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H. NYQUIST ET AL

2,045,720

TELEPHONE TRANSMISSION CIRCUIT

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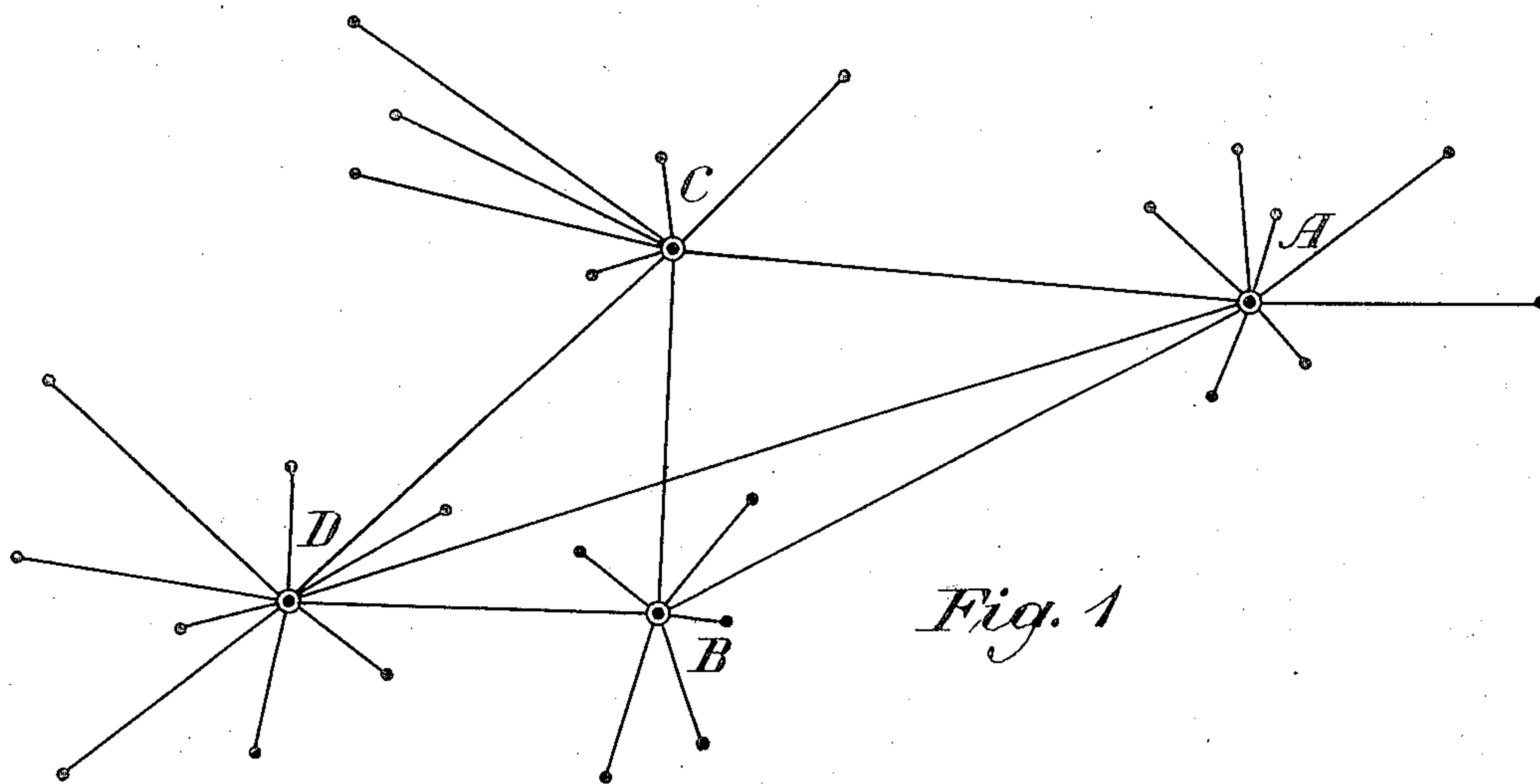


