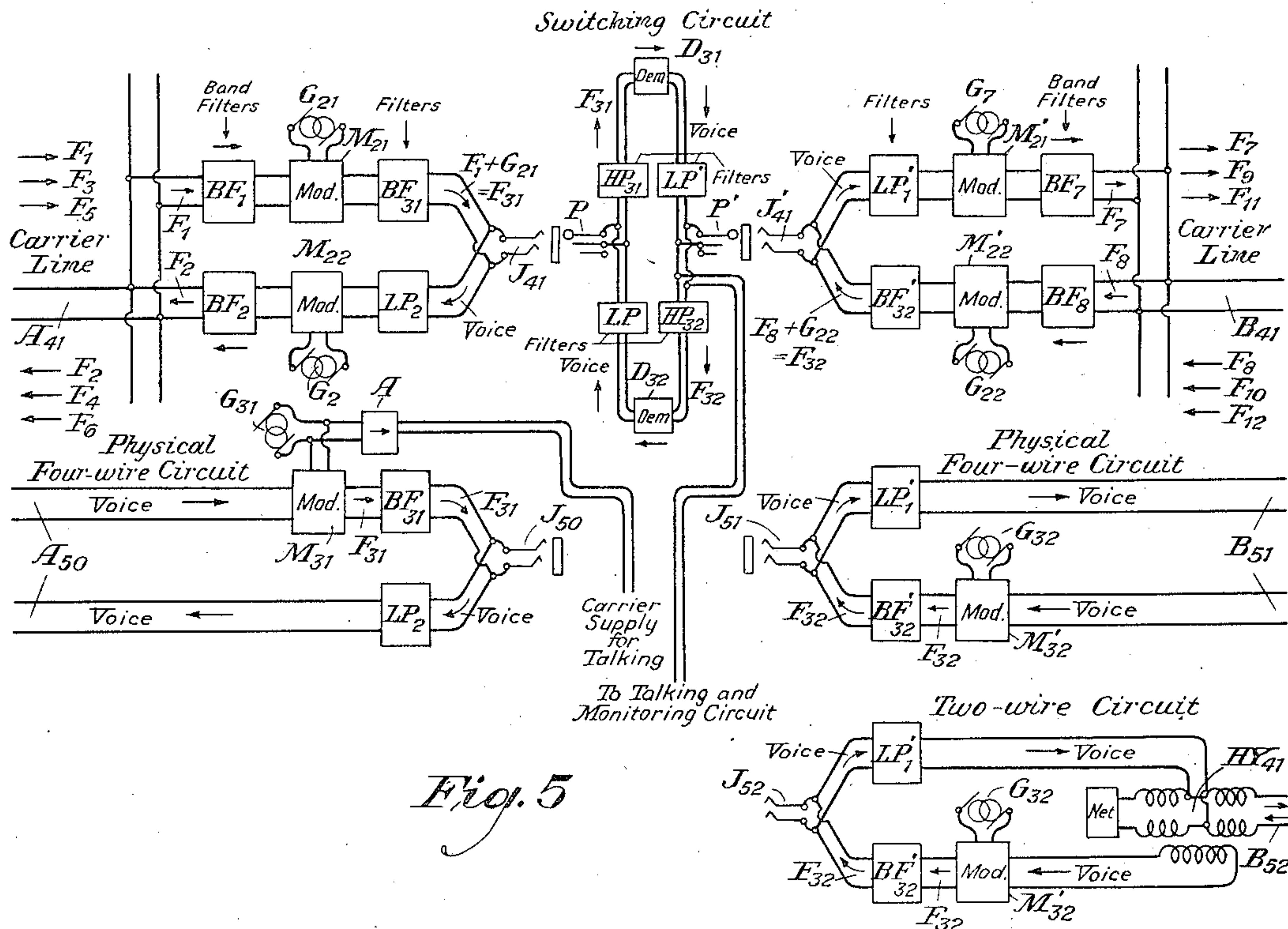


Fig. 5

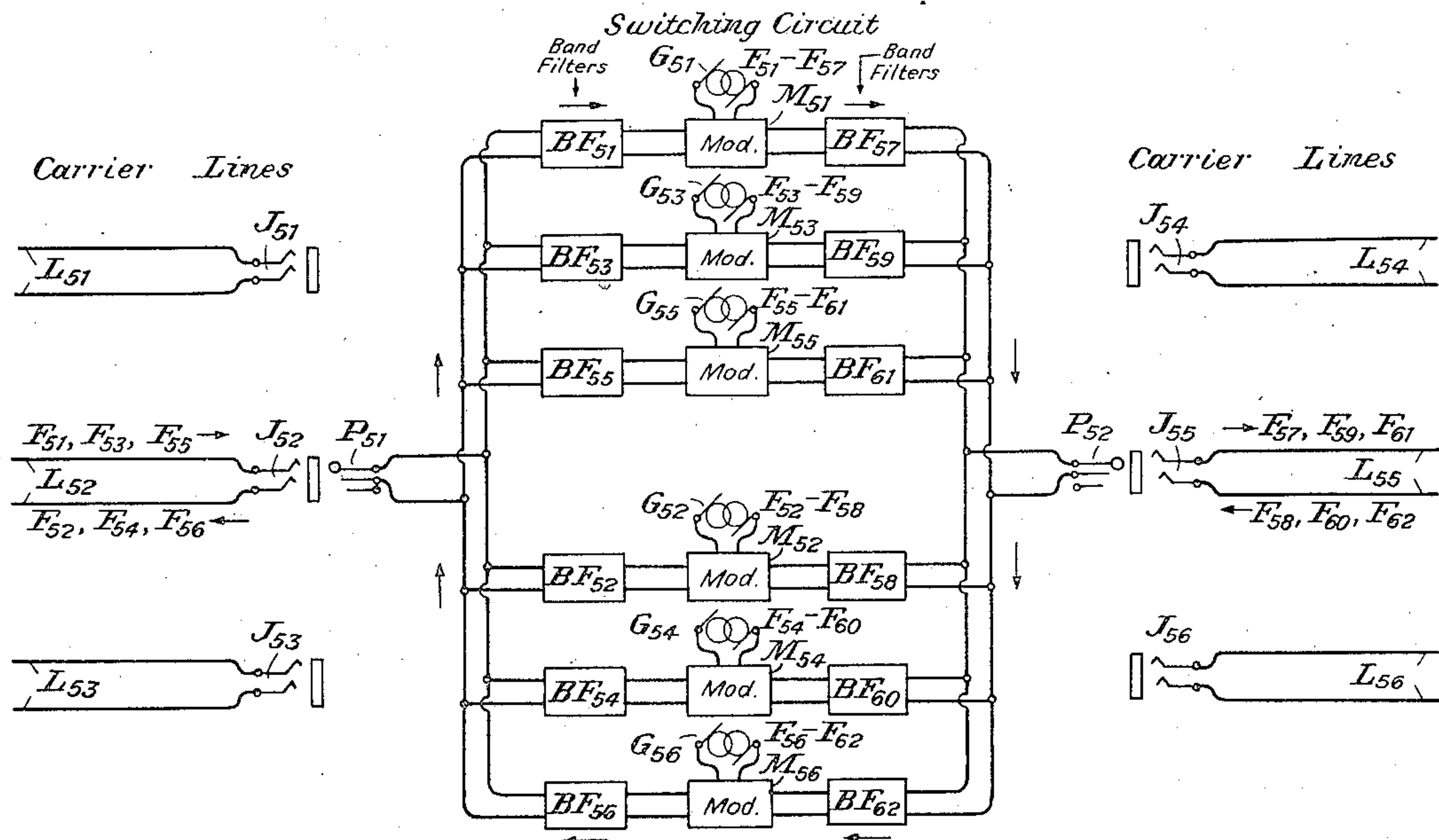


Fig. 6

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SWITCHING ARRANGEMENT FOR
FOUR-WIRE CIRCUITS

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Application March 2, 1933, Serial No. 659,410

18 Claims. (Cl. 179—15)

This invention relates to communication systems and more particularly to arrangements for switching physical or "equivalent" four-wire telephone circuits such as those in use today for long-haul service.

The present tendency in long distance telephone circuits is to employ separate transmission paths for transmission in opposite directions. These separate paths for opposite directional transmission may be physically distinct wire circuits as in the case of four-wire voice frequency transmission or they may be paths of different frequencies derived from a single physical circuit as is done in carrier transmission. The latter type of transmission has sometimes been called "equivalent four-wire" operation.

It becomes necessary for operating purposes at toll centers and other switching points to interconnect these various types of long distance circuits. This is ordinarily accomplished in the case of the voice frequency circuits by reducing them to two-wire circuits by the use of a hybrid coil and balancing network. In the case of the carrier frequency circuits the opposite directional transmission paths are converted to voice frequencies and reduced to a two-wire circuit by means of a hybrid coil. Both of these arrangements require that careful attention be paid to balance which is sometimes extremely difficult to secure.

