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PREVENTING SINGING IN TELEPHONE REPEATERS

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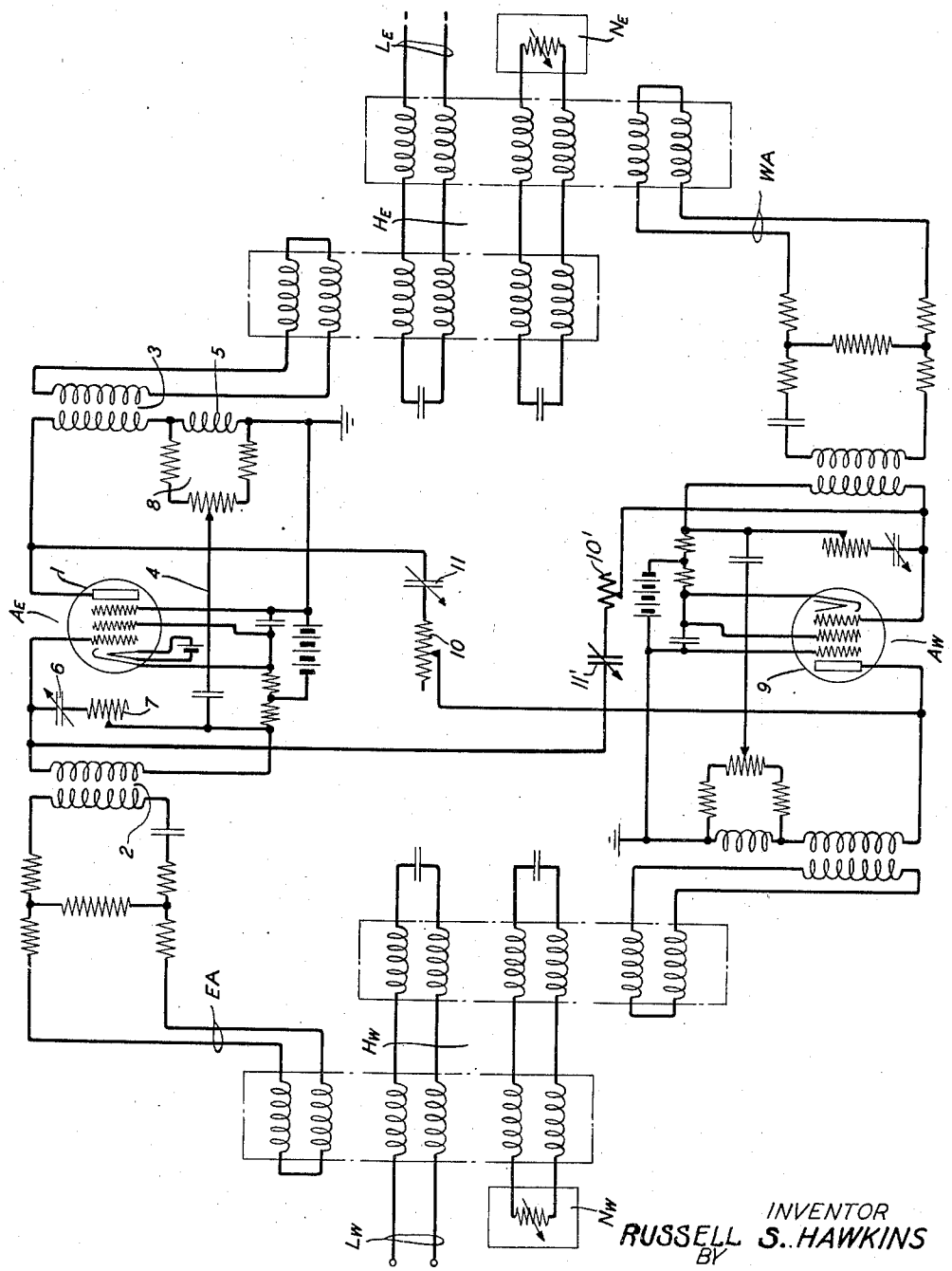

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PREVENTING SINGING IN TELEPHONE REPEATERS

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5 Claims. (Cl. 179—170)

The invention relates to two-way telephone repeaters and particularly to circuit arrangements for preventing singing in such repeaters.

In one form of telephone repeater used for repeating telephone signals between two sections of two-way telephone line, the oppositely directed one-way amplifying paths are coupled at their terminals to the line sections by hybrid coil sets operating as balanced Wheatstone bridge circuits. The balanced condition of each bridge circuit is maintained by providing a balancing network in one arm of the bridge which simulates the impedance of the line section connected in the opposite arm. For any degree of balance provided by such a network there is a critical amount of amplification in the amplifying paths which cannot be exceeded without setting up a local circulation of energy known as "singing." Where an accurate balance is impossible of attainment or requires a complexity of design of the balancing network too costly for commercial use, other expedients have been resorted to, to minimize singing, such as the use of filters in the repeating paths to limit the transmission frequency range or the use of amplifiers having a shaped gain-frequency characteristic.