Fig. 1

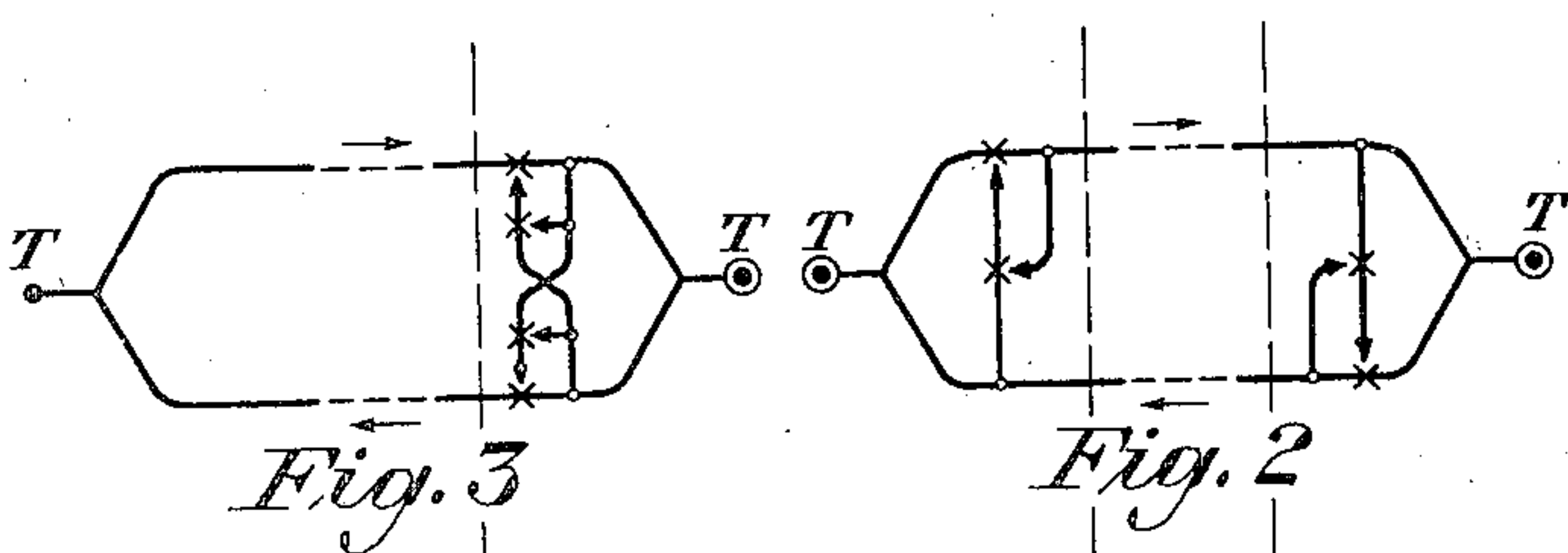


Fig. 3

Fig. 2

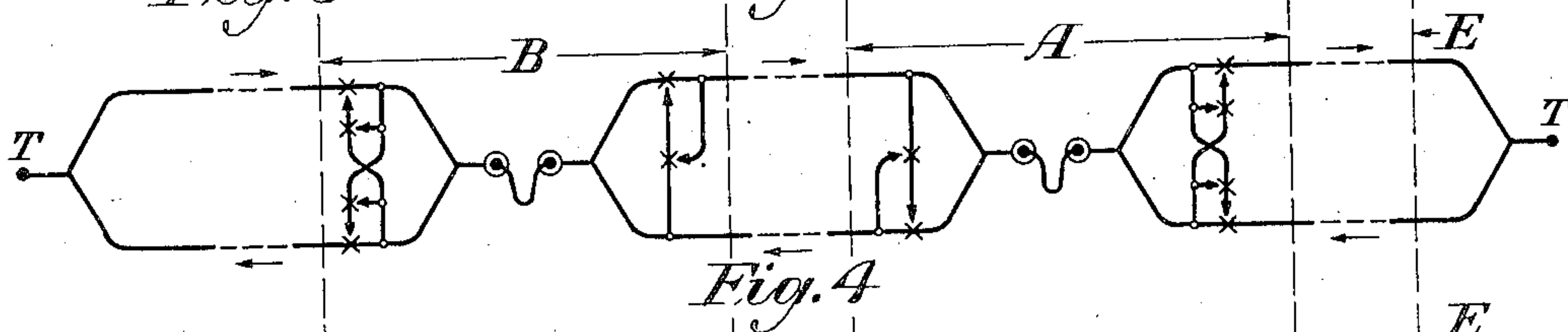


Fig. 4

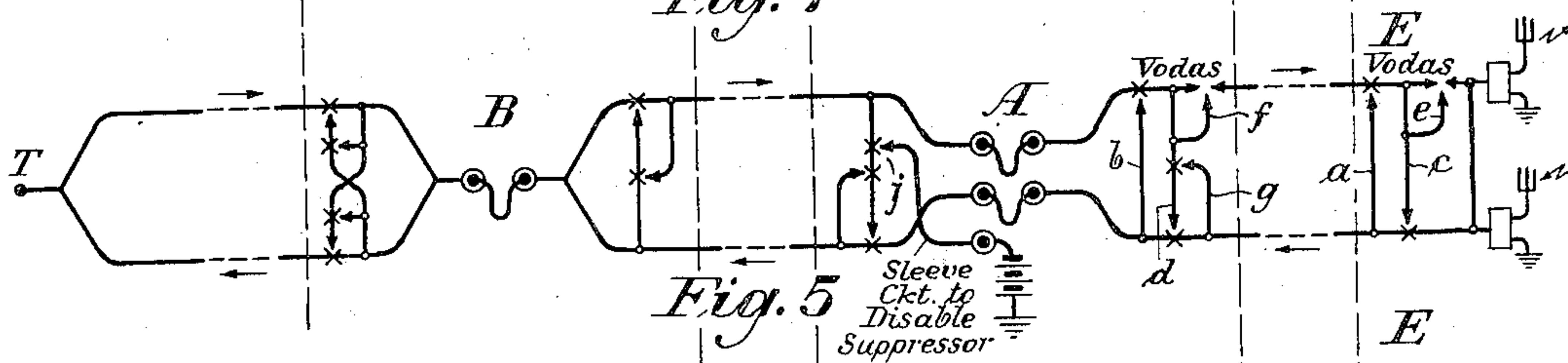


Fig. 5

T=Connection to Toll Center
or Subscriber.
⊙=Regional Center thru Board.
•=Primary Outlet " "

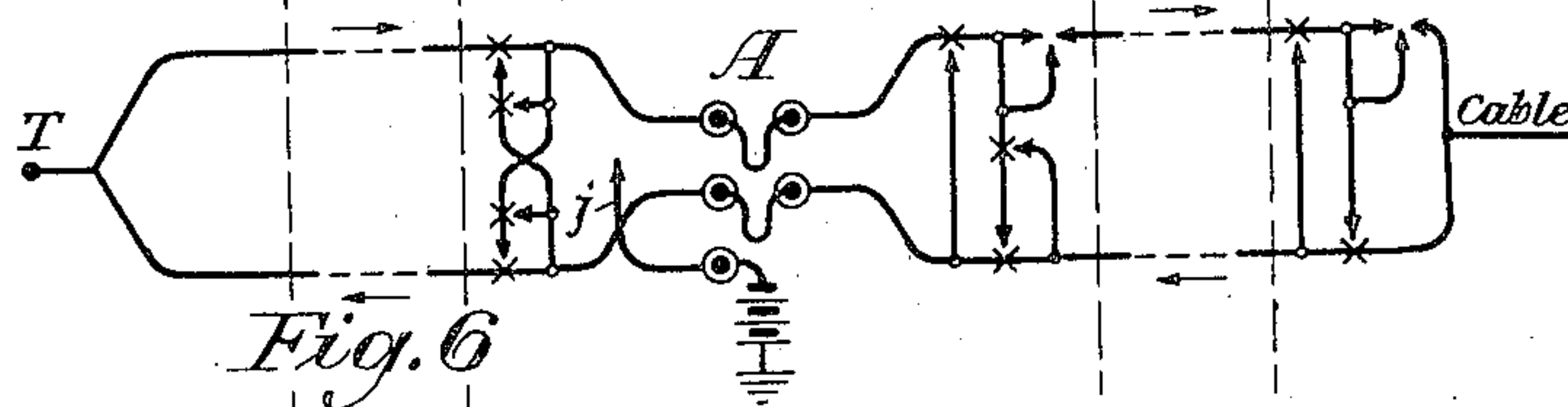


Fig. 6

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TELEPHONE TRANSMISSION CIRCUIT

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This invention relates to telephone transmission circuits and more particularly to circuits where a number of sections or links of signaling circuits, each normally provided with echo suppressors, are connected in tandem.

