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METHOD OF AND MEANS FOR REDUCING INTERFERENCE IN TRANSMISSION SYSTEMS

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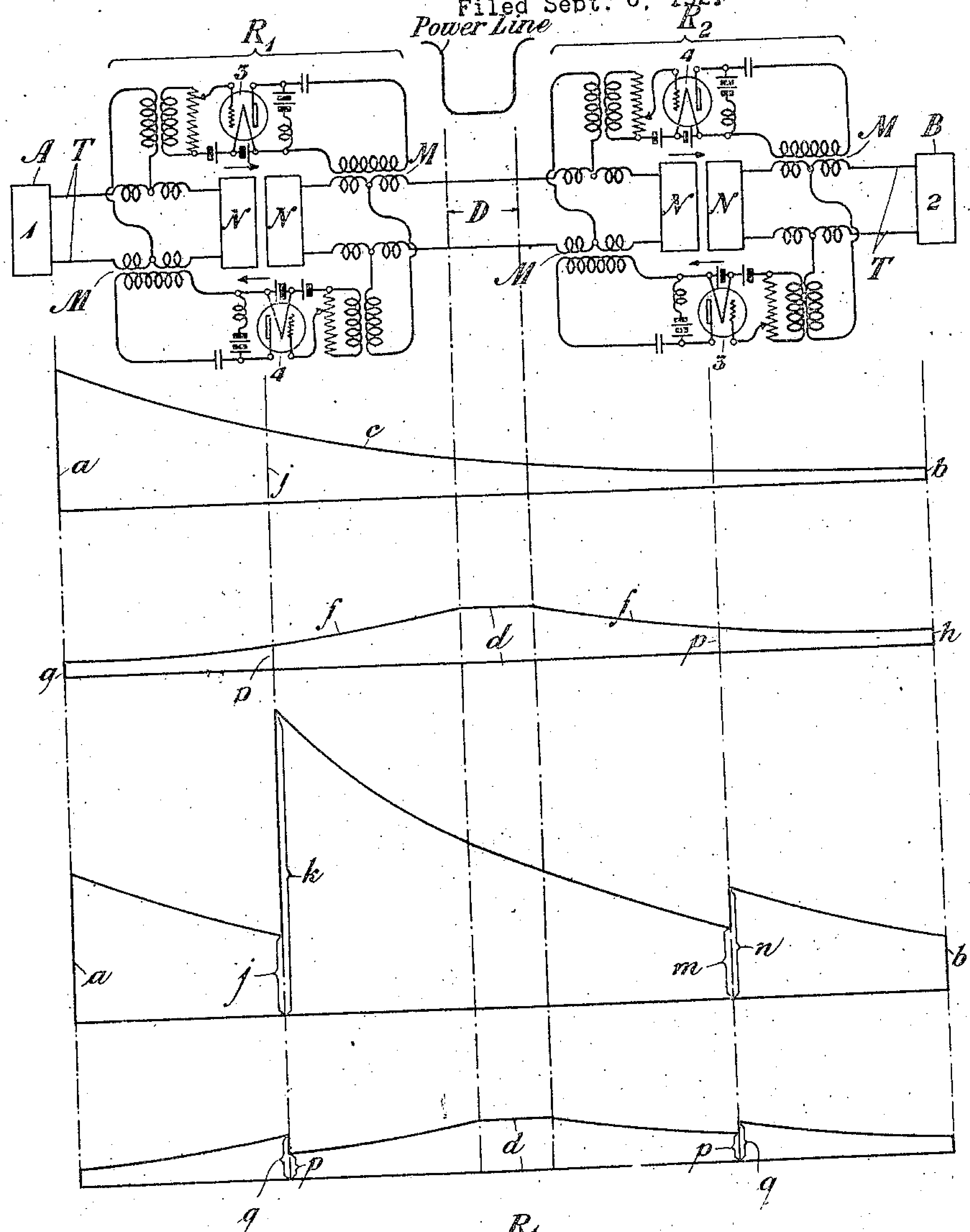

