May 10, 1938. B. G. BJÖRNSON 2,116,558

SIGNAL CONTROL CIRCUITS

Filed May 11, 1935 2 Sheets-Sheet 1

FIG. 1

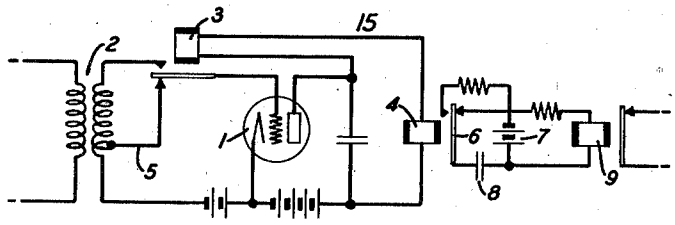


FIG. 2

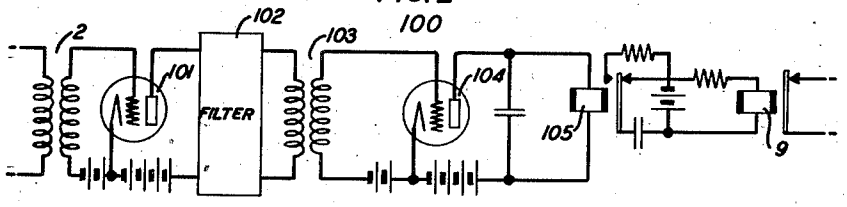
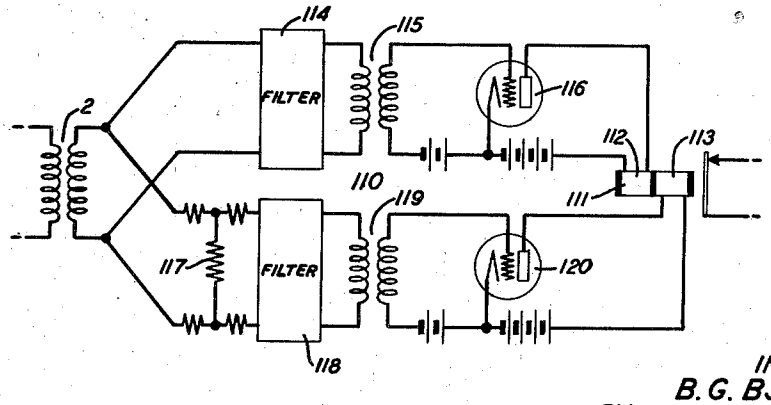