Its purpose is to provide means for reducing the lockout or preventing increase of lockout when such tandem or series connection of signaling links is made. A further purpose is to concentrate the echo suppressors at certain important switching centers and still a further purpose is the design of a new type of echo suppressor which makes their concentration feasible.

In the case of rather long telephone circuits in which the time of transmission exceeds a certain amount, the echoes which arise in such a circuit become sufficiently serious to justify the introduction of so-called echo suppressors and frequently of so-called anti-singing devices, both of which have become now fairly well known in the art of communication. When several such links, each equipped with echo suppressors, are connected in series, then the very presence of these echo suppressors leads to lockout over certain lengths of line, that is, each speaker disables the line for the other speaker and neither can get his message through. The frequency and seriousness of this lockout naturally varies widely under different conditions, but it is the aim of this invention to reduce the lockout zone to as low a value as possible and we have found that by the use of the proper types of echo suppressors and by their proper disposition, it is possible in the case of land connections to eliminate the lockout and, in case the circuit set up brings in a radio telephone link or a corresponding cable, to confine the lockout zone substantially to the radio channel or the cable.

The invention will be better understood by reference to the following specification and the accompanying drawing, in which Figure 1 gives a schematic layout of telephone circuits as used in such countries as the United States; and Figs. 2 to 6 are various communication links or combinations thereof, to illustrate our invention.

Referring more particularly to Fig. 1, there are shown certain important telephone centers represented by circles and which might correspond to such cities as New York, Chicago, Dallas and San Francisco. Important centers such as these have been classed as regional centers and will be referred to as such in this specification by the abbreviation RC. It is the practice, in general, to have each of these regional centers connected directly to each of the other regional centers, and

such connection between two regional centers will be referred to hereafter as an RC—RC link. At the same time each regional center is connected to a number of important outlying points commonly spoken of as primary outlets or as toll centers, and a link between a primary outlet and a regional center will be hereinafter referred to as a PO—RC link. Of course, it is to be understood that from these primary outlets there are still further circuits to fan out to outlying communities and on to subscriber stations, and thus it is possible to connect any two subscriber stations in the country by passing through a small number of switching points. These links may be anywhere from a few hundred to two or three thousand miles long.

In the event that these links are quite long or the character of the line is such that the velocity of transmission is rather low, then the echoes set up in the circuits become disturbing, the extent to which they become disturbing being approximately proportional to the delay of the echo behind the direct speech. To overcome these echoes, echo suppressors of various types have been designed and a type which has been used on the RC—RC links is that known as the single terminal echo suppressors, such as are described in the patent to Abraham No. 1,826,196, October 6, 1931. A form of echo suppressor which might be suitable for use in the PO—RC link is that known as the double terminal echo suppressor shown in the patent to Crisson, No. 1,961,279, June 5, 1934. Such links as described above are operated as four-wire circuits and the connection of two or more links in series at a switching point may be on a four-wire or a two-wire basis.

Another type of link which enters in present communication service is represented by that which extends from such a center as New York city and includes outlying radio receiving and transmitting systems for trans-Atlantic communication, or a long cable such as a trans-Atlantic cable. Such a link is subject to large changes or mutations, and the geographic location is such that frequent repeaters are not feasible as in the case of land lines, so that the message is subject to very large attenuation and numerous disturbances become more significant. On such links, therefore, it is necessary to take greater precautions against disturbances and mutations, and to this end it is customary to have the circuit, at least in one direction, normally disabled but so arranged that it is enabled by the speaker. A typical form of equipment for bringing this about is

known as a vodas, this standing for "voice operated device anti-singing".

An RC—RC link of the kind described above, is shown in conventional form in Fig. 2 in which the transmission is shown as going from terminal to terminal, the speech in one direction as it reaches the end of that section operating an echo suppressor to disable the line in the other direction, this being done through a simple echo suppressor. If, however, speech arrives at that point from the other direction first then this echo suppressor is disabled by that speech.

