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TELEPHONE TRANSMISSION CIRCUIT

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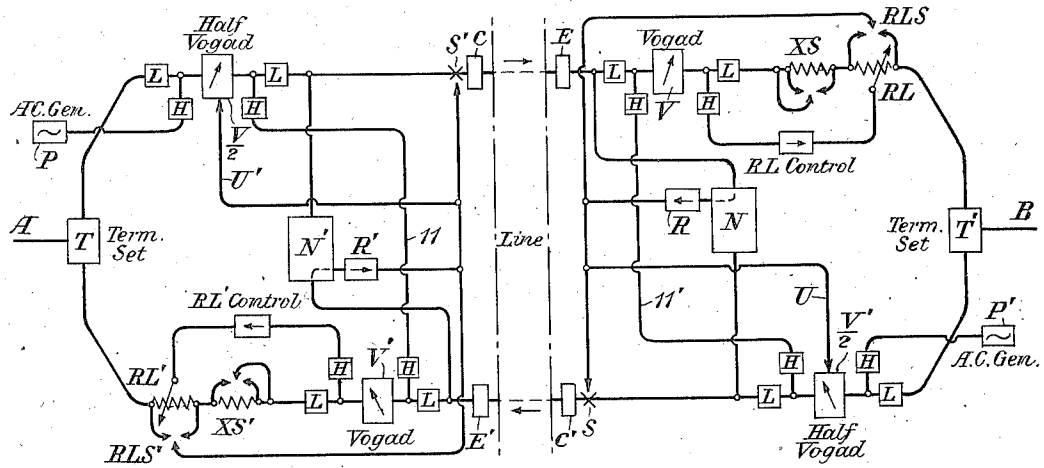


Fig. 1

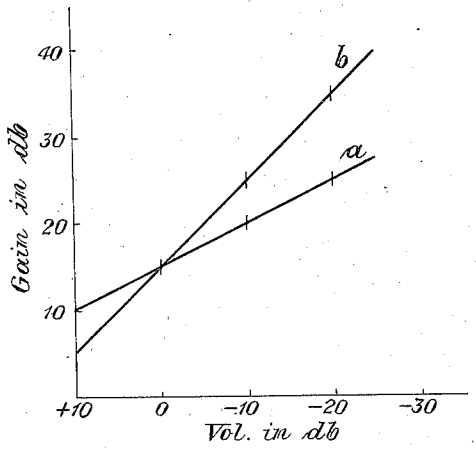


Fig. 2

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TELEPHONE TRANSMISSION CIRCUIT

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21 Claims. (Cl. 178—44)

This invention relates to telephone transmission on long distance circuits and more particularly to means for the improvement of transmission on circuits commonly spoken of as four-wire circuits. The invention relates to the type of circuits described in a copending application Serial No. 752,150, filed November 8, 1934 and is an improvement thereon.

The object of the invention is to associate various known forms of transmission control devices in new and useful combinations to obtain maximum gain over such circuits, consistent with maintenance of anti-singing conditions. A further object is to obtain maximum gain consistent with discrimination against echoes and against room and line noises. A still further object is to equalize received volumes in the two directions although the loudness of the speech by the two speakers may be widely different. Other objects will appear in connection with the description of the invention.

The invention will be better understood by reference to the following specification and the accompanying drawing in which Figure 1 is a circuit drawing showing a combination of certain devices for obtaining the results named above and Fig. 2 gives the characteristics of certain of the control devices.

The invention is applicable to circuits such as described in an article by Osborne on "General Switching Plan for Telephone Toll Service," published in the Bell System Technical Journal for July, 1930, in which it is shown how in such a country as the United States it is advantageous to select certain strategically located cities as regional centers, these being interconnected directly with each other and such connections being spoken of as RC—RC links. From such regional centers there are additional circuits fanning out to important points spoken of as primary outlets or toll centers, the connections from regional centers to primary outlets being spoken of as RC—PO links.

Referring to Fig. 1 there is shown such a link as an RC—RC or a PO—RC link extending from A to B, operating on a four-wire basis, and which may be connected directly to subscriber stations or which may be extended into other RC—RC or RC—PO links and then to subscriber stations. Such a link may be a few hundred or two or three thousand miles long. Also, so far as this invention is concerned, the link is assumed to be brought down to a two-wire basis in a well known manner by means of a terminating set including a hybrid coil and suitable attenuating or switching pads to adjust the gain of the link as a whole to a proper value.

