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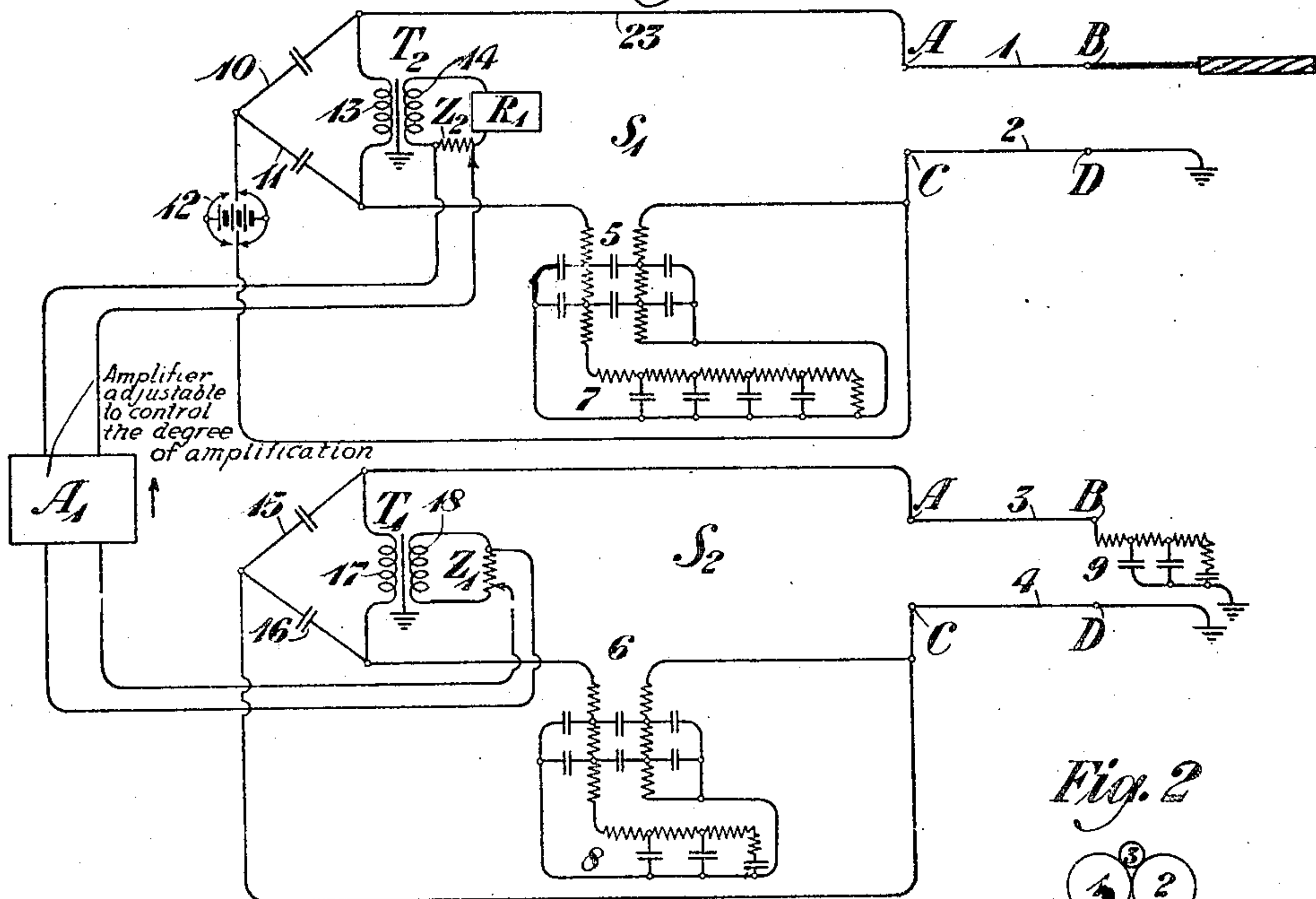
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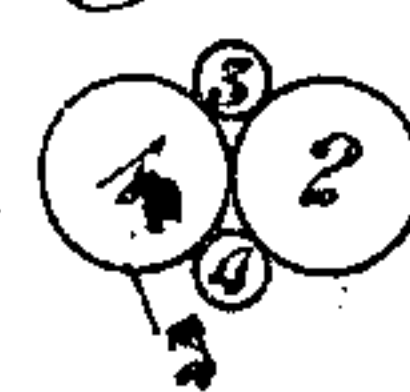
INTERFERENCE NEUTRALIZING ARRANGEMENT

