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RADIO VOLUME COMPRESSION SYSTEM

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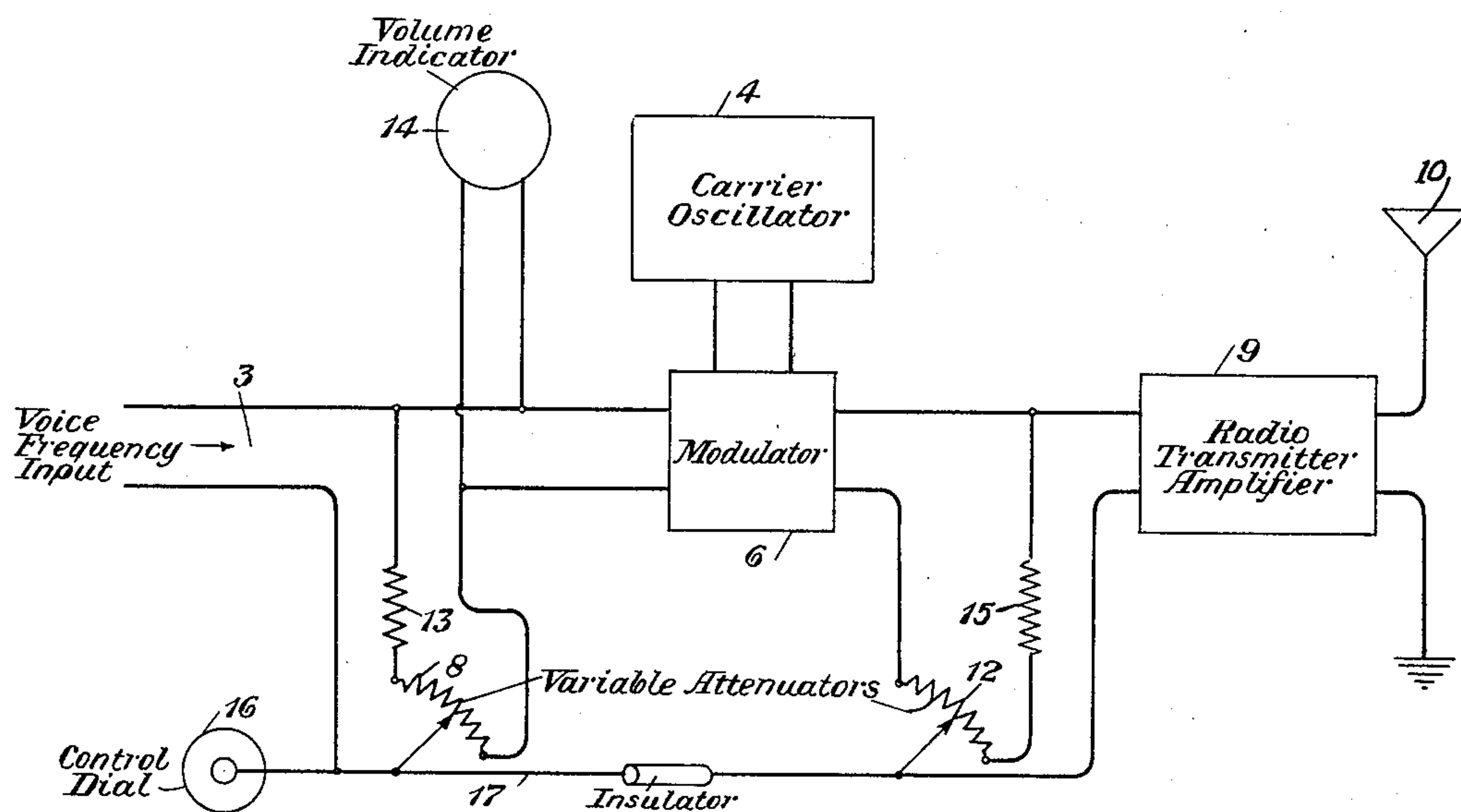