It may be pointed out that whereas in usual telephone systems it has been the practice to operate the line on the basis of constant net loss, that is, independent of volume, in this invention we operate on the basis of volume controlled gain. More specifically, we arrange that the amplification or gain of the speech message shall be relatively low if the impressed volume is high, the gain being increased as the impressed volume becomes smaller. Furthermore, whereas in circuits of the type described in the copending application named above, the two ends of the circuit are adjusted independently, the receiving volume at either end being limited by the worst possible conditions at the other end in order to prevent singing, in our present circuit arrangement, we apportion any reductions in receiving volume which are necessary to prevent singing between the two ends of the circuit.

The transmission circuit from A to B, which is over the upper path, is entirely symmetrical with that from B to A over the lower path. In each path there are introduced various devices which are fairly well known to those skilled in the art and here shown in highly conventionalized form. Each in itself does not constitute our present invention or a part thereof, but necessary units have been brought together in a new manner to yield the results which we desire. The details of these units will not be elaborated upon here but will be found in publications to which reference will be made hereinafter.

At station A there is a terminating set T including a hybrid coil and appropriate switching pads by means of which waves pass from the two-wire portion to the left of T to the four-wire portion to the right. Considering transmitted speech from the terminating set T which passes over the upper path, there is found a low pass filter and a half vogad

$$\frac{V}{2}$$

The term "vogad" is used in the art as an abbreviation for "volume operated gain adjusting device", and more specifically is a device in which the gain is greater for small volumes than for large volumes, and in such a manner that over the operating range here intended the output volume is constant and independent of the input volume, i. e. the volume range is reduced to zero. A half vogad, on the other hand, is a device similarly operated by incoming volume, but so designed that the volume range at the output is one-half the volume range of the input, the device thus acting to compress the volume range to one-half. The details of such a device may be found in patent to Doba, No. 1,854,828, April 19, 1932. The characteristics of this half vogad, as we use it, is shown in curve *a* of Fig. 2, in which the gain is plotted against the input volume, both expressed in decibels. An examina-

tion of this curve will show that any input volume range is contracted to one-half that range in the output and this is independent of a shift of the curve in a vertical direction, corresponding to equal increase in volume at all volumes without change in volume range.

Having passed over the transmission line to the receiving end, the speech wave passes through a vogad which has a characteristic such that the output volume range is zero. The characteristic of such a device is shown in curve *b* of Fig. 2, and examination of this curve will show that without regard to the input volume range the output volume range is zero. The gains of the two devices are thus made equal except for constant differences due to different levels and possible compression effects in the line itself. This independence of different level is illustrated in Fig. 2 in which it will be noted that curves *a* and *b* do not pass through the origin, and further, one or the other or both may be shifted parallel to itself as desired and still the one acts to compress the volume to one-half of its range and the other to zero range.

Following the vogad there comes in the line a crosstalk suppressor XS and a variable receiving loss RL, the construction and functions of which will be described hereinafter. The circuit then proceeds to the terminating set T' and out of the station B. The circuit for transmission in the reverse direction is the same.

The details of the construction of the vogad may be found in the patent to Hogg and Doba, No. 1,853,974, April 12, 1934. The details of the crosstalk suppressor may be found in the patent to Keith, No. 1,859,565, May 24, 1932, and the receiving loss device with its controls as here used may be found described in British Patent 381,831, filed and accepted in 1932.

In order to control the loss in one of the receiving loss devices, say RL', a pilot energy current is sent through the half vogad

$$\frac{V}{2}$$

in the transmitting side and the vogad V' in the receiving side at one end of the circuit. The source of this pilot energy is shown at P as an oscillation generator, preferably of some frequency outside the message band, such as a six-thousand cycle current, this value being taken for illustrative purposes only. In front of the half vogad is a low pass filter L to prevent this pilot current from being transmitted backwards to the terminal T. At the same time in the path of the pilot current there is a high pass filter H to prevent speech current from passing back into the source P. The pilot current passes through the half vogad and is subject to the same gain as speech current. Following the half vogad are again low pass and high pass filters permitting the speech message alone to pass out to the line and permitting the pilot current alone to pass over conductor 11 to the receiving side of the circuit at the terminal A. At the receiving side there are again suitable high and low pass filters which permit both currents to pass through the vogad V', after which by separation with filters the pilot current passes through an amplifier detector device, indicated as RL' Control, to determine the amount of loss introduced at RL', this being in accordance with the gain given to the pilot current in passing through

$$\frac{V}{2}$$

and V'. There are filters in the control circuits of the half vogad and vogad so that their gains are not affected by the pilot current.