Filed Aug. 14, 1920

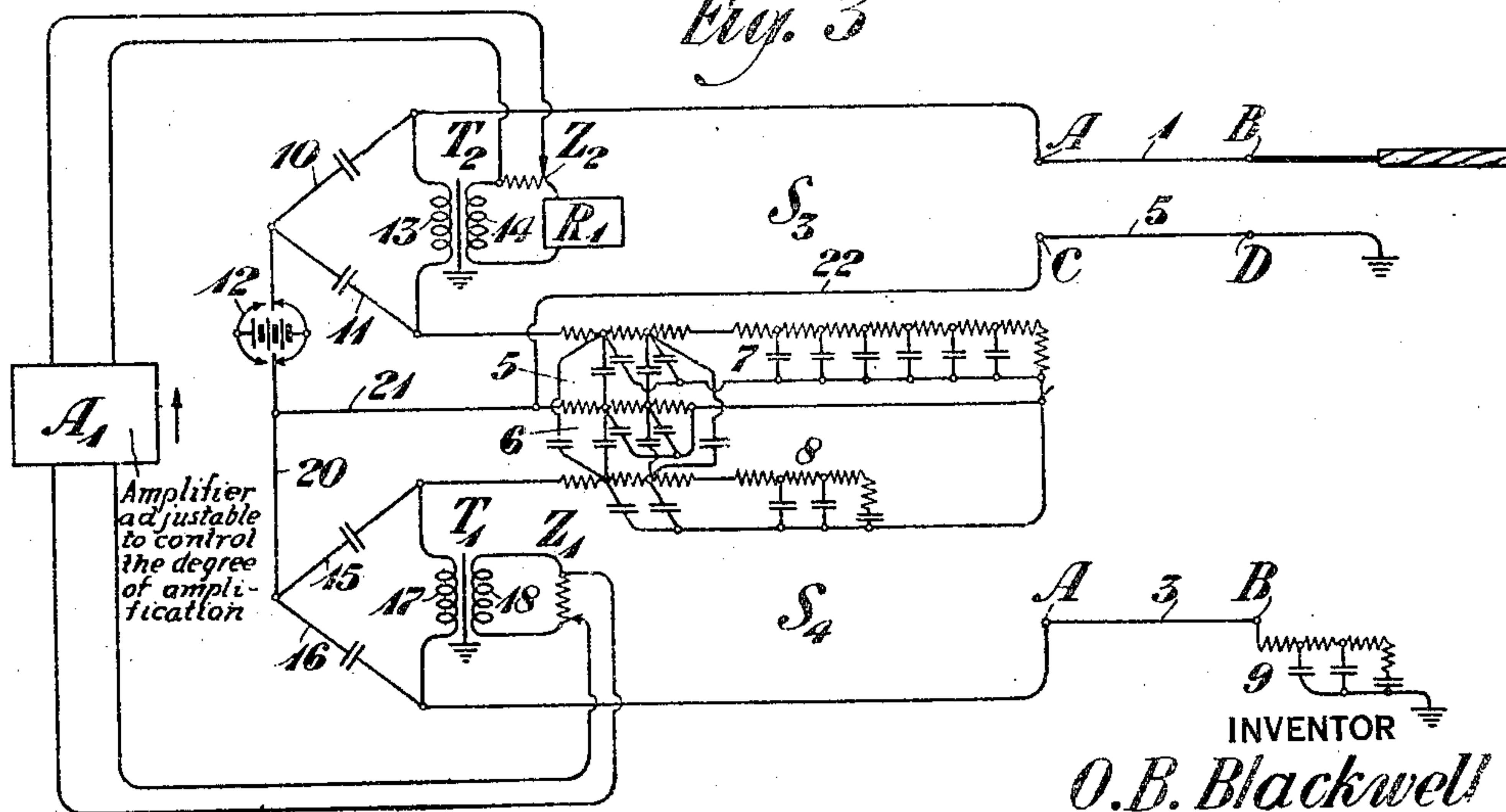
*Fig. 1*



*Fig. 2*



*Fig. 3*



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## UNITED STATES PATENT OFFICE.

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## INTERFERENCE-NEUTRALIZING ARRANGEMENT.

Application filed August 14, 1920. Serial No. 403,549.

*To all whom it may concern:*

Be it known that I, OTTO B. BLACKWELL, residing at Garden City, in the county of Nassau and State of New York, have invented certain Improvements in Interference-Neutralizing Arrangements, of which the following is a specification.

This invention relates to signaling systems and especially to means for neutralizing voltages that may be induced in electrical circuits by causes extraneous to the circuits themselves, in order to prevent such voltages affecting the receiving apparatus associated with such circuits.

As is well known, various arrangements have been proposed for the neutralization of interfering voltages in long signaling circuits, such as, for example, submarine cable circuits which are adapted for duplex operation. A proposed arrangement provides means for equalizing the impedance to ground of the signaling arm of the duplex network, and the sea ground connection of the said network by inserting at the sea ground an artificial line to balance the submarine cable. If the signaling conductor and the conductor constituting the sea ground connection remain balanced and are exposed to the same interference, they will both be raised to the same potential and consequently there will be no difference of potential between them. Accordingly, the receiving apparatus connected across the duplex network will not be affected by the effect of the interference upon the conductors.

Experience shows, however, that it is difficult to maintain the balance of a long circuit, such as a submarine cable circuit, and consequently there may be a difference between the impedance to ground of the signaling conductor and the conductor grounded through the artificial line. This will result in a difference of potential across the duplex network which affects the receiving apparatus associated therewith.

It is the object of this invention to provide means whereby any difference of potential caused by some interfering agency, which may arise or exist by virtue of the imperfect balance between the two sides of the said circuit, may be substantially reduced or neutralized.