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

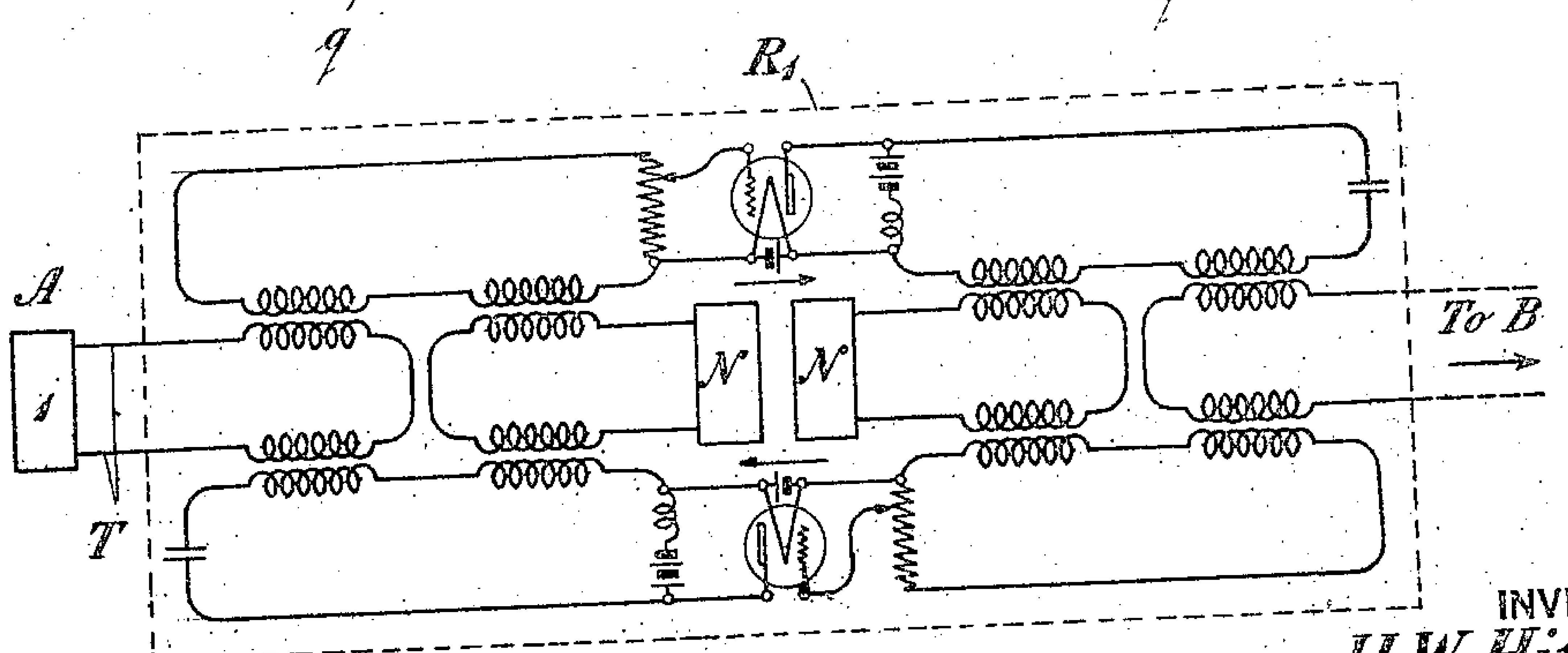

Fig. 6

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UNITED STATES PATENT OFFICE.

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METHOD OF AND MEANS FOR REDUCING INTERFERENCE IN TRANSMISSION SYSTEMS.

Application filed September 6, 1921. Serial No. 498,826.

To all whom it may concern:

Be it known that I, HARRY W. HITCHCOCK, residing at New York, in the county of Bronx and State of New York, have invented certain Improvements in Methods of and Means for Reducing Interference in Transmission Systems, of which the following is a specification.

This invention relates to methods of and means for reducing interference in signal transmission systems. The present application is in certain respects a continuation of my application, Serial No. 363,180, filed March 4, 1920. It is described with particular reference to the case in which a telephone line is inductively influenced by a power line, but is applicable to many widely varying types of transmission systems subject to interference.

The present invention proposes to reduce the interfering energy relatively to the useful energy by causing an amplification of the useful energy before the interfering energy enters the path of transmission and combines with the useful energy, this being accomplished in the particular case herein referred to by the use of amplifying elements associated with the transmission line at points substantially outside the zone in which the power line parallels the telephone lines.

In the preferred forms of embodiment of the invention, the amplifying devices are arranged to have different ratios of input to output according to the direction of flow of the energy traversing the same, so that the interfering energy—which flows from an intermediate point to the terminals of the line—is reduced relatively to the useful energy which traverses the line from terminal to terminal.

Whereas in the parent application, of which this is a continuation, I described and claimed specifically the case in which the ratio of output to input was larger than unity for the current flowing towards the zone of interference and less than unity for current flowing from the zone of interference to the terminals, in this application I describe and claim specifically the case in which the ratio is greater than unity for currents flowing in both directions but in which the ratio for currents flowing to the zone of interference is greater than for currents flowing from the zone of interference.

