

Oct. 4, 1938.

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2,132,180

TWO-WAY SIGNALING SYSTEM

Filed Oct. 22, 1936

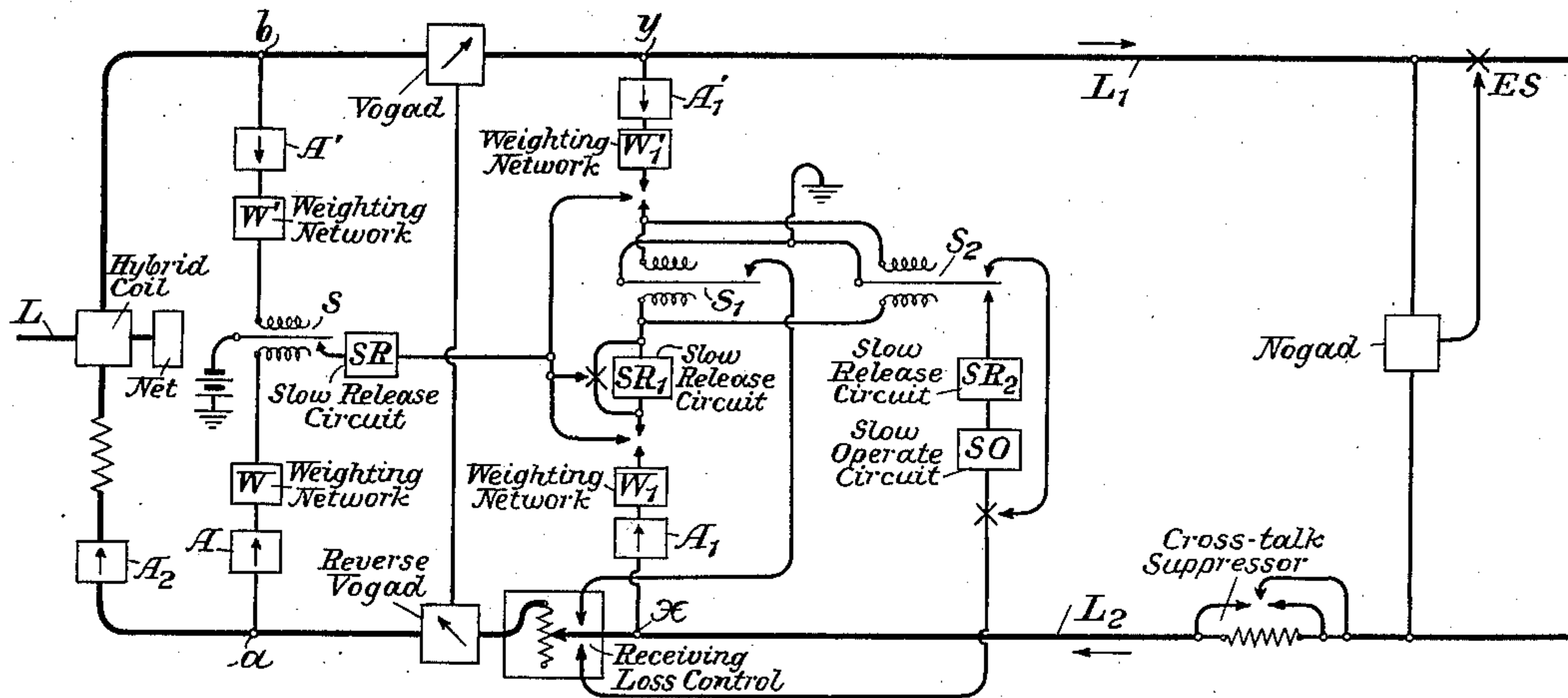


Fig. 1

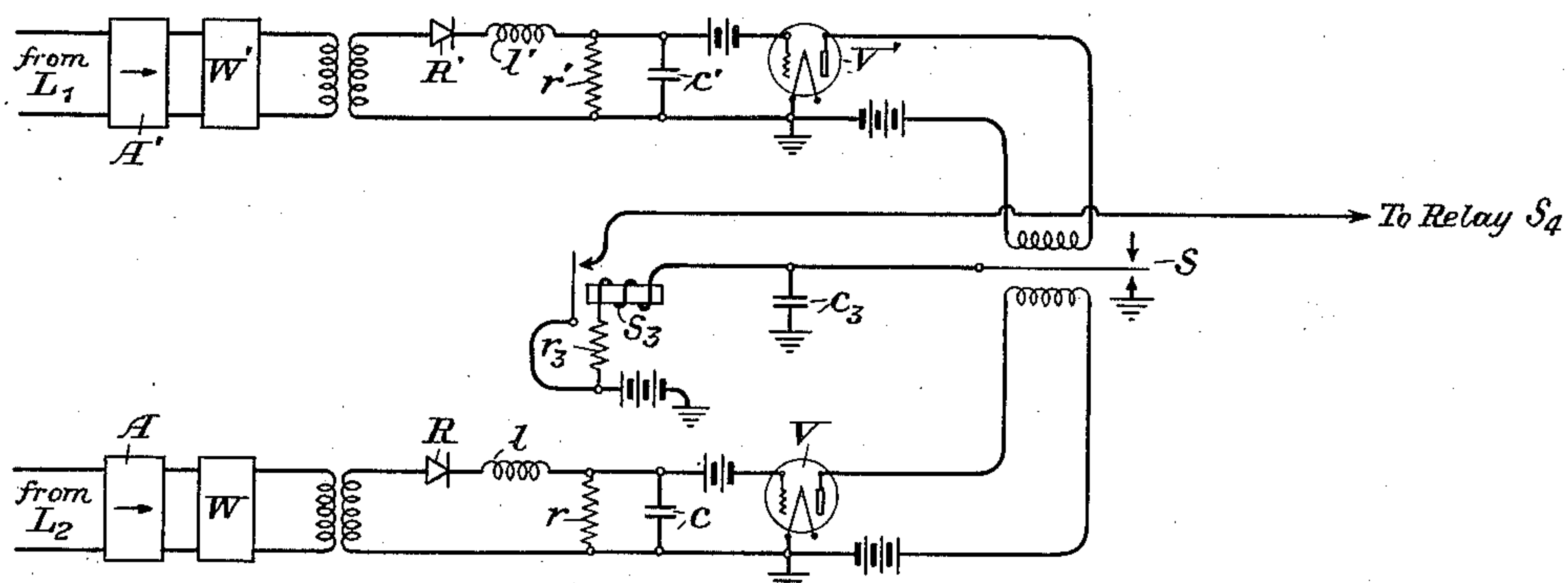


Fig. 2

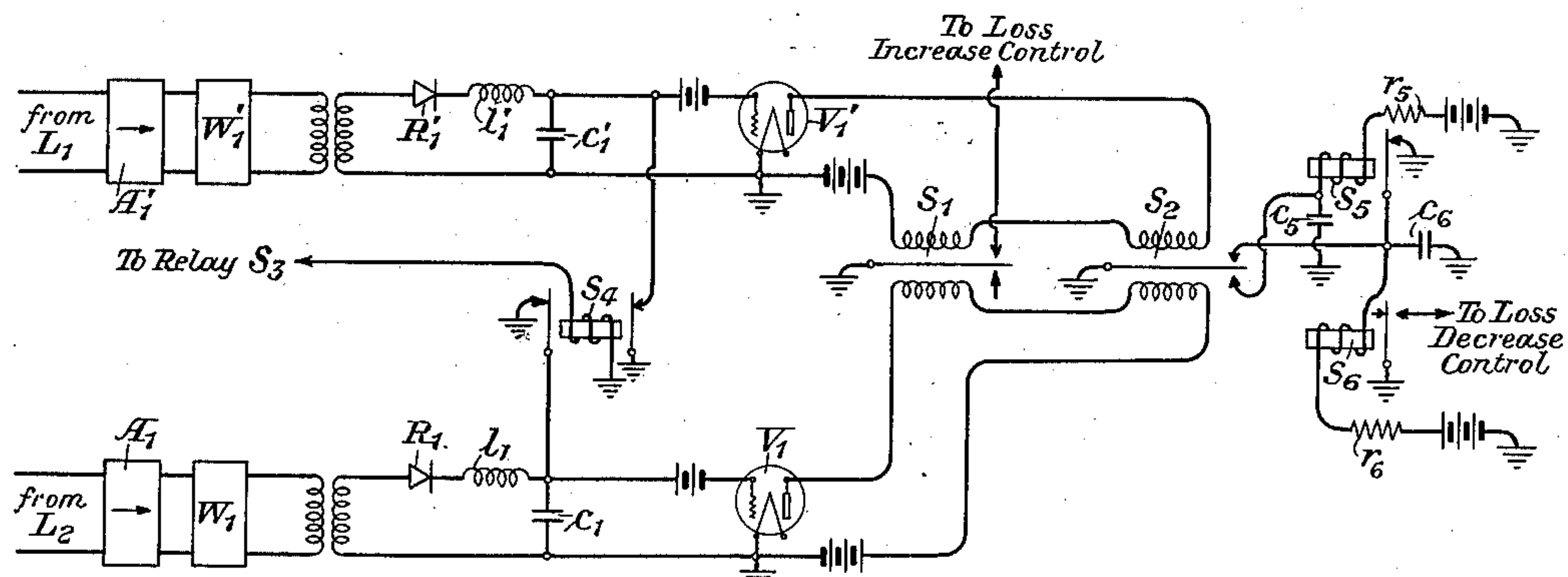


Fig. 3

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2,132,180

TWO-WAY SIGNALING SYSTEM

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Application October 22, 1936, Serial No. 107,097

9 Claims. (Cl. 178—44)

This invention relates to two-way transmission systems and more particularly to two-way signaling systems including a two-wire line and an adjoining link such as a four-wire circuit, which has separate paths, one for transmitting to the two-wire line and the other for transmitting from that line.

As is well understood in the art, it is the usual practice to connect a two-wire line and a link such as a four-wire circuit through a hybrid coil, and an artificial network is provided which "balances" the impedance of the two-wire line. It is well understood in the art that this "balance" is far from perfect and that when energy is transmitted to the two-wire line over one path of the four-wire circuit a part of this energy is returned over the other one-way path of the four-wire circuit. This return current may introduce problems such as the false operation of echo suppressors and the like. The closer the approximation to a perfect balance between the impedance of the two-wire line and the impedance of the balancing