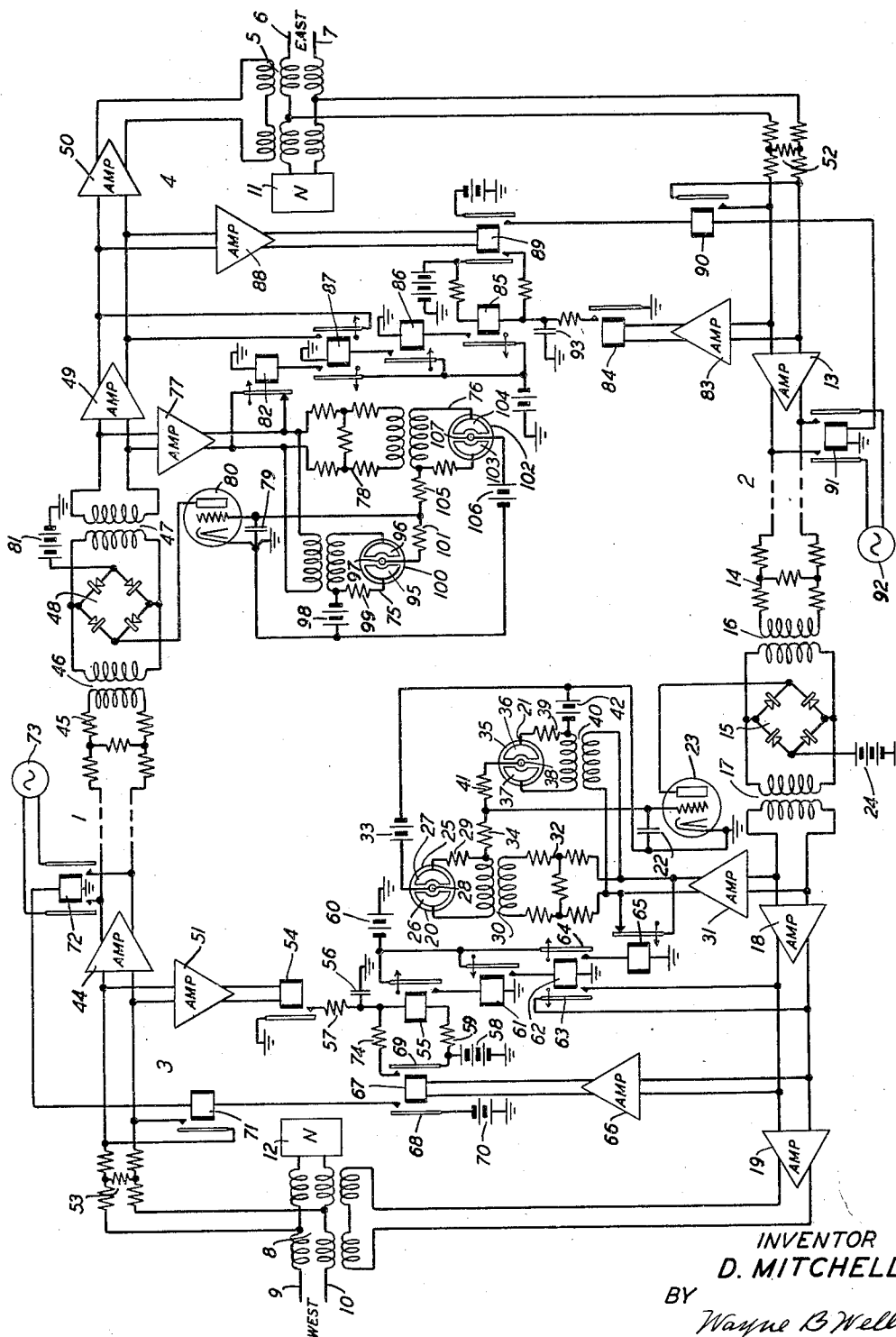


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SIGNALING SYSTEM

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SIGNALING SYSTEM

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This invention relates to signaling systems and particularly to the regulation of transmission in four-wire signaling systems.

