

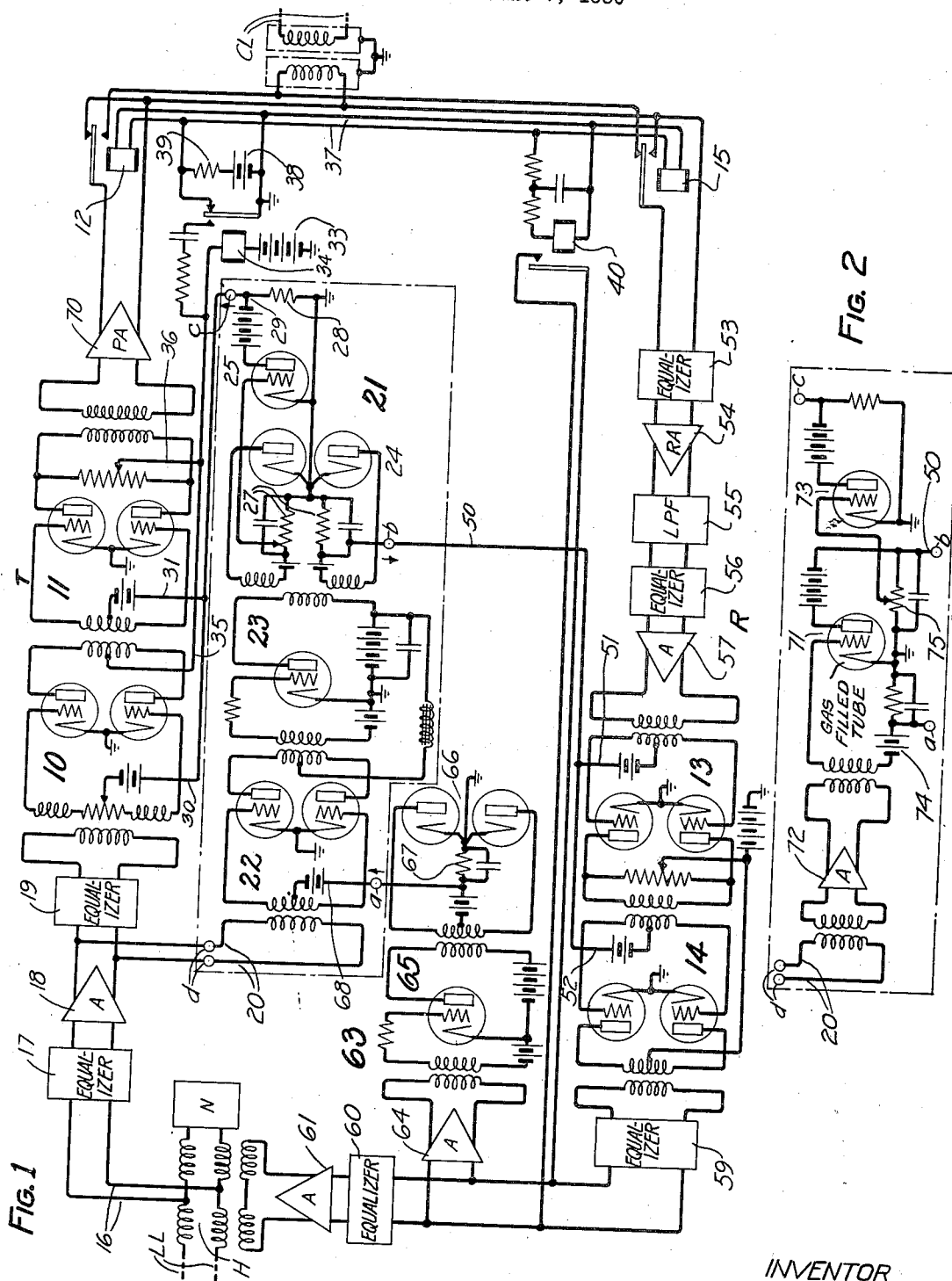
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C. N. NEBEL

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VOICE OPERATED TRANSMISSION CIRCUIT

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INVENTOR
C. N. NEBEL
BY *H. A. Burgess*
ATTORNEY

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VOICE OPERATED TRANSMISSION CIRCUIT

Charles N. Nebel, Newark, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

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The present invention relates to a telephone system employing what is commonly known in the art as voice operated directional switching. This type of switching as disclosed in the prior art is utilized in two-way transmission for connecting two oppositely directed one-way transmission paths, one at a time, to a common two-way transmission circuit, although in a broad sense voice operated switching may be used to establish and disable a one-way circuit without regard to an oppositely directed companion circuit.