FIG. 3



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SIGNAL CONTROL CIRCUITS

Filed May 11, 1935 2 Sheets-Sheet 2

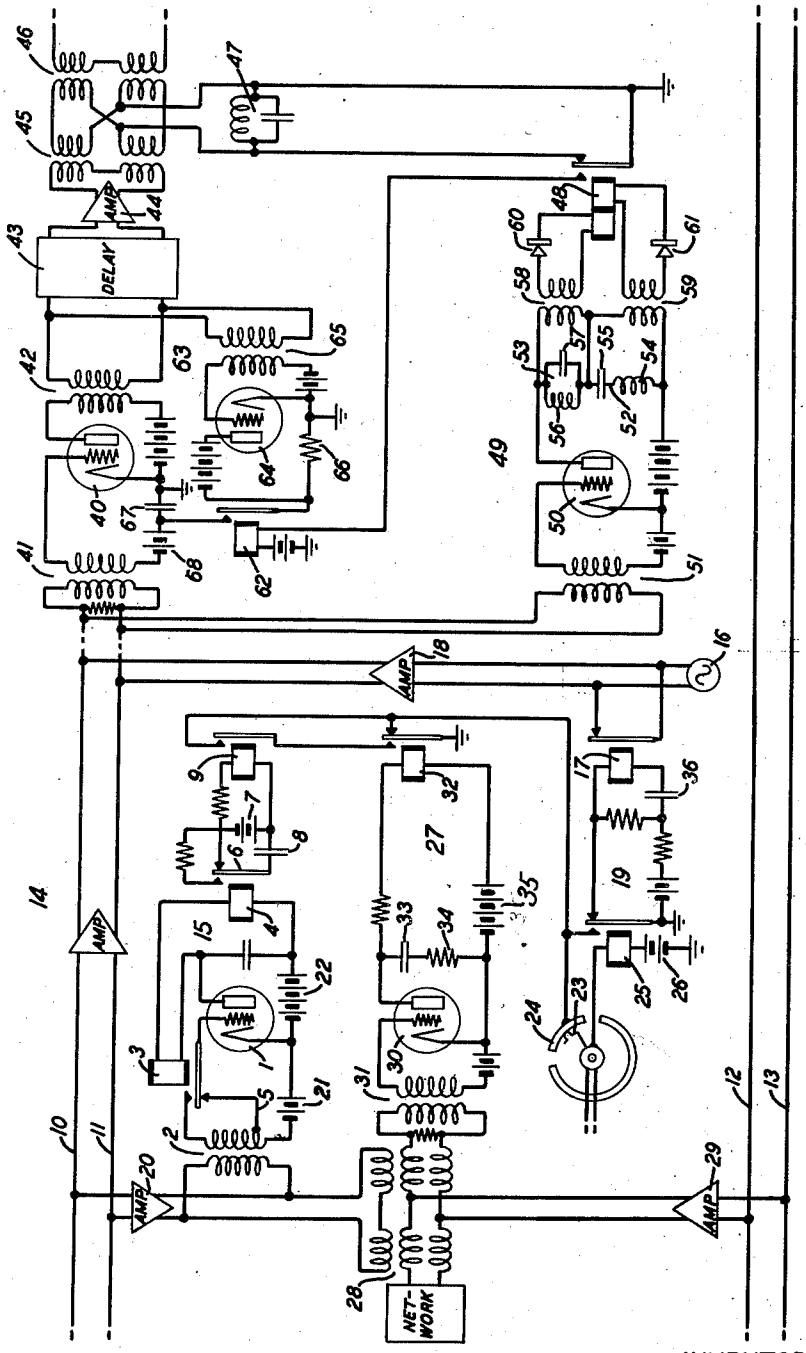

FIG. 4

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Patented May 10, 1938 2,116,558

UNITED STATES PATENT OFFICE

2,116,558

SIGNAL CONTROL CIRCUITS

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Application May 11, 1935, Serial No. 20,965

16 Claims. (Cl. 178—44)

This invention relates to control circuits and particularly to control circuits for adjusting the net loss on signal transmission lines.

One object of the invention is to provide a signal transmission line with control circuits that shall transmit over the line an impulse of control current having a frequency within the signal frequency range and controlled by the signal currents for governing the net loss on the transmission line.

Another object of the invention is to provide a signal transmission line with control circuits that shall transmit over the line between currents representing words of speech an impulse of control current having a frequency within the voice frequency range and under control of the speech currents for adjusting the net loss on the transmission line.

Another object of the invention is to provide a signal transmission line with control circuits governed by the amplitude of speech currents that shall transmit over the line between currents representing words of speech an impulse of control current having a frequency within the voice frequency range for adjusting the net loss on the line at a distant station thereon.

A further object of the invention is to provide a signal transmission line with control circuits governed by the amplitude of speech currents at a transmitting station that shall transmit over the line between currents representing words of speech an impulse of control current having a frequency within the voice frequency range and with control circuits at a receiving station that shall govern the net loss on the line at the receiving station according to the strength of the received impulse of control current.

In a transmission line, it is necessary to provide repeater stations at intervals along the line and to control the gain at the repeater stations for efficient transmission of signal currents. When the transmission line has considerable length, the small errors in the operation of the regulators at the repeater station may add together and produce an appreciable error at the receiving end of the line.

According to the present invention, a control current having a frequency within the voice frequency range is transmitted over the line at intervals to a distant receiving station for adjusting the net loss on the line at the receiving station. The transmission of the impulse of control current is governed by circuits under control of the speech current and between currents representing words in speech.