This invention will be more clearly under-

stood from the following description when read in connection with the attached drawing, of which Figure 1 shows a form of embodiment of the invention, Fig. 2 shows a detail, and Fig. 3 shows a desired modification of the arrangement shown in Fig. 1.

In the arrangement of submarine cable circuits, it is customary to have the transmitting and receiving apparatus of the terminal circuits located in offices which, as a rule, are not located directly at the shore end of the submarine cable, but at some distance inland, and the said terminal circuits are usually connected with the submarine cables and the sea grounds by cable conductors extending between the office and the shore. Thus, in Fig. 1,  $S_1$  and  $S_2$  represent two such terminal circuits. The circuit  $S_1$  embraces the ratio arms 10 and 11, to the junction point of which is connected a transmitting device 12, which may be of any well known type, as for example a tape transmitter. Bridged across the ratio arms is a winding 13 of the transformer  $T_2$  by means of which received impulses are transmitted to the winding 14 and thereby impressed across the input side of the receiving apparatus  $R_1$ . The arm 10 is connected by the conductor 23 to conductor 1 of the cable that extends from the point A of terminal circuit to a point B where it joins the submarine cable conductor. The distant end of the cable is connected with a terminal circuit which may be either of the same type as that shown in Fig. 1 or of any of the well-known types used in telegraphy. The point B represents the terminus of the submarine cable conductor and corresponds in position to the point D where the sea ground of the system is located. The arm 11 is connected through the artificial networks 5 and 7 of the terminal circuit to the conductor 2 of the cable that extends from the point C of the terminal circuit to a point D where the sea ground is located. The network 5 is designed to simulate closely the electrical characteristics of the conductors 1 and 2, and the network 7 to simulate the characteristics of the submarine cable extending from the point B to its distant end. The terminal circuit  $S_2$  is similar to the circuit  $S_1$ , comprising the ratio arms 15 and 16 which have their midpoint connected with the sea ground and having bridged across



