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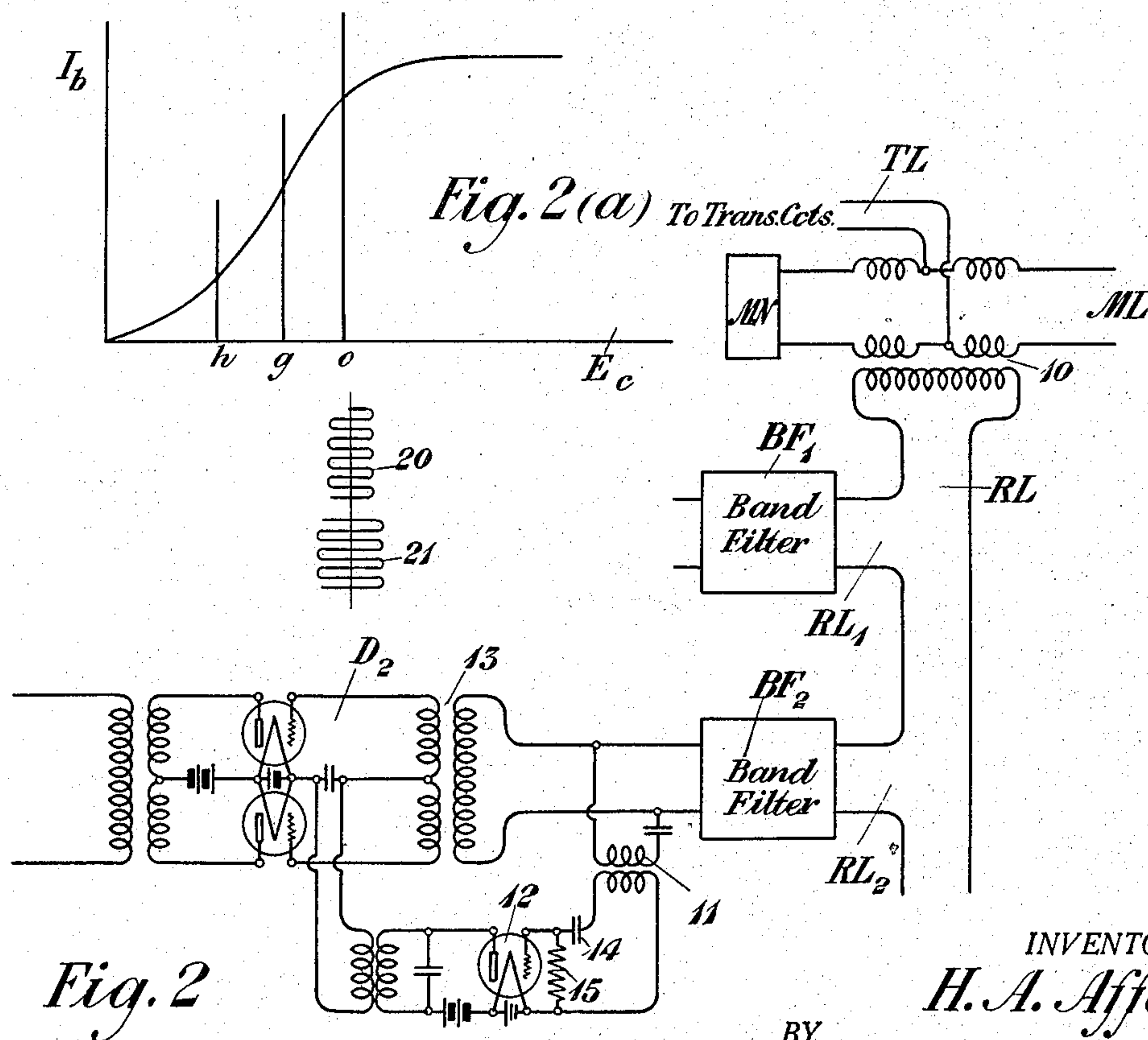
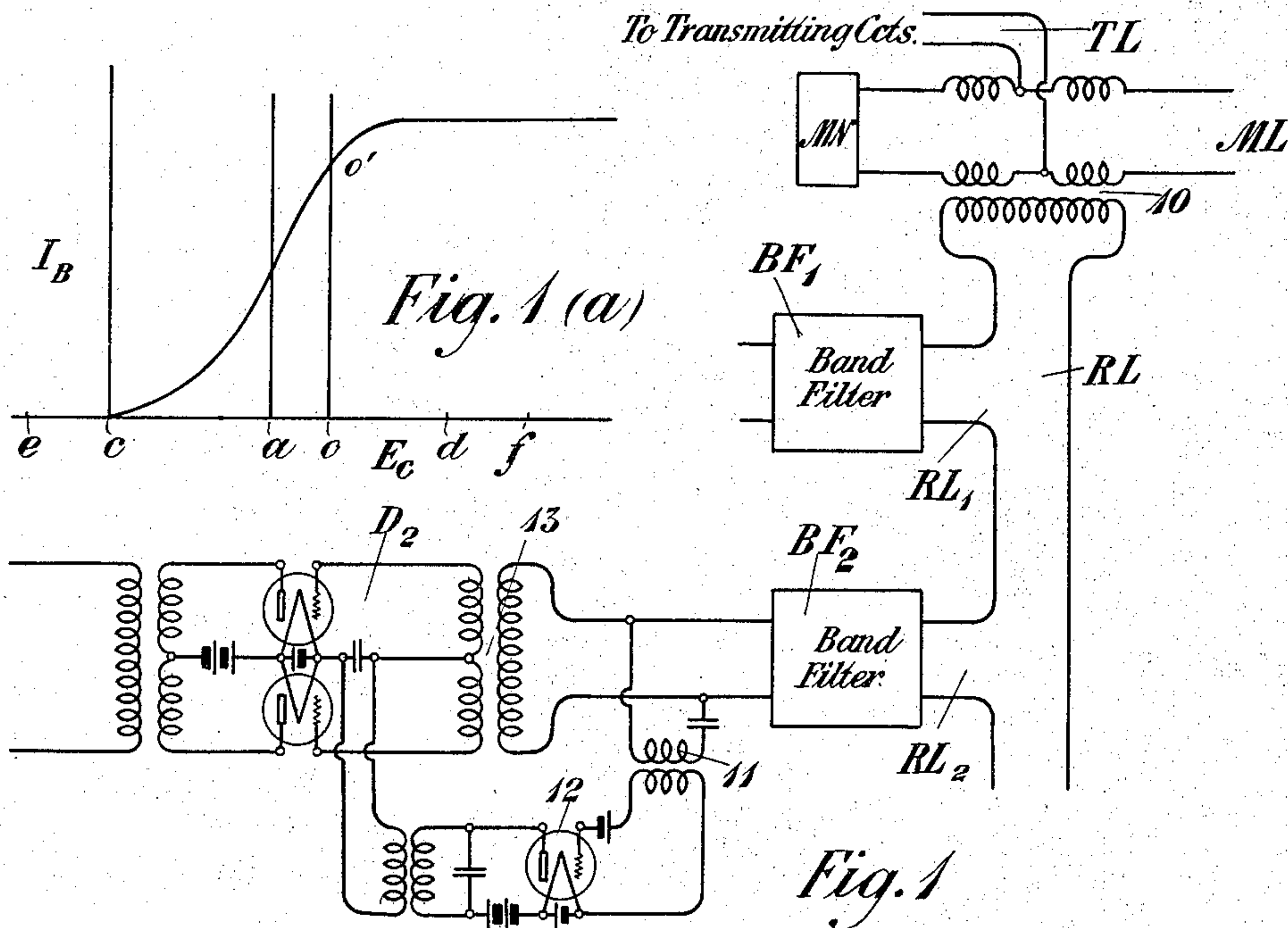
1,511,014