In the prior art the oppositely directed one-way circuits have been made operative or inoperative either by the movement of switching contacts, such as electromagnetic relay contacts or by the control of the grid bias voltage on a three-element space discharge device associated with the circuit. In either type of switching voice energy is amplified and rectified to provide suitable current or voltage for operating the relays or applying bias voltage to the grids of the vacuum tubes.

It is a general object of the present invention to improve the operation of voice operated switching systems, to render them more positive in their operation and to prevent false operation. A related object is to reduce the tendency of singing around the loop circuit including two oppositely directed paths.

In accordance with the present invention a dual type of control involving both vacuum tube control and relay switching is used. The advantages of vacuum tube control are retained but the disadvantages which have been experienced with this type of control are overcome by supplementing the vacuum tube control by relay switching. Practice has shown that vacuum tube control alone is very effective in preventing singing around the four-wire loop since it not only introduces a high impedance into the loop but removes at least in part the amplification which gives rise to such singing. It has been found, however, that where large differences exist in transmitting and receiving power interference from battery or other sources may prove troublesome. The relay switching, however, is arranged to sever the physical connections of the transmitting and receiving circuits at the proper points to prevent such interference.

Where reference is made throughout this specification to telephone systems or to voice operated devices it will be understood that these terms are intended to refer to any type of signal transmission whether employing waves in the speech frequency band or waves of lower or higher frequencies.

A better understanding of the invention will be had from the detailed description to follow, in which reference will be made to the accompanying drawing showing in Fig. 1 a schematic diagram of a four-wire circuit interconnecting two telephone lines, one of which may be an ocean cable, and in Fig. 2 an alternative type of amplifier-detector circuit capable of use in the circuit of Fig. 1.

While the present invention is applicable to various types of transmission systems the preferred embodiment to be described comprises a terminal circuit for an ocean cable. This terminal circuit comprises a transmitting branch T and a receiving branch R connected between the land line LL and the cable CL.

The transmitting branch is normally effectively disconnected from the cable while the receiving branch is normally in condition to receive signals from the cable and repeat them into the land line.

The transmitting branch T is normally disabled in two ways. The amplifiers 10 and 11 comprising vacuum tubes connected in push-pull relationship have their grids normally poled so far negative with respect to their cathodes that the space current of the vacuum tubes is practically zero thus rendering the tubes incapable of transmitting. Also the relay 12 is normally deenergized opening its lower contact and closing its upper contact so that the transmitting circuit is disconnected from the cable and has a short circuit placed across it as shown, extending through the upper contact of relay 12.

In the receiving branch R the receiving amplifier stages 13 and 14 have their grids normally polarized at the proper operating potentials so that these amplifiers are in condition to receive. Likewise the relay 15 is deenergized and closes at its upper contact the circuit leading from the cable CL to the receiving branch R.

When signals are received from the land line LL for transmission to the cable the receiving branch R is disabled and the transmitting branch T is rendered in condition for transmission. The steps by which this directional switching is brought about will be made clear from tracing through the operations which take place when signals are to be transmitted.

The land line LL is provided with a hybrid coil H and a balancing network N as usual in the art. Speech currents incoming from the line LL pass into the bridge circuit 16, through equalizer

17, amplifier 18, equalizer 19 and are applied to the grid circuit of the amplifier stage 10. A portion of the speech waves from the output of amplifier 13 also passes into circuit 20 from which they are applied to the amplifier-detector circuit indicated generally at 21. This circuit comprises the initial push-pull amplifier stage 22, a second stage 23, a full wave rectifier stage 24 and a bias reversing stage 25.

10 This amplifier-detector circuit 21 is a modification of a circuit that is disclosed and claimed in U. S. patent to Bjornson No. 1,866,592 dated July 12, 1932. It is a characteristic of this circuit that a steady direct current voltage of substantially constant value is produced across the terminals of the resistances 27 whenever speech is applied to the incoming circuit 20. The provision of a large grid resistance in stage 23 and of a negative biasing battery for the anodes of the rectifier 24 aids in securing this result, as more fully described in the B. G. Bjornson patent referred to.

The production of steady direct current in resistances 27, as described, results in applying to lead wire 50 a large negative voltage with respect to ground. This voltage is applied through conductors 51 and 52 respectively to the grid circuits of receiving amplifier stages 13 and 14 rendering these stages incapable of transmitting.