One object of the invention is to provide a four-wire signaling system having different paths for transmission in opposite directions that shall adjust the attenuation of the idle path in an improved manner when the other path is in service.

Another object of the invention is to provide a four-wire signaling system having different paths for transmission in opposite directions that shall block the ends of the idle circuit under control of the voice currents in the operating circuit and that shall govern the attenuation of the idle circuit solely under control of a single tone on the idle circuit.

Another object of the invention is to provide a four-wire signaling circuit that shall block the ends of the idle circuit under control of the voice currents in the operating circuit, that shall transmit a tone over the idle circuit under control of the voice currents in the operating circuit and that shall govern the attenuation of the idle circuit under control of the transmitted tone.

A further object of the invention is to provide a signal transmission circuit having a loss controlling device for controlling the attenuation of the circuit that shall selectively govern a gain increaser and a gain decreaser under control of a single tone for governing said device to maintain the attenuation of the circuit constant.

In long signaling systems it is desirable to adjust the net loss and hold the attenuation substantially constant in order to maintain a good quality of transmission. This is because small errors of regulation in the ordinary pilot wire or pilot channel regulators often add up sufficiently in a long circuit to cause considerable overall net loss variation. It is customary to transmit a tone over a line to effect control of the net loss adjusting apparatus. The tone which is transmitted over the circuit is within the voice frequency range and therefore care must be taken to prevent interference with voice currents and operation of the net loss adjusting apparatus by the voice currents. In a four-wire system the tone may be transmitted over the idle path when the other path is in operation.

In accordance with the invention the voice currents on the path or channel in operation control echo suppressor circuits to block the idle path or channel at each end thereof and effect transmission of a tone within the voice frequency range over the idle path. The tone transmitted over the idle path adjusts a loss device to control

the loss in the idle path. The attenuation in each path is controlled by a single tone having a frequency within the voice frequency range.

In the four-wire transmission system employed to describe the invention a loss device in the form of copper oxide rectifiers is placed in each path of the four-wire system. A gain increaser circuit and a gain decreaser circuit is provided for controlling each of said loss devices. The gain increaser circuit and the gain decreaser circuit are selectively controlled according to the strength of a tone transmitted over the path to which the loss device is connected.

When voice currents are on the west-to-east path of a four-wire circuit and are transmitted from a west station to an east station, the voice currents first block the east-to-west path at the west station and then block the east-to-west path at the east station. At the time the east-to-west path is blocked at the east station a tone having a frequency within the voice frequency range is transmitted over the east-to-west path from the east station to the west station. When this tone arrives at the west station the gain adjusting controls there are enabled. The tone which is transmitted over the east-to-west path selectively controls the gain decreaser circuit and the gain increaser circuit at the west station for controlling the loss device at the west station in the east-to-west path by means of a control condenser. The gain decreaser circuit and the gain increaser circuit control the charge on the control condenser according to the strength of the received tone. The control condenser governs the bias on the grid of a space discharge device to govern the loss effected by the loss device in the east-to-west path at the west station.

The loss devices respectively located at the east and west stations are controlled to maintain the attenuation on the two paths substantially constant. The adjustment of a path is always effected when the path is idle and free from voice currents. The adjustment of the attenuation in an idle path is initiated by the voice currents in an operating path and under control of a single tone having a frequency within the voice frequency range.

The single figure in the accompanying drawing is a diagrammatic view of the four-wire signaling system constructed in accordance with the invention.

Referring to the drawing, a four-wire system having a west-to-east path 1, and an east-to-west path 2, is shown connected to a west station 3 and an east station 4. The two paths 1 and 2

in the four-wire system are shown connected by a hybrid coil 5 to a two-wire circuit comprising conductors 6 and 7 at the east station 4. At the west station 3 the two paths 1 and 2 are connected by a hybrid coil 8 to a two-wire circuit comprising conductors 9 and 10. The hybrid coil 5 is provided with a balancing network 11 and the hybrid coil 8 is provided with a balancing network 12. The east-to-west path 2 comprises a pad 52 which prevents blocking of path 2 at station 4 from unduly changing the impedance facing the two-wire line comprising conductors 5 and 7, an amplifier 13 of any suitable type and preferably a thermionic amplifier at the east station 4 and a pad 14 at the west station 3 which serves to remove the variable impedance of a loss device 15 from the path 2 looking towards the right as viewed in the drawing. The variable loss device 15 is connected across the path 2 between two transformers 16 and 17. Two amplifiers 18 and 19, which are preferably of the thermionic type, are connected in the path 2 between the transformer 17 and the hybrid coil 8.