The present invention involves the introduction into the four-wire circuit at its terminal of simple frequency translating, and selecting apparatus which provide means for superimposing the two sides of the four-wire circuit at different frequencies upon a simple two-wire circuit. Switching and monitoring may then be done on a simple two-wire basis. An additional advantage is obtained by the elimination of the problem of balance, the singing path through the cord circuit being entirely eliminated.

One object of the invention is thus to interconnect any two of a plurality of four-wire circuits by a two-wire circuit over which transmission in one direction is effected at one frequency and transmission in the opposite direction at a different frequency.

A further object of the invention is to interconnect any channel of a carrier telephone system with any channel of a second carrier telephone system by translating the opposite directional frequencies of each channel to two different common frequencies.

Still a further object of the invention is a

common arrangement whereby, by means of a two-wire circuit, one carrier channel may be connected to another carrier channel; a carrier channel to a physical four-wire circuit or a physical two-wire circuit; or a physical four-wire circuit to another physical four-wire or two-wire circuit.

Yet another object of the invention consists in interconnecting a group of communication channels operated at different frequencies over one line circuit with a second group of channels operated at a second set of different frequencies over a second line circuit by means of a single two-wire circuit in which is included apparatus for segregating the several channels of the incoming group of circuits and translating the frequencies of the several channels to the operating frequencies of the channels of the outgoing group of circuits with which they are to be connected.

