

April 3, 1934.

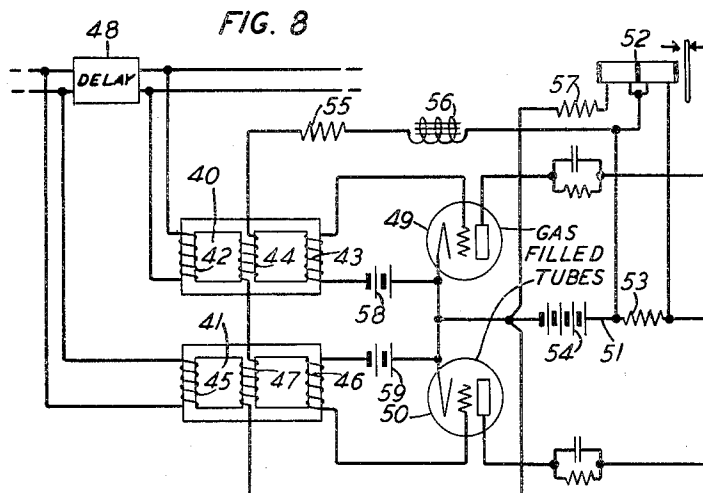
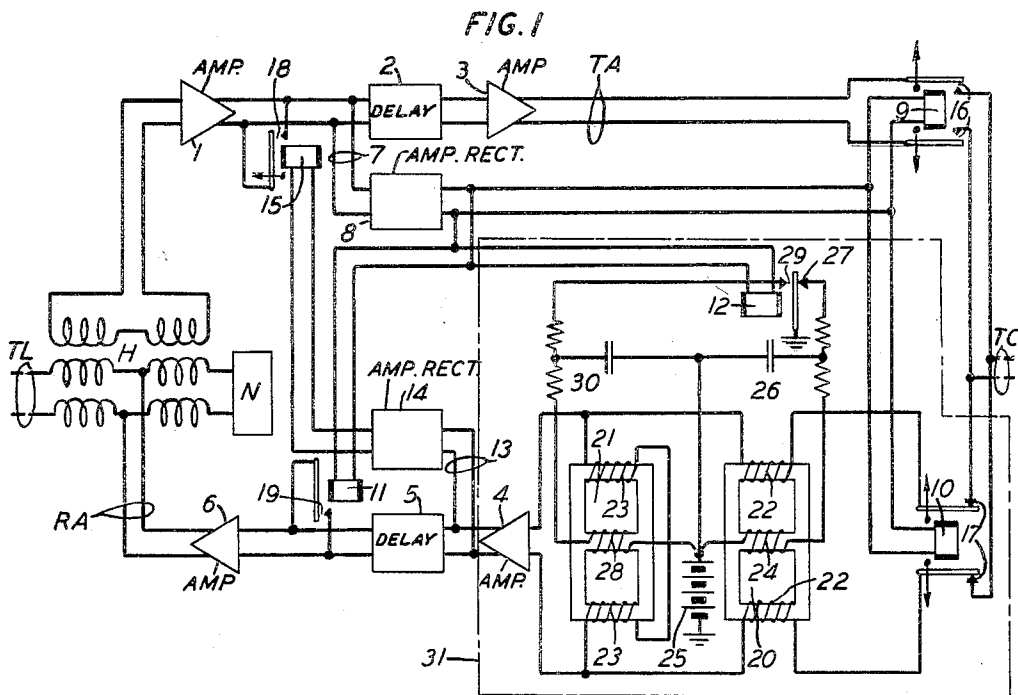
W. A. KNOOP

1,953,487

TRANSMISSION CONTROL CIRCUITS

Filed Nov. 17, 1931

3 Sheets-Sheet 1



INVENTOR

W. A. KNOOP

BY

H. A. BUNGER

ATTORNEY

April 3, 1934.