network the greater will be the "return loss". It is to be understood further that the two-wire line may be connected to a subscriber's set or other apparatus; the return loss, as affected by the two-wire line and the connected apparatus is referred to as the "active return loss". It should be understood further that it is customary to refer to the one-way path—or that portion of it—connected to the two-wire line and adapted to transmit from that line as the "transmitting" path while the opposite one-way path adapted to transmit to the two-wire line is customarily referred to as the "receiving" path.

While the present invention is applicable to a variety of two-way signal transmission systems, it is particularly applicable to circuits of the type described in the patent to Wright and Abraham, No. 2,043,403, issued June 9, 1936. That type of circuit is designed to solve some of the problems introduced when "weak" talkers are served by the circuit, and certain volume operated gain adjusting devices are included in the one-way paths of the four-wire circuit.

In general the system of the present invention is designed to measure the amount of current returned through the active return loss and other terminal arrangements of a two-way telephone or other signal circuit, (which arrangements may include the volume operated gain adjusting devices referred to hereinbefore), and if this return current is too great in comparison with the current in the receiving path to increase the loss introduced in the receiving path to the point at

which the ratio of return current to received current is satisfactory. The receiving loss is adjusted, if such adjustment be necessary, and when the suitable adjustment is made there will be no further change in the loss introduced in the receiving path unless some change occurs in some of the factors affecting the return current. In other words, the adjusting device of this invention may be termed "neutral".

The principal object of the invention is to prevent singing in the two-way signal transmission system.

It will be understood by those skilled in the art that the problem of singing in a two-way system can be solved by the use of a "vodash" (voice operated device anti-singing) and that the problem is solved in that way in the cases of certain systems such as transoceanic radio systems. It may also be solved by leaving a fixed loss in the circuit, but this degrades transmission to all talkers. For a circuit such as that disclosed in the above-identified patent, however, the use of a vodash imposes requirements with respect to noise and talker volume which can be handled from connecting circuits that need not be imposed, and the arrangement of the present invention is designed to provide satisfactory protection against singing in a simpler and more suitable manner, the arrangement being applicable to cases in which the range of volume control and the decibel singing margin required are smaller than those obtaining in the case of the transoceanic radio circuits.