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TRANSMISSION REGULATION

Filed May 4, 1922

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

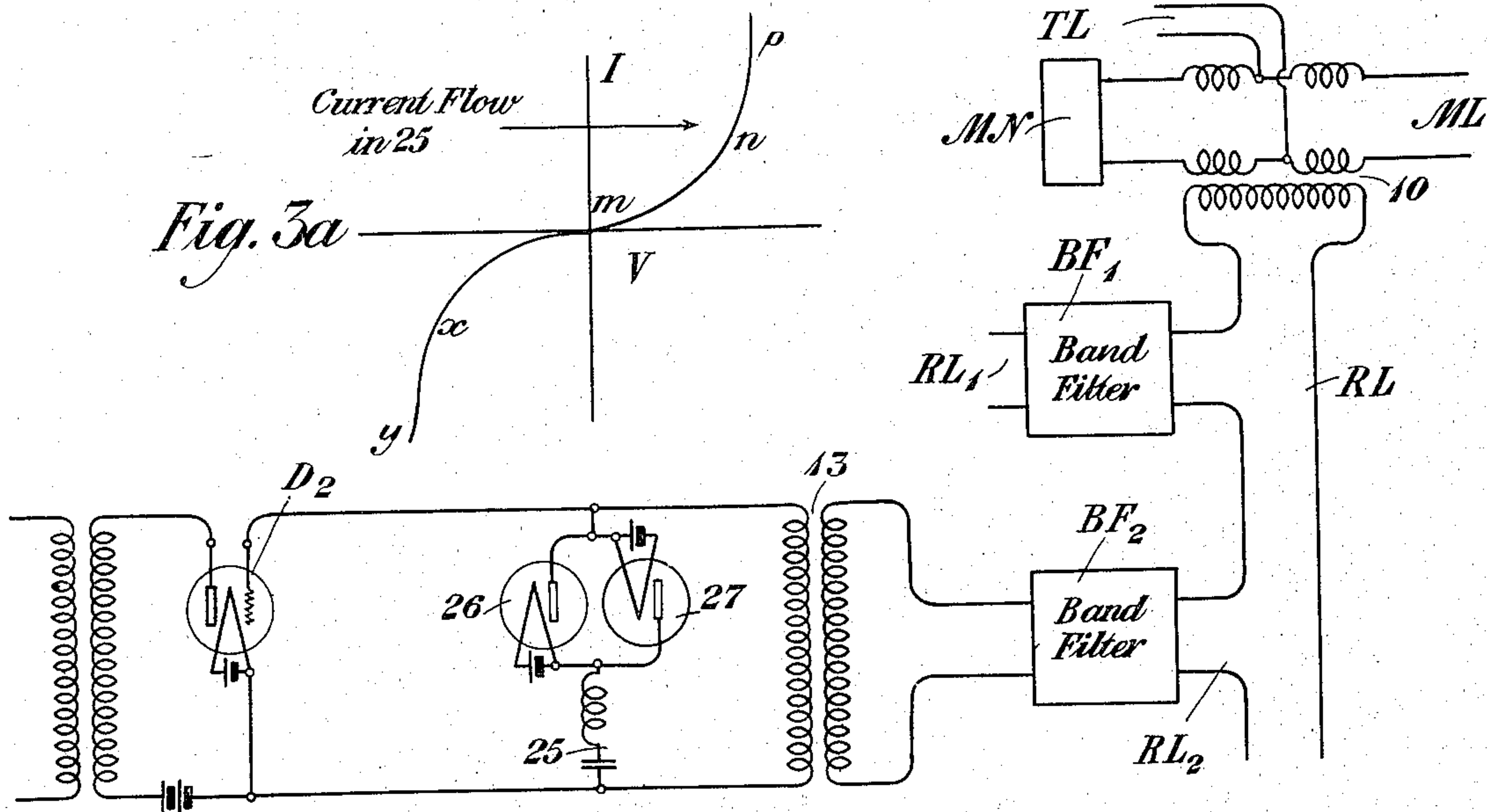


Fig. 3

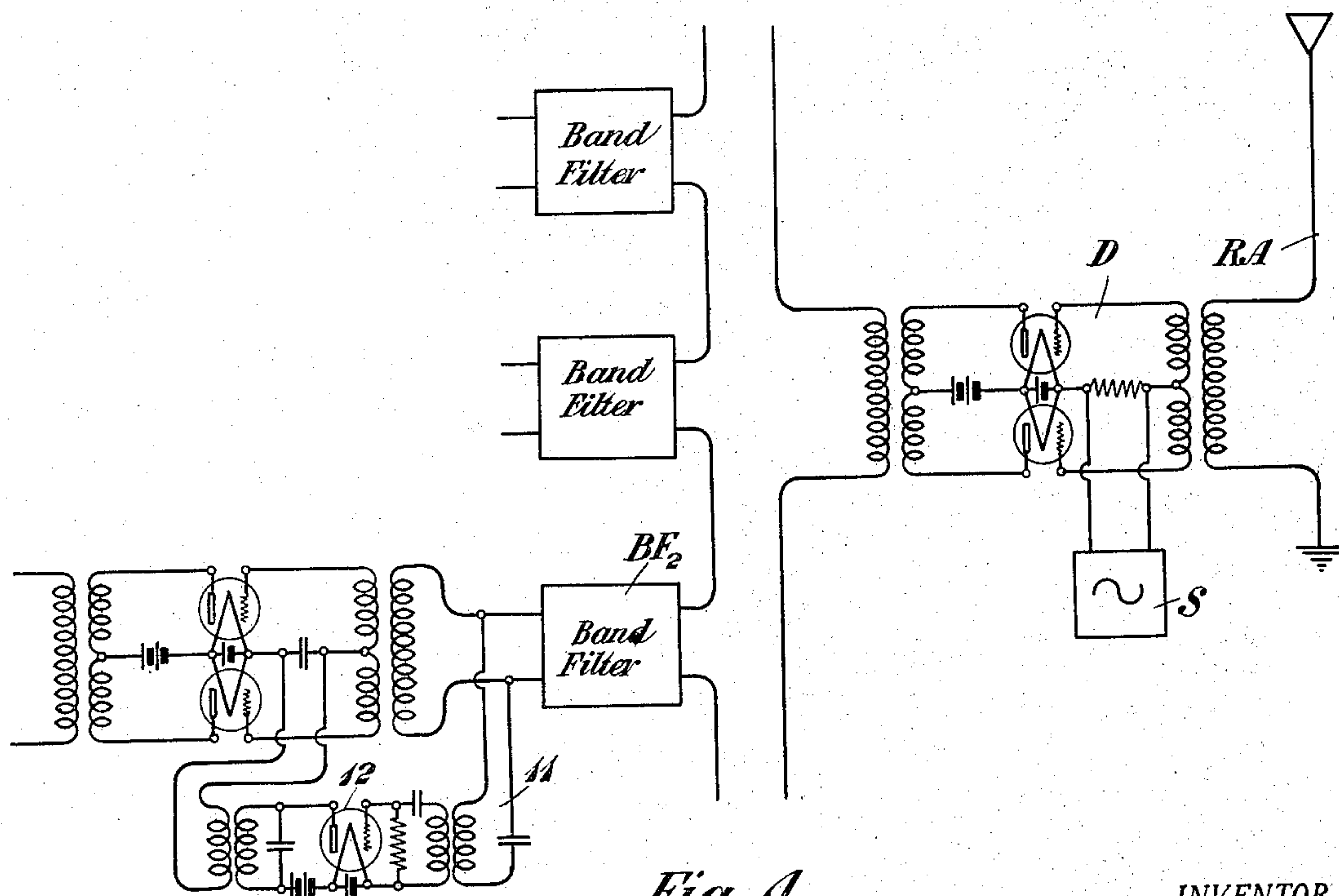


Fig. 4

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TRANSMISSION REGULATION.

Application filed May 4, 1922. Serial No. 558,445.

To all whom it may concern:

Be it known that I, HERMAN A. AFFEL, residing at Brooklyn, in the county of Kings and State of New York, have invented certain Improvements in Transmission Regulation, of which the following is a specification.

This invention relates to multiplex signaling circuits and more particularly to methods and arrangements for controlling the transmission over such circuits.

In a wire carrier or radio telephone system the fluctuations in attenuation of the transmission medium or line produce corresponding variations in the over-all transmission equivalent of the voice circuit. In one well known type of carrier system the carrier frequency itself is suppressed at the modulator end in connection with each channel, and a fundamental frequency which is relatively low is transmitted to the receiving end of the circuit and by harmonic regeneration caused to produce a synchronous carrier supply for the respective demodulators. The carrier supply in this case is transmitted at a frequency which is substantially independent of ordinary line attenuation fluctuations, and the variation in line attenuation at the side band frequency causes a directly proportional variation in over-all equivalent, there being substantially no fluctuation of the equivalent of the circuit due to the carrier component itself.

