

June 9, 1936.

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2,043,403

TELEPHONE TRANSMISSION CIRCUITS

Filed Nov. 8, 1934

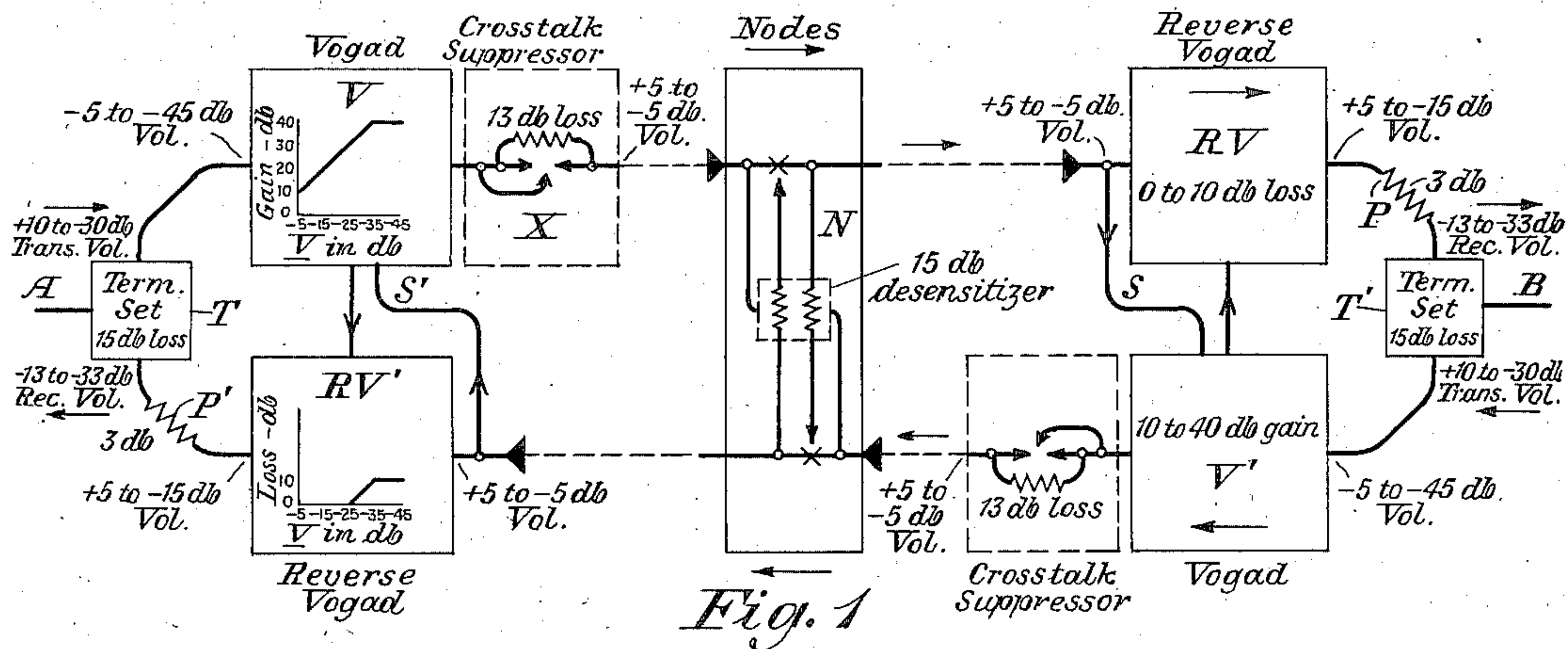


Fig. 1

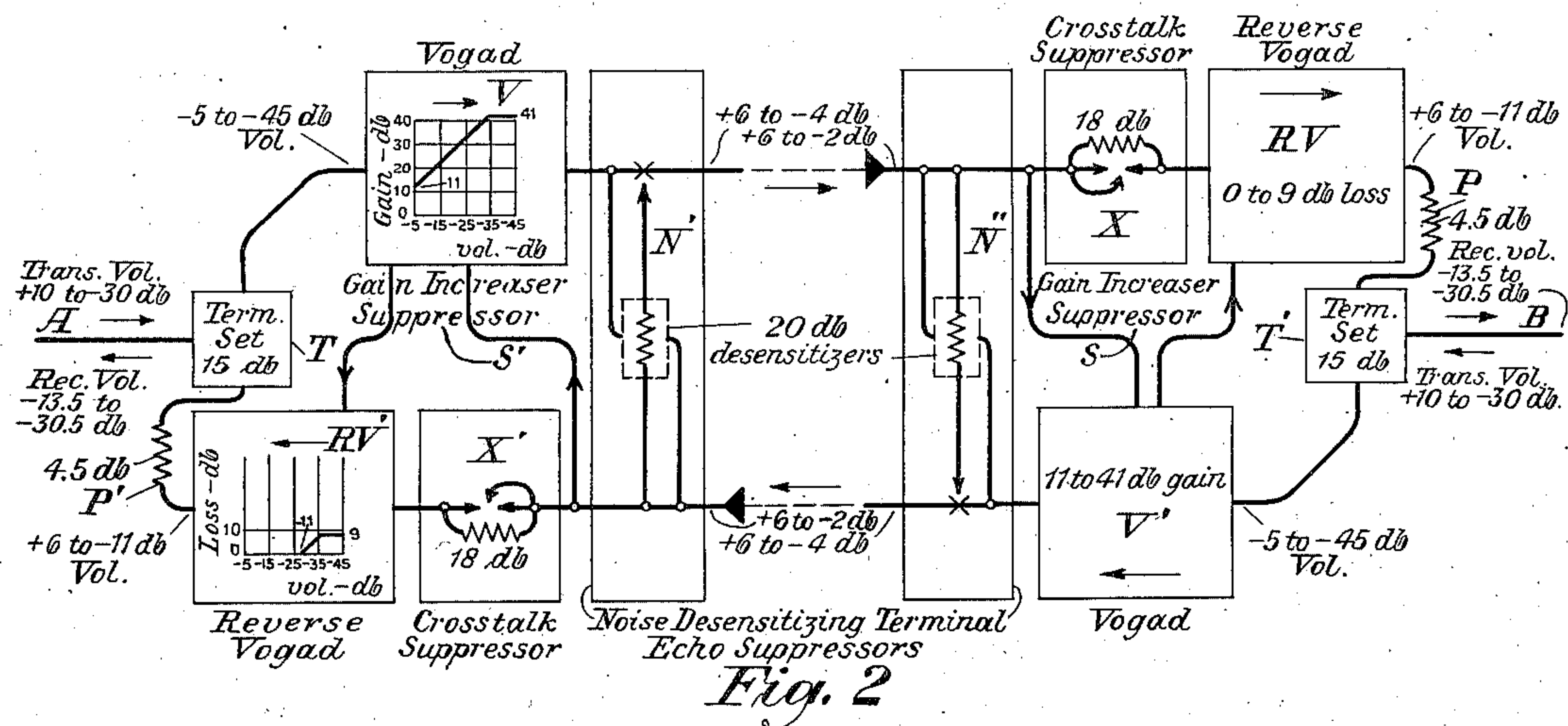


Fig. 2

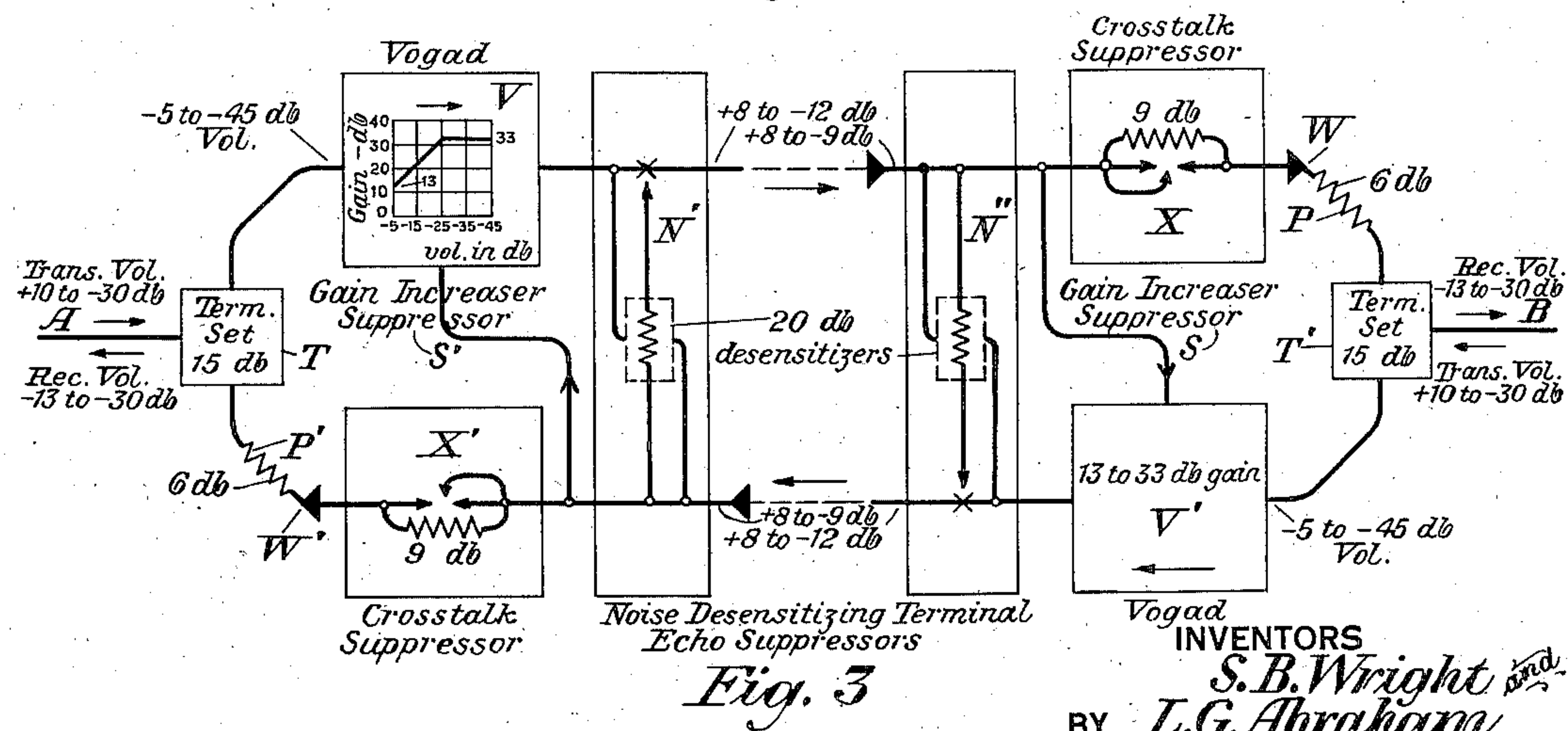


Fig. 3

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2,043,403

TELEPHONE TRANSMISSION CIRCUITS

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Application November 8, 1934, Serial No. 752,150

16 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.

5 The object of the invention is to associate various known forms of transmission control devices in a new and useful combination to obtain maximum gain over such a circuit consistent with maintenance of anti-singing conditions. A further object is to obtain maximum gain consistent with discriminating against echoes and against room and line noises. A further object is to equalize, so far as feasible, the received volume resulting from difference in loudness of the speech by the two speakers or to slow