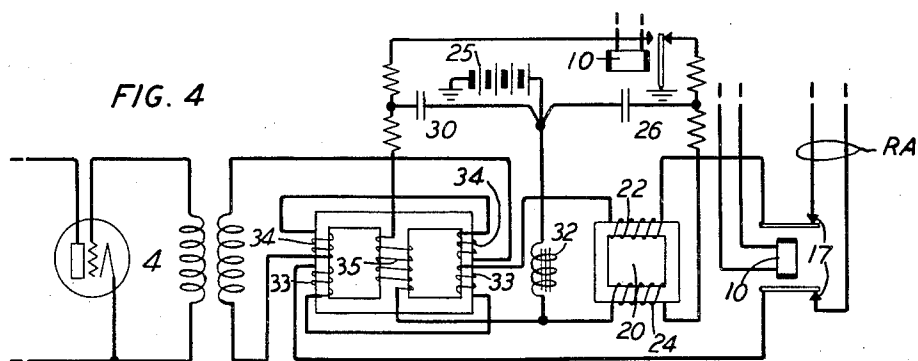
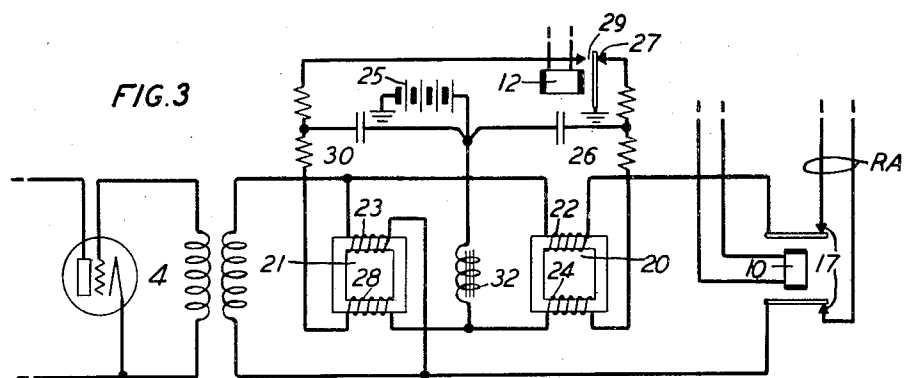
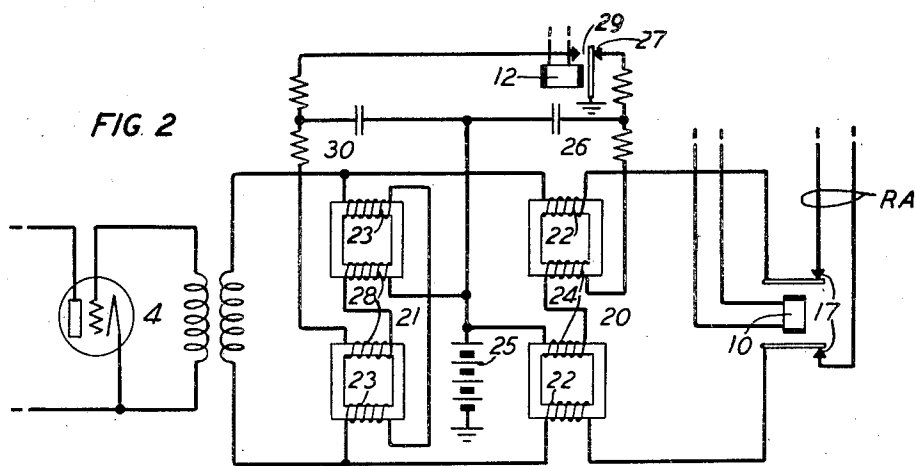
W. A. KNOOP

1,953,487

TRANSMISSION CONTROL CIRCUITS

Filed Nov. 17, 1931

3 Sheets-Sheet 2



INVENTOR

W.A. KNOOP

BY

H.A. Burgess

ATTORNEY

April 3, 1934.

W. A. KNOOP

1,953,487

TRANSMISSION CONTROL CIRCUITS

Filed Nov. 17, 1931

3 Sheets-Sheet 3

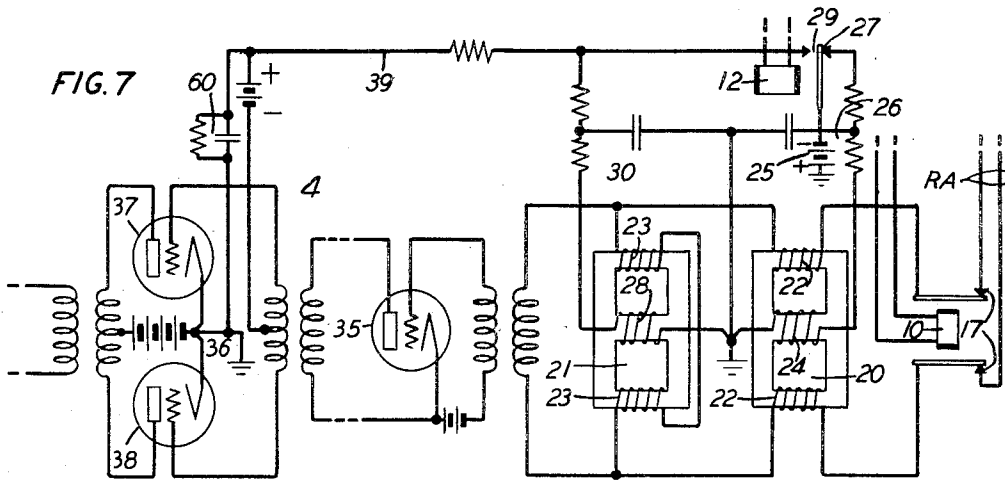


FIG. 5

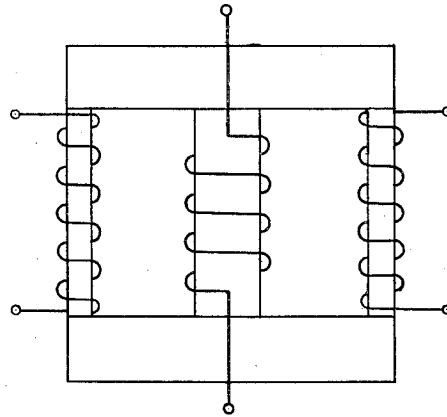
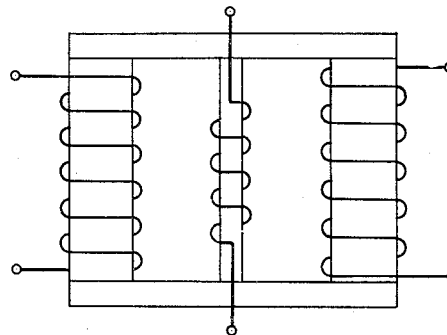


FIG. 6



INVENTOR
W.A. KNOOP
BY *H.A. Burgess*
ATTORNEY

UNITED STATES PATENT OFFICE

1,953,487

TRANSMISSION CONTROL CIRCUITS

William A. Knoop, Hempstead, N. Y., assignor to
Bell Telephone Laboratories, Incorporated,
New York, N. Y., a corporation of New York

Application November 17, 1931, Serial No. 575,563

6 Claims. (Cl. 179—170)

This invention relates to signal transmission systems and particularly to the control of transmission in such systems.