A good understanding of the invention may now be had from the following description of certain methods for practicing, and of certain forms and arrangements of apparatus and circuits for embodying the same, reference being had to the accompanying drawing, in which Figure 1 illustrates in diagrammatic view one form of circuits embodying the invention; Figs. 2 and 3, curves showing graphically the distribution of currents in the line conductors that would be obtained without the application of my invention; Figs. 4 and 5, curves similar to those of Figs. 2 and 3, showing the effect of the application of the methods and means of this invention; and Fig. 6 shows the application of the invention to another type of repeater circuit.

In Fig. 1, reference letter T designates a transmission line extending between stations A and B, each of which is provided with devices denoted 1 and 2 for applying current to, and responding to current in, the conductors of the line. These devices, for sake of simplicity shown in conventional manner, may be the ordinary subscribers' telephone sets comprising transmitters and receivers or any other suitable signaling apparatus. Line T is paralleled through a distance D by a power line which consequently induces in line T a disturbing current which it is the object of the present invention to attenuate relatively to the useful or voice current. Repeaters R_1 and R_2 are associated with line T intermediate the region D and the terminals of the line. These repeaters are provided for attaining the objects of this invention and their organization is described hereinafter.

To explain the manner in which I bring about the attenuation of the disturbing current relatively to the useful current, I shall first describe the conditions which would be obtained if the repeaters R_1 and R_2 were removed from the line. Let ordinate a in Fig. 2 designate the amplitude of voice current applied to line T by the transmitting element of the device 1. Due to dissipation of the voice energy by the line, the amplitude of this current decreases gradually from station A to station B, as indicated by the curve c, so that the current impressed on the receiving element of the device 2 is represented by the ordinate b. If the amplitude a is comparatively small or if the attenuation is large the amplitude 6 will be too small for satisfactory conversation and amplification would be desirable. Let the ordinate *d* in Fig. 3 denote the amplitude of the current induced in line T by the power line in the region D, this current having been drawn for sake of clearness to a disproportionately large scale for the ordinary actual case. This current flows towards the terminals A and B and, as indicated by the curve denoted *f*, it is gradually attenuated by the line so that when the current reaches the receiving element at stations A and B, the amplitude of the disturbance is as shown by the ordinates *g* and *h*, respectively. It will be observed that under the assumed conditions the amplitude of the disturbance is very large at station B compared to that of the voice current, showing that there is serious interference. If the frequency of the disturbance is within the audible range, the line is very noisy, making it extremely difficult to understand the received speech. Conditions are equally poor at station A for the reason that the voice energy applied to the line by the transmitting element of the device 2 is attenuated substantially like that of the transmitter at station A.

The repeaters R_1 and R_2 serve to reduce the relative loudness of the disturbance. The former of these is located between station A and the region of disturbance and the latter between station B and the said region. Each repeater consists of a pair of networks N, shown conventionally, for balancing the sections of line with which they are associated, and also includes a pair of three-winding transformers M, which serve to associate the devices 3 and 4 with the line conductors. These devices comprise amplifying elements, herein shown as electron tubes. The circuit arrangements for associating these are now well understood in the art. In this invention, however, I include as an element of each side of the repeater means for controlling the amplifying factor of each tube. In this case this means consists of a resistance r_1 shunted across the secondary of the input transformer of the device 3 and constituting, by means of a variable contact, a potentiometer to control the voltage impressed on the input terminals of the element 3. A similar potentiometer arrangement is provided for the element 4 and for the purpose of this invention, the potentiometer of Fig. 4 would be adjusted for a lower amplifying factor than that of the element 3. The potentiometer might equally well be put across the primary of the transformers.

As thus described, the repeaters R_1 and R_2 constitute the well-known two-way two-element or 22-type repeater. By virtue of the above described arrangements, R_1 serves to amplify currents traversing the same from east to west with one factor of amplification and to amplify currents in the opposite direction with a smaller factor of amplification, whereas R_2 amplifies currents from east to west with a large factor and amplifies those from west to east with a small factor. This is illustrated in Fig. 4, wherein *a* again represents the amplitude of the voice currents applied at station A to line T. When this current reaches the repeater R_1 it has been attenuated to a value *j* in accordance with the attenuation curve *c* of Fig. 2. The repeater R_1 amplifies the current to a value indicated by the ordinate *k*, the ratio of amplification being assumed in this case as 4 to 1. As this current flows toward R_2 it is attenuated by the line, so that at R_2 it has a value represented by the ordinate *m*. The repeater R_2 serves to amplify the current to a value indicated by *n*, so that the current which is impressed on the receiving element at station B is of about the normal value required for satisfactory service at such a station.