variations in the loudness of one speaker. A further object is to obtain more favorable signal-to-noise ratio for weak speakers and still a further object is to reduce the volume of a strong speaker thus reducing distortion due to overloading the line.

10 The invention will be better understood by reference to the following specification and the accompanying drawing in which Figure 1 is a circuit showing a combination of certain devices for obtaining the results named above. Figs. 2 and 3 are modifications thereof.

15 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, each of these being connected to each of the others, 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.

20 Referring to Fig. 1 there is shown such a link as an RC—RC or a PO—RC or a PO—PO 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 through 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 terminating sets including a hybrid set 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, within certain limits, as the impressed volume becomes smaller. Thus, there is a tendency for the received volume at the two ends to be largely independent of loudness of the speakers or of losses which may have been experienced by the message of one speaker before reaching the present link. To secure these results, the volume control apparatus to be described later may at times cause the circuit to be worked at a net gain. This gives rise to problems of suppressing singing and echoes and of difficulties to amplification of crosstalk from connected circuits. The problems are further complicated by the fact that room noise and noise on the connected circuit may set a limitation on the sensitivity of the various voice operated devices.

25 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 they are rather to be looked upon as so many pieces of building materials or bricks available for obtaining a new structure or system which may yield new and useful results. The details of these units will not be elaborated upon here but will be found in publications to which reference will be made hereinafter.