These and other objects and aspects of the invention will be more fully understood from the following description when read in connection with the accompanying drawings in which Figure 1 is an arrangement for connecting two physical four-wire circuits by employing different frequencies in the switching circuit for the different directions of transmission, while Fig. 1a, when read in conjunction with Fig. 1, shows how the same arrangement may be used for connecting a physical four-wire circuit to a physical two-wire circuit. Fig. 2 shows an alternate arrangement for connecting together two physical four-wire circuits in which the principle of frequency translation is employed to provide a two-wire switching circuit. Fig. 3 shows an arrangement for connecting together two equivalent four-wire or carrier circuits in which the opposite directional frequencies of the two carrier circuits are converted to two different common frequencies for transmission over a two-wire switching circuit. Fig. 4 shows an arrangement for connecting a carrier or equivalent four-wire circuit to a physical four-wire circuit. Fig. 5 is a method for interconnecting physical four-wire, carrier or physical two-wire circuits, which is independent of the types of circuits to be interconnected. Fig. 6 shows a method for interconnecting a group of equivalent four-wire or carrier circuits operating over one line with a second group of carrier circuits operating over another line, the second group employing different frequencies from the first group.

For connecting two physical four-wire circuits, the arrangement shown in Fig. 1 may be employed. This shows two physical four-wire cir-

cuits with transmitting lines TL and TL' and receiving lines RL and RL', respectively, which may be connected to a switching circuit through the jacks and plugs J, P and J', P'. The transmission in one direction over the switching circuit takes place over a voice frequency path while transmission in the opposite direction is stepped up in frequency by means of a modulator M, passed over the switching circuit, reduced to voice frequencies through the demodulator D and passed into the line. For talking and monitoring a circuit is taken off from the switching circuit and connected through the hybrid coil HY to filters and the necessary modulating and demodulating equipment.

The circuit shown in Fig. 1 is designed to operate as follows: From the receiving line RL of the physical four-wire circuit shown on the left side of the figure, transmission passes through the modulator M which is supplied with a carrier frequency from source G through the one-way device A whereby the voice frequencies are stepped up to some modulated carrier frequency above the voice range. The transmission then passes through the filter HP, jack J and plug P to the common switching circuit, thence through plug P' and jack J' to the high pass filter HP' and the demodulator D, at which point it is reduced to a voice frequency again and transmitted to the transmitting line TL' of the four-wire circuit shown on the right-hand side of the diagram. Transmission in the opposite direction is accomplished from the line RL' through the low pass filter LP', jack J' and plug P', over the common switching circuit to the plug P and jack J and the low pass filter LP and out to the transmitting line TL, the high pass filters HP and HP' preventing the transmission from taking the wrong paths.

For purposes of talking and monitoring, a circuit is taken off the common switching circuit and connected to a hybrid coil HY with its balancing network N. For talking over the line TL, speech passes from the transmitter T through the low pass filter LP₁ and hybrid coil HY through the filter LP and thence to the line TL. For transmitting in the opposite direction the voice frequencies from the transmitter T are modulated by means of modulator M₁, passed through the high pass filter HP₁ and the hybrid coil HY and thence through filter HP' to the demodulator D where they are reduced to the voice frequency range and passed into the line TL'. The modulator M₁ is supplied with carrier frequency from the source G through the one-way device A₁. For monitoring, speech coming from line RL is modulated as before by modulator M with its associated carrier frequency supply, passed through the high pass filter HP and through the hybrid coil and high pass filter HP₂ to the demodulator D₁ where it is reduced to voice frequency again and picked up in the receiver R. For monitoring speech currents from the opposite direction, the voice frequencies from the line RL' are passed through the low pass filter LP', the hybrid coil HY, and low pass filter LP₂, respectively, into the monitoring receiver R.

It may also be desirable to employ the switching circuit shown in Fig. 1 for connection to a two-wire circuit instead of a four-wire circuit. This may be readily accomplished by employing at the terminal of the two-wire circuit a hybrid coil arrangement. This is illustrated in Fig. 1a which may be substituted for that part of Fig. 1 to the right of the dotted line a-a. The hybrid

coil arrangement HY' is substituted for the physical four-wire circuit TL' and RL', thus permitting the four-wire circuit at the left of Fig. 1 to be connected to the two-wire circuit TW shown in Fig. 1a.

The arrangement of Fig. 1 requires that modulating, demodulating and filter equipment be permanently connected into the transmitting and receiving branches of the physical four-wire circuits. This could be avoided by the insertion of jacks and plugs in each branch of the four-wire circuits at the points X in Fig. 1 and omitting the jacks and plugs J, J' and P, P'. To simplify operation four-way jacks and plugs could be used.

Another arrangement for connecting together two physical four-wire circuits is shown in Fig. 2. In this arrangement a two-wire connecting circuit is employed, the switching circuit being arranged to connect to the terminals of the four-wire circuits through jacks and plugs J₁₁ and P₁₁ and J₁₂ and P₁₂.