In addition to the above, a receiving terminal noise desensitizing echo suppressor N is shown, the sensitivity of which is controlled by the amount of noise on the line, the device constituting what is called a "nodes" this being an abbreviation for "noise operated desensitizing echo suppressor". The part of this device which desensitizes the echo suppressor when noise is present is called a "nogad", this being an abbreviation for "noise operated gain adjusting device". In addition to acting as an echo suppressor the nodes also removes receiving loss from the transmission path, as shown at RLS, but this will occur only if the echo suppressor has disabled the other path. It should be noted that the nodes is connected to both sides of the circuit at a point where volume range is cut in half. This is advantageous in somewhat reducing the amount of desensitizing the nogad has to do on noise. This is because the sensitivity of the nodes referred to the circuit terminal, and therefore its susceptibility to noise is at the maximum value only when the minimum talker volume (and therefore maximum gain in the half vogad) is obtained. At all other times this sensitivity is lower. For this reason it is not necessary for the nodes to desensitize itself as often as in a constant net loss circuit where it is at its maximum sensitivity all the time.

Let us assume a two-way conversation with the speaker at A talking. Since the circuit is symmetrical its action in the two directions is identical. The useful part of A's speech waves passes upward through the low pass filter and half vogad

$$\frac{V}{2}$$

where it is regulated to a value half-way between what it would have been without any regulation and the value to be obtained by a talker of maximum volume. They then pass through the second low pass filter and over the line, provided the echo suppressor S' has not been operated by speech coming over the other path. The waves eventually reach the B terminal where they pass into the input of the low pass filter where the nodes is connected. From the output of this filter they pass into the vogad V, at the output of which they have been brought to a constant volume. From there they pass through other low pass filters to the crosstalk suppressor XS. The half vogad brings the volume up half-way to a constant value and the vogad at the receiving end of the circuit brings this volume up the rest of the way, thus the gain of the half vogad at the transmitting end and of the vogad at the receiving end will be equal, except for possible changes due to the line itself. These gains affect the amount of six-thousand cycle pilot tone which is transmitted through each device.

At the input of the first low pass filter at the receiving end, the waves will operate the receiving amplifier detector R if they are strong enough, while at the output of the vogad they will operate the crosstalk suppressor XS. The crosstalk suppressor is set sensitively enough to operate on the weakest part of the speech waves, so that it may at times operate on noise between syllables or sentences. Such operation on noise, however, is not serious for the noise will act to mask the crosstalk. The amplifier detector R is also set to operate on the weakest parts of the speech

waves provided the gain on the nodes is not lowered due to noise. When noise is present the gain of the nodes is lowered so that the detector R will not be falsely operated by this noise. In this case the echo suppressor S and receiving loss suppressor RLS may not be operated on all parts of speech. The nodes is arranged to receive noise from both sides of the circuit so that the sensitivities of the echo suppressors at the two ends will be approximately equal and there will be no danger of echo operation.

The circuit is arranged so that operation of the detector R also disables the half vogad

$$\frac{V'}{2}$$

on the transmitting side of the circuit, as shown at U thus preventing this half vogad from falsely adjusting due to echoes of receiving speech. Such echoes as may be returned are suppressed by the echo suppressor S.

The pilot current having passed through both the half vogad and the vogad at one terminal, and having suffered the gain of each of these devices, reaches the input of the receiving loss control. This latter effectively measures the amount of the pilot current at its input, and when this amount reaches a certain volume starts to insert receiving loss at the receiving side of the circuit in amounts equal in decibels to the amount which the pilot tone exceeds the threshold value. The sensitivity of this receiving loss control is so adjusted that it starts inserting loss at RL, at the point where singing around the complete circuit might otherwise occur.