30 Throughout the specification and the claims, certain synthesized words are used as an economy. In particular, the term "vogad" appears, this being an abbreviation of "volume operated gain adjusting device". The term "nodes" is also used, this being an abbreviation of "noise desensitized echo suppressor". The term "reverse vogad" is also used, the term "vogad" having the same significance as above but when combined with the word "reverse" indicating that an opposite action enters, all in a manner to be described hereinafter.

35 At station A, there is a terminating set T including a hybrid set and appropriate switching pads by means of which one passes 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 first found a device V called a "vogad". The structure and characteristics of such a device are well described in patent to Hogg and Doba, No. 1,853,974, April 12, 1932. In general, its characteristic is such that the smaller the impressed volume, the larger is the gain and the characteristic to which we would desire to adjust the device for the purposes of the circuit of Fig. 1 are shown by the curve at V, where the input volume is plotted against the gain given by the vogad, both expressed in decibels. It will be observed that for all input volumes from -5 to -35 decibels, the output volume is constant at 5 db. but that for still smaller input volume, the gain remains constant. Following the vogad V comes a crosstalk suppressor X. Such a device is well described in patent to Keith, No. 1,859,565, dated May 24, 1932. It has the characteristic of being a voice-operated device which will permit the introduction of a definite loss in the circuit when no speech is present or when the speech is below a definite assigned value but will remove the loss when speech is present.

Following this element one passes out onto the transmission line and through repeaters appropriately designed and spaced to make up the losses in the line. At about the middle of the line, there is connected a noise desensitizing echo suppressor N of a type which is well illustrated in patent to Bjornson, No. 1,873,268, dated August 23, 1932. This device which is connected to both paths of the line has the characteristic of a mid-line echo suppressor with the additional feature that the suppressor is automatically desensitized by the presence of an amount of electric current which has the characteristic of noise and in general is due to noise, the amount of desensitization being in proportion to the amount of noise. Such a device has been named a "nodes" as mentioned above.

Continuing through the line with its appropriate repeaters, one reaches the station B passing first a suppressor S which may disable the vogad V' in the other path. Following this, there comes a reverse vogad RV, a device which in one form is illustrated in the patent to Herman and Wright, No. 1,740,856, dated December 24, 1929 and in another form in patent to Mitchell, No. 1,853,070, dated April 12, 1932. This device is subject to control by the vogad V' and has the characteristic of introducing loss, if the gain of V' becomes high. The loss characteristic to which the reverse vogad is adjusted for the purposes of the circuit of this figure is illustrated by the curve in RV'. It will be noted that it starts introducing loss when the gain of its controlling vogad is 30 db. corresponding to input volume of -25 db. and, from that point on over a necessary range, the loss introduced increases with the gain of the vogad, db. for db. and then becomes constant. Following the devices RV, there is shown an attenuating pad P and the terminating set T' from which the message then goes to B.

We will now consider what occurs to speech coming from the point A and which may have a volume range which we will take as from +10 db. to -30 db. for illustrative purposes. Having passed through the terminal set T and suffered a loss of 15 db., the volume now to be impressed on the vogad V may range from -5 db. to -45 db.

The characteristic of the vogad is designed to give constant output volume except for the lowest

10 db. of input volume, as shown by the curve. If this input volume has the maximum value of -5 db., there will be a gain in the vogad of 10 db. This is in general lower than the maximum volume put into the line with a circuit operated at constant net loss, where the vogad would be replaced by a terminal repeater with about 25 db. gain in that case. As a result the maximum volumes are transmitted over the line with less distortion due to overloading with the vogad arrangement. The speech wave will operate the crosstalk suppressor and then pass out to the line at a value of +5 db. The loss from step to step is made up by the distributed repeaters so that the speech arrives at the input of the reverse vogad RV with a volume of +5 db. If the speech in the reverse direction has been of reasonably large volume the loss in RV is zero, and the speech is transmitted through to B with a loss of 18 db., arriving with a volume of -13 db. In its passage through the crosstalk suppressor, this suppressor has been operated by every syllable, but during periods between syllables or between sentences, a definite loss has been inserted in the circuit which discriminates very strongly against crosstalk during those periods. While syllables are being actually transmitted, this loss is cut out and the crosstalk comes through, but it is effectively masked by the speech message.