The operation of the circuit of Fig. 2 is as follows: Transmission coming in over the branch RL₁₁ of the four-wire circuit shown on the left of the figure is modulated by modulator M₁₁ which is supplied with a source of carrier frequency from the generator G₁₁ through the one-way device A₁₁ which may be a vacuum tube amplifier. The modulated high frequency passes into the switching circuit through jack J₁₁ and plug P₁₁ and is prevented from going through the lower branch of the switching circuit by the low pass filter LP₁₂. Accordingly, it passes through the high pass filter HP₁₂ and the demodulator D₁₁, in which it is dropped to the voice frequency range. The voice frequency currents are passed by the filter LP₁₃ through plug P₁₂ and jack J₁₂ and filter LP₁₄ into the line TL₁₂ which forms the outgoing branch of a second four-wire circuit. Transmission in the reverse direction is accomplished from circuit RL₁₂ to circuit TL₁₁ in an exactly analogous manner through modulator M₁₂, high pass filter HP₁₁, demodulator D₁₂ and low pass filters LP₁₂ and LP₁₁. The modulators M₁₁ and M₁₂ are supplied with carrier frequency from the source G₁₁ through one-way devices A₁₁ and A₁₂. These devices are for the purpose of preventing coupling between the various branches of the circuits. The one-way devices A₁₃ and A₁₄ serve as alternate arrangements for supplying carrier frequency to the modulators M₁₁ and M₁₂ in which case the one-way devices A₁₁ and A₁₂ and their associated wiring may be omitted.

In case it is desired to talk and monitor over the cord circuit this may be accomplished by means of a monitoring circuit similar to that shown in Fig. 1 which may be connected as indicated in Fig. 2.

In the arrangement shown in Fig. 2, it may be desirable to employ two different carrier frequencies instead of a single carrier frequency and the voice frequency circuit. This may be readily accomplished by the introduction of additional demodulators and the proper filters.

The arrangements so far described have been for the purpose of connecting together two physical four-wire circuits or a physical four-wire circuit to a physical two-wire circuit. Where it is required to connect together two carrier or equivalent four-wire circuits, the arrangement of Fig. 3 may be employed.

In this arrangement the carrier frequencies assigned to the transmitting channels of one of

the carrier systems are changed in frequency to some common frequency differing from the frequencies used by any of the carrier systems to be connected together. The receiving carrier frequencies of the receiving channels of a second carrier system to which the first is to be connected are derived by suitable translation of the common frequency to which the first carrier frequency channels were changed. Similarly the transmitting channels of the second system transmitting in the reverse direction are shifted to another common frequency and the frequencies of the receiving channels of the first carrier system are derived therefrom. Two channels operating on different frequencies may thus be connected together. By raising the frequencies of all of the channels of the carrier systems to be interconnected to two common frequencies, one for transmission in one direction and one for transmission in the reverse direction, any channel of any carrier system may be connected to any channel of any other carrier system. By means of additional filters, modulators and demodulators connected to the switching circuit as shown in Fig. 1, talking and monitoring over the switching circuit may also be accomplished.

The operation of the arrangement of Fig. 3 may be explained as follows: It is desired to connect channel 1 of the carrier system operating over the line A₂₁ with a channel of another carrier system operating over the line B₂₁. Communication is accomplished over channel 1 of the first carrier system by the use of two different frequencies F₁ and F₂, for transmission in opposite directions, while transmission over the carrier channel of the second system is effected by the use of two carrier frequencies F₇ and F₈ which may be the same as frequencies F₁ and F₂ or they may be different frequencies. These carrier frequencies may be any frequencies suitable for carrier frequency transmission. The incoming voice modulated carrier frequency currents from line A₂₁ are selected by the band filter BF₁ and raised in frequency by the modulator M₂₁, which is supplied with a source of carrier frequency G₂₁ to some frequency $F_{31}=F_1+G_{21}$ well above the frequencies normally used for carrier transmission. The modulated high frequency current F₃₁ including one side band is selected by filter BF₃₁ and passed through jack J₂₁ and plug P₂₁ and passed over the switching circuit C₂₁ and thence through plug P₂₂ and jack J₂₂ and band filter BF₃₁' into the modulator M₂₁'. M₂₁' is supplied with a source of carrier frequency G₂₁' such that when combined with the incoming modulated frequency F₃₁, the frequency F₇ is produced. This frequency and one of its accompanying side bands is selected by the band filter BF₇ and passed on to carrier line B₂₁. Transmission is effected from carrier line B₂₁ to carrier line A₂₁ in a similar manner, the common modulated carrier frequency F₃₂ and its accompanying side band being different from that used for transmission in the opposite direction.

By employing suitable frequencies in connection with modulators M₂₃, M₂₄, M₂₅, M₂₆, M₂₃', M₂₄', M₂₅', M₂₆', transmission in one direction through the switching circuit may be effected by the common frequency F₃₁ and transmission in the opposite direction by the common frequency F₃₂. Thus any channel of any carrier system so arranged may be connected to any channel of any other carrier system by means of the circuit illustrated. For example, by inserting plug P₂₁

in jack J₂₃ and plug P₂₂ in jack J₂₆, transmission may be effected from channel 2 of the carrier system indicated on the left of the figure to channel 3 of the carrier system on the right of the figure.