This is not true, however, of the energy of the disturbance, as illustrated by Fig. 5. The induced current flows from the region D towards the terminals of the line with normal attenuation, so that the amplitude thereof is as indicated by the ordinates *p*, when the currents reach the repeaters R_1 and R_2. These repeaters serve to amplify these disturbances also, as shown by ordinates *q* but in no greater ratio than for the voice current. As a result, my invention serves to reduce the noise on the line but gives the useful or voice current *a* value satisfactory for telephone communication.

The extent of the reduction of the noise depends on the relative value of the ratio of the two amplifiers at each repeater station. If this ratio is doubled, the noise is reduced accordingly and if the ratio is decreased, the relative noise is accordingly increased. The correct ratio in any particular case depends, of course, on the frequency and intensity of the noise, the maximum allowable amount of interfernece, and on certain commercial considerations as to cost, as will be readily understood by those familiar with the art. As an example illustrating the application of the invention, each repeater may be arranged to amplify 4 to 1 for currents flowing towards the zone of interference and 2 to 1 for currents flowing from the zone of interference. In this case, the total amplification of the voice current from station A to station B is roughly, 8 to 1, whereas that of the noise is but 2 to 1. In other words, although the noise is doubled in loudness, the volume of the voice is increased eightfold over what it would have been had there been no repeaters. The repeaters thus serve to bring about an amplification of the voice current, as well as to suppress the noise relatively to the voice.

In Fig. 6 I have shown the invention applied to a circuit with a different form of repeater. The substation A and the telephone line and transmission lines may be considered as identical to those of Fig. 1, but for simplicity I have shown only one end of the line, it being understood that the circuit as shown in Fig. 6 is to be associated with the transmission line which is subjected to interference effects. The repeater R_1 of Rig. 6 is also a two-way two-element repeater comprising transformers with a plurality of windings, which permit the conductive separation of the balancing network form its associated line and at the same time avoids the conductive connection from the repeater element to the lines. As described in connection with Fig. 1, so here the amplification of the repeater talking to the line is made higher than that for the repeater talking from the transmission line, the amount of amplification for each being determined in any suitable manner, such as by the potentiometers shown in the figure.

Various changes and modifications may be made in this invention, but it is to be understood that the invention is not limited to the particular arrangement herein described, but is capable of other forms of embodiment within the spirit and scope of the invention as set forth in the following claims.

What is claimed is:

1. A telephone transmission line subject to interference, substations associated therewith at its ends, a repeater between each of the substations and the line, said repeaters having amplifying factors greater than unity but different for currents flowing to the line than for currents flowing from the line.

2. A telephone transmission line subject to interference, substations associated therewith at its ends, a repeater between each of the substations and the line, said repeaters having amplifying factors greater than unity but higher for currents flowing to the line than for currents flowing from the line.

3. A telephone transmission line subject to interference, substations associated therewith at its ends, two-way repeaters between each of the substation sets and the line, said repeaters having amplifying factors greater than unity but different for currents flowing to the line than for currents flowing from the line.

4. A telephone transmission line subject to interference, substations associated therewith at its ends, two-way repeaters between each of the substation sets and the line, said repeaters having amplifying factors greater than unity but higher for currents flowing to the line than for currents flowing from the line.

5. A telephone transmission line subject to interference, substations associated therewith at its ends, 22-type repeaters between each of the substation sets and the line, said repeaters having amplifying factors greater than unity and higher for currents flowing to the line than for currents flowing from the line.

6. A telephone transmission line subject to interference, substations associated therewith at its ends, a repeater between each said substation set and the line, one side of said repeater comprising an amplifying element for current flowing to the line and the other side comprising an amplifying element for currents flowing from the line, the latter having an amplifying factor lower than the former.

7. The method of reducing the ratio of induced current to voice current in the output of telephone circuits, which consists in amplifying the voice currents by a high factor before they enter the region of induction and amplifying the currents by a low factor after they leave the said region.

8. The method of reducing interference in transmission systems which consists in amplifying energy which flows towards the region of disturbance and in amplifying energy flowing in the opposite direction at the same place with a lower factor of amplification.

In testimony whereof, I have signed my name to this specification this 31st day of August, 1921.

HARRY W. HITCHCOCK.