In Fig. 3 there is shown a PO—RC link equipped with the double type of terminal echo suppressor described in the patent to Crisson mentioned above at both ends of the link. In our invention, however, we desire to concentrate all echo suppressors so far as possible at regional centers, this being desirable because of the expense and added difficulty of maintaining such echo suppressors at outlying points such as the primary outlets. For this reason, according to our invention, the PO—RC links are set up as shown in Fig. 3 in which a double terminal echo suppressor is supplied to the link only at that end which comes in at a regional center. Also, according to our invention, this double terminal echo suppressor is the reverse of that shown and used in the prior art in that the connection for the suppressor operated by the speech message coming into the link from the regional center is placed in front of the break in the circuit which may be brought about by the echo suppressor from the other side of the line, whereas speech from the primary outlet must find its line enabled before it can reach the circuit to the echo suppressor which it controls. It will be noted that each echo suppressor may, itself, be disabled and an inspection of Fig. 3 will readily show that if speech has arrived from the primary outlet it disables the echo suppressor from the other side so that its own transmission path cannot be interrupted so long as speech is maintained. On the other hand, if the receiving side of the line has been disabled and speech comes in from the regional center this speech message will disable the echo suppressor and thus establish its own path, but at the same time cannot disable the transmitting side of the line so long as speech message continues coming from the primary outlet. Under these circumstances we find that it is not necessary to have an echo suppressor of either the single or double type at the primary outlet, and thus can confine the echo suppressors to regional centers.

The circuits of Figs. 2 and 3 show the arrangements of the special land circuits when they are used for regular business between telephones in the United States. They are shown here as four-wire circuits, and it is to be understood that the signaling may be carried on in the voice frequency channel range or on carrier current channels. Fig. 4 shows the arrangement in the case of a through or "via" call, that is, a call which requires the series connection of two or more links of the type described in Figs. 2 and 3. In this case the via call is represented as consisting of three links, the two outside links being PO—RC links, and any intermediate links being RC—RC links. In this figure, also, the connection is shown as a two-wire switching connection between the links, such connections taking place at regional centers, here designated by the letters A and B and including the equipment between the vertical dotted lines. Each link is provided

with echo suppressors in accordance with the plan given in connection with Figs. 2 and 3, and it will be observed that lockout can occur only over the RC—RC link. This restriction of the lockout to one zone represents an important part of our invention.

Fig. 5 shows the arrangement in the event that a connection is to be made to a link containing a vodas, that is, to such a link as the present trans-Atlantic radio link or to any long cable link, such as indicated in Fig. 5. Many arrangements for such a vodas link are possible and in the one shown here it is expected that there would be a reasonably long four-wire circuit running from such a point as New York to suitable radio transmitting and receiving stations or to a cable landing station. In such a circuit it would be desirable to have two simple echo suppressors *a* and *b* each connected to be operated by signal coming from the cable side. At the same time it is found desirable to have two simple suppressors *c* and *d* each operated by message from the regional center and operating to disable the receiving side from the cable. Also, in this circuit, it is desirable to have the transmitting side normally disabled, and preferably in two places *e* and *f*, but so arranged that the message from the regional center, if permitted to reach the necessary points, will automatically enable the lines and establish its transmission path. In addition it is found desirable to have a device *g* to disable the echo suppressor *d* in the event that message comes in over the cable. On this basis then it is seen that the vodas link has a vodas at each end of the four-wire portion both connected in a direction so that the transmitting line is normally disabled and the receiving line is normally enabled. The details of such a link are substantially described in patent to Crisson et al. No. 1,837,316, December 22 1931. Reference to that patent will show a vodas adjoining the radio or cable portion of the link which is the same as that shown at E of this application. The vodas shown at the A terminal in this case differs from the Crisson patent in that the vodas of this application includes the element *d*, which acts as a suppressor, and the element *g*, which acts as a disabler for that suppressor. We have found it desirable to add these two elements because of the fact that in some circuits the length of the line from A to E may be many hundreds of miles long and of a character which would permit of an appreciable amount of crosstalk. The suppressor *d* and disabler *g* are helpful in this situation.