Fig. 1

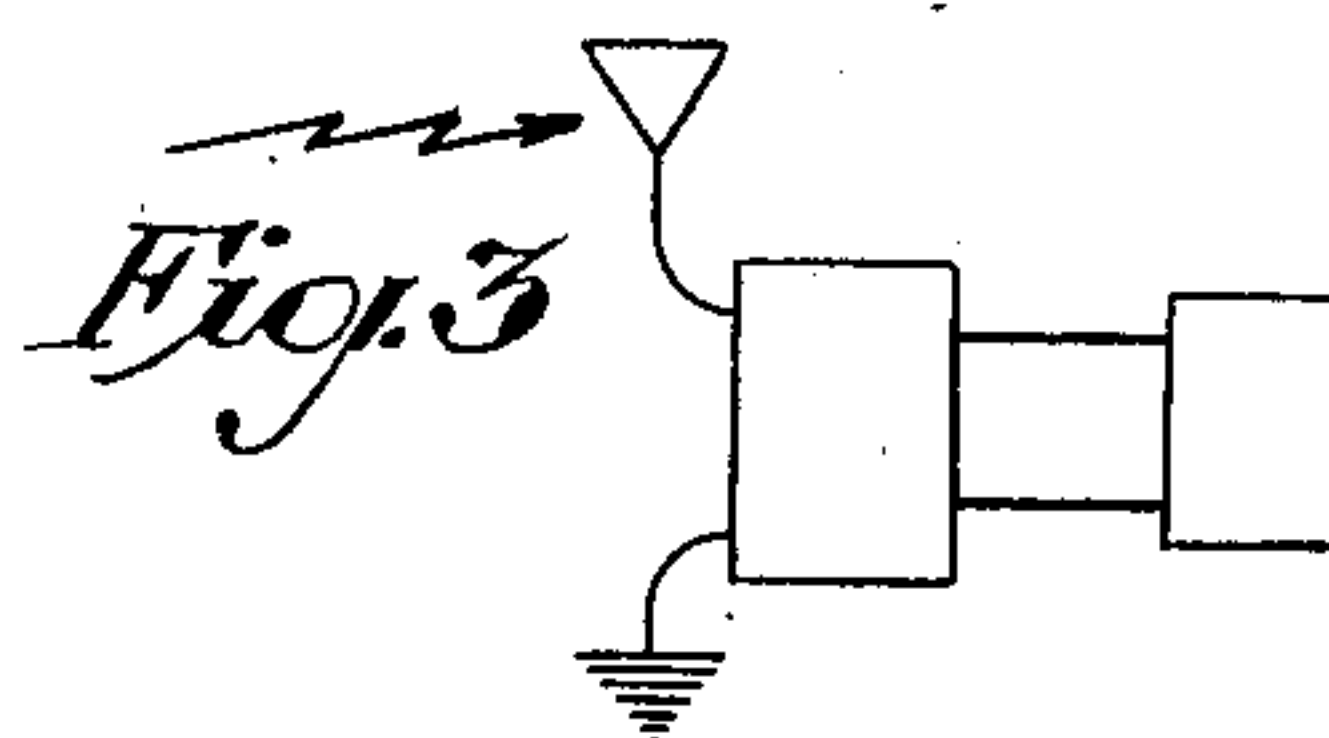


Fig. 3

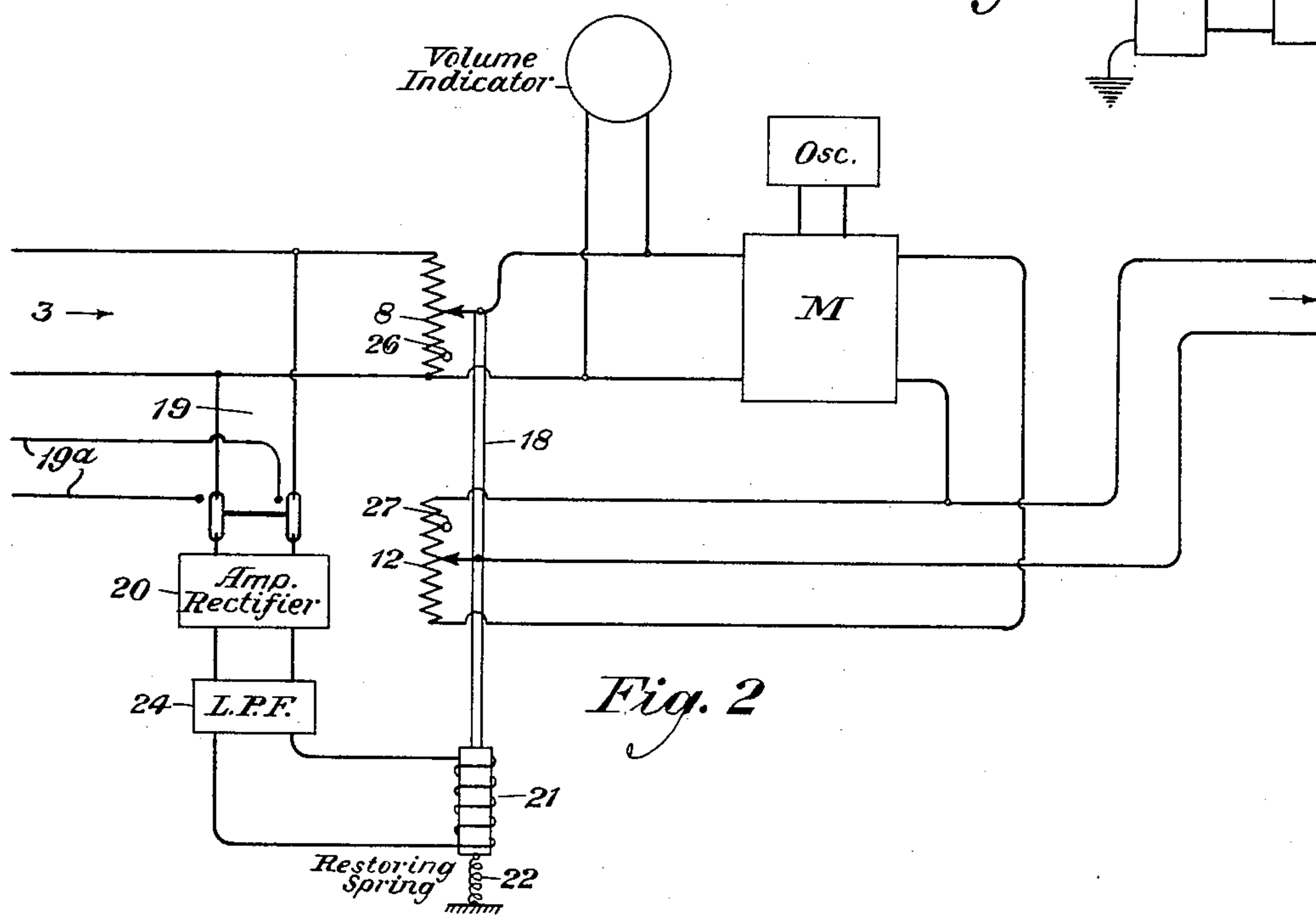


Fig. 2

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RADIO VOLUME COMPRESSION SYSTEM

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8 Claims. (Cl. 178-44)

This invention relates to a radio volume compression system, and more particularly a system for varying the relative amplitude of the carrier and the side band components in accordance with the volume of the signal wave to be transmitted.

In radio signaling, especially in broadcast programs, there are very wide variations in volume of the signal to be transmitted, sometimes as the nature of the program changes and sometimes within a given portion of a program itself. The extreme variations in amplitude are sometimes beyond the limits of the signaling system for satisfactory transmission. Thus, in the case of large volume there may be distortion due to overloading of tubes or from overmodulation of the carrier frequency by the signal message. On the other hand, when the volume falls to low values the ratio of noise to signal may become excessive. In the first case it is desirable to reduce the volume to reasonable values, and in the second to increase the volume, but it is still important that corrections for such changes shall be made in order that at the receiving end the volume range shall be in accordance with the original signal wave.

One of the objects of this invention is to provide an arrangement wherein the compression or expansion is subject to manual control. Still another object is to provide such an arrangement, the compression or expansion being automatic in accordance with the major swings of volume variation of the speech or other program being transmitted.

Arrangements having the above objectives are not entirely new in the art as shown, for example, by patents to Blackwell et al, 1,681,972, August 28, 1928 and 1,719,041, July 2, 1929, and the circuit which shows my invention represents a modification or improvement over such circuits as disclosed in the patents mentioned above.