In one form of the invention, a source of control current, which preferably has a frequency of the order of 300 cycles, is connected to one side of a four-wire line to transmit an impulse of control current under control of the voice frequency currents. The source of control current may be connected to the line at predetermined intervals under control of a timing circuit when there are no speech currents on either the transmitting channel or the receiving channel. A speech disabler circuit is provided for preventing sole control of the source of control current by the timing circuit when there are speech currents on either the transmitting channel or the receiving channel. A speech control circuit and the timing circuit jointly govern the source of control current when speech currents are on the channel to which the speech control circuit is connected.

At a receiving station, a starting circuit is operated when pure control current free from speech currents is received. The starting circuit, when operated, performs two functions. A gain control device in the transmission line is governed to adjust the net loss on the line and a filter is inserted in the line beyond the gain control device for preventing transmission of the control current to any of the speech receiving apparatus.

The preferred speech control circuit comprises a relay which is connected to the transmitting channels, by means of a space discharge detector tube, a transformer, and an amplifier device. When speech currents for a loud syllable are transmitted over the transmission line, the relay is operated to increase the sensitivity of the detector output circuit a definite amount. This increase in the sensivity of the detector output circuit operates a second relay which, in turn, completes a circuit for charging a condenser. When the input level to the detector tube falls below the initial operating level for the first relay, the second relay releases and the charge on the condenser momentarily operates a third relay. The third relay cooperates with the timing circuit for connecting the source of control current to the transmission line. The connection of the source of control current to the line will, in most cases, take place during the pause between words of speech. The chances are that this transmission of the control current takes place after the final consonant of a word has started, or if the syllable ends with a vowel, that little harm will be done if the final part of the vowel is eliminated.

At the receiving end of the line, a starting cir-

cuit is provided comprising a space discharge amplifier having an anti-resonant circuit and a resonant circuit connected to the output circuit thereof. The resonant and anti-resonant circuits are tuned to the frequency of the control current. The primary winding of a transformer is connected in shunt to the anti-resonant circuit and the primary winding of a second transformer is connected in shunt to the resonant circuit. Each of the secondary windings of the two transformers is connected in circuit with a rectifying device to a coil of a starting relay. The coil connected to the transformer whose primary is in shunt to the resonant circuit serves when supplied with rectified current in the right direction to produce a force tending to hold the armature of the starting relay in released position. The coil which is controlled by the anti-resonant circuit produces a force when supplied with rectified current in the right direction to effect operation of the relay. If an impulse of pure control current free from any speech frequency currents is received by the starting circuit, the starting relay will be operated. If currents of other frequencies than the control current frequency are received by the starting circuit, the coil connected to the resonant circuit will prevent operation of the starting relay.

A space discharge device is connected in the line at the receiving station for governing the net loss on the line at the receiving station. The starting relay, when operated, completes a circuit for permitting a backward acting circuit to control the space discharge device in the line. The starting relay also serves, when operated, to insert a filter in the line beyond the gain control device. The filter is tuned to the frequency of the control current. This filter serves to prevent any of the control current from reaching the receiving apparatus beyond the gain control device.

In the accompanying drawings—

Fig. 1 is a diagrammatic view of a speech control circuit governed according to the amplitude of the voice currents;

Fig. 2 of the drawings is a diagrammatic view of a modified speech control circuit governed by the currents representing the vowel sounds of speech;

Fig. 3 of the drawings is a diagrammatic view of a modified speech control circuit governed according to the frequencies of the currents representing the syllables of speech; and

Fig. 4 of the drawings is a diagrammatic view of the control circuits at transmitting and receiving stations on a transmission line for adjusting the net loss on the line according to the invention.

Referring to Fig. 1 of the drawings, a speech control circuit is shown for governing the connection of a control current to a transmission line under control of the voice currents. The control circuit comprises a detector tube 1 which is connected to a transmission line by means of a transformer 2. In the output circuit of the detector tube 1 are included the energizing coils of relays 3 and 4. The relay 3 is more sensitive than the relay 4 and will be operated by the speech currents representing a loud syllable. Normally, when the relay 3 is in released position, the armature of the relay engages a tap 5 extending from the secondary winding of the transformer 2. When the relay 3 is operated, the armature engages the terminal of the secondary winding of the transformer 2 so that the complete secondary winding is connected to the input circuit of the detector tube 1. The operation of the relay 3 serves to increase the sensitivity of the detector 1 a definite amount, for example, twenty decibels, and permits the operation of the relay 4. The relay 4, which is less sensitive than the relay 3, releases when the input level to the control circuit falls approximately twenty decibels below the initial operating level of relay 3. The armature 6 of the relay 4 completes a circuit from a battery 7 for charging a condenser 8 when the relay 4 is in operative position. Upon release of the relay 4, the charge on the condenser 8 serves to momentarily operate a relay 9.