Normally the switching connection from a land link to the vodas link is made on a four-wire basis as shown in Fig. 5, and in these circumstances the possibilities of excessive lockout are present, and one purpose of this invention is to avoid the increase of lockout on calls switched at a regional center from such a channel such as the trans-Atlantic link. It will be observed that lockout may occur on the vodas link and also that normally additional lockout might occur if an RC—RC link is switched in. To prevent such increase in lockout we proposed to disable the echo suppressor adjacent to the vodas link in the land link, and the manner we propose for doing this is through a circuit on the sleeve of the jack and plug by which four-wire connection to the vodas link is made. This is shown in Fig. 5 at *j*. This disabler consisting of a relay breaking the circuit of the adjacent echo suppressor, the relay itself being supplied with battery when the sleeve connection is established. With this connection it is seen that echoes are still suppressed as before but no lockout

can occur due to the RC—RC link, and such lock-out as does occur is definitely confined to the vodas and cable link.

In the event that a PO—RC link is to be connected directly to the vodas link it is again done by four-wire switching as shown in Fig. 6, but since the inner or adjacent terminal of the PO—RC link is equipped with a double suppressor as described in connection with Fig. 3, there will be no increase in the lockout zone and therefore, it is not necessary to disable any echo suppressors. Under such circumstances then, the sleeve circuit from battery to relay *j* is ineffective, and a feature of our invention is that when an RC—RC link is switched to the vodas link its near echo suppressor shall be disabled, but when the link to be connected is a PO—RC link then no operation on the suppressor takes place.

The operation of the circuits as shown in Figs. 5 and 6 may now be explained as follows: Assume that speech originates from the land side. In Fig. 5 the connection at center A has automatically disabled the terminal echo suppressor on the land circuit when the cord is put up. Assuming for the moment that there is no received speech, the double terminal echo suppressor operates at a regional center to suppress echoes coming from the two-wire connection at that point which is at the regional center B. The single suppressor at the regional center B is disabled by speech as well as the opposite bound half of the double suppressor. Upon arrival at station A the waves operate the vodas which clears the way for transmission to the cable or other channel.

Assuming that no waves are going out, waves may be received from the cable. These waves operate the receiving suppressor at station E, disable the suppressor in the vodas at station A, disable the transmitting side of the circuit at A and travel through to B where they operate the echo suppressor so as to suppress echoes from the unbalance at that point. Passing through the cord to the last link in the connection they operate the double terminal echo suppressor so as to suppress echoes from beyond and prevent the local subscriber from the land side from breaking in.

The avoidance of lockout may be understood by assuming that the local subscriber has started talking and his waves have reached the portion of the circuit between stations A and E. Incoming waves from the vodas link may then take control of the circuit because the echo suppressor at A on the land circuit has been disabled at *j*. These waves operate the suppressors at E and A in the vodas link but they are prevented from operating the suppressor at B on the end of the RC—RC link because the disabler has been operated by the outgoing waves. As a result of this some echo may be returned to the cable circuit from B or points beyond, but this echo will not operate the vodas on account of slow release or hangover on the receiving suppressor relays of the vodas, a characteristic of the vodas described in the patent to Crisson et al. cited above. Passing through the cord circuit at regional center B, the waves take control of the double echo suppressors away from the local speaker by disabling his echo suppressors and opening his line, this being made possible by the reversal in connection of this double suppressor.

In the circuit of Fig. 6, the action is similar except that there is no single terminal echo suppressor involved in the connection.

What is claimed is:

1. In a communication system of several four-

wire links connected in series at switching points by two wire cord circuits equipped with echo suppressors, at least one of the two outside links being a PO—RC link, means for suppressing echoes and for preventing lockout, said means being confined to regional centers and consisting of double echo suppressors on the PO—RC links and single terminal echo suppressors at each end of the inner links.

2. The combination of claim 1 characterized by the fact that the terminal suppressors of the inner links which are controlled by speech in one direction have disabling means controlled by transmission in the opposite direction.

3. In a communication system consisting of two or more four-wire links connected in series, one of the end links of which contains a vodas with four-wire switching to the adjacent link, the adjacent link being a PO—RC or an RC—RC link, means for avoiding echoes consisting of echo suppressors in each link, the echo suppressors in the case of the RC—RC links being a single terminal suppressor and in the case of the PO—RC links being a double suppressor at the inner end of the PO—RC link where it enters a regional center switching point.

