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TRANSMISSION CONTROL IN TWO-WAY SIGNALING SYSTEMS

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FIG. 1

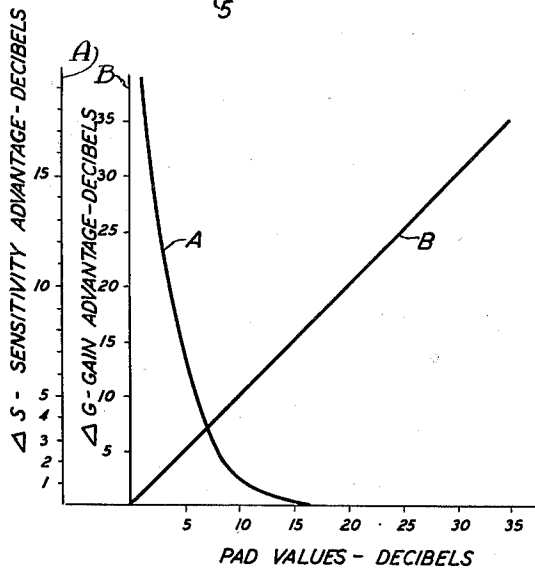
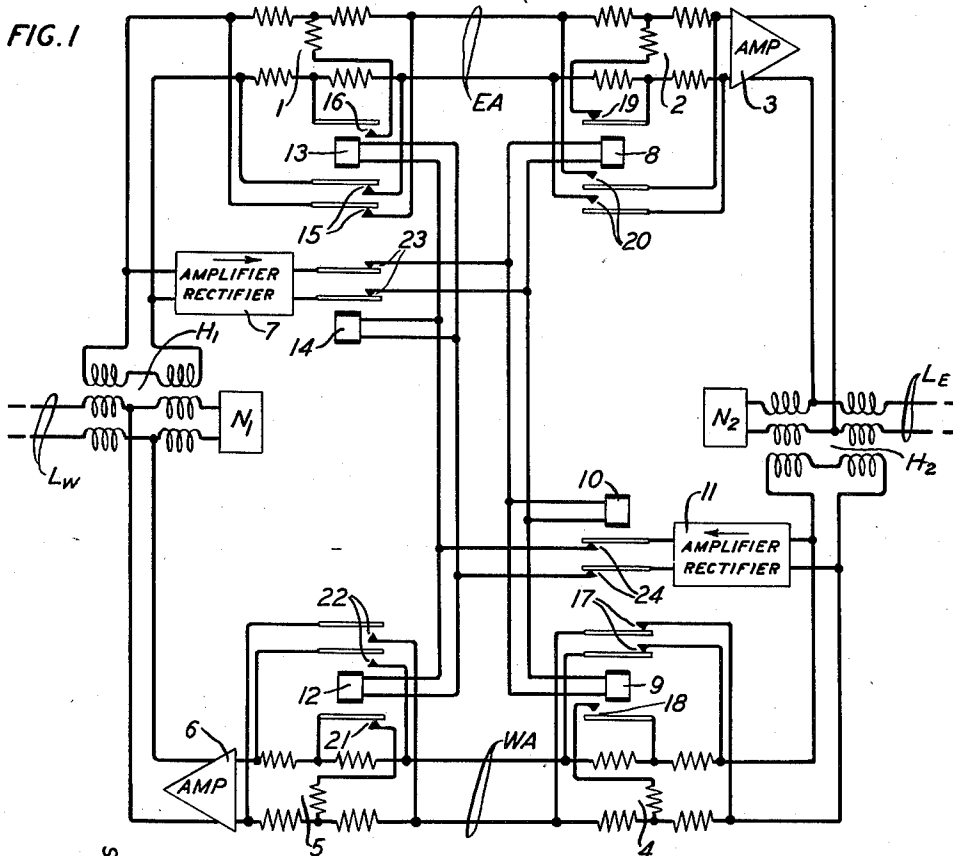


FIG. 2

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TRANSMISSION CONTROL IN TWO-WAY
SIGNALING SYSTEMS

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3 Claims. (Cl. 179—170)

This invention relates to two-way signal trans-
mission systems and particularly to two-way sig-
nal repeating systems.