An object of the invention is to improve the operation characteristics of signal transmission systems employing signal-controlled apparatus for determining the direction of transmission.

Another and a more specific object of the invention is to improve the operation of voice-operated switching circuit in two-way telephone transmission systems by employing in connection therewith so-called modulator or impulse coils.

An impulse or modulator coil for the purposes of this invention may be defined as a transformer with a closed magnetic circuit preferably composed of a high permeability magnetic material such as permalloy, adapted to saturate when magnetized by a biasing direct current applied through a biasing winding so that the permeability of the core is much reduced. In the case of a modulator coil, the variation in core permeability obtained when the biasing current is applied or removed from the coil is utilized to vary the effective inductance of the windings on the core and the mutual inductance therebetween, between low and high values. In the case of an impulse coil, the biasing current applied to the biasing winding is made such that when no alternating current signals are applied to the primary winding of the coil, or when the amplitude level of the applied signals is below a critical value, there will be substantially no coupling between the primary and secondary windings. When the amplitude level of the applied signals exceeds the critical value the coupling between the windings greatly increases, and impulses are produced in the secondary winding circuit which impulses may be used to actuate relay circuits. The impulse coils sharply discriminate between currents above and below the critical amplitude level. A simple and permanent adjustment of the coils may be obtained by changing the strength of the biasing currents in the magnetizing winding.

In one embodiment of the invention applicable particularly to the terminal circuits of a two-way telephone cable system, for example, a submarine telephone cable system modulator coils are utilized to improve switching operations. When the input of the high gain receiving amplifier in such a system is connected to the telephone cable suddenly after speech waves have been transmitted out over the cable, there may be some low frequency alternating voltage on the cable. If switch contacts are utilized for connecting the amplifier to the cable, these voltages will cause

high frequency transient voltages to be set up at the switching contacts which may produce harmful effects on the receiving amplifier or cause a loud click to be heard in the receiving telephone instrument. In the circuit of the invention, the biasing currents applied to modulator coils connected in the receiving circuit between the switch contacts therein and the input of the receiving amplifier are controlled in such manner as to provide a gradual connection of the receiving amplifier to the cable, thus preventing the high transient voltages set up by the switching contacts from reaching the receiving amplifier.

In another embodiment of the invention, impulse coils having the characteristics above described are used in combination with a delay circuit in the associated signal transmission path to provide hang-over in the operation of the signal-controlled switching circuits.

The exact nature and the advantages of the invention will be better understood from the following detailed description thereof when read in connection with the accompanying drawings in which:

Fig. 1 shows the invention embodied in the terminal circuit of a two-way submarine cable telephone transmission system;

Figs. 2, 3, 4 and 7 show different modifications of the invention which may be used in the circuit of Fig. 1;

Figs. 5 and 6 show different types of induction coils, which may be used in the circuits of the invention; and

Fig. 8 shows a modification of the invention employed for producing hang-over in the operation of a signal-controlled switching circuit.

Fig. 1 shows the west terminal station of a long two-way telephone cable system, for example, a submarine cable telephone system. The terminal station is shown as connecting a two-way line TL, such as a land telephone line, to the west end of a two-way cable TC, such as a deep sea submarine telephone cable. This west terminal station comprises a transmitting circuit TA for repeating telephonic waves from the line TL into the cable TC, and a receiving circuit RA for repeating telephonic waves received from the cable TC into the line TL.

The output of the transmitting circuit TA and the input of the receiving circuit RA are shown connected or adapted to be connected directly to the cable through relay contacts, but may be connected to each other and to the cable by means of a hybrid coil bridge circuit or any other type of coupling means. The input of the transmit-

ting circuit TA and the output of the receiving circuit RA are shown connected in energy transmitting relation with the line TL, and in substantially conjugate condition with each other by means of a three-winding transformer or hybrid coil H and associated balancing network N, but may be connected to each other and to the line in any other suitable manner.

The transmitting circuit TA comprises, connected between the hybrid coil H and the input of the cable TC, a one-way amplifier 1, a delay circuit 2 and a one-way amplifier 3. Similarly, the receiving circuit RA includes, connected between the cable TC and the hybrid coil H, a one-way amplifier 4, a delay circuit 5 and a one-way amplifier 6.