Repeaters of the type to which the invention is particularly applicable are those used in telephone exchange area circuits, which should be capable of introducing gains in each direction of transmission of from 5 to 10 decibels. Since these repeaters may be connected to telephone trunks of various gauges and types of loading, compromise balancing networks are found necessary in many cases to balance these lines and, in general, the gains obtainable are seriously limited by poor balances between the lines and networks associated with these repeaters. In many repeaters of this type in use, the balances are, in general, poor at frequencies below 300 cycles and at frequencies above 1700 cycles. Greater effective transmission gains have been introduced in such repeaters without improvement of the hybrid coil balance by employing amplifiers in the repeating paths which have a gain-frequency characteristic complementary to the average return loss characteristic.

It is an object of the invention to minimize singing in such telephone repeaters.

A more specific object is to minimize singing in such repeaters due to the unbalance of the hybrid coil sets at higher frequencies.

In accordance with the present invention, in repeaters of the above described type, further improvement from the standpoint of singing prevention is attained by by-passing through a suitable transducer arrangement a small amount of high frequency signal power directly from the repeating path transmitting signals to the oppositely directed repeating path and combining it with the power at the point of introduction due to unbalance between the line and network at high frequencies in such a way as to increase the singing margin.

The exact nature and the advantages of the circuits of the invention will be better understood from the following detailed description when read in conjunction with the accompanying drawing the single figure of which shows schematically a two-wire telephone repeater embodying a preferred modification of the invention.

The two-wire repeater shown in the drawing comprises a west to east repeating amplifying path EA including the vacuum tube amplifying device A_E and an east to west amplifying path WA including the vacuum tube amplifying device Aw. The input of the path EA and the output of the path WA are coupled in conjugate relation with each other and in energy transmitting relation with the west two-way telephone line section Lw by the hybrid coil network H_W and associated resistance balancing network Nw. Similarly, the output of the path EA and the input of the path WA are coupled in conjugate relation with each other and in energy transmitting relation with the east two-way telephone line station LE by the hybrid coil network H_E and associated resistance balancing network N_E.

Each of the vacuum tube amplifying devices Aw and A_E is designed to have a shaped gain-frequency characteristic which is complementary to the average return loss frequency characteristic of the associated lines and networks to permit greater effective transmission gains to be introduced without necessitating improvement in hybrid coil balance. The amplifier A_E having such characteristics comprises a single pentode amplifying vacuum tube 1 coupled in the path EA by the input transformer 2 and the hybrid coil output transformer 3. The amplifier has a shunt negative feedback circuit 4 connected from auxiliary winding 5 on the hybrid coil output transformer 3 to the control grid of tube 1. The input transformer 2 and the output transformer 3 are designed to give the amplifier a desired low frequency characteristic, and the high frequency response can be adjusted as desired by changing the amount of feedback through circuit 4 by adjusting the variable condenser 6 and the vari-

able resistances 7 and 8 connected in that circuit. The amplifier Aw in the amplifying path WA comprises a single amplifying vacuum tube 9 having a shunt negative feedback circuit and associated circuits identical with that of the amplifier AE in the path EA as described above.

The anti-singing arrangement of the invention consists of a variable condenser 11 and resistance 10, or other transducer network, connected in series between the plate circuit of the amplifying tube 1 in the west amplifier path WA and the plate circuit of the amplifying tube 9 in the amplifying path EA providing direct by-pass between the amplifying paths of a small amount of power of desired higher signaling frequencies. By proper selection and adjustment of the elements in the transducer network 10, 11 of this anti-singing arrangement, it can be made to operate in either of two ways or a combination thereof. First, the power introduced by the arrangement in the singing path may be of such a nature that it cancels the power of the circulating currents due to unbalance between the balancing network and associated two-way line at the higher frequencies to the extent that the magnitude is substantially reduced and singing thus discouraged; it may be made to shift the phase of these high frequency circulating currents sufficiently so that the singing condition is improved with no substantial reduction in magnitude; or it may combine these two methods so that at some frequencies one or the other may predominate. Ordinarily, the first method would be preferable because circulating current of appreciable magnitude tends to modify the through insertion gain characteristic. There are, however, cases where singing occurs at frequencies which are not important on the through circuit, and the latter methods would be more satisfactory in these cases.