If the impressed volume on the vogad has a value less than -35 db., the vogad has its maximum gain of 40 db. With this maximum gain the circuit will have an overall gain of about 7 db., whereas crosstalk limits have been set up on the basis of having a definite loss rather than a gain between the connecting circuit and the subscriber. A loss which may be properly taken in this case is 6 db., and for this reason we have shown the loss in the crosstalk suppressor as having a value of 13 db. The crosstalk suppressor should have a sensitivity high enough to be operated by impressed speech as low as -45 db. in volume, which will be -5 db. upon reaching the crosstalk suppressor. This suppressor has been shown as adjacent to but separate from the vogad, but in many cases it would be incorporated in and be a part of the vogad.

Upon reaching the nodes or noise desensitizing echo suppressor N, a part of the waves are diverted so as to disable the opposite bound transmission path and thus prevent echoes being heard at A. When the noise is not sufficient to operate the desensitizer the echo suppressor should preferably be adjusted to have a sensitivity corresponding to that of the crosstalk suppressor resulting in operation on every syllable. If the noise is great enough, however, the desensitizing circuit will operate to reduce the sensitivity in proportion to the amount that the noise exceeds a safe value. It will be appreciated that when the echo suppressor has been desensitized it will not operate on every syllable and thus some echo from the weak syllables will be present. Noise of this magnitude may operate the crosstalk suppressor thus increasing echo tendencies but, in this case, the noise will be effective in masking this echo.

If a gain so large as 40 db. is present in the vogad V there will be an overall gain in this path of 7 db. and it will be necessary therefore, in order to prevent singing to assure that there is sufficient loss in the other path to maintain a safe singing margin. To this end we introduce in the other path the reverse vogad RV' the loss characteristic of which is given by the curve. It

will be noted that with a gain of 40 db. at V, which corresponds to an impressed volume of -35 db. to -45 db., there is introduced in RV' a loss of 10 db. which, in itself, would more than offset the gain of 7 db. in the first path.

From the echo suppressor N, waves travel on over the circuit to the receiving terminal where a portion is diverted to an echo suppressor device S which is set relatively insensitive so as to never become operated by noise. The purpose of this device is to block the input of the vogad V' so that echoes of strong parts of speech will not cause it to adjust. This suppressor may very properly be spoken of as the gain increaser suppressor. Echoes of waves which fail to operate this device will always be too weak to operate the gain increaser of the vogad V'.

The received waves now enter the reverse vogad RV, the purpose of which is to maintain the singing margin whenever the gain adjustments of the vogad V' reduce the singing margin to the limit. The loss in RV will be zero unless the received volume at V' is so low as to call for large gain in V'. An attenuating pad P is now introduced and may be of any suitable value which we have here indicated as 3 db. This pad insures that there will be a sufficient loss between the last of the receiving terminal repeaters and the subscriber.

As an illustration of the operation of the circuit we may take an extreme case in which the speaker at A yields a volume of +10 db., while the speaker at B yields a volume of -30 db. In that case the input for V will be -5 db. and the input of V' will be -45 db. V will then operate to give a gain of 10 db. and V' a gain of 40 db. RV' will then offer no loss, but RV will be set to give a loss of 10 db. The received volume at B will thus be -23 db. and the received volume at A will be -23 db. The net loss over the path A to B is 33 db. and over the path AB is -7 db. Thus, a singing margin of 26 db. is maintained. The case taken is for illustrative purposes only, and many others could be used. In every case it will be found that if there is a difference in the impressed volume at A and B the tendency is to reduce this difference so far as the received volumes are concerned, but always in a manner consistent with maintaining a safe singing margin.

While in the calculations given above, the crosstalk suppressor and the suppressor N do not enter for the reason that they do not effect the gain of the speech, they are, nevertheless, of vital importance. With the crosstalk suppressor, for example, it will be noted that it acts effectively to introduce an appreciable loss in the circuit for intervals between syllables or sentences when the crosstalk would be quite noticeable, and yet introduces no loss during the time when syllables are being pronounced, for the syllables mask the much weaker crosstalk. It is essential in this combination, however, that the sensitivity of this crosstalk suppressor be set such that it will be operated by all speech syllables above a certain volume, such as -45 db. The desensitizing feature of the suppressor N is also of importance, for without such a desensitizer it would be operated more and more frequently by noise if, for any reason, the noise on the line should increase. Such operation by noise should, of course, be guarded against, and the desensitizing feature accomplishes this.

Fig. 2 shows a modification of the circuit of Fig. 1, this consisting chiefly in replacing the central type echo suppressor N of Fig. 1 by two

terminal echo suppressors N' and N''. Also, the crosstalk suppressor has been placed at the receiving terminal instead of at the transmitting terminal.