A gain decrease circuit 20 and a gain increaser circuit 21 are provided for controlling the charge on a control condenser 22. The control condenser 22 governs the bias impressed on the grid of a three-element space discharge device 23. The space discharge device 23 controls the direct current flow from a battery 24 through the elements of the loss device 15. The loss device 15 is shown composed of the copper oxide rectifiers connected as a bridge across the path 2. Two opposite vertices of the bridge are connected across the path 2 and the other two vertices of the bridge are connected in circuit with the battery 24 and the space discharge device 23.

The gain decrease circuit 20 comprises a cold cathode space discharge device 25 having two control electrodes 26 and 27 and an anode 28. The two control electrodes 26 and 27 are connected in circuit with a resistance element 29 to the secondary winding of a transformer 30. The path 2 between the transformer 17 and the amplifier 18 is connected to the transformer 30 of the gain decrease circuit by means of an amplifier 31, which is preferably of the thermionic type, and a pad 32. A battery 33 has the positive terminal thereof connected to the anode 28 of the gas-filled device 25 and the negative terminal thereof connected to one terminal of the control condenser 22. The other terminal of the control condenser 22 is connected to the circuit of the two control electrodes 26 and 27 of the device 25 by means of a resistance element 34. The control condenser 22 is connected between the cathode and grid of the space discharge device 23 as shown in the drawing.

The gain increaser circuit 21 comprises a gas-filled cold cathode tube 35 having two control electrodes 36 and 37, and an anode 38. The two control electrodes 36 and 37 are connected in circuit with a resistance element 39 to the secondary winding of a transformer 40. The transformer 40 is connected to the output circuit of the amplifier 31. The anode 38 of the device 35 is connected by a resistance element 41 to one terminal of the control condenser 22. The other terminal of the control condenser is connected by means of a battery 42 to the secondary winding of the transformer 40. It will be noted that the two batteries 33 and 42 are oppositely poled with respect to the control condenser 22 so that breakdown of the devices 25 and 35 produce opposite charges on the control condenser.

The gain decrease circuit 20 and the gain increaser circuit 21 are controlled by a tone having a frequency within the voice frequency range which is transmitted over the east-to-west path 2, as will be hereinafter set forth. The gain increaser circuit 21 is made sensitive enough to always operate on any tone transmitted over the east-to-west path. The resistance element 41 is made rather high in order to limit the effect of the gain increaser circuit on the control condenser 22. The gain decrease circuit is made less sensitive to the tone transmitted over the east-to-west path by the pad 32 connected to the transformer 30 and the resistance 34 is low in value when compared to the value of the resistance 41 in order that the gain decrease circuit 20 can take control of the condenser 22 away from the gain increaser circuit when necessary.

The west-to-east path 1 comprises a pad 53 and an amplifier 44 at the west station 3, a pad 45 at the east station which corresponds to the pad 14 at the west station, two transformers 46 and 47 and a loss device 48 which is connected across the path 1 between the transformers 46 and 47. The loss device of 48 corresponds in construction and operation to the loss device 15 in the east-to-west path at the west station. Two amplifiers, which are preferably of the thermionic type, are connected to the path 1 between transformer 47 and the hybrid coil 5.