Referring to Fig. 4 of the drawings, a four-wire transmission circuit, comprising transmitting conductors 10 and 11 and receiving conductors 12 and 13, is provided with a transmitting station 14 governed by a speech control circuit 15 of the type shown in Fig. 1 of the drawings. A source of control current 16 having a frequency preferably of the order of 800 cycles is connected under control of a relay 17 through a space discharge amplifier 18 to the transmitting conductors 10 and 11. The relay 17 is governed by a timing circuit 19 when speech currents are off the conductors 10 and 11 and 12 and 13 and is jointly controlled by the speech control circuit 15 and the timing circuit 19 when speech currents are on the conductors 10 and 11.

The speech control circuit 15 shown in Fig. 4 of the drawings is the same as the speech control circuit shown in Fig. 1 of the drawings and like parts have been indicated by similar reference characters. The primary winding of the transformer 2 is shown connected to the transmitting conductors 10 and 11 by means of an amplifier device 20. Batteries 21 and 22 are respectively provided for supplying potential to the grid and the plate of the detector tube 1. When speech currents representing a loud syllable appear on the conductors 10 and 11, the relay 3 will be operated. Relay 3, upon operation, increases the sensitivity of the detector tube 1 to effect operation of the relay 4. The relay 4 upon operation completes a circuit for charging the condenser 8 from the battery 7. When the input level of the detector tube 1 falls below the initial operating level for the relay 3, the relay 4 is released and the charge on the condenser 8 effects operation of the relay 9. In this circuit, it is assumed that the sensitivity of the speech control is so low that only the loud syllables, say one syllable out of every one hundred syllables, will operate the relay 9.

The timing circuit 19 comprises a contact arm 23 which is rotated at constant speed in any suitable manner. The arm 23 engages a conducting segment 24 for one-fourth the rotation of the arm 23. The engagement by the contact arm 23 and the contact segment 24 partially completes a circuit for operating a holding relay 25 from a battery 26. A speech disabling circuit 27, which is connected to a hybrid coil 28, serves to prevent operation of the relay 25 solely by the timing circuit when speech currents are on the conductors 10 and 11 or 12 and 13. The hybrid coil 28 is connected to the conductors 10 and 11 by the amplifier device 20 and to the conductors 12 and 13 by the amplifier device 29.

The speech disabler circuit 27 comprises a gas-filled space discharge device 30 having the input circuit thereof connected to the hybrid coil 28 by means of a transformer 31. The output circuit of the gas-filled device 30 is connected to

the operating coil of a relay 32. A condenser 33 and a resistance 34 are connected to the output circuit of the device 30 for effecting a hangover in the operation of the relay 32 when the gas-filled device 30 is broken down. When speech currents appear on the conductors 10 and 11 or 12 and 13, the gas-filled space discharge device 30 is broken down to effect operation of the relay 32 and to provide a discharge path for the condenser 33. When speech currents cease to flow on the transmitting line or the receiving line, the gas-filled device 30 is extinguished. The condenser 33 is then charged by a battery 35 through a circuit including the coil of the relay 32. The time taken to charge the condenser 33 provides a hangover in the operation of the relay 32.

If no speech currents are on the transmitting or receiving lines, the relay 32 is released and a ground circuit is provided for operating the relay 25 whenever the contact arm 23 engages the contact segment 24. The relay 17 is operated for each operation of the relay 25 by means of the charge on a condenser 36. Relay 17 upon operation removes a short across the source of control current 16 so that an impulse of control current is transmitted through the amplifier 18 to the conductors 10 and 11.