The manner in which the special devices of this circuit operate to minimize the effects of working one circuit at a gain, may be understood by considering the operation as follows: A volume range at A of +10 db. to -30 db. referred to reference volume, is assumed. After traversing the terminating set with hybrid coils and appropriate pads, giving a total loss of 15 db., a volume range of -5 db. to -45 db. is available at the input of the vogad V. As before, the characteristic of the vogad is designed to give constant output volume except for the lowest 10 db. of input volume, as shown by the curve relating the required gain to the transmitting volume, on the drawing. The output of the vogad is applied to the circuit with a volume range of +6 db. to -4 db., this value being chosen, so far as this illustration is concerned, so as not to cause any more crosstalk in the adjacent circuits than the usual spread of volumes does in many constant net loss circuits now in actual use.

Upon reaching the receiving terminal nodes N'', a part of the waves are diverted so as to disable the opposite bound transmission path and prevent echoes being heard at A. When the circuit is quiet the suppressor is to have a sensitivity such that operation occurs on all syllables. If, however, noise increases, which noise would itself tend to operate the suppressor, desensitization occurs in proportion to the amount of noise so that operation of the suppressor occurs only when the speech volume is in excess of the noise by a certain amount. Since the suppressor under these conditions will not operate on every syllable some echo from the weak syllables will be present, but the noise which is also present under these conditions will effectively mask this echo. The two suppressors in this Fig. 2, as well as the suppressor N in Fig. 1, are desensitized by noise from either direction so as to keep their sensitivities equal and thus avoid false operation from echoes.

Also at this point in the receiving terminal a portion of the wave is diverted to an echo suppressing device S similar to that described in connection with Fig. 1. The purpose of this device, as before, is to block the operation of the vogad V' so that echoes of strong speech will not cause it to adjust itself. In order to avoid changing the noise applied to the noise desensitizers, this device should not suppress transmission in the circuit, but suppress change in the transmission, that is, it should merely maintain such vogad gain at V' as is present at the moment.

The maximum vogad gain, here shown as 41 db., evidently amplifies crosstalk from the connecting circuits as well as speech sounds. This crosstalk, as explained in connection with Fig. 1, may be particularly troublesome between syllables or between sentences. We therefore include again in this circuit a crosstalk suppressor which introduces an appreciable loss, here shown as 18 db., appropriate for such circuits as are being described, this loss being present in the intervals between speech sound. To avoid the clipping out of certain words this device must be set so that operation occurs on all speech sounds which it is desired to transmit.

The received waves now enter a reverse vogad before passing through the pad and terminating

set to the subscriber, all in the manner described in connection with Fig. 1. This is for the purpose of maintaining the singing margin whenever the gain adjustments of the vogad become so high as to reduce the singing margin to the limit.

There is one feature characteristic of long lines with repeaters of the type herein described. In practice, each repeater when operated at large volume shows a little decrease of amplification due to slight curvature of the characteristic. This is not present appreciably, however, for low volume. The effect is cumulative, and on a reasonably long line with a considerable number of repeaters, may amount to about 5 decibels. Usually the repeaters are stepped up a little so that normal gain is obtained for loud volume, whereupon the gain for low volume will be higher. This amounts to a volume compression, as has been indicated in Fig. 2, by the fact that volume range at the input side of the line is +6 to -4 db., while at the output end it is +6 to -2 db. The effect is present also in the circuit of Fig. 1, but has been ignored there. It should in all cases be taken into consideration in making calculations on singing margin, etc.

One advantage of the reverse vogads which have been shown in connection with Figs. 1 and 2, is that when two people are talking over the same circuit the one with a weak voice and the other with a strong voice, the strong voiced person is able to hear the weak voiced person louder than he would without the reverse vogad. The received volumes tend to become equalized. Also, the signal to noise ratio within the RC-RC circuit is improved for the weaker talker for whom this is most important.

It may also be pointed out that with the vogad and the noise desensitized echo suppressor, the suppressor will not work so frequently on room or line noise, for with the vogad the suppressor need not be set so sensitively to operate on weak speech.