With the type of carrier system, however, in which the carrier frequency is transmitted along with the side band of each individual channel, the transmission fluctuations may be even more serious since in demodulation the resultant voice output may be, for normal operation of the demodulator, proportional to the product of the carrier and the modulated side band. If, therefore, the attenuation of the intervening line or other transmission medium varies, approximately the same variation will take place for both the carrier and the modulated side band, and the resultant voice circuit variation, being proportional to the product of these two factors, will be approximately double that of the line attenuation itself.

In accordance with the present invention it is proposed to overcome the difficulties encountered in connection with transmission fluctuations in the type of circuit in which

the carrier frequency is transmitted along with the side band, by controlling some element of the transmission channel or circuit to vary the transmission of such element in accordance with the amplitude of the carrier frequency of the channel. While the variation in the amplitude of the carrier, in response to different transmission conditions, may be made to adjust the circuit conditions in various ways, as the invention is herein specifically disclosed the control exercised by the variation in the amplitude of the carrier frequency is electrical rather than mechanical, although both methods of control are contemplated by and are within the scope of the present invention.

The invention may now be more fully understood by reference to the following description when read in connection with the accompanying drawing, Figures 1, 2, 3 and 4 of which show four circuit arrangements embodying the present invention, and Figs. 1^a, 2^a and 3^a of which are curves illustrating the operation of the apparatus in Figs. 1, 2 and 3 respectively.

Referring to Fig. 1, so much of a carrier system is shown as is necessary to an understanding of the present invention. In this figure, ML designates the carrier transmission line which is balanced by the usual balancing network MN, and is associated by means of a hybrid coil 10 with a common receiving channel RL, and a common transmitting circuit TL. As the apparatus associated with the transmitting circuit TL takes no active part in the present invention, such apparatus has not been illustrated. A plurality of individual receiving channels, such as RL₁, RL₂, etc., are connected with the common receiving circuit RL. Each receiving channel as, for example, the channel RL₂, includes a band filter such as BF₂ and a demodulator such as D₂. The demodulator D₂ may be of any well known type but is shown as being a balanced vacuum tube demodulator of the general type illustrated in the patent to Carson, 1,343,308, issued June 15, 1920.

A tuned circuit 11 is bridged across the receiving channel RL₂, this circuit being tuned to the carrier frequency and adapted to select the carrier frequency from the side band or bands transmitted therewith. The tuned circuit is associated with the input of

a vacuum tube 12 adapted to control the carrier frequency in a manner hereinafter described. The output circuit of the vacuum tube 12 is connected with the common branch of the input circuits of the demodulator D_2 , so that the carrier frequency selected from the channel RL_2 , is impressed upon the demodulator differentially with respect to the side bands, which are transmitted directly to the modulator. This differential or balanced connection at the detector prevents the possibility of singing at the carrier frequency over the path through the tuned circuit 11, the vacuum tube 12, the input circuit of the demodulator D_2 , and the transformer 13, by which the side bands are impressed upon the demodulator.

In order to understand how the variations in transmission of the carrier frequency operate through the vacuum tube 12 to control the transmission equivalent of the circuit as a whole, reference will be had to the characteristic curve of Fig. 1^a, said characteristic curve being the usual curve plotted between the grid voltage and space current. When the grid voltage of the tube 12 is zero, the space current will have the amplitude indicated at oo' . When the grid is made negative by the amount indicated at oc the space current will be zero. As the grid is made positive the current increases to a value slightly above the value oo' until the point of saturation is reached. Upon reaching the point of saturation, further increase in the grid potential produces no further increase in current.

Suppose now the normal grid voltage be adjusted by means of the usual C battery, so as to be negative by the amount indicated at oa . If, now, we assume that an alternating current alternating from the positive value ad to a negative value ac is superposed upon the normal grid voltage, the space current will fluctuate from zero to the value indicated at the horizontal part of the characteristic curve, and an alternating current whose amplitude is represented by the distance between the flat part of the curve and the base line will result. If the amplitude of the alternating potential is increased so that it alternates between e and f , for example, the fluctuation in current in the output circuit will be the same as before, and the resultant alternating current in the outgoing circuit will not be increased in amplitude, notwithstanding the increase in amplitude of the voltage applied to the input circuit.