Connected to the transmitting circuit TA between the hybrid coil H and the delay circuit 2 is a control path 7 comprising the signal-controlled, relay-controlling device 8, which may be a vacuum tube, amplifier-rectifier circuit of any one of the well known types, and the windings of mechanical relays 9 to 12 connected in parallel with the output of the device 8. Similarly, connected to the receiving circuit RA between the output of the receiving amplifier 4 and the delay circuit 5 is the input of a control path 13 comprising a signal-controlled, relay-controlling device 14, similar to the device 8, and the windings of a mechanical relay 15 connected to the output of the device 14.

In the transmitting circuit TA between the output of amplifier 3 and the cable TC are the normally open switches 16 adapted to be closed by operation of the relay 9. In the receiving circuit RA between the cable TC and the input of the receiving amplifier 4 are the normally closed switches 17 adapted to be opened by operation of relay 10. Bridged across the transmitting circuit TA between the point of connection of the input of control circuit 7 thereto and the output of amplifier 1 is a normally open switch 18 adapted to be closed by operation of the relay 15. In the receiving circuit RA between the delay circuit 5 and the input of the amplifier 6 is a normally open switch 19 adapted to be closed by operation of the relay 11.

In the receiving circuit RA between the switches 17 therein and the input of the receiving amplifier 4, are the modulator coils 20 and 21, each comprising a three-legged core of high permeability magnetic material, such as permalloy, two signal windings wound respectively on the two outer legs of the core, and a magnetizing winding wound on the central leg of the core. The signal windings 22 of the modulator coil 20 are connected in series with the line wires of the receiving circuit RA between the closed switches 17 and the input of the receiving amplifier 4, and the signal windings 23 of the modulator coil 21 are connected in series with each other in a circuit which is in shunt with the receiving circuit RA in the input of the amplifier 4.

The magnetizing winding 24 of modulator coil 20 is normally supplied with biasing direct current from the battery 25 over a path extending from the positive pole of battery 25 through winding 24, the resistance-capacity filter 26 and the normally closed contacts 27 of relay 12 to the negative pole of battery 25. The value of this biasing current is made such as to reduce effectively the permeability of the core of the coil 20 and, therefore, the effective inductance of the signal windings 22, to such a low value that the windings 22 normally present little im-

pedance to the signals traversing these windings. The magnetizing winding 28 of modulator coil 21 is arranged to be normally deenergized so that the permeability of the core of the modulator coil 21 is at its maximum value, and consequently the signal windings 23 of that coil provide a very high impedance in shunt with the line wires of the receiving circuit RA in the input of the amplifier 4. Thus, the receiving circuit RA is normally operative to transmit signals from the cable TC to the input of the receiving amplifier 4 with maximum efficiency.

When the winding of relay 12 is energized in response to currents impressed thereon, the normally closed relay contacts 27 are opened and the normally open contacts 29 are closed. The opening of contacts 27 causes the biasing current from battery 25 to be removed from the magnetizing winding 24 of modulator coil 20 thus immediately restoring the permeability of the core of that coil to its normal higher value and consequently increasing the inductance of the signal windings 22 of the coil to their normal high value. The closing of the normally open contacts 29 causes biasing current to be supplied from the battery 25 to the magnetizing winding 28 of coil 21 over a path extending from the positive pole of battery 25 through winding 28, the resistance-capacity filter 30, and the closed contacts 29 of relay 12 to the negative pole of battery 25. This biasing current supplied to magnetizing winding 28 is such as to reduce the permeability of the core of coil 21 and, therefore, the inductance of the signal windings 23 connected in shunt with the receiving circuit RC, to a low value thus introducing effectively a high loss in the input circuit of the amplifier 4.

Due to the symmetrical connection of the two signal windings of each coil with respect to the circuit RA the inductive couplings between the signal windings of each coil 20 and 21 are inherently balanced out, and the biasing current supplied to their magnetizing windings produces almost no voltage in the signal windings of the coils. A slight amount of residual unbalance may be present, so the resistance-capacity filters 26 and 30 respectively are inserted between the source of magnetizing current and the magnetizing windings to round off the front of the biasing wave.

From the above description it is apparent that the transmitting circuit TA at the terminal station of Fig. 1 is normally inoperative and the receiving circuit RA normally operative.

Now let it be supposed that speech waves to be transmitted over the cable TC are being received at the terminal station over the telephone line TL. These waves will be impressed by the hybrid coil H on the transmitting circuit TA, transmitted thereover to amplifier 1 and amplified thereby. The amplified waves in the output of amplifier 1 will be divided between the delay circuit 2 in the main transmitting path TA and the input of control path 7. The main portion of the amplified waves in the output of amplifier 1 will be transmitted through delay circuit 2, being delayed in transmission therethrough for a certain period. The transmitted waves will then be amplified by amplifier 3.

A small portion of the amplifier waves in the output of amplifier 1 will be diverted into the control path 7 and will operate the control device 8 therein causing the windings of relay 9 to 12 to be energized. Relay 12 will then operate to open its normally closed contacts 27 and to close its

normally open contacts 29. In the manner described above, the opening of the contacts 27 and the closing of contacts 29 cause the modulator coils 20 and 21 to insert effectively a high loss in the input of receiving amplifier 4 in receiving circuit RA. Relay 10 is designed to operate in response to the energization of its windings slightly after relay 12 operates, to open its normally closed contacts 17, thus open-circuiting the receiving circuit RA in its input, that is, between the point of connection therein of impulse coils 20 and 21 and the cable TC. Because of the high loss previously inserted in the input of the receiving amplifier 4 through operation of relay 12, the high transient voltages which would be ordinarily produced in the path RA by the operation of switch contacts 17 when there is alternating energy on the cable, and which might be quite harmful to the receiving amplifier, are prevented from reaching the input of amplifier 4.