If speech currents are on the conductors 10 and 11, the relay 32 is operated to prevent sole control of the source of control current 16 by means of the timing circuit 19. Under this circumstance, the speech control circuit 15 must be operated with the timing circuit 19 to effect operation of the relay 17 to connect the source of control current 16 to the transmitting conductors 10 and 11. The speech control circuit 15 is operated as before set forth when speech currents for a loud syllable appear on the conductors 10 and 11. The relay 25 is operated when the contact arm 23 engages the contact segment 24 and the relays 9 and 32 are in operative positions.

At the receiving end of the circuit, a space discharge device 40 is included in the transmitting line comprising conductors 10 and 11. A transformer 41 is connected to the input circuit of the device 40 and a transformer 42 is connected to the output circuit of the device 40. A delay circuit 43 is connected to the secondary winding of the transformer 42. A space discharge amplifier 44 is connected to the delay circuit 43 and two transformers 45 and 46 are connected to the transmitting line beyond the amplifier device 44. A filter 47, which is tuned to the frequency of the control current, is connected to the transmitting line between the transformers 45 and 46 under control of a starting relay 48 in a starting circuit 49.

The starting circuit 49 comprises a space discharge amplifier tube 50 having the input circuit thereof connected to the conductors 10 and 11 before the transformer 41 by means of a transformer 51. A resonant circuit 52 and an anti-resonant circuit 53 are included in the output circuit of the amplifier tube 50. The resonant circuit comprises an inductance element 54 and a condenser 55. The anti-resonant circuit comprises an inductance element 56 and a condenser 57. The anti-resonant circuit 53 is shunted by the primary winding of a transformer 58. The resonant circuit 52 is shunted by the primary winding of a transformer 59. The secondary winding of the transformer 58 is connected to a coil of the starting relay 48 through a rectifier 60 of any suitable type. The secondary winding of the transformer 59 is connected to another coil of the starting relay 48 through a rectifier 61 of any suitable type. When the relay 48 is in released position, as shown in Fig. 4 of the drawings, the filter 47 is short-circuited. When the relay 48 is in operative position, the filter 47 is inserted in the transmitting channel to prevent transmission of any control current beyond the transformer 46 to the receiving apparatus thereafter. An impulse of pure control current free from currents of other frequencies effects operation of the coil of relay 48 connected to the transformer 58. If currents of other frequencies besides the 800 cycle control current are received by the starting circuit 49, the coil of the relay 48 connected to the transformer 59 will be operated to insure against operation of the relay 48.

The starting relay 48, when operated, not only effectively inserts the filter 47 in the transmitting line but operates a relay 62. The relay 62, upon operation, connects a backward acting control circuit 63 to a control condenser 67 for governing the operation of the space discharge device 40. The backward acting control circuit 63 comprises a detector tube 64 having the input circuit thereof connected across the secondary winding of the transformer 42 by means of a transformer 65. A resistance element 66, which is included in the output circuit of the detector tube 64, is connected across the control condenser 67 when the relay 62 is operated. The control condenser 67 governs the negative bias impressed on the grid of the device 40. A constant bias for the grid of the device 40 is provided by means of a battery 68.

When an impulse of control current is received at the distant station, the starting relay 48 is operated under control of the starting circuit 49. The filter 47 is inserted in the transmitting line and the relay 62 is operated to insure impressing a charge on the condenser 67 according to the strength of the impulse of control current. The delay circuit 43 serves to prevent any transmission of the control current to any of the receiving apparatus beyond the transformer 46 prior to the operation of the starting relay 48.

In the circuit above considered, it is preferable that a constant volume control circuit of the type disclosed in the J. L. Hogg et al. Patent No. 1,853,974, dated April 12, 1932, is included in the system. It is to be understood that other types of volume control may be employed. If such were not the case, a strong talker could operate the speech tone circuit 15 on his weak syllable even though the number of line-ups would still be definitely limited by the timing circuit 19.