If then, the saturation point of the tube 12 be set sufficiently low so that the alternating potential of smallest amplitude resulting from the transmission of the carrier frequency will produce an output current fluctuating between zero and the point of saturation, any increase in the amplitude of

the carrier selected by the tuned circuit 11 will merely result in the transmission of the carrier frequency to the common branch of the demodulator D_2 , whose amplitude will be the same as before. In short, notwithstanding that the amplitude of the carrier frequency may be increased or decreased from time to time as it is received from the main line ML , the carrier frequency supplied to the demodulator D_2 will be constant in amplitude so long as the amplitude of the carrier received from the line ML is not less than that indicated by the limits cd .

It will be seen therefore that however the transmission over the line ML may vary, the carrier frequency supplied to the demodulator D_2 will be constant if the variation is kept within certain limits, and the detected talking current will only change in volume with the change in transmission of the side band. The variation in the transmission of the carrier will produce no additional variation in the volume of the low frequency talking currents.

Fig. 2 shows an arrangement in which the system will compensate for the variation in transmission of both the side band and the carrier. Referring to Fig. 2, the tube 12 has a blocking condenser included in its input circuit and a leak resistance 15 is connected between the grid and the filament. Otherwise, the circuit is similar to that illustrated in Fig. 1. The constants of the tube 12 are so adjusted that the point of saturation will not be reached by the alternating potentials applied to the tube, and for an alternating potential of any amplitude occurring in practice the tube will only be working over a relatively small portion of its characteristic, instead of over the major portion of its characteristics, as described in connection with Fig. 1.

Referring now to Fig. 2^a, which illustrates the characteristic curve of the tube 12 of Fig. 2, let us assume that normally no potential is applied to the grid. If an alternating potential is then applied to the grid circuit as indicated by the curve 20, the successive negative waves will be trapped by the blocking condenser 14 to produce an accumulated charge upon the grid which will leak off at some definite rate through the resistance 15. By properly adjusting the resistance 15 a steady state will soon be reached at which the accumulated charge upon the grid will have the value indicated by og . When this condition is reached the alternating potential 20 may be considered as alternating about the point g instead of the point o so that for an alternating potential having an amplitude indicated at 20, the tube 12 will be operating upon the amplifying portion of its characteristic at the point of greatest amplification.

If now, the alternating potential applied

to the grid be increased in amplitude, as indicated at 21, the charge which builds up upon the grid will become greater when the steady state is reached so that the average negative charge on the grid may be considered to have the value represented by oh . The alternating potential will now fluctuate about the point h instead of about the point g , so that the tube will be operating at a part of its characteristic which produces a smaller amplification than was produced at the point g . The resultant alternating current in the output circuit of the tube will therefore be smaller in amplitude for an alternating potential, as indicated at 21, than it will be for the alternating potential of smaller amplitude indicated at 20. In other words, the tube 12 will operate to decrease the output alternating current of carrier frequency as the input alternating current of carrier frequency increases in amplitude. By properly adjusting the characteristic of the tube, this decrease in amplitude of the carrier applied to the demodulator D_2 as the amplitude of the carrier transmitted over the line ML increases, may be made to compensate for the increase in the amplitude of the side band with the result that the detected voice currents, which are proportional to the product of the carrier and the side band applied to the demodulator, will have substantially the same volume regardless of changes in the transmission equivalent of the line ML.

A modified arrangement obtaining substantially the same result is illustrated in Fig. 3. In the arrangement shown in Fig. 3, the demodulator D_2 may be a simple vacuum tube demodulator instead of a duplex arrangement such as that illustrated in Figs. 1 and 2. Across the input circuit of the demodulator a circuit 25, tuned to the carrier frequency, may be bridged, and in this circuit is included a pair of two-element vacuum tubes 26 and 27, of the rectifying type. One of these tubes will transmit one-half of the alternating carrier wave and the other tube will transmit the other half of the alternating carrier wave. The impedance of these tubes will be decreased as the amplitude of the carrier frequency increases, so that the amount of energy of the carrier frequency which is by-passed through the tuned circuit 25 will increase with the amplitude of the carrier frequency.