Relay 11 is designed to operate simultaneously with relay 10 to close its normally open contacts 19, so as to short-circuit the output of the receiving circuit RA and thus prevent any energy which may have been stored in delay circuits 5 at the time relay 10 operated, from being transmitted to the hybrid coil H.

Delay circuit 2 in the transmitting circuit TA is designed to produce sufficient delay in the transmission of speech waves therethrough as to prevent their arrival at switches 16 in the output of amplifier 3 until after those switches have been closed by the operation of relay 9.

Relay 9 is designed to operate slightly after relay 10 has operated, to close the normally open switch contacts 16 in the output of transmitting circuit TA, making that circuit operative to transmit from the output of amplifier 3 to the cable TC. The speech waves after amplification by amplifier 3 will, therefore, be transmitted from the output of amplifier 3 directly to the cable TC and will be transmitted thereover to the east terminal station.

Relay 9 is designed also so as to remain operated for a definite period of time after the input of speech energy to the control path 7 ceases, so as to prevent clipping of the speech, i. e., the loss of the portion of the speech which has not reached the switching point in transmitting circuit TA (switch 16) at the time the control device 8 releases due to a fall in the level of the waves impressed on its input. Similarly, relay 10 is designed so that it will remain operated for a definite period of time after the control device 8 has released so as to insure that the switches 17 in the circuit RA will remain open at least until all of the speech energy passing over the transmitting circuit TA has been sent into the cable TC. This will prevent false operation of the control device 14 in control path 13 connected to the receiving circuit RA. Relays 9 and 10 may be so designed by well known mechanical construction making them slow to release, or by the use of electrical auxiliary hang-over circuits in connection with the relays, such as disclosed, for example, in the patent to J. Herman, No. 1,793,202, issued March 5, 1931.

When control device 8 releases with cessation in the transmission of speech waves over the circuit TA, relays 9 to 12 will release. The release of relay 9 will cause its switching contacts 16 to return to their normally open condition disconnecting the transmitting amplifier 3 from the cable TC. The release of relays 10 and 11 will cause switch contacts 17 and 19 to return

to their normally closed and open conditions, respectively, rendering the receiving circuit RA operative in its input and output. The release of relay 12 will open its contacts 29 and close its contacts 27, switching the biasing battery 25 from the biasing winding of coil 21 to the biasing winding of coil 20. The effective inductance of the series signal windings of coil 20 will be thereby decreased and the effective inductance of the shunt signal windings of coil 21 thereby increased so that the high loss in the input of receiving amplifier 4 will be removed. However, the circuits are so adjusted that there will be such a lag in the change in condition of coils 20 and 21, that the high loss will not be removed until after any high transient voltages caused by the closing of switch contacts 17 have been dissipated. Thus, harmful effects on the receiving amplifier, and loud clicks in the receiving telephone instrument due to these transient voltages are prevented.

When the transmitting circuit TA is not transmitting, any speech waves incoming over cable TC will be transmitted directly into the input of the receiving circuit RA, switch contacts 17 being in their normally closed condition and the modulator coils 20 and 21 being in their normal condition. The incoming waves after traversing the signal windings of coil 20 are impressed upon the input of amplifier 4 and amplified thereby. The amplified waves in the output of amplifier 4 will be divided, the main portion being transmitted through the delay circuit 5 and a smaller portion being diverted into control path 13.

The portion of the speech waves diverted into control path 13 will operate control device 14 therein causing the winding of relay 15 to be energized. Relay 15 will then operate to close the normally open switch 18 in the input of the transmitting circuit TA. The circuit TA, therefore, will be rendered inoperative to transmit waves from the line TL, or unbalance energy from the output of the receiving circuit RA passing through the coupling H, thus preventing false operation of relays 9 to 12. The main portion of the speech waves in the output of amplifier 4 in receiving circuit RA will be transmitted through delay circuit 5. After being delayed in that circuit for a certain period of time, the speech waves will be transmitted to the input of amplifier 6, amplified by that amplifier and impressed by the hybrid coil H on the circuit TL, over which they will be transmitted to the distant receiving terminal.

The delay circuit 5 is designed so as to delay transmission of the speech waves therethrough for a sufficient time interval to insure that switch 18 in the input of transmitting circuit TA is closed by relay 15 in sufficient time to prevent any unbalance signaling energy from hybrid coil H getting into the control path 7 to cause false operation of relays 9 to 12. The relay 15 may be designed to remain operated for the required length of time after the cessation of supply of speech energy to the input of control path 13, to prevent the closing of the switch 18 until after all of the east to west speech waves have been transmitted into the circuit TL from the output of the receiving circuit RA. The relay 15 may be so designed by making it slow to release by well known methods of mechanical design as indicated by the arrow in the drawings, or by associating with this relay an auxiliary hang-over circuit such as disclosed in the patent of J. Herman referred to above.