Although in the arrangement shown in Fig. 3 the frequencies used for transmission in opposite directions through the switching circuit are different carrier frequencies F₃₁ and F₃₂, it would be possible to employ the voice frequency range for one direction of transmission, say the direction from east to west, by assigning such frequencies to the generators G₂₂', G₂₄', and G₂₆' as to step the received carrier frequencies to zero. The frequencies assigned to generators G₂₂, G₂₄ and G₂₆ will then be F₂, F₄ and F₆. The filters BF₃₂ and BF₃₂' will then be designed to pass the voice band.

Still another arrangement employing the principles outlined in this invention may be used for connecting a carrier or superimposed four-wire circuit to a physical four-wire circuit. An arrangement for doing this is shown in Fig. 4. Modulated carrier frequency coming in from the carrier line is selected by the proper filter, demodulated, passed through jack J₃₁ and plug P₃₁ and over the switching circuit C₃₁ through plug P₃₂ and jack J₃₂ and low pass filter LP₃₁ to the outgoing line of the physical four-wire circuit. Transmission in the opposite direction is effected by modulating the voice frequencies coming from the physical four-wire circuit, transmitting them as high frequencies over the switching circuit C₃₁ and again modulating the high frequency currents to a frequency which is the same as that of the outgoing carrier frequency.

In more detail the operation of this circuit is as follows: The incoming modulated carrier frequency current corresponding to channel 1 of a carrier system operating over line A₃₁ and employing carrier frequencies F₃₁ and F₃₂ is selected and passed by the band filter BF₃₁, demodulated to a voice frequency by the demodulator D₃₁, transmitted through jack J₃₁ and plug P₃₁ and the switching circuit C₃₁ through plug P₃₂ and jack J₃₂ and low pass filter LP₃₁ to the outgoing line TL₃₁ of the physical four-wire circuit. Speech coming in from the incoming line RL₃₁ of the physical four-wire circuit is modulated by means of modulator M₃₄ with a high frequency supplied by the generator G₃₇ and passed through jack J₃₂ and plug P₃₂, the switching circuit C₃₁, plug P₃₁ and jack J₃₁ into modulator M₃₂ where it is again modulated by a carrier frequency G₄₂ of such a value that the interaction of frequencies G₄₂ and F₃₇ provides a frequency F₃₂. The modulated carrier frequency F₃₂ and its appropriate side band are selected by band filter BF₃₂ and passed through it to the carrier system. The frequency of the generator G₃₇ may be chosen to be of such value that it lies outside the range of frequencies normally used for carrier transmission.

Here again, although the frequency bands used for illustration in Fig. 4 for transmission in opposite directions through the switching circuit consist of a voice frequency band and a carrier frequency band, it would be possible to employ two different carrier frequency bands differing in turn from any band employed by the carrier systems. In this case, the band filter BF₃₈ and the demodulator D₃₄ which are shown in Fig. 4 would be included in the outgoing branch of the physical four-wire circuit.

Still another arrangement by which it is possible to connect one carrier channel to another

carrier channel; a carrier channel to a physical four-wire circuit or a physical two-wire circuit; or a physical four-wire circuit to another physical four-wire or two-wire circuit is illustrated in Fig. 5. The arrangement shown in this figure comprises a very flexible circuit arrangement by which practically any type of circuit may be interconnected to any other type of circuit by a two-wire switching circuit. The switching circuit employed is, in general, similar to that illustrated in Fig. 2. A talking and monitoring arrangement may be associated with the switching circuit. Such an arrangement, which might be similar to that shown in Fig. 1, could be connected to the circuit as indicated in the figure.

The operation of Fig. 5 is as follows: Assuming that the carrier channel of line A₄₁ which employs the carrier frequencies F₁ and F₂ is to be connected to the carrier channel of line B₄₁ which employs the carrier frequencies F₇ and F₈, the plug P of the switching circuit will be inserted in the jack J₄₁, and the plug P' in the jack J₄₁'. The carrier frequency F₁ from the carrier line A₄₁ will then be combined in the modulator M₂₁ with the frequency G₂₁ to produce a frequency F₃₁ which passes through the filter HP₃₁ of the switching circuit to the demodulator D₃₁. The demodulator D₃₁ steps the frequency F₃₁ down to the voice frequency which passes through the low pass filter LP' and thence over the plug P' and jack J₄₁' and through the low pass filter LP₁' to the modulator M₂₁'. The voice current is modulated on the frequency F₇ supplied to the modulator M₂₁', and the carrier frequency F₇ and the side band or bands pass through the filter BF₇ to the line B₄₁. In transmitting in the opposite direction the carrier frequency F₈ from the line B₄₁ is modulated with the frequency G₂₂ in the modulator M₂₂' to produce the frequency F₃₂ which passes through the band filter BF₃₂' and through the high pass filter HP₃₂ in the lower branch of the switching circuit to the demodulator D₃₂. The demodulated voice frequency from the output of the demodulator D₃₂ passes through the low pass filter LP and over the plug P in jack J₄₁, and thence through the low pass filter LP₂ to the modulator M₂₂. In this modulator the voice frequency modulates the carrier frequency F₂, and the carrier frequency F₂ and the side band pass through the band filter BF₂ to the line A₄₁. It will be understood, of course, that other channels of the carrier line A₄₁ will have such frequencies assigned to terminal modulators of the line as to translate the other eastbound carriers to the frequency F₃₁, and likewise, the line B₄₁ will have such frequencies assigned to its modulators as to translate the other westbound carriers to the frequency F₃₂. Consequently, any carrier channel of the line A₄₁ could be connected to any carrier channel of the line B₄₁ through the switching circuit.