This action may be understood by referring to the curve of Fig. 3^a, which illustrates the characteristic of the shunt circuit 25. In Fig. 3^a the portion of the curve mnp may be considered to correspond to the voltage-current curve of one of the tubes 26 or 27, while the portion of the curve mxy may be considered the corresponding characteristic curve of the other tube. The characteristics of these tubes are such that as the ap-

plied voltage increases the current increases more rapidly than the voltage, provided the voltage is kept somewhat below saturation.

If, therefore, an alternating current of zero amplitude is impressed upon the circuit 25, the circuit will have an infinite impedance and zero current will flow. If the amplitude of the applied alternating potential be increased the impedance of the circuit will be decreased and the impedance continually decreases with increase in amplitude. By operating with alternating potentials between maximum and minimum limits the current will increase with the increase in the applied voltage at such a rate that the shunt circuit 25 will compensate for the variations in transmission over the line ML. For example, for a given transmission equivalent of the circuit ML a definite proportion of the energy of the carrier frequency will be by-passed through the circuit 25 and the carrier energy applied to the demodulator D_2 will have a certain amplitude while the side band will be impressed upon the demodulator without having any of its energy diverted over the path 25. If, now, the transmission equivalent of the circuit ML is changed so that the amplitude of both the carrier and the side band are decreased without being transmitted over said circuit, a smaller proportion of the carrier frequency energy will be by-passed by the shunt circuit 25, and the actual amount of energy of the carrier frequency impressed upon the demodulator may be increased over that before impressed thereon. This increase, by proper adjustment, may be made sufficient to compensate for the decreased amplitude of the side band impressed upon the demodulator, so that the resultant detected voice currents will have the same volume, these currents being produced by the product of the carrier frequency and side band.

In some cases, and particularly in radio transmission, it would be difficult to select the carrier frequency from the modulated side band, owing to the fact that the frequencies involved are relatively high, and the selectivity, particularly that provided by simple tuned circuits, is low. In such a case it is desirable that an arrangement similar to that shown in Fig. 4 be utilized. In this circuit the energy incoming from the receiving antenna RA is impressed upon an intermediate demodulator D so that the incoming energy beats with a frequency from the source S to step down the received carrier and side band in the frequency spectrum. The stepped down carrier frequency and side band may then be passed together through the band filter BF_2 and a carrier selected from the side band by means of the tuned circuit 11, as in the case of Figs. 1 and 2. The tube 12 may function as described in connection with Fig. 2, to maintain the

volume of the detected voice currents substantially constant regardless of changes in the attenuation of the original frequencies during transmission.

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

What is claimed is:

1. The method of controlling transmission in a carrier system in which the carrier is transmitted along with the side band, which
15 consists in transmitting components corresponding to the carrier and side band over a medium whose transmission is variable under different conditions, selecting a component corresponding to the carrier from the
20 corresponding side band component, producing from the selected component a current having characteristics depending upon the transmission conditions to which the transmitted energy has been subjected, and
25 controlling the amplitude of the low frequency signaling currents produced from the transmitted side band component in accordance with the characteristics of the current produced from the component corresponding to the carrier.

2. The method of controlling transmission in a carrier system in which the carrier is transmitted along with the side band, which
35 consists in transmitting components corresponding to the carrier and side band over a medium whose transmission is variable under different conditions, selecting a component corresponding to the carrier from the corresponding side band component, producing from the selected component a current
40 whose amplitude depends upon the transmission conditions to which the transmitted energy has been subjected, and controlling the amplitude of the low frequency signaling currents produced from the transmitted side band component in accordance with the amplitude of the current produced from the component corresponding to the carrier.

3. The method of controlling transmission in a carrier system in which the carrier is transmitted along with the side band, which
50 consists in transmitting components corresponding to the carrier and side band over a medium whose transmission is variable under different conditions, selecting a component corresponding to the carrier from the corresponding side band component, translating the selected component into a current
55 of greater amplitude if the amplitude of the component corresponding to the carrier after transmission is less than the average, and translating the selected component into a current of lesser amplitude if the component
60 corresponding to the carrier after transmis-

sion is greater than the average, and combining the translated component and a component corresponding to the side band, to produce detected signals whose amplitude depends on the translated component and said
70 component corresponding to the side band.