Figs. 2, 3 and 4 show different modifications of the invention which may be used in the circuit of Fig. 1 in place of the portion shown within the dot-dash box 31.

5 The circuit shown in Fig. 2 differs from the alternative circuit within the box 31 in Fig. 1 merely in that the two signal windings 22 in the modulator coil 20 are wound on separate magnetic cores instead of on a single core structure as in Fig. 1, and a portion of the magnetizing winding 24 is wound on each of the two cores; and in that the two signal windings 23 of the coil 21 are wound on separate cores instead of on the same core structure as in Fig. 1, a portion of the magnetizing winding 28 being wound on each of the two cores. The operation of this circuit is similar to that of the circuit of Fig. 1 described above.

10 The circuit of Fig. 3 differs from the portion of Fig. 1 within the dot-dash box 31 in that each of the modulator coils 20, 21 comprises only one signal winding instead of two signal windings as in Fig. 1. This requires the use of a choke coil 32 in the magnetizing circuit of each coil between the magnetizing winding thereof and the battery 25 to prevent dissipation of signal energy. The operation of this circuit is also similar to that of the corresponding circuit shown in Fig. 1.

30 The circuit of Fig. 4 differs from that of Fig. 3 merely in that in the former circuit the coil 21 comprises a transformer mounted on a three-legged magnetic core having a primary winding 33 and a secondary winding 34 each having a portion wound on each outer leg of the core and a magnetizing winding 35 wound on the central leg of the core. The primary winding 33 of the transformer 21 is connected across the line wires of the receiving circuit RA in the output of the series coil 20, and the secondary winding 34 of the transformer 21 is connected across the terminals of the primary winding of the input transformer for the receiving amplifier 4. The transformer 21 has very little coupling between its primary and secondary windings when its magnetic core is saturated, that is, when the relay 10 is operated and biasing direct current is being furnished to its magnetizing winding 35 from battery 25; and the primary and secondary windings of the coil have very close coupling when the permeability of the core of the coil 21 is high, that is, when relay 10 is unoperated and the biasing direct current is removed from its magnetizing winding 35.

55 Two different forms of modulator coils employing three-legged cores which may be used in the circuits of the invention are shown in Figs. 5 and 6. The preferred construction is shown in Fig. 5 in which construction the winding on the center leg is the biasing or magnetizing winding, and the two signal windings are located respectively on one of the outside legs. In the core shown in Fig. 5, the cross-section of the yoke and center leg of the magnetic core is much greater than that of the outside leg, so that the outside legs saturate and their permeability decreases while the permeability of the center leg remains high. In the coil shown in Fig. 6, the biasing or magnetizing winding is also wound on the center leg of the magnetic core and the signal windings on the outer legs of the core. In this case, however, the cross-section of the other legs is much greater than that of the yoke and the center legs of the core. When this coil is used in the circuits above described the two signal windings would be

connected opposing instead of aiding, and when the middle leg of small cross-section is not saturated, the AC flux from each outside leg threads through the center leg. When the center leg is saturated, the two outside windings oppose each other because the AC flux cannot readily pass through the center core.

80 The circuit of Fig. 7 shows another modification of the invention which may be used in place of the circuit within the dot-dash box 31 in the circuit of Fig. 1. The circuit of Fig. 7 differs from the circuit shown in Fig. 1 in the following respects. The magnetic cores of the impulse coils 20 and 21 are of the type shown in Fig. 5, that is, the yoke and center leg have a cross-section which is much greater than that of the outside legs, so that when magnetizing current is applied to the magnetizing winding 24 or 28 on the center leg of the core from the battery 25, the outside legs of the core saturate and their permeability decreases while the permeability of the center leg remains high. The receiving amplifier 4 comprises two vacuum tube stages 35 and 36, the second stage 36 comprising the three electrode vacuum tubes 37 and 38 connected in push-pull relation. The closing of the switch contacts 29 in response to operation of the relay 12 besides causing the biasing current from battery 25 to be switched from the magnetizing winding of coil 20 to the biasing winding 28 of coil 21, also causes a blocking potential to be applied through the circuit 39 in common to the grids of the push-pull tubes 37 and 38 in the second stage 36 of the amplifier 4. By suitably proportioning the resistances and condensers in the resistance-capacity circuit 30 and in the resistance-capacity circuit 39 in the circuit 39, the second stage 36 of amplifier 4 may be made disabled in response to operation of relay 12 before the input of the receiving circuit has been open-circuited through operation of relay 10 and the first stage 35 of amplifier 4 has been disabled through the instrumentality of impulse coils 20, 21. This will also insure that when relay 12 releases in switching the terminal circuit from send to receive, the input of the receiving circuit will be made operative again through the release of relay 10 before the blocking potential is removed from the tubes 37 and 38 in the second stage 36 of amplifier 4.