them the winding 17 of the transformer  $T_1$ . The secondary winding 18 of the transformer is bridged across the impedance  $Z_1$  by means of which the proper potential may be maintained across the input side of the amplifier  $A_1$ . The output side of the said amplifier is adjustably connected across the impedance  $Z_2$  of the input circuit of the receiving apparatus  $R_1$ . The ratio arm 15 is connected with the conductor 3 extending from the point A of the terminal circuit to the point B and is there connected with the network 9 which simulates the characteristics of the submarine cable which is connected with the conductor 1 at the point B. The other ratio arm 16 is connected with an artificial line comprising the networks 6 and 8 which, in turn, are connected with the conductor 4 which extends from the point C to the point D at the sea ground. The network 6 is designed to simulate electrically the characteristics of the conductors 3 and 4 and the network 8 is designed to simulate and to balance the network 9 which is located at the sea ground.

Fig. 2 shows schematically a preferable form of arrangement for cabling the conductors that extend from the terminal circuit to the sea ground. Since the conductors 3 and 4 have to transmit only the current induced therein by the source of interference, they may be of much smaller gauge of wire than conductors 1 and 2 which are designed to transmit not only interference currents but also the signaling currents.

The arrangement shown in Fig. 3 differs from that shown in Fig. 1 in that a single common conductor 5 extends from the joint terminal circuits  $S_3$  and  $S_4$  to the sea ground at the point D. In this figure, the parts corresponding to similar parts in Fig. 1 have been given the same designations. The transmitting device 12 connected to the midpoint of the ratio arms of the circuit  $S_3$  and the conductor 20 connected with the midpoint of the circuit  $S_4$  are connected over conductors 21 and 22 with the conductor 5 extending to the sea ground. The arrangement of the balancing networks of the artificial lines in Fig. 3 differs from that shown in Fig. 1 in view of the fact that in Fig. 3 the cable extending from the terminal circuit to the sea ground comprises only three conductors instead of four as shown in Fig. 1. In the artificial line as shown, the network 7 simulates electrically the characteristics of the submarine cable extending from the point B to its distant end. The networks 5 and 6 simulate the characteristics of the conductors 1, 3 and 5 and the network 8 balances the network 9 which is connected with the conductor 3 at the sea ground and which is designed to simulate the characteristics of the submarine cable connected with conductor 1.

The distant end of the cable shown in Fig. 3 has connected therewith a terminal circuit which may be either of the types shown in Figs. 1 and 3 or of any other well-known type for terminating telegraph cables.

Having in mind the foregoing description of the various parts of the circuits and the function that each is to perform the invention will be clearly understood from the following description of the manner in which the result is attained.

Considering first the arrangement shown in Fig. 1, if a source of interference impresses itself upon conductors 1 and 2 the current set up in conductor 1 will be somewhat different from that set up in conductor 2 due to the fact that the impedance to ground of the conductor 2 at the point D is different from the impedance to ground of the conductor 1 at the point B, and even though the points B and D coincide there will still be sufficient unbalance as to cause an interfering difference of potential to impress itself across the arms 10 and 11 of the terminal circuit  $S_1$ . Such difference of potential will, of course, manifest itself in the receiving apparatus  $R_1$ . In view of the close physical relationship of the conductors 3 and 4 with 1 and 2 the interference that sets up the difference in potential in conductors 1 and 2 will similarly affect 3 and 4. Since conductor 3 together with the balancing network 9 at the sea ground closely simulates conductor 1 and the submarine cable connected therewith, and likewise conductor 4 simulates 2, the unbalance between 3 and 4 will be substantially the same as that between 1 and 2. This unbalanced voltage will impress itself across the arms 15 and 16 and will be induced in the winding 18 of the transformer  $T_1$ . The drop in potential across the impedance  $Z_1$  will be impressed across the input side of the amplifier  $A_1$  and the resulting current will be impressed across the impedance  $Z_2$ . By arranging the circuits so that the interference voltage set up in conductors 3 and 4 is opposed to that set up in 1 and 2 and by adjusting the values of  $Z_1$  and  $Z_2$  and the degree of amplification of  $A_1$  substantial elimination of interference will be effected.