4. In a communication system consisting of two or more four-wire links connected in series, one of the end links of which contains a vodas with four-wire switching to the adjacent link, the adjacent link being a PO—RC or an RC—RC link, means for avoiding echoes consisting of echo suppressors in each link, the echo suppressors in the case of the RC—RC links consisting of a single terminal suppressor and in the case of the PO—RC links being a double suppressor at the inner end of the PO—RC link where it enters a regional center switching point, and means to avoid increasing lockout upon the connection of such links in series, said means being at the inner terminal of the vodas link and consisting of a device to disable the adjacent terminal suppressor if and when the switching link is an RC—RC link and to leave it enabled if the link is a PO—RC link.

5. The combination of several communication links to be connected in series, the link at one station looking in one direction containing a vodas, and the link looking in the other direction containing single terminal echo suppressors, and means at that station which after a connection of the links at that point automatically disables the echo suppressor at the near end of the last-named link.

6. The combination of claim 5 characterized by the fact that the means for disabling the echo suppressor comprises a relay operated through the sleeve circuit of the plug when connection is made.

7. The combination of several telephone links to be connected in tandem, one of which contains vodases, means at the station where a link is to be connected to said vodas link which means, when the connection is made, automatically disables the echo suppressor of the link to be connected if it is a single echo suppressor, but leaves it enabled if it is a double echo suppressor.

8. The combination of claim 7 characterized by the fact that the switching connection is a four-wire connection and that the single echo suppressor is disabled by a relay connection through the sleeve of the four-wire cord circuit.

9. In a four-wire communication system a PO—RC link, means for suppressing echoes, said means being confined to the regional center end

and consisting of a double echo suppressor with disablement, the double suppressor being so connected that the signal wave from the regional center passes the point of connection of the echo suppressor unit operated by the wave before it reaches the point of suppression, while the wave from the primary outlet passes in the reverse order the point of suppression and the point of connection of the echo suppressor unit operated by the wave.

10. In a four-wire communication system a vodas link connected to the equivalent of a two-wire link, a vodas at each end of said link to maintain the transmitting side normally open at each end, an echo suppressor at each end on the transmitting side and controlled by the incoming signal on the receiving side, the suppression point in each case being reached by transmitting signal before reaching the corresponding vodas, an echo suppressor on each end on the receiving side controlled by transmitted signal, and means on the receiving side for disabling the one of these suppressors remote from the connection to the side equivalent to the two-wire link.

11. In a communication system of several four-wire links connected in series at switching points by two-wire cord circuits equipped with echo suppressors, at least one of the two outside links being a PO—RC link, means for suppressing echoes and for preventing lockout, said means being confined to regional centers and consisting of double echo suppressors with disablements on the PO—RC links, the double echo suppressor being so connected that the signal wave from the regional center reaches a point of suppression, or break, for its line at substantially the same point but behind the point of disablement of that suppressor, and that the signal wave from the primary outlet reaches the point of suppression for its line at substantially the same point but in front of the point of disablement for that suppressor.

12. The combination of claim 3 characterized by the fact that in the double suppressor the signal wave from the regional center reaches a point of suppression, or break, for its line at substantially the same point but behind the point of disablement of that suppressor and that the signal wave from the primary output reaches the point of suppression for its line at substantially the same point but in front of the point of disablement for that suppressor.

13. In a four-wire communication system a PO—RC link, means for suppressing echoes and for preventing lockout, said means being confined to the regional center end and consisting of a double echo suppressor with disablement, the double suppressor being so connected that the signal wave from the regional center reaches a point of suppression, or interruption, for its line at substantially the same point but behind the point of disablement of that suppressor and that the signal wave from the primary outlet reaches the point of suppression for its line at substantially the same point but in front of the point of disablement for that suppressor.

14. In a communication system of several four-wire links connected in series at switching points, at least one of the two outside links being a PO—RC link, means for suppressing echoes and for preventing lockout, said means being confined to regional centers and consisting of double echo suppressors with disablements on the PO—RC link, the double suppressor being so connected that for transmitting signal waves from the primary outlet the path cannot be enabled by said transmitting wave if it is disabled by received signal wave, and that for the received signal wave from the regional center the path is enabled by said received wave even though it has been disabled by transmitted signal wave.

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