It has been pointed out above that the gain of the vogad at the receiving end of the circuit is equal to that of the half vogad at the transmitting end of the circuit, except for any constant differences which might be necessary due to different levels. Since these constant differences would be the same for both ends, it is apparent that the sum of the gain of the half vogad and vogad at one terminal will be equal to the sum of the gain of the half vogad and vogad at the other terminal or end of the circuit. Therefore, the amount of pilot current tone at the input of the receiving loss control at each end of the circuit will be the same. Thus, the adjustment of receiving loss will be substantially the same at both ends of the circuit, and receiving volume will be substantially the same. This receiving volume will depend on the average of the two transmitting volumes since the gain in the pilot channel depends on

$$\frac{V}{2}+\frac{V'}{2} \text{ or } \frac{V+V'}{2}$$

Attention is to be called to the fact that the operation of vogads is a very slow one indeed. They respond to the peaks of speech only. In this respect they differ from many types of devices used for compressing volume, such as the compressing and expanding device shown in patent to Green, No. 1,738,000, December 3, 1929. Such a device, which has been given the name in the art of "compander", as abbreviation for compressor and expander, responds usually to the envelop of the speech wave, operating usually for each syllable. The vogad, on the other hand, may perhaps be better described as responding to the envelop of the envelop. Thus, after reduction of volume range by a half-vogad or a vogad, there is still very considerable variation of volume range occurring between settings of the vogads, and in some cases we find it desirable to reduce the volume range between such settings of the vogad. The operation of the vogad is so slow that it does not lead to speech distortion but reduces the differences in volume between a strong speaker and a weak speaker, or between a speaker in different parts of his speech. In the case of the compressor type of volume range reducer shown in the patent to Green, however, there is definite distortion and it is important that such distortion be corrected. The "compander" of the Green patent is designed to do this. In our invention we desire to make use of the advantages of such volume compression and to this end there is shown at C and E in the one path the compressor and the expander portions of such a device as is disclosed in the patent to Green, and in the other path, a similar compander C' and E'. The introduction of such a compander in each path does not modify the operation of the rest of the system as described above, the calculation of losses and gains remaining as already given.

It is of interest to note that any variations in the four-wire line changes the singing margin in the same direction as the variations. In other words, if the circuit net loss becomes lower the singing margin becomes lower and vice versa. These variations affect singing margin in the same amount as they appear, however, and are not multiplied.

The effect of any possible compression in this circuit, due to the characteristics of the numerous repeaters in the line itself, is also similar to its effect in a circuit without volume control. Thus, for weak transmitting volumes where there is no overloading of tubes, there is little or no compression, and since singing margin is determined by the gains and losses for weak currents, the receiving volume delivered is the maximum possible. With stronger transmitting volumes, however, a slight curvature in the repeaters shows itself cumulatively, thereby giving rise to some compression. This causes the gain of the vogad to increase to make up for the compression, but this increase also increases the amount of six-thousand cycle tone at the input of the receiving loss control. This causes receiving volume to be lowered by an amount equal to the compression, provided the pilot tone is above the threshold of operation of the receiving loss control.

While the invention has been described particularly in terms of a half vogad at the transmitting end, it should be noted that this may be any "partial vogad". Thus the device may be designed to reduce the volume range to ⅔ at one end and to zero at the other end or any other similar relationship. In such a case the pilot current is adjusted in accordance with some other function of the two volumes, and the receiving volume reduction is apportioned in some other manner than equally between the two ends.

What is claimed is:

1. In a telephone system including a volume controlled four-wire circuit, the method of obtaining equal receiving volumes at the two ends independent of the speakers, which consists in partially reducing the volume range at one point, further reducing the volume range to zero at another point, and introducing a loss proportional to the sum of the gain changes necessary to effect the two reductions.

2. In a telephone system including a volume controlled four-wire circuit, the method of ob-

taining equal volumes at the two ends independent of the speakers, which consists in introducing gains in each path at one terminal of an amount determined by the speech volume coming to that path and introducing a loss at that terminal in one of the paths governed by the sum of the gains in the two paths.

3. In a telephone system including a volume controlled four-wire circuit, the method of equalizing transmission over the two paths, which consists in introducing a gain at the transmitting side of one terminal, introducing gain at the receiving side of the same terminal, and introducing a loss on the receiving side proportional to the sum of the two gains.

4. In a signaling system, the method of transmission over a four-wire circuit, which consists in introducing gain and loss in one of the paths which is inversely proportional to the sum of the volume of the two speakers.