Referring to Fig. 2, a modified speech control circuit 100 is shown which may be substituted for the speech control circuit 15 shown in Figs. 1 and 4 of the drawings. The speech control circuit shown in Fig. 2 of the drawings comprises a detector tube 101 having the input circuit thereof connected to the secondary winding of the transformer 2 shown in Fig. 4 of the drawings. The output circuit of the detector tube 101 is connected to a band-pass filter 102 which passes currents having frequencies of the order of 90 to 300 cycles. The band-pass filter 102 is connected by a transformer 103 to the input circuit of a detector tube 104. The output circuit of the detector tube 104 includes the coil of a relay 105. The relay 105 controls the relay 9 shown in Fig. 4 of the drawings by a circuit similar to the control

circuit for the relay 9 shown in Figs. 1 and 4 of the drawings.

The circuit shown in Fig. 2 of the drawings differentiates between the frequencies of the currents representing vowels and consonants. The vowels will have a prime frequency located within the band of frequencies passed by the band-pass filter 102. The band-pass filter 102 is assumed to pass only the pitch frequencies of the vowels. When the vowel sound is stopped, the relay 9 will operate. In this speech control circuit, the same as in the speech control circuit shown in Fig. 1, the impulse of control current will be applied during a silent period if the word causing the operation of the speech control circuit ends with a vowel.

The modified speech control circuit 110 shown in Fig. 3 of the drawings does not necessarily involve transmission of the control current at the end of a word although it could be so designed. The speech control circuit 110 comprises a relay 111 having two coils 112 and 113. The relay 111 serves the same purpose as the relay 9 shown in Figs. 1, 2, and 4 of the drawings. The coil 112 of the relay 111 which opposes operation of the relay is controlled by a circuit extending from the secondary of the transformer 2 through a band-pass filter 114, transformer 115, and a detector tube 116. The band-pass filter 114 is assumed to pass frequencies of the order of 250 to 800 cycles. Coil 113 of the relay 111 is controlled by a circuit extending through a pad 117, a band-pass filter 118, a transformer 119, and a detector tube 120. The band-pass filter 118 passes currents having frequencies between 800 and 2750 cycles. The relay 111 will operate on loud syllables which have stronger energy components in the range of 800 to 2750 cycles per second rather than in the frequency band included between 250 and 800 cycles per second. The frequency bands for the two filters 114 and 118 are tentative and optimum frequency bands may be determined in accordance with transmitting conditions. The relative sensitivity of the two circuits, respectively, including the filters 114 and 118, can be varied by means of the pad 117.

Modifications in the circuits and in the arrangement and location of parts may be made within the spirit and scope of the invention and such modifications are intended to be covered by the appended claims.

What is claimed is:

1. In combination, a two-wire signal transmission line, a transmitting station, a source of control current at said station having a frequency within the voice frequency range, and means at said station under control of the signal currents on said line for transmitting an impulse of said control current between transmission of currents representing contiguous words in an uninterrupted transmission of speech.

2. In combination, a two-wire signal transmission line, a transmitting station, a source of control current at said station having a frequency within the voice frequency range, a control circuit governed in accordance with the amplitude of the speech currents on said line, and means governed by said control circuit for transmitting an impulse of said control current between transmission of currents representing contiguous words in an uninterrupted transmission of speech.

3. In combination, a signal transmission line, a transmitting station, a source of control current at said station having a frequency within the voice frequency range, a control circuit at said station governed in accordance with the amplitude of the signal currents on the line, a timing circuit at said station operated at predetermined time intervals, and means jointly governed by said control circuit and the timing circuit for transmitting an impulse of said control current between transmission of currents representing words in speech.

4. In combination, a signal transmission line, a transmitting station, a source of control current at said station having a frequency within the voice frequency range, control means at said station operated when currents representing a loud syllable of speech are on the line and auxiliary means governed by said control means upon a predetermined reduction of the amplitude of the speech currents on the line for transmitting an impulse of said control current over the line.

5. In combination, a signal transmission line, a transmitting station, a source of control current at said station having a frequency within the voice frequency range, a control circuit governed in accordance with the amplitude of the speech currents on the line, a timing circuit operated at predetermined time intervals, an auxiliary circuit operated when speech currents are on said line, means jointly governed by said control circuit and the timing circuit for transmitting an impulse of said control current between transmission of currents representing words of speech when speech currents are being transmitted, and means jointly governed by said timing circuit and the auxiliary circuit for transmitting an impulse of said control current at predetermined time intervals when speech currents are not being transmitted over the line.