30 As a further result of the production of steady direct current in resistances 27 as above described, the grid of amplifier 25 is made more negative than normal by the application of speech waves to the circuit 20 as described. In the normal condition when no speech is being received there is sufficient space current flowing in tube 25 through resistance 28 to make the terminal 29 highly negative with respect to ground. This negative voltage is applied through leads 30 and 31 to grid circuits of amplifiers 10 and 11 respectively, and is considerably in excess of an amount sufficient to reduce the space currents of these amplifiers to zero. This voltage is the IR drop across resistance 28. The production of a negative voltage on the grid of tube 25 by the incoming speech reduces the space current in tube 25 and thereby reduces the negative voltage at terminal 29 to such a point that the grids of the amplifier stages 10 and 11 are brought to suitable operating potential. For this purpose batteries may be inserted, if necessary, in leads 30 and 31 as shown.

The foregoing action of the amplifier-rectifier 21 is substantially instantaneous so that upon the arrival of the speech waves at the input of amplifier 10 this amplifier stage and stage 11 are rendered suitable for transmission of the speech waves onward through the transmitting branch T.

When the grid potentials of amplifier stages 10 and 11 are changed from a highly negative value to the proper operating value as described, space current flow is established in the amplifier stages 10 and 11. This current flows from grounded battery 33 through the winding of master relay 34 through leads 35 and 36 respectively to the anodes of stages 10 and 11 and thence across the space paths of the tubes to ground. (For simplicity in the showing the filament heating circuits of all of the vacuum tubes in the drawing have been omitted. Any suitable provision for heating the filaments may be made, such as the provision of individual heating batteries or a common battery for certain of the filaments.) The establishment of the

space current flow energizes relay 34 which attracts its armature and opens at its back contact a normally closed shunt across circuit 37. When this shunt is removed relays 12 and 15 are immediately energized by current from battery 33, through resistance 39, leads 37 and windings of relays 12 and 15. Relay 40 is also energized for a purpose to be described later.

Relay 15 thus being energized opens at its upper contact the circuit connecting the cable 10 to the receiving branch R, so that the receiving branch, in addition to having amplifier stages 13 and 14 blocked is also disabled by the opening of its input circuit by relay 15. Relay 15 also closes at its front contact a shunt circuit across the receiving branch R.

Relay 12 which energizes at substantially the same instant as relay 15, breaks its upper and closes its lower contact thus removing the normal shunt across the transmitting branch and extending the upper conductor of the transmitting branch through to the cable.

Relay 40 operates with relays 12 and 15 its release timing being governed by the two series resistances shown and the shunt condenser. This relay on energizing places a short circuit across the receiving branch R at a point between the amplifier stages 13 and 14 and the line LL.

Reviewing briefly the operations that have been described it will be noted that the building up of the direct current voltage across resistances 27 immediately blocks receiving amplifier stages 13 and 14 and renders transmitting stages 10 and 11 in condition for operation. When the armature of relay 12 leaves its back contact the normal shunt across the transmitting branch is broken. When the armature of relay 15 leaves its back contact the receiving circuit branch is broken. Thus by the time the transmitting branch is completely established by the closing of the lower contact of relay 12 the receiving branch is disconnected from the cable, has a shunt closed across its input and is further disabled by the blocking of stages 13 and 14. Shortly thereafter relay 40 places a further short circuit across the receiving branch. By the timing of the relay operation as described, there is no opportunity for any of the transmitting energy, which is to be applied to the cable, to pass into the receiving circuit. This is an important provision since the transmitting energy level is enormously higher than that at which the receiving branch R is designed to operate.

At the cessation of speech on the line LL, and therefore in the circuit 20 leading to the amplifier-detector, the voltage across resistances 27 is quickly reduced to zero thus blocking the transmitting tubes 10 and 11 and at the same time rendering the receiving stages 13 and 14 in condition for operation. The blocking of the transmitting tubes 10 and 11 reduces their space current to zero causing master relay 34 to release and close at its back contact the shunt across circuit 37. Relays 12, 15 and 40 are thus deprived of current and release their armatures. Relay 40, however, is slow to release for a purpose to be described later.

Relay 12 in releasing its armature opens at its lower contact the upper side of the transmitting branch to the cable and closes at its upper contact a shunt across the output side of the transmitting branch.