Assuming the carrier channel employing frequencies F₁ and F₂ of the line A₄₁ is to be connected to the physical four-wire circuit B₅₁, the plug P' of the switching circuit will be connected to the jack J₅₁ of the physical four-wire circuit. The eastbound transmission F₁ will appear as a voice frequency at the plug P', and passing over the jack J₅₁ will be transmitted through the filter LP₁' to the east-going line of the physical four-wire circuit B₅₁. The voice frequency from the westbound line of the four-wire circuit will modulate the frequency F₃₂ supplied to the modulator M₃₂', and the frequency F₃₂ and its side band

will pass through the filter BF₃₂', thence passing over the jack J₅₁ and the plug P' into the lower branch of the switching circuit from which point the operation will be as previously described.

In the case of the connection from the line A₄₁ to the two-wire line B₅₂, since the two-wire line terminates in eastbound and westbound branches by means of the hybrid coil HY₄₁, and these two branches contain the same apparatus as is used in the four-wire circuit B₅₁, the operation when the line A₄₁ is connected to the line B₅₂ will be obviously similar to that described in connection with the line B₅₁.

If the physical four-wire circuit A₅₀ is to be connected to the carrier channel comprising frequencies F₇ and F₈ of line B₄₁, the eastbound voice frequency in the upper line of the four-wire circuit will be modulated in the modulator M₃₁ upon the carrier frequency F₃₁ and the modulated carrier will pass through the band filter BF₃₁ and over the jack J₅₀ into the upper branch of the switching circuit. In the switching circuit the demodulator D₃₁ again steps the frequency down to the voice range, and the demodulated voice frequency passes over the jack J₄₁' and through the filter LP₁' of the upper carrier channel of the line B₄₁ to the modulator M₂₁'. In the modulator M₂₁' the voice frequency is modulated on the carrier F₇ supplied by generator G₇ and transmitted to the line B₄₁. The carrier F₈ from the line B₄₁ transmitted in the opposite direction is by means of modulator M₂₂', translated to the frequency F₃₂ which passes into the lower branch of the switching circuit and is demodulated by means of the demodulator D₃₂ to the voice frequency which passes over the jack J₅₀ and through the low pass filter LP₂ into the lower line of the physical four-wire circuit A₅₀.

If the four-wire circuit A₅₀ is to be connected to the four-wire circuit B₅₁, the voice frequency after being stepped up to the frequency F₃₁ in the upper line of the four-wire circuit will pass through the upper branch of the switching circuit wherein it is stepped down again to voice frequency. The voice frequency then passes over the jack J₅₁ into the eastbound line of the physical four-wire circuit B₅₁. The voice frequency from the westbound line of the four-wire circuit B₅₁ modulates the frequency F₃₂ in the modulator M₃₂' and the modulated frequency then passes through the band filter BF₃₂' into the lower branch of the switching circuit where it is stepped down to voice frequency by means of the demodulator D₃₂, the voice frequency then passing to the lower line of the physical four-wire circuit A₅₀.

If the four-wire circuit A₅₀ is to be connected to the two-wire line B₅₂ the operation will be similar to that just described.

Still another arrangement which embodies the general principles of the invention is illustrated in Fig. 6. By means of this arrangement two carrier telephone systems having different frequency assignments may be connected together by a switching circuit which includes selecting band filters and modulators for changing the incoming frequencies of one carrier system to the outgoing frequencies of the other carrier system and the reverse. A number of different filters and modulators are connected in parallel in the switching circuit, thereby making possible the interconnection of carrier lines employing a wide variety of frequencies by the same switching circuit.

Referring to Fig. 6, the operation of the ar-

rangement is as follows: The incoming modulated carrier frequency F_{51} representing one channel of any one of the carrier lines on the left of the figure, such as L_{52} , is transmitted through jack J_{52} and plug P_{51} to the switching circuit. Here it is selected by the band pass filter BF_{51} and modulated by modulator M_{51} . Modulator M_{51} is supplied by a source of carrier frequency G_{51} , the frequency of which is equal to the difference between the frequency F_{51} and the frequency F_{57} , which is assumed to be the outgoing carrier frequency of the channel to which the incoming channel of frequency F_{51} is to be connected. The proper modulation products and the frequency F_{57} , if necessary, issuing from the modulator M_{51} are selected by the band filter BF_{57} and transmitted to the carrier line L_{55} through plug P_{52} and jack J_{55} . Signals coming in the opposite direction, such as the modulated frequency F_{58} from the carrier line L_{55} are transmitted through the switching circuit in an exactly analogous manner, being modulated in the switching circuit by modulator M_{52} with a frequency equal to the difference between F_{58} and F_{52} , the frequency F_{52} being the opposite direction channel frequency of the carrier system corresponding to the incoming frequency F_{51} . A plurality of band filters and modulators are connected in the switching circuit as shown, in order that all channels of any of the carrier lines shown on the left may be connected to all channels of any of the carrier lines shown on the right. It should be noted that the frequencies assigned to the carrier lines may be any different frequencies, it merely being necessary to provide in the switching circuit suitable band filters and modulators supplied with frequencies equal to the difference between the frequencies of the channels which it is desired to connect together.