Fig. 3 shows a circuit which obtains much the same results as Fig. 2, but in a somewhat simplified and more economical manner. It differs from the previous two circuits in that it is operated without the reverse vogads. This, of course, makes it impossible to countenance such large gains in the vogad as were shown in Figs. 1 and 2. In this figure then, it will be noted that the maximum gain of the vogad has been set for 33 db., the general characteristic being such that constant output volume is present for impressed volume range from +10 db. to -10 db., beyond which the gain, itself, remains constant. Aside from this the circuit operates in the same manner. Some of the different values for gains and losses in the different units have been shown to illustrate the variations which are possible in this direction, but still values which are consistent with the requirements of the circuit as described heretofore. It will be noted that with the particular values shown the volumes on the line fall to lower values than in the case of Figs. 1 and 2. For this reason the sensitivity of the noise desensitizing echo suppressors or vogads would have to be made somewhat greater in order that they shall be operated by every syllable. This will result in a greater number of cases where the noise desensitizing circuit will have to operate to reduce the sensitivity, although the range of the desensitizer need not be increased. The reason for this increased number of noise operations is that the strong talkers are given the same gain by the vogad as in the circuits of Figs. 1 and 2,

and, thus, the sensitivity of the suppressor referred to, or as seen from, the terminal, will be greater for all strong talkers than in the arrangement of Figs. 1 and 2. Consequently, more operation from room noise and line noise with stronger talkers may be expected.

At the receiving end of the circuit there might be false operation of the gain increase disabler S by transmission from the wrong end of the circuit. This is made possible because of the removal of the reverse vogad which, itself, is a unilateral device. To prevent such false operation it is desirable to introduce some other unilateral device such as a vacuum tube repeater, as shown at W, which may, in addition, introduce gain or loss of any desired value, or may be neutral.

On account of the higher volume transmitted on the line it is desirable that the pad P shall have a larger loss in order to bring volume at B to a standard value and so is here shown as 6 db. instead of 3 db., as in Fig. 1. This, incidentally, has the salutary effect of reducing the received noise somewhat. In connection with this last circuit it may be said that while it offers some economy in apparatus it increases the difficulties from crosstalk and noise within the four-wire circuit, and does not give as much improvement to either volume, or volume to interference ratio, as the circuits of Figs. 1 and 2, of which Fig. 2 is the preferred circuit. On the other hand, it has the advantage of making the received transmission independent of the outgoing volume.

While this invention has been described with an RC-RC link in mind it is to be understood that it is applicable to other links, such as PO-PO links or that the terminal apparatus shown in each of the flanges as associated definitely with a circuit link such terminal and echo suppressing apparatus may be attached to the cord circuit so that it is automatically introduced on a connection between any two specified links.

What is claimed is:

1. A telephone system including a link having separate paths for transmitting in opposite directions, with two-wire terminating sets, and means for improving transmission comprising for each path a vogad, and a nodes the sensitivity of which is controlled in part by the gain of the vogad.
2. A telephone system including a link having separate paths for transmitting in opposite directions, with two-wire terminating sets, and means for improving transmission, comprising for each path a vogad, a gain increase suppressor therefor operated from the other path, and a nodes the sensitivity of which is controlled in part by the gain of the vogad.
3. A telephone system including a link having separate paths for transmitting in opposite directions, and means for equalizing the received volume from speakers at the two ends, comprising for each path a vogad, a nodes and a reverse vogad, and means whereby the vogad at one end controls the loss in the reverse vogad in the other path and controls the sensitivity of the nodes.
4. A telephone system including a link having separate paths for transmitting in opposite directions, and means for equalizing the received volume from speakers at the two ends comprising for each path a vogad, a gain increase suppressor therefor operated from the other path, a nodes and a reverse vogad, and means whereby the vogad at one end controls the loss in the reverse vogad in the other path and controls the sensitivity of the nodes.

5. A telephone system including a link having separate paths for transmitting in opposite directions, with two-wire terminating sets, each path of the link comprising a vogad, a gain increase suppressor therefor operated from the other path, and a crosstalk suppressor coming after the vogad, each device being adjusted to a gain and loss characteristic and operational sensitivity to permit maximum volume on the line without singing.

6. A telephone system including a link having separate paths for transmitting in opposite directions with two-wire terminating sets and means for improving transmission comprising in each path a vogad, a gain increase suppressor therefor operated from the other path and controlling the vogad, a nodes the sensitivity of which is controlled in part by the vogad, and a crosstalk suppressor.