The invention will be better understood by reference to the following specification and accompanying drawing, in which Figure 1 shows in block form the essential elements in a circuit arrangement to carry out my invention; Fig. 2 shows a modification of the circuit of Fig. 1 whereby the volume compression becomes automatic and Fig. 3 shows a receiving station of the usual form.

Referring particularly to Fig. 1, there is shown at 3 an incoming line for the voice frequency message to be transmitted. An oscillator 4 to generate the carrier frequency is provided, and the voice frequency and carrier frequency are impressed upon any suitable form of modulator

6. The amplitude of the voice frequency which is supplied to the modulator can be controlled by any attenuating device, such as the shunt device 8. The output of the modulator, and in particular the carrier frequency and the two side bands, is impressed upon the radio transmitter amplifier 9 and from there upon antenna 10. It is to be understood, of course, that instead of being impressed upon an antenna for radio broadcasting, the high frequency signal may be impressed upon a transmission line, the two being equivalent in every respect. The amplitude of the radio message to be impressed on the transmitter 9 may be controlled by any suitable attenuator, such as the potentiometer 12. In addition to the above, I provide a volume indicator 14 bridged across the input terminals of the modulator, this volume indicator showing the amplitude of the program signal to be transmitted. There is thus provided a system in which the amplitude of the signal to be impressed upon the modulator may be varied, and in which the carrier oscillation amplitude from the oscillator 4, remains constant, and in which the amplitude of the modulation products as impressed upon the transmitter may be varied.