It will be obvious that the general principles herein disclosed may be employed in many other organizations widely different from those illustrated without departing from the spirit of the invention as illustrated above and defined in the appended claims.

What is claimed is:

1. In a telephone switching office having terminated therein a plurality of physical four-wire circuits, a plurality of carrier lines having superimposed on each a plurality of equivalent four-wire circuits, a plurality of two-wire physical circuits and a switching circuit for interconnections, the method for interconnecting any circuit to any other circuit comprising the translating of the opposite directional frequencies of any pair of circuits to be interconnected to two different common frequencies for transmission over the switching circuit.

2. In a telephone toll switching office having terminated therein a plurality of physical four-wire circuits, a plurality of carrier lines having superimposed on each a plurality of equivalent four-wire circuits, and a plurality of two-wire physical circuits, a switching circuit to interconnect any circuit to any other circuit, and means for translating the opposite directional frequencies of any pair of circuits to be interconnected to two different common frequencies for transmission over said switching circuit, said switching circuit including means for talking and monitoring on any circuits to which said switching circuit may be connected.

3. In a telephone system, means for switching a plurality of two-way communication channels including a switchboard provided with terminals

of a plurality of line circuits carrying a plurality of communication channels, a pair of terminals for each of said channels available on the switchboard for making connection thereto, a switching circuit for interconnecting any two of said channels upon call, said switching circuit including two pairs of movable contacts, and means related to said switching circuit for translating the incoming frequency band of each channel to the outgoing frequency band of the corresponding channel.

4. An electric communication switchboard comprising a plurality of two-wire line circuits conveying communication channels on particular frequency bands and each of said channels appearing on a pair of terminal contacts, and means for connecting together upon call any two of said pairs of contacts, and means for translating the frequency bands of one of the corresponding communication channels to the frequency bands of the other.

5. In a telephone switching office, the method for interconnecting four-wire circuits which consists in translating the frequency band of the incoming transmission from one direction at the switching office to some common frequency band, translating the frequency band of the incoming transmission in the opposite direction at the switching office to some other common frequency band, transmitting the two different opposite directional common frequency bands over at least a portion of a switching circuit and retranslating the two common frequency bands to the frequency bands employed for the outgoing transmission.

6. In a telephone switching office, the method for interconnecting physical four-wire circuits which consists in translating the frequency band of the incoming transmission from one direction at the switching office to some common frequency band for transmission over a switching circuit, translating the frequency band of the incoming transmission in the opposite direction at the switching office to some other common frequency band, transmitting the two different opposite directional frequency bands over a switching circuit and retranslating the two frequency bands to the frequency bands employed for the outgoing transmission.

7. The method of interconnecting by a switching circuit at a switching point a plurality of physical four-wire circuits in pairs for two-way telephone communication, which consists in raising the incoming voice frequencies from each incoming line at the switching point to some frequency band above the voice frequency range and translating in the switching circuit the modulated high frequency currents received from each incoming line into voice frequency currents for transmission over each outgoing line.

8. In a telephone switching office in which a plurality of carrier frequency channels are to be interconnected in pairs for two-way communication, the method which consists in raising the incoming modulated carrier frequencies from each incoming channel in one direction to some common frequency band different from those used by the carrier channels, interconnecting one of said channels to an outgoing circuit in the same direction by a switching circuit, translating the common frequency band so that in each outgoing carrier channel in the same direction will appear the frequency band used for transmission over its carrier line, transmission in the reverse direction occurring in a similar manner but employing

a second common carrier frequency band which is different from the first mentioned common frequency band.

9. In a telephone switching office, the method for interconnecting equivalent four-wire circuits which consists in translating the frequency band of the incoming transmission from one direction to some common frequency band, translating the frequency band of the incoming transmission in the opposite direction to some other common frequency band, transmitting the two different opposite directional frequency bands over at least a portion of a switching circuit and retranslating the two frequency bands to the frequency bands employed for the outgoing transmission.

10. In a telephone switching office in which are terminated a plurality of carrier frequency lines, each having a plurality of two-way communication channels operating over it, and a plurality of physical four-wire circuits the method for interconnecting any one of said carrier communication channels to any one of said physical four-wire circuits which consists in translating the incoming modulated carrier frequencies to the voice frequency range, passing the voice frequencies over a portion of a switching circuit to the outgoing branch of the physical four-wire circuit; translating the voice frequencies from the incoming branch of the physical four-wire circuit to some frequency band different from the frequency bands employed by the carrier circuits, passing said modulated high frequency band over a portion of the switching circuit and translating said modulated high frequency band to the outgoing frequency band of the carrier channel.