Relay 15 in releasing its armature opens at its front contact the shunt across the receiver

input and at its back contact reestablishes connection of the receiving branch to the cable.

At this instant relay 40 is still energized by virtue of the charge on the condenser in the timing circuit of the relay so that a short circuit is maintained across the receiving branch near its output side. The reason for this is that up to this instant the transmitter has been sending energy at high level into the cable and when the transmitter is suddenly cut off there is a tendency for a relatively large discharge of current to pass from the cable back into the receiver and produce a click or noise in the subscriber's set. Relay 40 is timed to maintain its shunt circuit across the receiver output for a sufficient length of time to allow the cable discharge current to die away to a large extent. After relay 40 releases its armature opening the shunt across the receiver output the system is in condition to receive speech from the cable and transmitted into the land line LL.

Speech currents incoming from the cable CL pass into the receiving branch R through the normally closed upper contact of relay 15, equalizer 53, receiving amplifier 54, low pass filter 55, equalizer 56, amplifier stages 57, 13 and 14, equalizers 59 and 60, amplifier 61 and through the hybrid coil transformer H into the line LL.

Some of the speech is taken off at a point between the equalizers 59 and 60 and impressed on the echo suppressor circuit 63. This comprises amplifiers 64 and 65 and double wave rectifier 66 which includes in its common branch resistance 67. Speech currents impressed on the echo suppressor are amplified, rectified and caused to produce a steady drop of potential across resistance 67. This potential is applied by way of lead wire 68 to the grids of amplifier stage 22 of the transmitting amplifier-detector, making these grids so far negative that the amplifier-detector 21 remains unaffected by any noise or speech currents that may be present in the input circuit 16 of the transmitting branch T. Thus, in case of unbalance between the line LL and network N, such as to permit some of the received speech to pass into branch 16, the transmitting switching circuits are protected against false operation by such speech energy.

In addition to the amplifier stages 10 and 11 in the transmitting branch it will generally be desirable to use a power amplifier stage 70. If vacuum tube control alone were relied upon without the addition of relay control it will be noted that in the receiving condition the input of the receiver will be connected directly to the output terminals of power amplifier 70. Power amplifier 70 has associated with its output terminals a high voltage power circuit comprising a battery or other suitable source. Noise interference is liable to arise from this power circuit unless precautions are taken to keep the circuit extremely quiet and unless the shielding against interference in the receiver circuit is carried back, at least as far as the power circuit of the amplifier 70. The provision of relay 12 for opening the transmitting circuit during receiving, however, eliminates this important source of interference.

In the receiving branch, if vacuum tube control were relied on entirely for direction switching, it is seen that the input side of receiving branch R remains at all times connected to the cable. The transmitter impresses about 150 volts on the cable terminals. The input transformer for the receiving amplifier 54 is generally a high

ratio step-up transformer so that with this high transmitting voltage applied directly to the receiver terminals a very excessive voltage might be applied to the amplifier 54. The provision of relay 15 in the receiving circuit, however, prevents this voltage from getting into the receiver since the receiving branch is open during transmission. It is undesirable to apply vacuum tube control to the input receiving amplifier 54 since complication is to be avoided in this amplifier circuit on account of the extremely low level at which the amplifier operates, requiring the utmost of protection from external interference.

It will be understood that where the invention is applied to a circuit of high attenuation and long time constant, such as a transatlantic telephone cable CL of Fig. 1, various equalizers will ordinarily be used to compensate for the unequal attenuation of the speech currents by the cable and to give a favorable signal to noise ratio. Such equalizers, while forming no part of the present invention, have been indicated in both the transmitting and receiving branches of Fig. 1 at various points. For a disclosure of the design of such equalizers reference is made to United States patent to R. C. Mathes and A. W. Horton, Jr., No. 1,844,422 issued February 9, 1932, and to patent application Serial No. 332,011, filed July 29, 1929, by A. M. Curtis. It will be understood also that suitable amplification may be used at different points in the circuit and amplifiers are shown by way of example in Fig. 1. The low pass filter 55 in the receiving branch prevents transmission through the subsequent repeater stages of high frequency static and tube and resistance noise which may be present in the circuit, as disclosed in the Curtis application referred to.

The amplifier-detector circuit of Fig. 2 may be substituted for the circuit 21 of Fig. 1 by severing the connections in Fig. 1 at the terminals marked a, b, c and d and connecting the correspondingly labeled terminals of Fig. 2 to these several points.