Obviously, by utilizing more elements in the anti-singing network, the better the device can be made to work over the frequency range at which unbalance occurs. Also, it will be evident that the anti-singing connection between the plates of the amplifier tubes as shown in the drawing may be effective for both hybrid coil sets. If the unbalances are identical, i. e., the two lines and networks are the same, this is probably a tolerable condition. If they are different, the arrangement may be adjusted to act as a compromise or, better perhaps, two similar anti-singing by-pass paths should be provided, one connected between the input circuits of the two amplifiers, for example, between their control grid circuits as indicated, and the other between the two amplifier output circuits as previously described, the values and adjustments of the elements in the two arrangements being separably controllable and correlated to the respective lines and networks. The elements in the transducer network connected between the control grid circuits of the amplifier tubes AE and Aw may be the same as in the transducer network 10, 11 connected between plates of these tubes, as indicated by the use of similar characters for identifying the corresponding elements in the two networks except that each character in the case of the former network is followed by a prime (') mark.

Tests have been made of a two-wire repeater essentially as shown in the drawing in which the balancing networks were 1800-ohm resistances simulating the impedances of the associated loaded lines, with and without the anti-singing condenser (of value 0.02 microfarad) between the plates of the two amplifier tubes. These tests showed that at different high audio frequencies ranging from 3500 to 9000 cycles per second a substantial improvement was attained by the use of the anti-singing arrangement, the increase in transmission loss ranging from 12.2 decibels at 3500 cycles to 3.7 decibels at 9000 cycles. It will be seen from these figures that the improvement decreases in magnitude as the frequency increases. This is not necessarily so but is often desirable because the singing margin may be reduced as the frequency is removed further from the transmitted band. If some frequency or range of frequencies is considerably more critical than others, the arrangement should be adjusted to favor them. Entirely different results will be obtained if the poling is reversed in a particular set-up since the phase is changed by 180 degrees, and singing will, generally speaking, be poorer than if no anti-singing device were employed, assuming an improvement is obtained with normal poling.

Various modifications of the circuit of the invention as illustrated and described which are within the spirit and scope of the invention will occur to persons skilled in the art. It is to be understood that the values of the anti-singing condenser and the resistance network given are to be taken by way of example only and not as limiting the invention.

What is claimed is:

1. In a two-way signal transmission system including a two-way signal transmission line and a two-way repeater comprising two oppositely directed one-way signal amplifying paths each including an amplifier, connected in said line by hybrid balancing sets and associated balancing networks, means to prevent the setting up of a singing condition in said repeater due to unbalance between said line and said balancing networks at certain higher frequencies, comprising auxiliary means to balance the current of said certain frequencies only in the circuits of the amplifiers in the two one-way repeating paths against each other.

2. The system of claim 1 in which the amplifier in each one-way repeating path includes an electron discharge amplifying device having a plate circuit, and said auxiliary means comprises a capacitive connection between the plate circuits of the two electron discharge devices for by-passing the output currents of said certain frequencies in the proper phase and magnitude to balance out circulating currents of said certain frequencies.

3. The system of claim 1 in which the amplifier in said one-way repeating path includes an electron discharge amplifying device having a plate circuit, and said auxiliary means comprises a transducer network connected directly between the plate circuits of the two electron discharge devices, designed to by-pass between said paths the output currents of said certain frequencies in the proper phase or magnitude, or both, to increase the singing margin at said certain frequencies.

4. The system of claim 1, in which the amplifier in each one-way repeating path includes an electron discharge amplifying device having a plate circuit, each of said amplifiers having a gain-frequency characteristic which is complementary to the average return loss characteristic of said repeater, and said auxiliary means comprises a transducer network connected between the plate circuits of the two electron discharge de-

vices for by-passing output signal currents of said certain frequencies in the proper phase and magnitude to effectively balance out the circulating unbalance currents of said certain frequencies, thereby allowing greater effective transmission gains to be introduced in said amplifiers without necessitating improvement in the balance between said balancing networks and said two-way line.

5. The system of claim 1, in which the amplifier in each one-way repeating path includes an electron discharge amplifying device including a plate circuit and a control grid circuit, each of said amplifiers having a gain-frequency characteristic which is complementary to the average return loss characteristic of said repeater, and said auxiliary means comprises a transducer network connected directly between the plate circuits of the amplifying devices in the two amplifying paths and a second transducer network connected directly between the control grid circuits of said amplifying devices, for respectively by-passing certain frequencies corresponding to the unbalance frequencies of a different one of said hybrid sets, in the proper phase and magnitude relations to effectively balance out the circulating currents of the unbalance frequencies.

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