The invention will be clearly understood when the following description is read with reference to the accompanying drawing, in which

Figure 1 shows schematically, and in part diagrammatically, a suitable arrangement to be applied to one terminal of a four-wire circuit or other link having separate one-way paths for transmitting in opposite directions;

Fig. 2 shows diagrammatically a suitable arrangement of a portion of the system more generally disclosed in Fig. 1, which portion may be termed the "direction indicating circuit"; and

Fig. 3 shows diagrammatically a suitable arrangement of what may be termed the "return current indicating circuit", more generally disclosed in Fig. 1.

Like characters of reference in the several figures of the drawing designate corresponding parts.

With particular reference, first, to Fig. 1 of the drawing, a two-wire line L is connected to one end of a four-wire circuit, or other link hav-

ing separate one-way paths for transmitting in opposite directions, through a hybrid coil, and the impedance of the line L is roughly balanced by a network. The upper one-way path L₁ is adapted to transmit from the line L while the lower one-way path L₂ is adapted to transmit to the line L. In the transmitting path L₁ there is included a vogad (volume operated gain adjusting device), while the receiving path L₂ includes a reverse vogad. The nature and functions of these devices are disclosed and discussed in the patent to Wright and Abraham, identified hereinbefore. Certain other elements are indicated in Fig. 1, which elements will be more fully understood by reference to that patent. These elements include a cross-talk suppressor included in the path L₂ and a portion of anodes (noise desensitized echo suppressor) comprising a nogad (noise operated gain adjusting device) and echo suppressing means for disabling the transmitting path L₁, as is indicated at ES.

The system of the present invention includes a variable loss control introduced into the receiving path L₂ (on the input side of the reverse vogad); a "direction indicating circuit" for the operation of which energy is diverted at a point *a* in path L₂ and point *b* in path L₁; and a "return current indicating circuit" for the operation of which energy is diverted at points *x* and *y* in paths L₂ and L₁, respectively. The return current indicating circuit serves to measure the return current in path L₁ with reference to the signal current in path L₂ and to adjust the receiving loss, if such adjustment is required, by suitable operation of the receiving loss control. It is to be borne in mind that the problem solved by the present invention involves the maintenance of a suitable relation between the magnitude of the signal current in the receiving path L₂ and the magnitude of the current returned over path L₁ as a result of the transmission over path L₂ and the inevitable irregularities involved in the connection of the four-wire circuit with the two-wire line L.

It is believed that the arrangement of the various elements making up the system will be best understood from a reading of the following general description of the operation of the circuits disclosed, for the most part schematically, in Fig. 1:

When signal waves, such as waves representing speech in the case of a telephone system, come in toward the line L over the path L₂, a portion of this incoming energy passes through the amplifier A and current flows in the lower winding of the relay S which forms a part of the direction indicating circuit. When current is returned from the two-wire line L over path L₁, energy is passed through amplifier A' and current flows in the upper winding of relay S. The sensitivities of the windings of relay S are so adjusted that with the poorest active return loss the armature of relay S will operate in the downward direction, at least initially. It will be understood from the discussion to appear hereinafter that no detriment will result from the subsequent upward operation of this armature in response to delayed echoes. When the armature of relay S operates downward, battery is connected to a slow release circuit SR and the operation of this circuit places in operating condition the several portions of the return current indicating circuit to be described hereinafter. Since it is the function of the return current indicating circuit to control the adjustment of the receiving loss, it is

seen that the direction indicating circuit serves to prevent any change in the setting of the receiving loss control except when speech or other signal energy is coming in over the one-way path L₂. If signals are sent from the line L over path L₁, the armature of relay S will be operated in the upward direction and, as will be clear from an examination of Fig. 1, the return current indicating circuit will remain in an inoperative condition.