4. The method of controlling transmission in a carrier system in which the carrier is transmitted along with the side band, which
75 consists in transmitting components corresponding to the carrier and side band over a medium whose transmission is variable under different conditions, producing a change in the amplitude of a received component corresponding to the carrier before detection, said change being determined by the amount by which the amplitude of the received component varies from the average, and combining the component as thus
80 changed in amplitude with a component corresponding to the received side band to produce a signaling current.

5. The method of controlling transmission in a carrier system in which the carrier is transmitted along with the side band, which
85 consists in transmitting components corresponding to the carrier and side band over a medium whose transmission is variable under different conditions, changing the amplitude of a component corresponding to the carrier after transmission and before detection by an amount depending upon the transmission conditions to which the carrier has been subjected, and then combining the component thus changed in amplitude with a
90 component corresponding to the side band, to produce a signaling current.

6. In a system for controlling transmission, a transmitting medium over which a carrier is transmitted together with the side
95 band, the transmission efficiency of said medium being variable under different conditions, means for selecting a component corresponding to the carrier from a component corresponding to the side band after transmission, means to produce from the selected component a current having characteristics depending upon the transmission conditions to which the carrier has been subjected, means to produce low frequency signaling current
100 from the side band, and means to control the amplitude of the low frequency signaling currents produced from the side band in accordance with the characteristics of the current produced from the selected component.

7. In a system for controlling transmission, a transmitting medium over which a carrier is transmitted together with the side
105 band, the transmission efficiency of said medium being variable under different conditions, means for selecting a component corresponding to the carrier from a component corresponding to the side band after transmission, means to produce from the selected component a current whose amplitude de-
110
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120
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130

pend upon the transmission conditions to which the carrier has been subjected, means to produce low frequency signaling current from the side band, and means to control the amplitude of the low frequency signaling currents produced from the side band in accordance with the amplitude of the current produced from the selected component.

8. In a system for controlling transmission, a transmitting medium over which a carrier is transmitted together with a side band, the transmission efficiency of said medium being variable under different conditions, means to select a component corresponding to the carrier from a component corresponding to the side band, a translating device upon which the selected component may be impressed, said translating device being so arranged as to increase the amplitude of the component if it is less than the average and to decrease the amplitude of the component if it is greater than the average, a demodulator, and means to impress the component thus translated in amplitude upon said demodulator together with a component corresponding to the side band, thereby producing a low frequency signaling current whose amplitude will depend upon the translated component and received side band.

9. In a system for controlling transmission, a transmitting medium over which a carrier is transmitted together with the side band, the transmission efficiency of said medium being variable under different conditions, means to select a component corresponding to the carrier from a component corresponding to the side band, a vacuum tube upon which the selected component may be impressed, said vacuum tube having a characteristic such that when the amplitude of the component is greater than the average the component frequency in the output circuit will be decreased in amplitude and

when the amplitude of the component is less than the average the amplitude of the component frequency appearing in the output circuit will be increased, a detector, and means to impress the frequency appearing in the output circuit of said vacuum tube upon said detector together with a component corresponding to the side band, thereby producing a detected signaling current whose amplitude is determined by the frequency appearing in the output circuit of the vacuum tube and by the side band.

10. In a system for controlling transmission, a transmitting medium over which the carrier may be transmitted along with the side band, the transmission efficiency of said medium being variable under different conditions, a detector upon which components corresponding to the carrier and side band may be impressed, and means for subjecting the component corresponding to the carrier to a change in amplitude before impressing it upon the detector, said change being determined by the attenuation to which it is subjected by the transmission medium.

11. In a system for controlling transmission, a transmitting medium over which the carrier may be transmitted along with the side band, the transmission efficiency of said medium being variable under different conditions, a detector upon which components corresponding to the carrier and the side band may be impressed, and means for changing the amplitude of the component corresponding to the carrier before impressing it upon the detector, the change in amplitude being inverse with respect to its variation from the average amplitude resulting from transmission over said transmission medium.

In testimony whereof I have signed my name to this specification this 3rd day of May, 1922.

HERMAN A. AFFEL