An object of the invention is to improve the
operation of two-way repeaters used in signal
transmission systems subject to noise.

It is frequently found desirable to insert re-
peating or amplifying systems between two-way
transmission lines in a two-way signaling system,
for example, a two-way telephone system, to
compensate for attenuation in the signals trans-
mitted in opposite directions thereover. In the
prior art one form of repeating system comprises
two oppositely-directed, one-way repeating paths
which, to enable amplification of the signals for
both directions of transmission, are coupled to
each other and to the two-way transmission line
by three winding transformers or hybrid coils in
such manner as to form a Wheatstone bridge cir-
cuit. As is well known, the balanced condition
of such a bridge circuit is maintained by providing
a balancing network in one arm of each bridge
circuit which closely simulates the impedance of
the associated transmission line in another arm.
For any degree of balance maintained by the
balancing networks, there is a critical amount of
amplification that can not be exceeded without
setting up a local circulation of energy known as
singing. In another form of circuit in the prior
art, repeating of the signals in opposite directions
is obtained without necessitating balancing of the
impedances of the transmission lines to avoid
singing due to local circulation of energy, by uti-
lizing switching means responsive to the trans-
mission of voice currents or other signals in either
direction to disable the repeating path for the
other direction and the associated switching
means, so that signal transmission can take place
only in one direction at a time. Design of the
latter type of repeating system is complicated by
problems such as break-in difficulties, clipping
of the signals and lock-up of the switching de-
vices by line noise.

The disadvantages of the above systems are ob-
viated or minimized in the repeating system of
the invention, one embodiment of which utilizes
in addition to means such as hybrid coils and line
balancing networks for obtaining partial con-
jugacy of the oppositely directed repeating paths,
means responsive to initiation of signal trans-
mission in either direction to switch sufficient loss
out of the repeating path transmitting the signals
and sufficient loss into the oppositely directed
path so as to maintain the necessary singing
margin.

The objects and advantages of the invention
will be better understood from the following de-
tailed description thereof when read in connec-
tion with the accompanying drawing in which
Fig. 1 shows schematically a two-way telephone

repeater embodying the invention and Fig. 2
shows curves illustrating the invention.

The two-way telephone repeater circuit of Fig.
1 comprises a transmission path EA including the
loss networks 1 and 2 and the one way amplifying
device 3, for repeating telephonic signals in the
direction from west to east between the west two-
way line section L_w and the east two-way line
section L_e, and the transmission path WA in-
cluding the loss networks 4 and 5 and the one
way amplifying device 6, for repeating signals in
the direction from east to west between the east
two-way line section L_e and the west two-way
line section L_w. The oppositely directed one-way
repeating paths EA and WA are connected in
conjugate relation with each other and in energy
transmitting relation with the west line section
L_w and the east line section L_e by the hybrid coil
transformers H₁ and H₂ and associated balanc-
ing networks N₁ and N₂ in well known manner.

Connected across the path EA between the hy-
brid coil transformer H₁ and the loss networks
1 and 2 is the input of a control circuit compris-
ing the signal-controlled, amplifier-rectifier de-
vice 7, and the mechanical relays 8, 9 and 10 hav-
ing their windings connected in parallel to the
output of the device 7. Similarly, connected
across the repeating path WA between the hybrid
coil transformer H₂ and the loss networks 4 and
5 is the input of another control circuit compris-
ing the signal-controlled, amplifier rectifier de-
vice 11 and the mechanical relays 12, 13 and 14
having their windings connected in parallel to the
output of the device 11. The amplifier-rectifier
devices may be of any appropriate type for con-
verting the alternating current signals applied to
their inputs into direct current suitable for op-
erating the mechanical relays connected to their
outputs.