11. In a telephone switching office, the method for connecting any one of a plurality of carrier frequency lines, each of which has operating over it a plurality of communication channels, to any other of said carrier frequency lines which consists in separating the incoming carrier channels in a switching circuit, and translating the frequency band of each incoming carrier channel to the frequency band of the corresponding outgoing carrier channel.

12. In a telephone switching office containing a plurality of physical four-wire circuits, means for interconnecting any two of said circuits comprising translating means at the switching office for raising the incoming voice frequencies in each incoming branch of said circuits to some frequency band above the voice frequency range and superimposing this incoming high frequency branch on the outgoing voice frequency branch, a switching circuit having two branches each branch including means for selecting and translating each incoming high frequency band to the voice frequency range and means for connecting each end of the switching circuit to the physical four-wire circuits.

13. In a telephone switching office containing a plurality of physical four-wire circuits means for interconnecting any two of said circuits comprising translating means in each incoming branch of said circuits for raising the incoming voice frequencies to some frequency band above the voice frequency range and superimposing this incoming high frequency branch on the outgoing voice frequency branch, a switching circuit having two branches each branch including means for selecting and translating each incoming high frequency band to the voice frequency range and means for connecting each end of the switching circuit to

the physical four-wire circuits, said switching circuit including means for talking and monitoring on the interconnected circuits.

14. In a telephone switching office, a plurality of physical four-wire circuits, each of said four-wire circuits including translating means in its incoming branch for raising the incoming voice frequency to some frequency band above the voice frequency range, the incoming high frequency and outgoing low frequency branches of each of said four-wire circuits being connected together, a two-wire switching circuit for connecting any one of said physical four-wire circuits to any other of said physical four-wire circuits, said switching circuit including means for passing the transmission in opposite directions over two separate branches, each branch including means for selecting the incoming modulated high frequency band and translating it to voice frequencies, and means for connecting said switching circuit to the physical four-wire circuits.

15. In a telephone switching office in which are terminated a plurality of carrier telephone lines each line having superimposed thereon a number of communication channels employing different frequencies for the different directions of transmission, means for terminating each channel in two branches, one branch for receiving and one branch for transmitting, the two branches being connected together on the office side, means included in the receiving branch for selecting and translating the received frequency band to some other frequency band b_1 , differing from any frequency band employed on the carrier lines, means included in the transmitting branch for selecting and changing a common frequency band b_2 , differing from any frequency band used on the carrier lines and differing from b_1 , to that frequency band normally used for transmission over that particular channel of the carrier line, and means comprising a switching circuit for interconnecting any channel of one carrier line to another channel.

16. In a telephone switching office in which are terminated a plurality of carrier telephone lines, each line having superimposed thereon a number of communication channels employing different frequencies for the different directions of transmission, means for terminating each channel in two branches, one branch for receiving and one branch for transmitting, the two branches being connected together on the office side, means included in the receiving branch for selecting and translating the received frequency band to some common frequency band, differing from any frequency band employed on the carrier lines, means included in the transmitting branch for selecting and changing another common frequency band, differing from any frequency band used on the carrier lines and differing from said first-mentioned common band, to that frequency band normally used for transmission over that particular channel of the carrier line, a plurality of physical four-wire circuits, means for interconnecting any terminal of any carrier channel to any terminal of any physical four-wire channel comprising a two-wire switching circuit, the incoming branch of each four-wire circuit including a modulator for raising the incoming voice frequencies to a common frequency band to said switching circuit, and a demodulator so related to each outgoing branch as to translate a common modulated frequency band to voice frequencies.

17. In a telephone toll switching office, a plu-

5 rality of carrier lines, each line having super-
imposed thereon a plurality of channels employ-
ing different frequencies for the different direc-
tions of transmission, means for terminating each
10 channel in two branches for the opposite direc-
tions of transmission, said branches being con-
nected together on the office side, the incoming
branch containing translating means for the pur-
pose of shifting the incoming modulated carrier
15 frequencies to frequencies in a common range,
and each outgoing branch including means for
translating another common band to the fre-
quency band of the outgoing carrier channel, a
plurality of four-wire circuits, the incoming
20 branch of each of said four-wire circuits contain-
ing a translating device for the purpose of rais-
ing the incoming voice frequency band to a com-
mon carrier frequency band differing from any
frequency band employed on the carrier lines, the
outgoing branch of each of said four-wire circuits
containing voice frequency selecting means, said
incoming high frequency and outgoing low fre-

quency branches of said four-wire circuit being
connected together, and switching means for
interconnecting any carrier channel to any physi-
cal four-wire circuit.

18. In a telephone switching office having a plu- 5
rality of carrier lines associated therewith, each
line having superimposed thereon a plurality of
communication channels operating on different
frequencies, said lines comprising two groups, 10
each line of each group employing the same set of
carrier frequencies but the two groups employing
different sets of frequencies, means for intercon-
necting all of the channels on any line of one
group to all of the channels on any line of the
second group comprising a two-wire switching 15
circuit, said circuit including in parallel a plu-
rality of selecting filters and modulators for
translating the frequency of each channel of one
group of carrier lines to the corresponding chan-
nel of the second group of carrier lines. 20

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