If the conductors 2 and 4 are grounded at the same point as conductor 3 the neutralization will be effected in the manner just described. If, however, the conductors 2 and 4 are both grounded at the same point which is closer to the receiving terminal than the grounding point of conductor 3 the terminal circuit  $S_2$  will be required to neutralize more of the disturbance impressed upon conductor 1 between the terminal circuit and the point B. If the grounding points of conductors 2 and 4 are located directly at the terminal circuit, the circuit  $S_2$  is required to neutralize all the



interference voltage impressed upon the conductor 1 between the terminal circuit and the point B.

In the arrangement shown in Fig. 3, the conductor 5 is common to the circuit of conductor 1 and also of conductor 3. If a source of interference acts upon the cable containing conductors 1, 3 and 5 a difference of potential will be established between conductors 1 and 5 and likewise between conductors 3 and 5. The difference of potential between 1 and 5 will be impressed across the ratio arms 10 and 11 of the terminal circuit  $S_3$  and eventually will be impressed upon the receiving circuit comprising the winding 14 and the impedance  $Z_2$ . Similarly, the difference of potential between conductors 3 and 5 will be impressed across the ratio arms 15 and 16 of the terminal circuit  $S_4$  which results in establishing a difference in potential across the impedance  $Z_1$ . This difference of potential may be passed through a vacuum tube device either with or without amplification and be impressed across the impedance  $Z_2$  of the input circuit of the receiving apparatus  $R_1$ . By properly adjusting  $Z_1$ ,  $Z_2$  and the amplification of  $A_1$  neutralization may be effected.

It will be seen that the arrangement discloses means for neutralizing interference in submarine telegraph cables which by means of an artificial network located at the sea ground avoids the necessity of extending the shielding conductor for a great distance along the length of the submarine cable to be protected. This arrangement, furthermore, discloses means whereby a single conductor may be substituted for two conductors constituting the other side of the cable circuit and of the shielding circuit respectively.

Although this invention has been shown as embodied in certain specific forms, it is manifest that it is capable of embodiment in other and different forms without departing from the spirit and scope of the appended claims.

What is claimed is:

1. In an electrical interference neutralizing device, the combination of a transmission circuit comprising a grounded signaling conductor and a grounded return conductor, a second circuit one side of which simulates by natural and artificial means the grounded signaling conductor of said transmission circuit and the other side being the grounded return conductor common to said first circuit, both of the said circuits being exposed to substantially the same interference, balanced terminal circuits for each of the said circuits, and means associated with the said terminal circuits for opposing the interference voltages set up in said transmission and said second circuit and for neutralizing the same.

2. In an electrical interference neutralizing device, the combination of a transmission circuit comprising a grounded signaling conductor and a grounded return conductor, a second circuit one side of which simulates by natural and artificial means the grounded signaling conductor of said transmission circuit and the other side being the grounded return conductor common to said first circuit, both of the said circuits being exposed to substantially the same interference, balanced terminal circuits for each of said circuits, and means associated with the said terminal circuits comprising a unilateral device whereby the interference voltage set up in said second circuit may be impressed upon the receiving circuit of the said transmission circuit in opposition to the interference voltage impressed directly upon said receiving circuit from said transmission circuit, the said unilateral device preventing reaction of the said transmission circuit upon the said second circuit.