7. A telephone system including a link having separate paths for transmitting in opposite directions with two-wire terminating sets and means for equalizing the received volume from the two ends comprising in each path a vogad, a gain increase suppressor therefor operated from the other path, two terminal nodes and a crosstalk suppressor, each device being adjusted to a gain and loss characteristic and operational sensitivity such that no singing around the link occurs the sensitivity of the nodes being controlled in part by the vogad.

8. The combination of claim 7 characterized by a unilateral device at the receiving end of each path to prevent transmission of speech over the wrong path.

9. A communication system including a link having separate paths for transmitting in opposite directions, and means for improving transmission comprising in each path a vogad, a gain increase suppressor therefor operated from the other path and controlling the vogad, a nodes the sensitivity of which is controlled in part by the vogad, a crosstalk suppressor and a reverse vogad the loss of which is controlled by the vogad.

10. A signaling system including a link having separate paths for transmitting in opposite directions, and means for equalizing the received volume from speakers at the two ends comprising in each path a vogad, a gain increase suppressor therefor operated from the other path, a nodes, a crosstalk suppressor and a reverse vogad, and means whereby the vogad at one end controls the loss in the reverse vogad in the other path and controls the sensitivity of the nodes, the loss characteristics of the elements being adjusted to maintain a singing margin.

11. A telephone system including a link having separate paths for transmitting in opposite directions, and means for equalizing the received volume from speakers at the two ends comprising in each path a vogad, a nodes, a crosstalk suppressor and a reverse vogad, and a suppressor circuit from the receiving end of one path operating on the vogad at the transmitting end of the other path to prevent change of gain therein when speech is present in the first path the sensitivity of the nodes being controlled in part by the vogad.

12. A telephone system including a link having separate paths for transmitting in opposite directions with two-wire terminating sets and means for equalizing the received volume from speakers at the two ends comprising in each path a vogad,

a gain increase suppressor therefor operated from the other path, a single terminal nodes, the sensitivity of which is controlled by noise from both paths, a crosstalk suppressor and a reverse vogad, the loss in the reverse vogad being controlled by the gain in the vogad in the other path the sensitivity of the nodes being also controlled in part by the gain in the vogad.

13. In a telephone system, a volume controlled link having separate channels for transmitting in opposite directions, each channel including at the transmitting end a vogad followed by a crosstalk suppressor, a noise desensitizing echo suppressor and at the receiving end a gain change disabler followed by a reverse vogad, the vogad introducing loss in the reverse vogad on the other side at times of high gain and controlling the sensitivity of the nodes, the gain change disabler holding the gain of the vogad on the other side constant in response to received waves above a predetermined value, whereby impressed loud volume is subjected to loss in transmission, and impressed low volume is subjected to gain.

14. In a telephone system, a volume controlled link having separate channels for transmitting in opposite directions, each channel including at the transmitting end a vogad followed by a crosstalk suppressor, a mid-circuit noise desensitizing echo suppressor and at the receiving end a gain change disabler followed by a reverse vogad, the vogad introducing loss in the reverse vogad on the other side at times of high gain and controlling the sensitivity of the nodes, the gain change disabler holding the gain of the vogad on the other side constant in response to received waves above a predetermined value, whereby if high volume is impressed at one end of the link and low volume at the other end, loss is introduced in the first path and gain is introduced in the second path.

15. In a telephone system a volume controlled link having separate channels for transmitting in opposite directions, each channel including at the transmitting end a vogad followed by a crosstalk suppressor, and at the receiving end a receiving terminal nodes the sensitivity of which is controlled in part by the vogad, a gain change disabler followed by a reverse vogad, the vogad introducing loss in the reverse vogad on the other side at times of high gain, the gain change disabler holding the gain of the vogad on the other side constant in response to received waves above a predetermined value.

16. A telephone system including a link having separate paths for transmitting in opposite directions, with two-wire terminating sets, the combination of a vogad at the transmitting end of each path and a noise desensitized echo suppressor for each path coming after the vogad, the vogad giving low gain for high input volume and high gain for low input volume, the suppressor being adjusted to a sensitivity to operate when the line is without noise on all speech sounds to be transmitted, and adapted to become less sensitive in proportion to the increase of line and room noise, whereby at times of high vogad gain for weak speech the echo suppressor is set at less sensitivity for such weak speech without substantial increase in frequency of operation of the noise desensitizing mechanism of the suppressor.

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