An amplifier detector 51 of any suitable type is connected to the path 1 before the amplifier 44 for controlling the operation of a relay 54 when the path 1 is in operation. Operation of the relay 54 immediately effects operation of a relay 55 by reason of the quick discharge of condenser 56 through the resistance element 57 and the armature of relay 54 to ground. The circuit completed through the winding of the relay 55 may be traced from grounded battery 58 through a resistance element 59, coil of relay 55, resistance element 57, armature of the relay 54 and ground return to the battery 58. The relay 55 is quick to operate and slow to release. The relay 55 has a slow release time due to the time required for the battery 58 to charge the condenser 56 through the relay winding and resistance 59 upon release of the relay 54. The release time for the relay 55 is assumed to be $D+e$. The time D is assumed to be the time required to transmit a signal from station 3 to station 4. The time e is assumed to be very short and is added merely for a factor of safety, as will be pointed out. The relay 55 upon operation completes a circuit from a battery 60 for operating a relay 61. The relay 61 is slow to operate and quick to release. The slow operation of the relay 61 may be effected in any well-known manner. The slow operation of the relay 61 is made equal to the time D and since the relay 55 has a slightly longer slow-release time, it is apparent that relay 61 will always operate for every operation of the relay 55.

When the relay 61 operates after the time D , the relay 62 is operated. The relay 62 is quick to operate and slow to release. The release time for the relay 62 is assumed to be $D+\Delta$. The relay 62 is provided with two switch members 63 and 64 and performs two functions. The switch member 63 when operated short-circuits the path 2 beyond the amplifier 18 and effectively blocks the path 2 at the west station 3. The switch member 64 completes a circuit from the battery 60 for operating the relay 65. Relay 65 is slow to operate and has a time constant equal to D .

The armature of the relay 65 in released position completes a short circuit across the output circuit of the amplifier 31 so as to prevent any operation of the gain decrease circuit 20 or the gain increase circuit 21 by voice currents. Upon operation of the relay 65 after a time D the short circuit across the output of the amplifier 31 is removed to permit operation of the circuits 20 and 21 and control of the loss device 15 in the path 2.

An amplifier detector 66, which is preferably of the thermionic type, is connected to path 2 beyond the amplifier 18. The amplifier detector 66 is connected to a relay 67. The relay 67 is provided with two switch members 68 and 69. The switch member 68 while in operation completes a circuit from a battery 70 for operating relays 71 and 72. The relay 71, when operated, short-circuits the path 1 before the amplifier 44. The operation of the relay 71 prevents any echoes over the path 1 when the path 2 is in service. The relay 72 when operated connects a source of alternating current 73 to the path 1. The source 73 preferably has a frequency within the voice frequency range. The tone supplied by the source 73 serves as the control means at station 4 for controlling the operation of the loss device 48. The operation of the switch member 69 effectively short-circuits the winding of the relay 55 and causes the condenser 56 to be immediately charged from the battery 58 through the resistance 74 if it has not already been charged. The charging of the condenser 56 effectively wipes off any accumulated hang-over time in the operation of the relay 55.

The loss device 48 at station 4 is controlled by a gain increase circuit 75 and a gain decrease circuit 76 which correspond in construction and operation to the gain increase circuit 21 and the gain decrease circuit 20 at station 3. The gain decrease circuit 76 is connected to the path 1 by means of an amplifier 77 and a pad 78. The gain increase circuit 75 is connected to the path 1 by means of the amplifier 77. The two circuits 75 and 76 control the charge on a control condenser 79, which in turn controls a space discharge device 80. The space discharge device 80 controls the current flow from a battery 81 through the loss device 48 in the same manner as that described with respect to the loss device 15 at station 3. The output circuit of the amplifier 77 is controlled by a slow operating relay 82 which corresponds in construction and operation to the relay 65 at station 3. The relay 82 is controlled from the path 2 in the same manner as the relay 65 is controlled from the path 1. An amplifier detector 83 connected across the path 2 controls the operation of a relay 84. The relay 84 controls a slow release relay 85. The relay 85 in turn controls the operation of relays 86 and 87. The relay 87 controls the operation of the relay 82. The relay 87 is slow to release and is similar to the relay 62 at station 3. The relay 86 is slow to operate and is similar to the relay 61 at station 3. The relay 85 is slow to release and is similar to the relay 55 at station 3.