125 Fig. 8 shows how impulse coils may be utilized in combination with voice-operated switching circuits such as the control circuits 7 and 13 in the system of Fig. 1 to eliminate the necessity of using an auxiliary hang-over relay to provide the required hang-over in the operation of the switching relays to prevent clipping of speech. Two impulse coils 40, 41 are employed. The impulse coil 40 comprises a three-legged magnetic core of high permeability magnetic material such as permalloy, a primary winding 42 wound on one outer leg of the core, a secondary winding 43 wound on the other outer leg of the core, and a magnetizing winding 44 wound on the center leg of the core. Similarly, the impulse coil 41 comprises a three-legged magnetic core, a primary winding 45 wound on one outer leg of the core, a secondary winding 46 wound on the other outer leg of the core, and a magnetizing winding 47 wound on the center leg of the core. The primary winding 45 of impulse coil 41 is connected across the main signal transmission path in the input of the delay circuit 48 therein, which delay circuit would correspond to the delay circuit 5 or the delay circuit 2 in the system of Fig. 1. The pri-

mary winding 42 of the impulse coil 40 is connected across the output of the delay circuit 48. The secondary winding 43 is connected across the input of a gas-filled, three-electrode tube 49 and the secondary winding 46 of impulse coil 41 is connected across the input of a gas-filled, three-electrode tube 50. The gas-filled tubes 49 and 50 have a portion 51 of their space current supply circuit in common. The operating winding of the switching relay 52 which would correspond, say, to the switching relay 15 in control circuit 13 in the system of Fig. 1, is connected across a resistance 53 in the common portion 51 of the space current supply circuit of tubes 49 and 50.

The magnetizing winding 44 of impulse coil 40 and the magnetizing winding 47 of impulse coil 41 are normally supplied in series with magnetizing currents from the plate battery 54 of tubes 49 and 50 through the resistance 55 and choke coil 56 so that the permeability of the magnetic cores of these coils is normally reduced to a low value. This insures that in each of these coils there is normally very little coupling between the primary and secondary winding. Relay 52 is normally biased to be unoperated, by direct current supplied to its biasing winding from battery 54 through resistance 57. The grids of tubes 49 and 50 are negatively biased by grid batteries 58 and 59 respectively so that these tubes are normally inoperative.

When signal currents are being transmitted over the signal transmission path, a portion thereof is picked off in the input of the delay circuit 48 and impressed upon the primary winding 45 of the coil 41. When these signals become of sufficient amplitude the magnetization of the core of coil 41 is effectively increased so that the permeability of the core greatly increases. This increase in permeability greatly increases the coupling between the primary winding 45 and the secondary winding 46 of coil 41 with the result that a greatly increased voltage is produced at the terminals of the secondary winding 46. This voltage is impressed upon the input electrodes of the gas-filled tube 50 causing that tube to become operative so that space current will flow in its output circuit. This space current flows through the resistance 53 and the RI drop therein applied across the operating winding of relay 52 in parallel causes that relay to operate to actuate its contacts in the desired direction.

After the signals in the main transmission path have been transmitted through the delay circuit 48, a portion thereof is picked off in the output of the delay circuit and impressed upon the primary winding 42 of the coil 40. These currents in the same manner as in the case of the coil 41 described above will cause the coupling between the primary and secondary windings of the coil to be greatly increased. The resultant increase in the coupling between the primary winding 42 and the secondary winding 43 of coil 40 causes a greatly increased voltage to be produced at the terminals of the secondary winding 43 which is impressed upon the gas-filled tube 49 causing it to become operative so that space current begins to flow in its output circuit. This space current flowing through the resistance 53 produces an RI drop reinforcing the RI drop produced by operation of the tube 49, which when applied to the operating winding of the relay 52 will maintain that relay operated.

Now let it be supposed that the flow of signal currents to the delay circuit 48 in the main signal transmission path ceases. The potential ap-

plied to the primary winding 45 of the coil 41 will first fall off causing the magnetization of the core to increase and thus the permeability to decrease to the point where there is little coupling between the primary winding 45 and the secondary winding 46. This will result in a decreased voltage across the terminals of the secondary winding 46 causing the gas-filled tube 50 to return to its unoperated condition. The portion of the current due to that tube, flowing through the resistance 53 in its output circuit is then reduced to zero. However, the signal voltage applied across the primary winding 42 of impulse coil 40 will be maintained for an additional interval, i. e., that interval required for the signals to be transmitted through the delay circuit 48. Tube 49 will, therefore, be maintained in the operated condition for an additional time interval after tube 50 has been rendered inoperative, thus maintaining sufficient current flowing through the resistance 53 in its output circuit to maintain the operating winding of relay 52 energized for that additional interval of time. At the end of that interval the tube 49 will be rendered inoperative due to the decrease in the voltage across the terminals of the secondary winding 43 of coil 40 caused by the falling off of the signal currents applied to the primary winding 42. Relay 52 will therefore return to its unoperated condition. The hang-over interval may be made of any desired length by suitable design of the delay circuit 48.

The invention is not limited to the particular circuits described above. Other modifications and applications within the spirit and scope of the invention will occur to persons skilled in the art.

What is claimed is:

1. A terminal circuit for a two-way signal transmission medium comprising a transmitting circuit and a receiving circuit connected thereto, an amplifier in said receiving circuit, means responsive to the initiation of signals in said transmitting circuit for effectively disabling the input of said receiving circuit during transmission of said signals to said medium, and means for preventing the transient voltages set up in said receiving circuit by the disabling thereof from harmfully affecting said amplifier, comprising an induction coil connected in series with said receiving circuit between the disabling point therein and said amplifier and normally offering a low impedance to signals, a second induction coil connected in shunt with said receiving circuit between the disabling point therein and said amplifier, and normally offering a high impedance to signals, and means also responsive to said signals in said transmitting circuit for effectively increasing the inductance of the series coil and decreasing the inductance of the shunt coil substantially at the same time as said receiving circuit is disabled.