When the direction indicating relay S has operated and the return current indicating circuit is as a result rendered operative, the incoming signal waves will cause the flow in the lower windings of relays S₁ and S₂ of a current of which the magnitude is dependent upon the magnitude of the incoming signal energy. As will be discussed briefly hereinafter, the current in these windings is also determined, in part, by the operation of the weighting network W₁, which is connected to the output of the amplifier A₁. The current in these lower windings of relays S₁ and S₂ will be maintained for a short period because of the operation of the slow release circuit SR₁.

The current returned over the path L₁ as a result of the signal transmitted over the path L₂ will tend to build up currents in the upper windings of the return current indicating relays S₁ and S₂. The upper winding of relay S₂ should be made somewhat more sensitive than the upper winding of relay S₁, with the result that a given amount of return current may operate the armature of relay S₂ upward against the opposing force of the lower winding without producing a similar operation of relay S₁.

It will be noted that weighting networks W and W' are included in the branches of the direction indicating circuit and that weighting networks W₁ and W₁' are included in the branches of the return current indicating circuit, and it has been indicated hereinbefore that the current flowing in the various relay windings is determined in part by these networks. It is the purpose in including such networks to cause any adjustment of the receiving loss to depend on the return currents which are important in producing singing. Thus it would be suitable to provide networks which introduce a high loss in the frequency range around 1,000 cycles and a low loss at substantially lower and higher frequencies, in the case of speech transmission.

It will be noted from an examination of the diagram of Fig. 1, that if relay S operates in the downward direction and relay S₂ also operates in the downward direction, ground is connected through the armature of relay S₂ to operate the receiving loss control in path L₂ to reduce the loss introduced in that path. Accordingly it will be understood that the sensitivities of relay S₂ should be such that if the return current in path L₁ is too small to cause singing trouble, relay S₂ will be operated in the downward direction by any incoming wave of considerable magnitude. As the value of the return current in path L₁ increases in comparison with the value of the receiving current in path L₂, however, relay S₂ may be operated in the upward direction and, as is indicated by the scheme of Fig. 1, such operation prevents further reduction of the receiving loss.

In order to prevent undesirable results when relay S₂ is operated downward in response to the incoming signal waves and is subsequently operated upward as the delayed echoes build up in the path L₁, an arrangement is provided including the slow release circuit SR₂ and the slow

operate circuit SO. While this portion of the system will be more fully discussed hereinafter, it is to be stated at this point that the slow release circuit SR₂, upon operation, initiates the operation of the slow operating circuit SO, that the circuit SO has a time equal to the longest delayed echo and that circuit SR₂ has a time which is slightly greater than that of circuit SO. Accordingly the operation of relay S₂ in the upward direction by any echo, whether it be direct or delayed, will prevent further reduction of the loss introduced by the receiving loss control.

It has been stated hereinbefore that the return current measuring and adjusting arrangement of the invention is "neutral". This point will now be developed briefly. It has been indicated that, on the assumption that the direction indicating relay S has operated in the downward direction, the relay S₁ of the return current indicating circuit may be operated upward to increase the loss introduced in the receiving path L₂ and that the other return current indicating relay S₂ may be operated in the downward direction to introduce a reduction of the receiving loss. It will be understood that one or the other of these two operations may result from a relation between the value of the incoming signal waves and the value of the return current in the opposite one-way path. In other words, if the return current in path L₁ is small with reference to the incoming signal current in path L₂, relay S₂ will operate downward to reduce the receiving loss; on the other hand, if the return current is great with reference to the incoming current, relay S₁ will operate in the upward direction to increase the loss introduced by the receiving loss control and thus serve to reduce the return current. However, there is a range of return current values with reference to the value of the incoming signal current in which the setting of the receiving loss control should be maintained, neither the loss-decreasing circuit nor the loss-increasing circuit being operated. To meet this need the arrangement of Fig. 1 provides that when relay S₁ is operated in the downward direction and relay S₂ is operated in the upward direction (which situation, with the proper setting of the sensitivities, should result from a return current value in the intermediate range), ground is connected to neither the loss-increasing nor the loss-decreasing control and the previously established setting of the receiving loss control is maintained.