An amplifier detector 88 of any suitable type is connected to the path 1 beyond the amplifier 49. The amplifier detector 88 controls the operation of a relay 89. The relay 89 corresponds in operation to the relay 67 at station 3. The relay 89 controls the operation of relays 90 and 91. The relay 91 impresses a tone from a source 92 upon the path 2 for controlling the loss device 15. The source 92 has a frequency within the voice fre-

quency range. The relay 90 short-circuits the path 2 before the amplifier 13 in order to prevent any echoes from the path 1 when in service. The relay 89 also short-circuits the winding of the relay 85 and insures the charging of a condenser 93. This insures that the relay 85 will be held in released position.

Assuming that voice currents are transmitted over the path 2 from station 4 to station 3, a portion of the voice currents on the path 2 will be taken by the amplifier detector 83 for operating the relay 84. The relay 84 completes a circuit for operating the relay 85 and for discharging the condenser 93. The relay 85 operates the relay 86, which in turn operates the relay 87 and the relay 82. The relay 82 will not be operated until after a time 2D because of the slow operation of the relay 86 and relay 82. It is assumed that the time D is equal to the time required to transmit a signal between the two stations. Therefore, the relay 82 will be operated in the time required to transmit signals to station 3 and transmit a tone back to station 4 from station 3. The relay insures that control of the loss device 48 can only take place when voice currents are on path 2. The relay 87 also blocks the path 1 between the amplifiers 49 and 50.

At station 3 the voice currents on the path 2 effect no control of the gain decrease circuit 20 and the gain increase circuit 21 because the relay 65 is in released position and the output from the amplifier 31 is blocked. The amplifier detector 66, which is connected to the path 2 beyond the amplifier 18, supplies current for operating the relay 67. The relay 67 operates the relay 71 for blocking the path 1 before the amplifier 44 and for operating the relay 72 for transmitting a tone from the source 73 over the path 1. The voice currents on the path 2 which were received through the hybrid coil 5 from conductors 6 and 7 are transmitted through the hybrid coil 8 to the west conductors 9 and 10.

The tone from the source 73 which is transmitted over the path 1 controls the operation of the gain decrease circuit 76 and the gain increase circuit 75 to control the operation of the loss device 48. The relay 87 being in operative position prevents any tone being transmitted on the path 1 to the amplifier 50 or the amplifier detector 88. The amplifier 77 supplies the tone received at station 4 over the path 1 to the two circuits 75 and 76. The gain increase circuit 75 is made sensitive enough to be operated by any tone that may be transmitted over the path 1. The gain decrease circuit 76 is made less sensitive than the gain increase circuit 75 by reason of the pad 78 which is included in the circuit between the amplifier 77 and the circuit 76.

Assuming that the measuring tone from the source 73 on the path 1 is too low to operate the gain decrease circuit, the gain increase circuit 75 alone is operated. The gas-filled device 100 in the gain decrease circuit 75 is broken down by the voltage across its two control electrodes 95 and 96. Current then flows from the battery 98 through the electrodes 96 and 97 of the device 100 and the resistance 101 for charging the control condenser 79 so as to impress negative bias on the grid of the space discharge device 80. Impressing negative bias on the grid of the device 80 will cause the space current flow through the device 80 from the battery 81 to decrease and thereby decrease the current flow through the

loss device 48. The decrease in the current flow through the loss device 48, which comprises copper oxide rectifiers, causes the impedance of the rectifier elements to increase and thereby lower the loss effected through the loss device 48.

When the strength of the measuring tone on the path 1 is sufficient it will break down the gas-filled tube 102 in the gain decreaser circuit 76, by causing a very small current to flow across the control electrodes 103 and 104. A circuit is then completed by the anode 107 and the control electrode 104 of tube 102 for charging the control condenser 79. The circuit for charging the condenser 79 may be traced from one terminal of the condenser through the resistance 105, secondary of the transformer electrode 104, anode 107 and battery 106 to the other terminal of the condenser 79. The condenser 79 is charged by the gain decreaser circuit 76 in a direction opposite to that in which it is charged by the gain increaser circuit 75. Furthermore, the resistance 105 is made small compared with the resistance 101 so that the gain decreaser circuit 76 when operated will always control the charge impressed on the condenser 79. When gain decreaser circuit 76 operates, the potential impressed on the grid of the device 80 becomes less negative. The space discharge device 80 will then tend to allow more current flow through the loss device 48 and accordingly a greater loss will be caused on the path 1 at the station 4. A condition of equilibrium will soon be obtained where the two opposing charging currents from the gas-filled tubes 100 and 102 will cancel each other. Tube 100 will then be operating on practically all the wave but tube 102 will be operating on only the peaks of the wave. In case the measuring tone is too strong, however, the device 102 will take control and the condenser 79 will put a less negative potential on the grid of the device 80, thereby increasing the space current flow and the current flow through the loss device 48.