In accordance with my invention, the attenuators are operated in such a way that if a certain gain or decrease in loss, expressed in transmission units such as decibels, is introduced at 8, then an increase in loss of half this number of transmission units is introduced at 12. Expressed in another form, this means that if the attenuator 8 is set to change the amplitude impressed on the modulator by the factor x , then the attenuator 12 is to be changed in the reverse direction to alter the amplitude impressed on the transmitter 9 by the factor $\sqrt{x}$. By such an operation, a compression or expansion of the volume of signal impressed on the modulator may be effected and the program variations at the output of a detector will be identical with those which appeared at the input to the entire system.

This may be shown by the following considerations. Assume, for simplicity, that the current variations in a vacuum tube used as a modulator or a detector is given by

$$i = me + ne^2$$

and for further simplification, let us assume that $m = n = 1$. Let us also assume a single speech frequency coming in at 3 given by a $\cos qt$ and that the carrier oscillation is given by $b \cos pt$. If, now, the attenuators 8 and 12 are set at points

corresponding to unity, the input to the modulator will be given by

$$a \cos qt + b \cos pt$$

5 The modulation products of interest in this connection, the carrier and side bands, would then be given by

$$b \cos pt + ab \cos (p+q)t + ab \cos (p-q)t$$

10 If such a carrier with its side bands is received at a detector of the characteristics given above, the portion of the detector output which would be of interest will be the cross-product terms given by $ab^2 \cos qt$ this being the message frequency. Returning, now, to the transmitting station, let us assume that a certain amount of transmission loss is introduced at 8 such that the amplitude of the signal impressed upon the modulator becomes

$$20 \quad \frac{a}{x} \cos qt.$$

The total input of the modulator will then be

$$25 \quad \frac{a}{x} \cos qt + b \cos pt$$

and the modulator output of interest in this connection will be

$$30 \quad b \cos pt + \frac{ab}{x} \cos (p+q)t + \frac{ab}{x} \cos (p-q)t$$

If, in accordance with the steps mentioned above, a gain or decrease in loss now be introduced at the attenuator 12 such that the amplitude of the modulation products is increased by the factor $\sqrt{x}$, then the wave impressed upon the detector at the receiving station would be represented by

$$40 \quad \sqrt{x} b \cos pt + \sqrt{x} \frac{ab}{x} \cos (p+q)t + \sqrt{x} \frac{ab}{x} \cos (p-q)t$$

45 That portion of the output of the detector which corresponds to the signal frequency is given by the cross-product of the carrier with one or the other side band, and it will be noted that when such cross-product is taken the factors x cancel out, yielding

$$ab^2 \cos qt$$

50 which is the same as that obtained in the first case. It is thus seen that the introduction of loss or gain at 8 is compensated for by a reverse change of half the amount (expressed in transmission units) at 12, so far as the effect after detection is concerned.

55 It is to be understood that any type of attenuator may be used at 8 and 12. The forms shown in the figure are those of shunts or potentiometers but T type networks would also be suitable, and in general it would be convenient to have these two attenuators geared together and so built that when a given number of transmission units is introduced at 8, half as many will be removed at 12. In Fig. 1 I have shown a control dial 16 and connecting rods 17 by means of which such changes can be made. Furthermore, it is evident that instead of using physical attenuators of the form described the same results may be obtained by changing the grid bias of amplifiers or by equivalent means.

60 While in the description above it has been implied that compression in case of high volume or expansion in case of low volume are to be done manually thus decreasing volume range, it should be pointed out that these changes could

be made automatically and in some cases to large advantage. Various ways for bringing about such automatic control are feasible, and Fig. 2 shows one method, this being for illustrative purposes only. In that Fig. 2, the attenuators 8 and 12 have been placed adjacent to each other. The variable contacts are secured to an arm 18, and it will be noted that the connections are such that as the potential output of attenuator 8 is increased on the one hand, the potential output of the attenuator 12 is decreased. In order to render the action automatic, I have bridged across the transmission line 3 a circuit 19 leading to an amplifier-rectifier 20, in the output circuit of which is a solenoid 21. The core of this solenoid is secured to the bar 18 and is normally held in a definite position by the restoring spring 22. In case the volume of the incoming signal increases the movement of the core is downward, moving the contacts on 8 and 12 correspondingly, whereas if the volume decreases there is a corresponding motion in the reverse direction. In order to assure that the motion of the rod 18 shall be in accordance with the major swings of volume only, one may introduce a low pass filter 24, although it is apparent that the inertia of the solenoid and bar 18 would generally be sufficient in themselves for that purpose.