6. In combination, a signal transmission line, a transmitting station, a source of control current at said station having a frequency within the voice frequency range, means comprising a relay operated when currents representing a loud syllable of speech are on the line, and means comprising a second relay operated upon release of said first relay after a predetermined reduction of the amplitude of the speech currents on the line for transmitting an impulse of said control current over the line.

7. In combination, a two-wire signal transmission line, a transmitting station, a source of control current at said station having a frequency within the voice frequency range, and means controlled only by currents representing a vowel sound in speech on said line for effecting transmission of an impulse of said control current over the line.

8. In combination, a signal transmission line, a transmitting station, a source of control current at said station having a frequency within the voice frequency range, and a control circuit having means for separating the higher frequency speech currents from the lower frequency speech currents to control the transmission of an impulse of said control current over the line when the higher frequency components of the speech currents predominate.

9. In combination, a signal transmission line having signal currents transmitted thereover, means for transmitting impulses of control current over said line within the frequency range of the signals transmitted over the line, a receiving station, a loss adjusting device in the line at said station, and means comprising a starting

circuit operated only when a pure control current free from signal current is received for governing said device to adjust the net loss on the line and for blocking the line beyond said device to the transmission of the control current.

10. In combination, a signal transmission line having voice frequency signal currents transmitted thereover, means for transmitting impulses of control current over said line within the voice frequency range of the signals transmitted over the line, a receiving station, a space discharge device in the line at said station, a starting circuit operated only when a pure control current free from signal currents is received, and means controlled by said starting circuit when operated for governing said device to adjust the net loss on the line and for blocking the line beyond said device to the transmission of the control current.

11. In combination, a signal transmission line having signal currents transmitted thereover, means for transmitting impulses of control current over said line within the frequency range of the signals transmitted over the line, a receiving station, a loss adjusting device in the line at said station, delay means in the line beyond said device, a starting circuit operated only when a pure control current free from signal currents is received, means for blocking the line to the control current beyond said delay means, and means controlled by said starting circuit when operated for governing said device to adjust the net loss on the line and for operating said blocking means, said delay means insuring a delay in the transmission of the control current during the operation of the starting circuit.

12. In combination, a signal transmission line having signal currents transmitted thereover, a transmitting station, a source of control current at said station having a frequency within the frequency range of the transmitted signal currents, means at said station under control of the signals on the line from said station for transmitting an impulse of said control current between signals representing words in an uninterrupted transmission of speech, a receiving station, and means at said receiving station responsive only to a transmitted impulse of control current free from signal currents for adjusting the net loss on the line at the receiving station.

13. In combination, a signal transmission line having signal currents within the voice frequency range transmitted thereover, a transmitting station, a source of control current at said station having a frequency within the voice frequency range of the transmitted signal currents, means at said station under control of the signal currents on the line from said station for transmitting an impulse of said control current between transmission of currents representing contiguous words in an uninterrupted transmission of speech, a receiving station, a gain control space discharge device in said line at the receiving station, and means at the receiving station responsive to a transmitted impulse of control current for governing said device to adjust the net loss on the line at the receiving station and for blocking the line beyond said device to the transmission of the control current when the control current is received.

14. In a transmission system, a method which consists in transmitting speech signals over a transmission path, in transmitting current impulses over the path in the same direction as the speech signals and between contiguous words in an uninterrupted transmission of speech, and in controlling the current impulses by the speech signals on the path without interfering with the speech signals.

15. In combination, a two-wire signal transmission line, a transmitting station, a source of control current, means at said station for transmitting speech signals over said line, and means under control of the signals on said line for transmitting impulses of said control current over said line between contiguous words in an uninterrupted transmission of speech without interference with the signals.

16. In combination, a two-wire signal transmission line, a transmitting station, a source of control current at said station, means at said station for transmitting voice currents over said line, and means under control of the voice currents for transmitting impulses of said control current over said line in the same direction as the voice currents and between contiguous words in an uninterrupted transmission of speech without interference with the voice currents.

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