3. In an electrical interference neutralizing device, the combination of a submarine cable signaling circuit adapted for duplex operation, a second circuit having one conductor in common with said first circuit, and a second conductor extending through the zone of interference with the said signaling circuit and having an artificial network inserted at the sea ground in order that the said conductor may have the same impedance to ground as the signaling conductor of the signaling circuit, and means to impress the interference voltages set up in each of said circuits upon a common circuit in such manner as to neutralize each other.

4. In a system for neutralizing interfering currents set up in a signaling transmission system by a source external to the transmission system itself, the combination with a submarine cable of a terminal circuit having ratio arms and a receiving circuit connected across the extremities of the said arms, a second terminal circuit also having ratio arms and a receiving circuit connected across their extremities, an artificial cable simulating said submarine cable, a connecting cable having three conductors of which the first connects the submarine cable to one ratio arm of its terminal circuit, the second connects one ratio arm of the second terminal circuit with an artificial cable located at the sea-ground of the system, the third conductor having one end connected with the sea-ground, a second artificial line having one side connected with the said third conductor and having its other side connected with the other ratio arm of each terminal circuit, and means for connecting the receiving circuits of both terminal circuits to neutralize interfering currents set up in said receiving circuits by voltages created in the said connecting ca-



ble by sources extraneous to the system itself.

5. In a system for neutralizing interfering currents set up in a signaling transmission system by a source external to the transmission system itself, the combination with a signaling Wheatstone bridge network comprising two ratio arms, a third arm including one conductor of a terminating cable, a submarine cable having a grounded receiving device at the distant end thereof and a second conductor of a terminating cable connected with a sea-ground, and a fourth arm balancing the said third arm comprising artificial lines simulating each of the elements of the said third line, a non-signaling Wheatstone bridge network comprising two ratio arms, a third arm including a third conductor of the said terminating cable, an artificial line grounded at the sea-ground and balancing the said submarine cable, the said third arm also including the said second conductor of the said terminating cable which is common to the third arm of both networks, and a fourth arm comprising artificial lines balancing the said third arm, a receiving circuit for each Wheatstone bridge network connected across the ratio arms thereof, and means connecting the said receiving circuits having therein a unilateral device controlling the magnitude of the interfering current impressed upon one receiving circuit by the other and preventing reaction between the said circuits.

6. In a system for neutralizing interfering currents set up in a signaling transmission system by a source external to the transmission system itself, the combination with a signaling cable of the multiconductor terminating cable exposed to an external source of interfering voltage, the first of the said conductors being connected with the said signaling cable, the second conductor being connected to a sea-ground and the third conductor being connected at the sea-ground with an artificial line simulating the said signaling cable, two

ratio arms of a Wheatstone bridge circuit, one of which is connected with the first conductor of the terminating cable, another group of two ratio arms of a second Wheatstone bridge circuit, one of which is connected with the second conductor of the terminating cable, an artificial line constituting the third arm of each Wheatstone bridge circuit connected with the remaining arm to each group of ratio arms, and also connected with the said third conductor of the terminating cable to balance the fourth arm of each bridge, a receiving circuit connected with each group of ratio arms, and means to equalize and oppose the interfering currents set up in each receiving circuit resulting from a voltage set up in the conductors of the terminating cable by the said external source of interference.

7. In a system for neutralizing interfering currents set up in a signaling transmission system by a source external to the transmission system itself, the combination with a Wheatstone bridge signaling circuit having two ratio arms, a third arm comprising the signal transmission circuit and the fourth arm comprising an artificial line to balance the said third arm, of a second Wheatstone bridge circuit having two ratio arms, a third arm comprising a real line and an artificial line, a part of the said real line being common to the third arms of both bridge circuits, and a fourth arm comprising an artificial line to balance the said third arm, a receiving circuit individual to and connected to each bridge circuit, and means connecting both receiving circuits and having therein a unilateral device for controlling the magnitude of a current transmitted therethrough and for preventing undesirable reactions between the receiving circuits.

In testimony whereof, I have signed my name to this specification this 13th day of August 1920.

OTTO B. BLACKWELL.