While the amplifier-rectifier circuit is shown as bridged across the transmission line 3 just in front of the first attenuator, it is to be understood that this bridging circuit may be derived from the transmission line at some remote point nearer the ultimate source of the signaling frequency. This is shown indicated in Fig. 2 by the lines 19a.

While the invention has been described with the two attenuators at the transmission station and immediately following the modulator, it is to be understood that the attenuator 12 may be placed at any point in the transmission channel between the output of the modulator and the input of the detector at the receiving station. If it is placed at the receiving station there will be the necessity of installing some control from the transmitter to the receiver station whereby a change in the first attenuator will be accompanied by an appropriate change in the second attenuator. While this might be desirable in some cases, it would in general be preferable and I consider it an important feature of my invention that it is possible to put in the "correcting" attenuator at the transmitting station where it can be readily operated in conjunction with the first attenuator.

Also while in the mathematical relationships related above, the treatment has been on the basis of no attenuation in the channel as a whole such as in the ether channel for radio, it will be understood that this, of course, is not the actual condition existing but that there will be a large attenuation between the transmitter and receiver stations. It should be noted, however, that this operation, which might be represented by the factor K , would be a constant attenuation and therefore it is not operative to alter the conclusions drawn. The correction for the volume change in front of the modulator can only be made by a corresponding but a reverse change in the channel between the output of the modulator and the input of the detector, the two changes being made simultaneously.

In the figures thus far described, it will be noted that extreme motion of the attenuator

arms might lead to infinite attenuation in the one attenuator or the other. To avoid this, various expedients may be resorted to. Thus, as shown in Fig. 1, additional resistance elements 13 and 15 may be introduced or, as in Fig. 2, stops 26 and 27 may be provided to limit the motion of the movable contacts.

What is claimed is:

1. In a high frequency signaling system in which a carrier frequency is modulated by a signal frequency, the method which consists in varying the volume of the signal frequency, modulating it against a carrier frequency of fixed amplitude, and varying the volume of the modulation products by a factor which is the square root of the reciprocal of the previous variation.

2. In a high frequency signaling system in which a carrier frequency is modulated by a signal frequency, the method which consists in varying the volume of the signal frequency by an arbitrary number of transmission units, modulating it against a carrier frequency of fixed amplitude, and varying the volume of the modulation products in the reverse way by half as many transmission units.

3. In a high frequency volume compression system, a source of carrier frequency of fixed amplitude, a source of signal frequency, a modulator on which the carrier and the signal frequency are impressed, means for varying the volume of the signal frequency impressed on the modulator, and means coupled to the first named means for simultaneously varying the volume of the output of the modulator impressed upon the transmitter in the reverse way by half the amount.

4. In a high frequency system comprising a transmitting and receiving station, a source of carrier frequency and a source of signal frequency, a modulator on which the two frequencies are impressed, means in the path of the signal frequency for controlling the volume, and means in the output of the modulator for controlling the volume, devices for changing the first means to

compress or expand the volume range and to simultaneously change the second means in the reverse direction by half the amount to neutralize at the receiving station the effect of the volume compression or expansion.

5. The combination of claim 4 characterized by the fact that the devices for changing the means are controlled by the signal wave to operate automatically in accordance with the major swings in the volume of the signaling frequency.

6. The combination of claim 4 characterized by the fact that the devices for changing the said means are operated from a remote point.

7. In a high frequency signaling system in which a carrier frequency is modulated by a signal frequency, the method which consists in varying the volume of the signal frequency, modulating it against a carrier frequency of fixed amplitude and varying the volume of the modulation products in the reverse way and by such an amount that the signal demodulation product at the output of a non-linear receiving detector is restored to the original volume range.

8. In a high frequency system comprising a transmitting and a receiving station, a source of carrier frequency and a source of signal frequency, a modulator on which the two frequencies are impressed, means in the path of the signal frequency for controlling the volume and means in the output of the modulator for controlling the volume of the modulator output, devices for changing the first means to compress or expand the volume range and to simultaneously change the second means in the reverse direction by an amount definitely related to the change in volume range of the signal, a detector at the receiving station of non-linear characteristics, the aforesaid definite relationship being so connected to the non-linear characteristic of the detector that the signal output of the detector is restored to the original volume range of the signal frequency.

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