In the form disclosed in the drawing the return current indicating and adjusting circuit will operate not only on voice waves coming in over path L₂ but also on some noise and on singing currents. In general such operation will not be objectionable. The important consideration is that the circuit will operate to adjust the receiving loss when conditions of fogged loss, reverse fogged loss and active return loss are such that the prevention of singing requires adjustment. If singing begins, the circuit will operate to stop the singing by adjustment of receiving loss, and if the terminal arrangement disclosed is duplicated at the other end of the four-wire circuit, the receiving loss will be adjusted at that end also.

In connection with the statements made hereinbefore with respect to the operation of relay S only in response to incoming waves, it will be noted that a one-way amplifier A₂ is included in path L₂ between the point *a* and the hybrid coil. This one-way device serves to prevent energy which comes in from line L and divides in the

hybrid coil from reaching point *a* and operating the direction indicating circuit.

It has been seen that with the arrangement generally disclosed in Fig. 1, if the return current in the path L₁ is small with reference to the signal current coming in over path L₂, both relays S₁ and S₂ will operate in a downward direction, the operation of S₂ resulting in the reduction of receiving loss. If, on the other hand, the return current is large with reference to the incoming current, both relays will operate in an upward direction: the operation of S₁ will cause an increase of the receiving loss and the operation of S₂ will prevent any decrease of the receiving loss. If the return current has a value in an intermediate range with respect to the incoming current, relay S₂ may be operated upward but the less sensitive relay S₁ will be operated in a downward direction. In this case relay S₁ has no effect on the receiving loss while the upward operation of S₂ prevents any operation to decrease the receiving loss. In other words, as indicated hereinbefore, with this intermediate value of return current, the setting of the receiving loss control remains at the value last established.

In Fig. 2 of the drawing there is disclosed in somewhat greater detail a suitable arrangement of the direction indicating circuit schematically shown in Fig. 1. Incoming energy from path L₂ passes through the high impedance amplifier A and the weighting network W, of which the function has been discussed hereinbefore. The energy is rectified in a suitable rectifier such as R. The inductance *l* and the capacity *c* serve to smooth off the rectified current, and a direct current is set up in resistance *r* of which the magnitude depends upon the magnitude of the energy impressed upon amplifier A. A corresponding positive voltage will be applied to the grid of the thermionic vacuum tube V, this voltage, of course, being likewise dependent upon the input to the amplifier A. The lower winding of relay S is included in the plate circuit of the tube V.

Likewise the branch of the direction indicating circuit bridged across path L₁ includes the high impedance amplifier A', the weighting network W', the rectifier R', inductance and capacity *l'* and *c'*, respectively, a resistance *r'* and the vacuum tube V', which includes in its plate circuit the upper winding of relay S.

Incoming signal waves will build up a voltage on condenser *c* which will be greater than the voltage built upon condenser *c'* in the upper branch by any return currents reaching this direction indicating circuit immediately. Accordingly the attraction of the lower winding of relay S will be greater than that of the upper winding and the armature of the relay will be operated downward. This operation connects ground over the armature and causes the discharge of the condenser *c*₃. The charging circuit for this condenser includes a resistance *r*₃ and the winding of relay S₃. Once the condenser has discharged, current flows through this charging circuit and relay S₃ is operated to place battery on the control lead to relay S₄ of the return current indicating circuit. Relay S₃ will have a slow release determined by the value of resistance *r*₃, etc. This release period should be at least as great as the delay of the longest delayed echo which may be returned over path L₁.

Fig. 3 shows in somewhat greater detail a suitable arrangement of the return current-indicating circuit, generally disclosed in Fig. 1. As is the case with the direction indicating circuit al-

ready discussed, each branch of the return current indicating circuit is bridged across the appropriate path of the four-wire circuit, the lower branch including high impedance amplifier A_1 , weighting network W_1 , and rectifier R_1 , while the upper branch includes amplifier A'_1 , weighting network W'_1 , and rectifier R'_1 . Likewise there are included in the lower branch an inductance L_1 , a condenser c_1 and the vacuum tube V_1 while corresponding elements, including the vacuum tube V'_1 , are found in the upper branch. It will be noted that the plate circuit of tube V_1 includes in series the lower windings of relays S_1 and S_2 while the upper windings of these relays are connected in series in the plate circuit of tube V'_1 .