In Fig. 2 the tube 71 is a "trigger" or gas-filled tube of well known type, the characteristic action of which is to give a sudden rise in space current when the ionization potential of the gas is reached by the application of a control voltage to the grid. The initial amplifier 72 may be of any suitable type and the bias reversing tube 73 may be a high vacuum tube similar to tube 25 of Fig. 1.

Speech waves in the incoming circuit 20 are amplified at 72 and after overcoming by sufficient amount the normal negative bias on the grid of tube 71, due to biasing battery 74, cause a sudden rise in space current of the tube 71. This produces a sudden increase in voltage drop across the large resistance 75, which voltage is applied over conductor 50 to terminal b and to the receiving vacuum tubes (shown in Fig. 1). This voltage is also in part applied to the grid of tube 73 which operates the same as tube 25 of Fig. 1.

On account of the large resistance 75 in the plate circuit of tube 71 and the negative bias source 74 in the grid circuit, when the speech waves in circuit 20 cease the tube 71 restores to its normal unoperated condition.

Among the advantages of use of a trigger tube, such as 71, are that the operating time is shorter; the operating time is practically constant with all input levels above the initial operating level; the no-operate to operate input level change may be less than 0.5 db; the hang-over time is practically constant with input level; less amplifica-

tion is needed in initial amplifier 72, and the tube is a peak operated device. The fact that the circuit is fully operated, if it operates at all, makes for positive operation of the switching circuits.

5 Also less complication is required to obtain the desired operating characteristics than in the case of high vacuum tubes throughout. This fact and the fact that less initial amplification is necessary make for simplicity in the circuit as a whole.

10 It will be understood that, when negative voltage is applied to terminal *a* by received speech, as in Fig. 1, the grid of tube 71 is driven so far negative as to prevent operation of tube 71 by speech or noise currents in circuit 20.

15 In applying the circuit of Fig. 2 to the system of Fig. 1 instead of disabling the tube 71 directly by a voltage applied at *a*, this disabling can be done in the previous stage 72 in the same manner that stage 22 is disabled by voltage applied at *a*, over lead 68.

It is within the invention also to use a trigger or gas-filled tube in the echo suppressor circuit 63. Thus, stages 65 and 66 may be replaced by stages 72 and 71 of Fig. 2 in which case lead 50 would extend to lead 68.

25 Preferably, master relay 34 is provided with a hang-over circuit which may consist of a resistance-condenser combination adapted to be connected to the relay winding when the armature is attracted, as indicated in Fig. 1. This delays the release of the armature without affecting its operate time.

Instead of a hybrid coil and two-wire termination on the land line side, the cable terminal circuit may be extended as a four-wire circuit.

35 The shunt that is maintained across the receiver output by relay 40 after the other disabling means in the receiving branch have been restored to normal serves also, in addition to the suppression of relaxation current as described above, to prevent transmission to the land line of any click that might be produced by release of relays 15 and 12.

What is claimed is:

45 1. In a signal transmission circuit, a space discharge device for repeating signals in said circuit, a source of anode voltage therefor, an electromagnetic relay controlling a switch contact in said circuit, said relay being operated by the space current of said device, and means acting in response to signals to be transmitted for conditioning said device for the transmission of said signals over said circuit and for, in turn, operating said relay to close the switch contact to establish said circuit.

50 2. In a signal transmission circuit, a space discharge device, means for utilizing the space current energy of said device to transmit signals, means controlled by signal energy impressed on said circuit for alternately establishing the steady flow of space current in said device and reducing the space current substantially to zero, the space current being substantially zero in the absence of signals to be transmitted, a switch contact for establishing and disabling said circuit, an electromagnet for controlling said contact, and means to operate said electromagnet by the space current of said device.

70 3. In a two-way signaling system, a two-way circuit, a transmitting branch and a receiving branch therefor, a space discharge tube in series in the transmitting branch, a break point in the transmitting branch between said tube and the two-way circuit, means controlled by signals for establishing steady space current flow in said

tube, and means operated by the space current flow in said tube for closing said break point.

4. In a signal transmission circuit, a first circuit disabling means comprising a space discharge device interposed in said circuit, a second circuit disabling means in said circuit on the output side of said space discharge device, means normally maintaining said device in non-transmitting condition, means controlled by said discharge device normally maintaining said second circuit disabling means operative to disable said circuit, and means acting in response to initiation of signals in the input side of said circuit for conditioning said device for transmitting and also causing said second circuit disabling means to render said circuit on the output side of said space discharge device operative to transmit.