If the relay 82 is released during pauses of speech on the path 2, it is apparent that the condenser 79 will control the setting of the loss device 48 for a limited period of time. The voltage of the condenser 79 and the potential of the two batteries 98 and 106 are far too small to break down either of the gas-filled tubes 100 and 102 so that the condenser 79 effectively floats and maintains the bias on the grid of the space discharge device 80. During an ordinary conversation the longest pauses that may usually be effected are about ten seconds. A charge may be maintained on the condenser 79 almost without change for ten seconds. For intervals between calls, however, the charge on the condenser 79 will gradually leak off. This will cause the current flow through the space discharge device 80 to increase and, therefore, will increase the loss effected by the variable loss device 48. This will increase the net loss on the circuit and tend to prevent singing. When conversation is again started, however, a few words or phrases in each direction will be sufficient to adjust the losses and bring the net loss of the two sides of the circuit to the correct value.

When the voice currents cease to flow on the path 2, the relays 67, 71 and 72 at station 3 are released to remove the short circuit across the path 1 at station 3 and to prevent the further transmission of a tone from station 3 over the path 1. At station 4 the relays 84, 85, 86, 87 and 82 are released in the manner before set forth to

reestablish a short circuit across the output circuit of the amplifier 77 thus preventing any further operation of the gain increaser circuit 75 and the gain decreaser circuit 76.

When voice currents are being transmitted over the path 1 from the west conductors 9 and 10 to the east conductors 6 and 7, the relay 90 is operated for blocking the path 2 at station 4 and the relay 62 is operated for blocking the path 2 at station 3. The relay 65 is operated to remove the short circuit across the amplifier 31 and permit control of the gain decreaser circuit 20 and the gain increaser circuit 21 by the tone transmitted over the path 2 from the source 92. The tone received over the path 2 from the source 92 controls the loss device 15 in the same manner as that above described with reference to the tone transmitted over the path 1 for controlling the loss device 48.

Modifications in the circuits and in the arrangement and locations 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 a four-wire transmission system having paths for signal transmission in opposite directions between two stations, normally inoperative control means associated with each path for governing the attenuation of the paths, means governed by the signal currents on an active path at one station for transmitting a tone over the idle path, means at the second station controlled by the signal currents on the active path at the second station to enable operation of said control means associated with the idle path by said tone, and means governed by the control means when operated by the tone to maintain the attenuation of the idle path constant.

2. In a four-wire transmission system having paths for signal transmission in opposite directions between two stations, means governed by the voice currents on an active path at one station for transmitting a tone having a frequency within the voice frequency range over the idle path, normally inoperative control means at the second station governed solely by said tone and according to the energy level of the tone for controlling the attenuation of the idle path and means governed by the voice currents on the active path at the second station for enabling operation of said control means by the tone.

3. In a four-wire transmission system having paths for transmission of signals in opposite directions between two stations, loss devices in said paths respectively located at said stations, normally inoperative control circuits associated with each path for governing the loss devices, means governed by the voice currents on an active path for transmitting a tone over the idle path, means governed by the voice currents on the active path at the station having the loss device in the idle path to prepare the control circuits for operation by the tone, and means governed by the control circuits according to the energy level of said tone for adjusting the loss device in the idle path to control the attenuation of the idle path.

4. In a four-wire transmission system having a west-to-east path and an east-to-west path, east and west stations respectively located at the terminals of said system, loss devices in said paths respectively located at said stations, means for blocking the west-to-east path at the east

station under control of voice currents on the east-to-west path at the east station, means for blocking the west-to-east path at the west station under control of the voice currents on the east-to-west path at the west station, means controlled by the voice currents on the east-to-west path for transmitting a tone within the voice frequency range over the west-to-east path from the west station, and means at the east station controlled by said tone for controlling the loss device at the east station.