It will be observed that the voltages on the grids of the vacuum tubes are determined in part by the condensers c_1 and c'_1 and that no charge can be built up on either of these condensers until ground is removed by the operation of relay S_4 . The operation of this relay in turn is controlled by the operation of relay S_3 of the direction indicating circuit. One relay S_4 has operated, a charge will be built up on condenser c_1 , dependent as to magnitude upon the voltage applied to the lower branch of the circuit from the incoming path L_2 . The charge on c_1 will remain for an appreciable length of time, which is determined by the leakage back through rectifier R_1 and through the tube. This charge should remain substantially constant for the delay time of the return current. The return currents build up a charge on condenser c'_1 and the relation between the magnitudes of the charges on condensers c_1 and c'_1 will determine the operation of relays S_1 and S_2 .

This operation of the return current indicating relays S_1 and S_2 and the function with respect to the receiving loss control have been discussed in connection with Fig. 1. It will be understood that if relay S_1 operates downward there is no effect, while if this relay operates in an upward direction the circuit is completed to increase the receiving loss. This is indicated in Fig. 3 by the connection from ground over the armature of the relay to the loss increase control. It remains, however, to disclose and discuss in somewhat greater detail the slow releasing and slow operating circuits associated with relay S_2 .

It is to be borne in mind that the upper winding of relay S_2 is adjusted to be somewhat more sensitive than the upper winding of relay S_1 . Since the charge on condenser c_1 is built up immediately upon the arrival of the incoming waves while the charge on condenser c'_1 may be built up in part with the delay involved in the delayed echoes, relay S_2 will usually operate in the downward direction initially even of the return current develops to the extent which will cause a subsequent operation in the upward direction. In order to meet this situation and provide for the suitable operation of the receiving loss controls, it is necessary to provide a time action such as that now to be described.

If relay S_2 operates in the downward direction, condenser c_5 is discharged to ground and relay S_5 will be operated due to the fact that its winding is included with a resistance r_5 in the charging circuit of the condenser. The values of this circuit are so chosen that relay S_5 will have a considerable slow release period. Thus even if the armature of relay S_2 is subsequently operated upward, relay S_5 will remain operated for the time required to charge condenser c_5 . When relay S_5 operates, ground is disconnected from the armature as indicated. This operation initiates the re-

lease of relay S_6 . If the circuit conditions are such that relay S_6 does release, ground is connected over its armature to the loss decrease control and the result is the decrease of the receiving loss. If, however, relay S_2 after its downward operation operates in the upward direction before the release of relay S_6 , condenser c_6 is immediately discharged to ground over the armature of S_2 , and since the charging circuit of this relay includes a resistance r_6 and the winding of relay S_6 , relay S_6 will be held operated for a period not shorter than the charging time of the condenser c_6 . This time should be made equivalent to the longest echo contemplated and the release time of relay S_5 should be made slightly longer. Thus it is seen that if relay S_2 operates in the upward direction due to return current, ground will not be connected over the armature of relay S_6 to the loss decrease control, but if relay S_2 after operating downward does not subsequently operate in the upward direction, relay S_6 will eventually release and the circuit will be completed to decrease the receiving loss.

While the invention has been disclosed specifically for the purpose of illustration, it is to be understood that this specific form may be departed from within the spirit of the invention as defined in the appended claims.

What is claimed is:

1. In a two-way signal transmission system including a two-wire line and a link having a first path for transmitting from and a second path for transmitting to said line, means for making a comparative measurement of the signal energy transmitted over the second path and the current returned from the two-wire line over the first path as a result of such transmission, and adjusting means rendered operative only when energy is transmitted over said second path for controlling the loss introduced in said path so as to maintain the desired relation between the magnitude of the current in said path and the magnitude of the return current in said first path, said loss remaining at the value last established pending a new operation of said adjusting means.

2. In a two-way signal transmission system including a two-wire line and a link having a first path for transmitting from and a second path for transmitting to said line, a volume operated gain adjusting device in said first path, a reverse volume operated gain adjusting device in said second path, means on the output side of said volume operated gain adjusting device for measuring the current returned from the two-wire line over said first path in comparison with the signal current in said second path on the input side of said reverse volume operated gain adjusting device, and adjusting means rendered operative only when energy is transmitted over said second path for controlling the loss introduced in said path so as to maintain the desired relation between the magnitude of the current in said path and the magnitude of the return current in said first path, said loss remaining at the value last established pending a new operation of said adjusting means.