5. In a two-way signaling system, a two-way circuit, a transmitting branch and a receiving branch adapted for connection alternatively to the same end of said two-way circuit, said receiving branch containing a space discharge device normally in an operative condition to receive signals, a normally closed break point between the two-way circuit and the input side of said discharge device, means acting in response to signals in the transmitting branch for opening said break point and means operating on said discharge device to convert it from its normal transmitting to a non-transmitting condition.

6. A system according to claim 5, in which said receiving branch also includes a contact on the output side of said device normally conditioning the circuit to receive, and means acting in response to signals in the transmitting branch for operating said contact to disable said circuit an interval after the opening of the break point and the disabling of said discharge device.

7. In a signal transmission system, a two-way circuit, a four-wire circuit connected thereto and including in each side an amplifying device each including a grid, means for alternatively disabling opposite sides of the four-wire circuit comprising means acting in response to signals for alternatively biasing the grids of said amplifiers so far negative as to reduce their space current substantially to zero, and circuit closing means synchronized in its action with said first means for further establishing and disabling the respective sides of said four-wire circuit alternatively.

8. In a signal transmission system, a four-wire circuit containing means producing high amplification in each side of the circuit providing a tendency to singing around the loop, means controlled by signals for removing some of the amplification from the circuit branch that is not at the time used for signaling, and additional means controlled by signals for introducing loss into the same branch of the loop circuit.

9. In a signal transmission system, a two-way circuit, a four-wire circuit adapted for connection thereto, including amplifying means in each of its branches, means controlled by signals for alternatively effectively connecting the respective branches of said four-wire circuit to said two-way circuit, one at a time, and additional circuit disabling means controlled by signals comprising means for removing amplification from the branch that is at the time effectively disconnected from said two-way circuit, said additional means comprising a circuit for applying to the amplifying means in the respective branches a voltage derived from said signals.

10. In a telephone system including an ocean cable, a transmitting circuit leading to the cable,

a receiving circuit leading from the cable at the same terminal, each circuit including high gain amplifiers, means including electromagnetic relays for effectively establishing connection of said two circuits to said cable one at a time, voice operated circuits controlling the operation of said relays, and means controlled by said voice operated circuits for reducing the gain of the amplifier in the respective one of said two circuits that is effectively disconnected from the cable.

11. In a telephone system utilizing a voice current repeater tube, voice controlled means for alternately rendering said tube effective and ineffective to repeat speech waves comprising a gas-filled space discharge tube having an input circuit and an output circuit, polarizing means normally maintaining the input voltage on said tube below the discharge point, an amplifier for impressing amplified voice waves on the gas-filled tube to cause its break-down, and a circuit operated by the discharge current of said tube for applying a blocking potential to said repeater tube.

12. In a signaling system, a space discharge device having anode and control circuits for repeating signals, a gas-filled space discharge tube having input and output circuits, means normally biasing the input circuit of said gas-filled tube against operation, means deriving signal voltages from said system and applying them to said gas-filled tube to cause it to break down, and means controlled by the discharge current of said gas-filled tube for applying a voltage to the control circuit of said space discharge device sufficient to convert the condition of the latter device between its transmitting and blocked conditions.

13. In a four-wire circuit, oppositely directed branches each containing a repeater, means normally blocking one repeater, means comprising a gas-filled space discharge tube for rendering said normally blocked repeater capable of repeating signals and for blocking the opposite repeater, and means deriving signal voltage from said four-wire circuit for controlling said gas-filled tube.

14. A signal transmitting circuit comprising a space discharge device having cathode, anode and control electrodes, a source of space current therefor, an outgoing transmission path, means in the control-electrode circuit of said device for varying the impedance of the device to change the space current flow therethrough, a relay in series between the anode and said space current source, actuated by changes in said space current, and means controlled by said relay for opening and closing said outgoing path.

15. In a signal transmission circuit, a space discharge device interposed in said circuit, means normally maintaining said device in non-transmitting condition, means dependent upon the non-transmitting or transmitting condition of said device for respectively disabling said circuit on the outgoing side of said device or enabling said circuit to transmit, and means acting in response to the initiation of signals on the input side of said device for changing said device from its normal non-transmitting to its transmitting condition, and, dependent upon the change in transmitting condition of said device, causing said second means to enable said circuit on the outgoing side of said device to transmit.

CHARLES N. NEBEL.