The loss networks 1, 2, 4 and 5 in one form, as
illustrated, are identical resistance pads of the
balanced ladder type each comprising two resist-
ance elements in series in each side of the path
EA or WA and a shunt resistance arm connected
or adapted to be connected across the junction
points between the series resistance elements in
each side of the path. In the normal condition
pad 1 is ineffective to insert loss in the path EA
because the incoming signals are by-passed
around the pad through the circuit formed by the
normally closed switch contacts 15 and the shunt
resistance arm of the pad is open-circuited by the
normally open switch contacts 16 therein. Op-
eration of relay 13 to open the switch contacts
15 in the by-pass circuit and to close the switch
contacts 16 in the shunt resistance arm will ren-
der the pad 1 effective to insert its maximum loss
in the path EA. Similarly in the normal condi-
tion, the incoming signals are by-passed around
the pad 4 in the path WA, and the pad 4 is ren-

dered effective to insert its maximum amount of loss in the path WA by operation of relay 9 to open the normally closed switch contacts 17 in the by-pass circuit and to close the normally open switch contacts 18 in the shunt resistance arm of the pad.

In the normal condition, pad 2 is effective to insert its maximum loss in the path EA, and is rendered ineffective to insert any loss therein by operation of relay 8 to open the normally closed switch contacts 19 in the shunt resistance arm of the pad, and to close the normally open switch contacts 20 to provide a by-pass circuit for signals around the pad. Similarly, in the normal condition pad 5 is effective to insert its maximum loss into the path WA and is rendered ineffective to insert any loss therein, by operation of relay 12 to open the normally closed switch contacts 21 in the shunt resistance arm of the pad, and to close the normally open switch contacts 22 to provide a by-pass circuit for signals around the pad.

The normally closed switch contacts 23 in the output of the amplifier-rectifier device 7 are arranged to be opened by operation of relay 14 to disable the inputs of relays 8, 9 and 10, and the normally closed switch contacts 24 in the output of amplifier-rectifier device 11 are arranged to be opened by operation of relay 10 to disable the inputs of relays 13, 14 and 15.

The system of Fig. 1 operates as follows:

Let it be assumed that signals are applied to the four-wire circuit from the west line section L_w and that no signals are being simultaneously applied thereto from the east line section L_e. The incoming signals are impressed by hybrid coil transformer H₁ on the path EA and are transmitted thereover. A portion of the signals will be diverted into the control circuit connected to the input of the path EA and will cause operation of the amplifier-rectifier 7 causing relays 8, 9, and 10 to be operated. In the manner explained above, operation of relay 8 effectively removes loss network 2 from the transmission path EA, and operation of relay 9 introduces loss network 4 into the transmission path WA. The main portion of the signals impressed on EA will be transmitted around the loss network 1 through the by-pass circuit including closed switch contacts 15 and around the loss network 2 through the by-pass circuit including closed switch contacts 20 to amplifier 3, and the amplified signals in the output of the amplifier 3 will be impressed on the line section L_e by hybrid coil transformer H₂.

Since the loss values of the two networks 2 and 4 are equal, the singing margin of the circuit is not changed but the gain of the path EA through which the signals are passing is increased by an amount equal to the loss value of the network 2 effectively removed from that path. At the same time, the gain of the path WA through which no useful signal is passing is effectively reduced by an amount equal to the loss value of the network 4 inserted therein. Relay 10 operates, substantially at the same time as relays 8 and 9, to open switch contacts 24 to effectively disconnect relays 12, 13 and 14 from the amplifier-rectifier 11. Thus any unbalance signal energy which may be applied to the path WA through the hybrid coil transformer H₂ due to imperfect balancing of the line section L_e by the balancing network N₂, can not cause false operation of the relays 12, 13 and 14.

Similarly, signals applied from the east line section L_e when no signals are being applied from the west line section L_w will cause operation of the amplifier-rectifier 11 to energize the windings of relays 12, 13 and 14. These relays will operate respectively to effectively remove the loss network 5 from the transmission path WA, to introduce loss network 1 into the transmission path EA, and to open switch contacts 23 in the output of amplifier-rectifier 7 thus preventing subsequent operation of the latter by any unbalance signal energy which may be transmitted to the path EA through hybrid coil transformer H₁ from falsely operating relays 8 to 10.