2. A terminal circuit for a two-way signal transmission medium comprising two one-way circuits each including amplifying means, connected to said medium and respectively adapted for transmitting signals thereto and receiving signals therefrom, means responsive to signals initiated in the transmitting one-way circuit for operating switch contacts in the receiving one-way circuit so as to disable the input thereto, and responsive to cessation of said signals to restore said contacts to their normal unoperated condition, and means for preventing the transient voltages set up in said receiving circuit by operation or release after operation of said contacts from harmfully affecting the amplifying means in

said receiving circuit comprising inductive means connected in said receiving circuit between the amplifying means therein and said contacts and normally providing an impedance of low value to signals in series with said receiving circuit and an impedance of high value to signals in shunt therewith, means also responsive to said signals initiated in said transmitting circuit for effectively increasing the value of said series impedance and decreasing the value of said shunt impedance substantially at the same time or prior to operation of said contacts by said signals, and means for maintaining said series impedance at its increased value and said shunt impedance at its decreased value until after said contacts have been restored to the unoperated condition with cessation of the signals in said transmitting circuit.

3. The terminal circuit of claim 2 and in which said inductive means comprises a plurality of induction coils each comprising a core of high permeability magnetic material, an operating winding and a magnetizing winding wound on said core, the operating winding of one of said coils being connected in series with said receiving circuit and the operating winding of the other coil being connected in shunt with said receiving circuit, and a source of direct current normally connected to the magnetizing winding of said one coil and of such value as to reduce the permeability of the core to a low value, and said means for increasing the value of said series impedance and decreasing the value of said shunt impedance comprises means responsive to said signals in said transmitting circuit to switch said source from the magnetizing winding of said one coil to the magnetizing winding of said other coil so as to increase the permeability of the core of said one coil and to decrease the permeability of the core of said other coil.

4. The terminal circuit of claim 2 and in which said inductive means comprises an induction coil having a closed magnetic circuit of high permeability material, a signal winding and a magnetizing winding wound thereon, said signal winding being connected in series with a line wire of said receiving circuit and said magnetizing winding being normally supplied with energizing direct current so as to reduce effectively the permeability of said magnetic circuit, and a transformer comprising a three-legged magnetic core, a primary winding having a portion wound on each outer leg of said core and connected effectively in shunt with the input of said receiving circuit, a secondary winding having a portion wound on each outer leg of the three-legged core and connected effectively in shunt with the input of said amplifying means in said receiving circuit and a magnetizing winding wound on the center leg of the core and in which said means for increasing the value of said series impedance and decreasing the value of said shunt impedance comprises means for removing the direct current supply from the magnetizing winding of said induction coil and connecting it to the magnetizing winding of said transformer.

5. A terminal circuit for a two-way signal

transmission medium, comprising a transmitting circuit and a receiving circuit connected thereto, a multi-stage vacuum tube amplifier in said receiving circuit, means responsive to the initiation of signals in said transmitting circuit for disabling said receiving circuit by open-circuiting its input, an induction coil connected in series with said receiving circuit between the disabling point therein and the input of said receiving circuit amplifier, and normally offering a low impedance to transmission of signals therethrough, a second induction coil connected in shunt with said receiving circuit between the disabling point therein and the input of said receiving circuit amplifier, and normally offering a high impedance to transmission of signals therethrough, means responsive to said signals in said transmitting circuit and operative substantially at the same time or before the receiving circuit is open-circuited in response to said signals, to increase effectively the inductance of said series inductance coil and to decrease effectively the inductance of said shunt coil, and to apply a blocking potential to the second stage of said amplifier, and means for maintaining said blocking potential until after the induction coils have returned to their normal condition with cessation of said signals.

6. A signal transmission system comprising signal transmission paths, a delay circuit in one of said paths, normally unoperated relay means which when operated controls the transmission efficiency of at least one of said paths, and means for operating said relay means in response to transmission of signals in said one path, and for maintaining said relay operated for a definite hang-over interval after the supply of said signals to said one path ceases, comprising two normally inoperative three-electrode space discharge devices, each adapted when operated to cause operation of said relay means, two induction coils each comprising a three-legged magnetic core having a primary winding wound on one outer leg thereof, a secondary winding wound on the other outer leg, and a magnetizing winding wound on the central leg thereof and energized by direct current so as to maintain the effective permeability of the core low in the absence of a voltage applied to its primary winding, the primary winding of one coil being connected across said one transmission path in the input of said delay circuit and its secondary winding being connected to the input electrodes of one of said space discharge devices, the primary winding of the other coil being connected across said one transmission path in the output of said delay means and its secondary winding being connected to the input electrodes of the other of said space discharge devices, the effective change in the permeability of the core of each of said coils when signals are applied to its primary winding causing such increase in the voltage across the secondary winding thereof as to render the associated space discharge device operative.

WILLIAM A. KNOOP.