3. In a two-way signaling system including a two-wire line and a link having a first path for transmitting from and a second path for transmitting to said line, the method of preventing singing which consists in comparing the magnitudes of the signal energy in a given frequency range in the second path and the energy of corresponding frequency returned over the first path as a result of such signal transmission in said second path, and effecting an adjustment of the

loss in said second path whenever it is necessary to the maintenance of the desired relation between said magnitudes.

4. In a two-way signal transmission system including a first path for transmitting in one direction and a second path for transmitting in the opposite direction, said paths being so associated that currents in the second path will be in part returned over the first path, means in said second path for introducing a variable loss therein, means associated with both paths for measuring the resulting return current in the first path with relation to the magnitude of the signal current in the second path, and means responsive to such measurement for decreasing the loss in the second path when the return current is relatively low and increasing said loss when said current is relatively high.

5. In a two-way signal transmission system including a first path for transmitting in one direction and a second path for transmitting in the opposite direction, said paths being so associated that currents in the second path will be in part returned over the first path, a variable transmission loss control in said second path, means associated with both paths for measuring the return current in the first path with relation to the magnitude of the signal current in the second path, and means responsive to such measurement and associated with said loss control for decreasing the loss in the second path when the return current is relatively low and increasing said loss when said current is relatively high while preventing any variation of said loss while the return current is in an intermediate range of magnitude with relation to the current in the second path.

6. In a two-way signal transmission system including a two-wire line and a link having a first path for transmitting from and a second path for transmitting to said line, a variable transmission loss control in the second path, a return current indicating circuit associated with said loss control whereby when the current returned from the two-wire line over said first path is below a predetermined value with reference to the incoming signal current in said second path, the loss control is adjusted to reduce the loss in said second path, and when the return current is above a predetermined value with reference to said signal current, said loss control is adjusted to increase said loss, means for preventing adjustment of said loss when the return current is in a range of magnitude intermediate to said predetermined values with reference to said signal current, and a direction indicating circuit for rendering said return current indicating circuit operative only when signal energy is coming in toward said two-wire line over said second path.

7. In a two-way signal transmission circuit hav-

ing separate paths for transmitting in opposite directions, the paths being so related that signal transmission over the second path will result in the return over the first path of a part of the energy so transmitted, the second path having associated with it a variable transmission loss control; a return current measuring and adjusting circuit comprising a first differential relay associated with both paths and designed to cause the operation of the loss control to increase the loss in the second path when the return current in the first path is above a predetermined magnitude with reference to the signal current in the second path, a second differential relay associated with both paths and designed to cause the operation of said loss control to decrease the loss in said second path when said return current is below a predetermined magnitude with reference to said signal current, and means for preventing variation of the loss introduced in said second path by said loss control when said return current is in an intermediate range of magnitude with reference to said signal current.

8. In a two-way signal transmission system including a first path for transmitting in one direction and a second path for transmitting in the opposite direction, said paths being so associated that currents in the second path will be in part returned over the first path, means in said second path for introducing a variable loss therein, means associated with both paths for measuring the return current in the first path with relation to the magnitude of the signal current in the second path, means responsive to such measurement for decreasing the loss in the second path when the return current is relatively low and increasing said loss when said current is relatively high, and means for delaying any reduction of said loss for the time of the longest delayed echo to be returned over said first path.

9. In a two-way signal transmission system including a first path for transmitting in one direction and a second path for transmitting in the opposite direction, said paths being so associated that currents in the second path will be in part returned over the first path, means in said second path for introducing a variable loss therein, means associated with both paths for measuring the return current in the first path with relation to the magnitude of the signal current in the second path, means responsive to such measurement for decreasing the loss in the second path when the return current is relatively low and increasing said loss when said current is relatively high, means for delaying any reduction of said loss for the time of the longest delayed echo to be returned over said first path, and means for preventing reduction of said loss in response to echo energy in said first path.

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