While the signals from the west line L_w maintain the relay 10 operated, it is apparent that signals subsequently applied to the repeating circuit from the east line section L_e can not gain control of the switching circuits due to the open condition of the contacts 24 in the output of amplifier-rectifier 11. During this period the maximum losses of both networks 4 and 5 are effective in the path WA. Since transmission over the path WA is not completely blocked, but only reduced in amplification by the loss networks, the signals from the east line section L_e will pass through to the west line section L_w. Similarly while signals from the east line section L_e maintain relay 14 operated, the path EA includes both loss networks 1 and 2 which act to reduce the amplification in path EA but not to completely block that path, so that signals may still pass from line section L_w to line section L_e. Thus, if the circuit is used as a telephone repeater neither talker is ever completely blocked from the other; one talker can always interrupt the other. This improves the ease of carrying on a two-way conversation.

When speech is first applied to the circuit, for example, from the west line section L_w, a certain portion of the speech currents may pass through to the amplifier 3 in the path EA before the relay 8 has operated under control of the amplifier-rectifier 7 to effectively remove the network 2 from the path, and thus, this portion of the speech will be transmitted to the east line section L_e with reduced amplification as compared to the following portion. The amount of the speech thus reduced in relative amplifications or "clipped" depends largely on the voltage required to cause amplifier-rectifier 7 to operate relay 8 if the pad 2 introduces a loss of more than 10-15 decibels, being reduced in proportion to the reduction in the operating voltage. The minimum values of the operating voltage of the amplifier-rectifiers are limited by the noise present on the lines L_w and L_e, since, if noise operates the amplifier-rectifier for either direction steadily, the talker from the other direction can not obtain the desired amplification. If, as is often the case, the amplitude of the noise present is higher than that of the weaker but still important parts of speech, and the sensitivity of the amplifier-rectifiers is set so as not to operate on noise, operation on speech may occur at a point where significant parts of words do not receive full amplification.

The importance of this clipping depends largely on the sensitivity of the amplifier-rectifiers and the loss values of the pads switched. Fig. 2 illustrates graphically the advantage from the standpoint of allowable increase in sensitivity of the amplifier-rectifiers and usable gain obtainable with the circuit of the invention as shown in Fig. 1 for different pad values effectively

switched from the path transmitting signals to the oppositely directed repeating path to maintain the required singing margin. Curve A shows the sensitivity advantage, ΔS , and curve B the gain advantage, ΔG . Sensitivity advantage may be defined as the difference in sensitivity in decibels required to give equally noticeable clipping with an amplifier-rectifier switching a pad of infinite loss and an identical amplifier-rectifier switching a pad of any selected loss from the talking path into the non-talking path. As indicated by the curve A, the sensitivity advantage increases for pad values below 10 decibels and a large sensitivity advantage is obtained when the pad values are in the order of 5 decibels or less. For example, if the loss of the pad switched is 5 decibels, the amplifier-rectifier can be made 8 decibels less sensitive than if the loss of the switched pads were infinite (which is the case where the non-talking path is completely suppressed in response to the signals in the talking path) to give equally noticeable clipping of speech. Thus, if each of the pads switched in the circuit of Fig. 1 are made of value 5 decibels or less, operating difficulties due to noise on the lines are minimized. As shown by curve B, where the switched pads have values of 5 decibels the gain advantage is 5 decibels. The invention is especially adapted, therefore, for use in systems where there is a substantial amount of noise and requiring only a moderate increase in amplification. For example, the system is particularly applicable to a suburban switched trunk telephone system for use in a population center, such as New York city or Chicago.

The losses of the pads required may be computed in the following manner. Let

G_E =Gain (in decibels) from line L_W to line L_E with pads 1 and 2 cut out of the circuit.

G_W =Gain (in decibels) from line L_E to line L_W with pads 4 and 5 cut out of the circuit.

B_W =Balance (in decibels) of balancing network N_1 against line L_W .

B_E =Balance (in decibels) of balancing network N_2 against line L_E .

X =Loss in decibels of pads 1, 2, 4 or 5 (for purposes of illustration all pads are assumed to have the same loss value).

Without loss of generality, it may be assumed for simplicity in illustration that $G_E=G_W=G$ and that $B_E=B_W=B$.