5. In a four-wire transmission system having separate paths for transmission of signals in opposite directions between two stations, loss devices in said paths respectively located at said stations, means for blocking one path at each of said stations under control of the voice currents on the other path at each of said stations, means controlled by voice currents on the active path for transmitting a tone within the voice frequency range over the idle path between stations, and means controlled by said tone for controlling the loss device on the idle path.

6. In a four-wire transmission system having separate paths for transmission in opposite directions between two stations, means controlled by voice currents on an active path at one of said stations for blocking the idle path at one of said stations, means controlled by voice currents on the active path for transmitting a tone within the voice frequency range over the idle path between stations, means controlled by voice currents on the active path at the second station for blocking the idle path at the second station and means governed by said tone for controlling the attenuation of the idle path.

7. A signal transmission system having a west-to-east path and an east-to-west path, east and west stations located at the terminals of said system, a loss controlling device in each of said paths, respectively, located at said stations and comprising copper oxide rectifiers, control means at the east station for governing the device at the east station by governing the current flow through the rectifiers and comprising a gain increaser circuit to lower the loss effected by the device and a gain decreaser circuit to increase the loss effected by the device, means controlled by signal currents on the east-to-west path for transmitting a tone over the west-to-east path when free from voice currents, means controlled by said tone on the west-to-east path for governing said control means at the east station to selectively operate the gain increaser circuit and the gain decreaser circuit and maintain the west-to-east path attenuation constant and means governed by the signal currents on the east-to-west path at the east station for enabling operation of said control means at the east station by the tone on the west-to-east path.

8. In a four-wire transmission system having a west-to-east path and an east-to-west path, east and west stations respectively located at the terminals of said system, an echo suppressor circuit at the west station operated by voice currents when the east-to-west path is in service, means operated by said echo suppressor circuit for blocking the west-to-east path and for transmitting a tone within the voice frequency range

over the west-to-east path to the east station, a loss device in the west-to-east path at the east station, normally inoperative control means for controlling said loss device according to the strength of the received tone and means governed by the voice currents on the east-to-west path at the east station for enabling operation of said control means by the tone.

9. In a four-wire transmission system having a west-to-east path and an east-to-west path, east and west stations respectively located at the terminals of said system, an echo suppressor circuit at the west station operated by voice currents when the east-to-west path is in service, means operated by said echo suppressor circuit for blocking the west-to-east path and for transmitting a tone within the voice frequency range over the west-to-east path to the east station, a loss device in the west-to-east path at the east station, normally inoperative control means comprising a gain increaser circuit and a gain decreaser circuit for controlling said loss device according to the strength of the received tone and means governed by the voice currents on the east-to-west path at the east station for enabling operation of said control means by the tone.

10. In a four-wire signal system having paths for transmission in opposite directions, adjustable loss devices respectively located in said paths, means controlled by voice currents on an operating path for transmitting a tone over the idle path to control the loss device on the idle path, control means associated with each loss device for normally preventing change in the value of the loss device, and means controlled by the voice currents on the operating path for disabling said control means, for controlling the time of disabling said control means and for controlling the time at which the control means again prevents change in the value of the loss device.

11. In a four-wire signal system having paths for transmission in opposite directions, adjustable loss devices respectively located in said paths, means controlled by voice currents on an operating path for transmitting a tone over the idle path to control the loss device on the idle path, control means associated with each loss device for normally preventing change in the value of the loss device, and means controlled by the voice currents on the operating path for disabling said control means and for controlling the time of disabling said control means to permit setting of the loss device on the idle path according to the strength of the tone on the idle path.

12. In a four-wire signal system having paths for transmission in opposite directions, adjustable loss devices respectively located in said paths, means controlled by voice currents on one path for transmitting a tone over the idle path to control the loss device on the idle path, control means associated with each loss device for normally preventing change in the value of the loss device, and timing means controlled by the voice currents in the operating path for disabling said control means when the tone transmitted over the idle path reaches the loss device therein.

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