5. In a communication system, the method of transmission over a four-wire circuit which consists in introducing gain on the transmitting side at one terminal inversely proportional to the transmitting volume, introducing gain on the receiving side at the same terminal inversely proportional to incoming volume, and introducing loss on the receiving side proportional to the average of the two gains.

6. In a telephone system a volume controlled four-wire circuit, means for equalizing transmission over the two paths while maintaining anti-singing conditions, comprising in each path a transmitting half-vogad and a receiving vogad, and means subject to the gain of the half-vogad and the vogad at one terminal for introducing a loss in each path.

7. In a four-wire transmission circuit with two-wire terminating sets, means for equalizing transmission over the two paths while maintaining anti-singing conditions, comprising in each path a partial vogad and a full vogad one at each terminal, and means subject to the gain of the two vogads at one terminal for introducing a loss in each path.

8. The combination of claim 7 characterized by the fact that the second named means comprises a pilot current passing through the half-vogad and vogad at one terminal.

9. The combination of claim 7 characterized by the fact that the second named means comprises an alternating pilot current of frequency outside the message band passing through the half vogad and vogad at one terminal.

10. The combination of claim 7 characterized by the fact that the introduced loss is adjusted in accordance with the sum of the two gains.

11. The combination of claim 7 characterized by the fact that the second named means comprises an alternating current of frequency outside the message band and that the loss introduced is adjustable in accordance with the sum of the two gains.

12. In a telephone system a volume controlled four-wire circuit, means for equalizing transmission over the two paths comprising in each path a transmitting half-vogad, a receiving vogad, a gain-change suppressor operating on the half-vogad, and means subject to the gain of the half-vogad and the vogad at one terminal for introducing a loss at that terminal.

13. The combination of claim 12 characterized by the fact that the gain-increase suppressor is at the receiving end of the circuit.

14. In a transmission circuit with two-wire terminating sets, a transmitting half-vogad and a receiving vogad at each terminal and means subject to the gain of the half-vogad and the vogad at one terminal for introducing a loss in the receiving path at that terminal, a crosstalk suppressor for each path and a noise desensitized voice-operated relay, an echo suppressor, a gain-change suppressor for the half vogad and means for removing the said loss, the last three elements being controlled by the said voice operated relay.

15. In a telephone system, a volume controlled four-wire circuit comprising at one end of the circuit a half-vogad in the one side and a vogad and an adjustable loss in the other side, and means controlled by the gain in these to control the adjustable loss.

16. In a telephone system, a volume controlled four-wire circuit comprising at one end of the circuit a half-vogad in the transmitting side and a vogad in the receiving side, an adjustable loss in one side and means controlled by the gain in these to control the adjustable loss.

17. The combination of claim 16 characterized by the fact that the adjustable loss is in the receiving side and comes after the vogad.

18. In a transmission circuit with two-wire terminating sets, means for equalizing transmission over the two paths comprising at one end of the circuit a half-vogad in the transmitting side, a vogad in the receiving side, a source of pilot alternating current at the input of the half-vogad and sending pilot current through both devices, and means controlled by the pilot current to introduce loss in the receiving side in proportion to the sum of the gains.

19. In a transmission circuit with two-wire terminating sets, means for equalizing transmission over the two paths comprising at one end of the circuit a half-vogad in the transmitting side, a vogad in the receiving side, a source of pilot alternating current at the input of the half-vogad and sending pilot current through both devices, and means controlled by the pilot current to introduce loss in the receiving side in proportion to the sum of the gain, and a receiving terminal echo suppressor with nogad for disabling the transmitting circuit, for preventing gain changes in the half-vogad at that terminal and for removing the adjustable loss in the event that receiving speech takes control of the circuit.

20. In a telephone system, a volume controlled four-wire circuit, means for improving transmission over the two paths comprising in each path a transmitting half-vogad, a receiving vogad, a crosstalk suppressor and a gain increase suppressor, and means subject to the gain of the half-vogad and the vogad at one terminal for introducing a loss in the receiving path at that terminal, and a compander introduced in the circuit with the compressor portion at the transmitting end and the expander portion at the receiving end.

21. The combination of claim 14 characterized by the fact that the input of the noise desensitized relay is connected to a point in the circuit where volume range is reduced, whereby the susceptibility of said relay to noise is reduced.

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