Also, let singing margin be defined as the amount in decibels that the gain around the loop comprising paths EA and WA, or $2G$, needs to be increased to just cause singing. Then, if it be assumed that the minimum singing margin required is 10 decibels, it can be seen that the limiting condition occurs when $2B-2G+2X=10$ or when $G=B+X-5$. For a two-way repeater not employing voice operated switching to maintain the 10 decibel singing margin, $2B-2G=10$, or $G=B-5$. Thus the difference in usable gain due to the pad switching is

$$\Delta G=B+X-5-(B-5)$$

or $\Delta G=X$. The difference in usable gain is equal to the loss of the pad switched from one direction of transmission to the other. This relationship is shown graphically by curve B in Fig. 2.

In the preferred form of the invention which has been illustrated and described, two loss networks have been employed in connection with each one-way portion of the circuit. It is to be

understood that it is within the scope of the invention to utilize only a single loss network in each one-way path which is normally effective but under the control of signals is removed from the path for the direction of transmission. The circuit of Fig. 1 would represent the latter form of the invention if pads 1 and 4, and relays 9 and 13 are eliminated.

In the circuit of the invention as illustrated and described, a particular form of resistance pad is utilized for each loss network and switching contacts controlled by mechanical relays are utilized for switching the pads in and out of the repeating paths to control the transmission equivalent of said paths. It is within the scope of the invention to utilize other means for producing and removing the required loss in the transmission paths. For example, the loss device may be a tapped transformer or potentiometer connected in the transmission path, the values of which may be changed by switching the grid lead of the line amplifier from one tap or contact point to another. Also, the loss in the transmission path might be controlled by changing the grid bias of one vacuum tube stage of the line amplifier to control the gain thereof in proper manner, under control of the amplifier-rectifier. Any other method known in the art for automatically varying the losses in the one-way paths may be used.

The invention has been illustrated and described in connection with a voice operated two-way telephone repeater. However, the advantages of the invention may be utilized in any two-way voice or signal-operated device in which it would be desirable to switch small rather than large or infinite losses to directionally control transmission and to maintain a margin against singing.

The invention is to be limited only within the scope of the appended claims.

What is claimed is:

1. In a telephone system comprising a four-wire repeating circuit coupling two two-wire lines subject to noise, means for minimizing the effects of noise while preventing singing in said circuit comprising voice-operated switching devices for removing loss from that side of said circuit carrying voice signals and simultaneously inserting loss in the opposite side of said circuit to maintain a desired margin against singing, the net amount of loss effectively switched from the first side to said opposite side of said circuit being within the range of values over which the amount of protection against false operation of said devices by noise for a given reduction in speech clipping increases rapidly as the value of said switched loss decreases.

2. In a two-way telephone system comprising a four-wire repeating circuit coupling two two-wire lines subject to noise, means for improving the operation of said circuit comprising switching means connected to each side of said circuit and responsive to voice signal transmission thereover to remove loss from that side of the circuit and simultaneously to insert an equivalent loss into the opposite side of the circuit to maintain the transmission equivalent of said paths such as to prevent singing for the desired amount of repeater gain, the amount of loss thus effectively switched from the first side of the circuit to the opposite side being within that range of values over which the reduction in speech clipping for a given amount of protection against false operation of said switching device by noise is a

function of the value of said switched loss and varies rapidly with small changes in the value of said loss.

3. In a two-way telephone transmission system, two two-way lines, a four-wire repeater therebetween consisting of two oppositely directed one-way repeating paths coupled in partial conjugate relation with each other and in energy transmitting relation with said two-way lines, and means for improving the operation of said circuit under line noise conditions comprising means normally inserting in said paths an amount of loss which is just sufficient to prevent singing for a given amount of repeater gain, and switching means connected to each path

and responsive to signal transmission therein to remove loss from that path and to simultaneously insert loss in the other one-way path, the net amount of loss thus effectively switched between the paths being within that range of values for which the amount of protection against false operation of the switching devices by noise for a given reduction in signal clipping is a function of the value of the switched loss and increases rapidly as the value of said switched loss is decreased, and the sensitivities of the switching means being set at the optimum values permitted by the selection of the proper value for the loss switched.

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