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TWO-WAY AMPLIFIER

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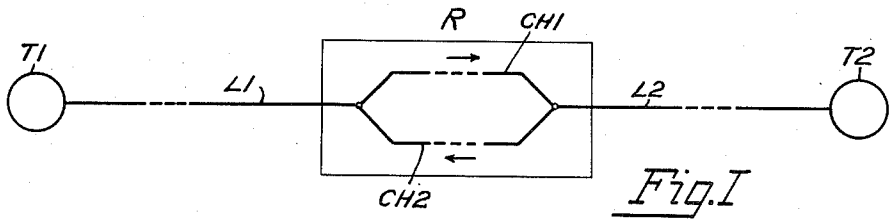


Fig. 1

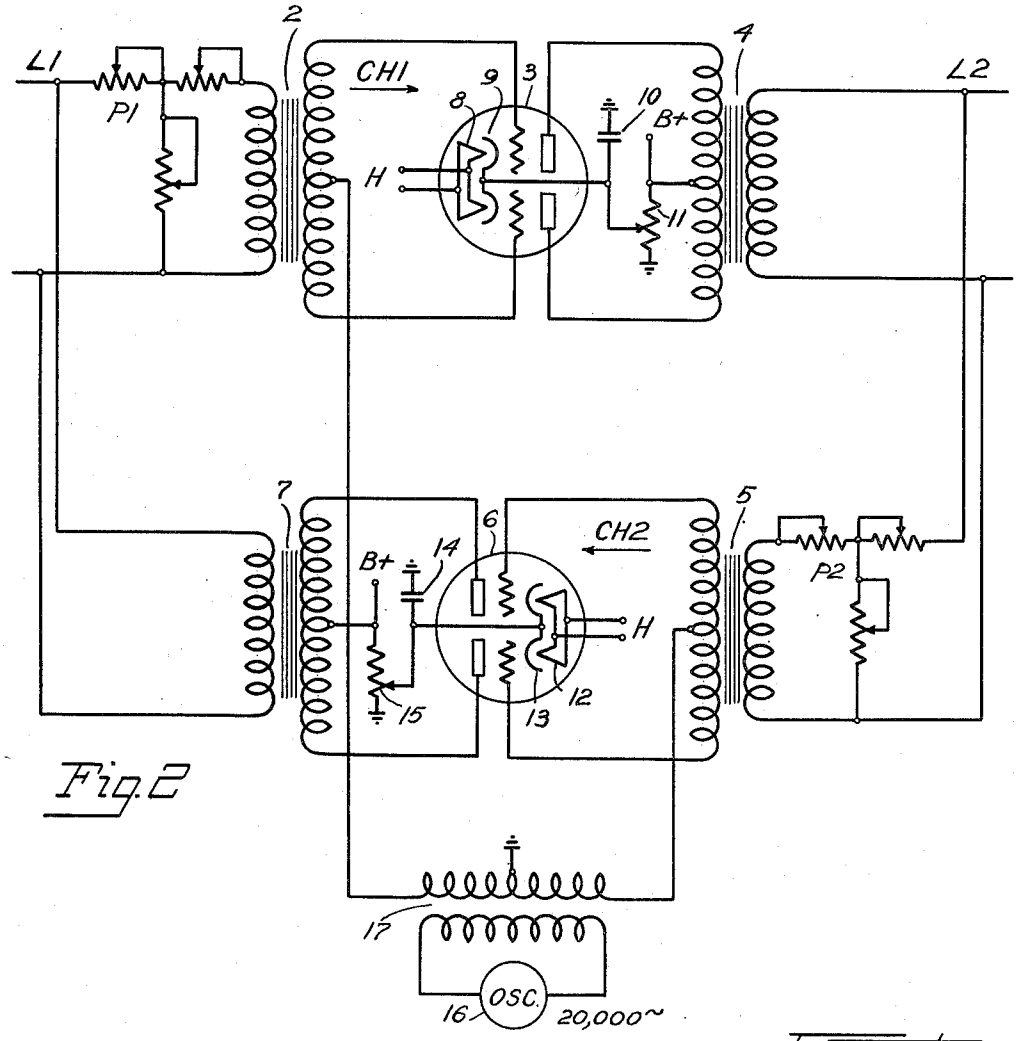


Fig. 2

Inventor:
Harry J. Donaldson
By C. P. Soper
Atty.

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TWO-WAY AMPLIFIER

Harry J. Donaldson, Chicago, Ill., assignor to Kellogg Switchboard and Supply Company, Chicago, Ill., a corporation of Illinois

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1 Claim. (Cl. 179—170)

The present invention relates to two-way amplifiers.

The object of the invention is the production of a simple arrangement for interrelating the two amplifying portions of a two-way amplifier to avoid the feed-back or "singing" which renders such amplifiers inoperative unless special precautions are taken.

The invention is particularly useful as a two-way voice-current repeater for use in telephone systems, although its use is not limited thereto.

When voice currents are transmitted over long-distance telephone lines, they are soon attenuated to such an extent that they cannot be heard at the distant end unless amplified at one or more points along the line. Likewise, voice currents coming from a distance in the reverse direction must be amplified if they are to be heard. Accordingly, amplification must be provided for in both directions, and this is accomplished by what are termed telephone repeaters, such a repeater being in reality two amplifiers arranged respectively to amplify the voice currents passing in opposite directions. The expedient ordinarily adopted for preventing the two amplifiers, comprising a voice-current repeater, from oscillating or singing is substantially to eliminate feed-back from the output of either to the input of the other by employing what is sometimes called an artifical line at the output of each, the artificial line being substantially balanced with the natural line. Feed-back from the output of one amplifier to the input of the other is then prevented by suitable balance coils connecting the output terminals of the amplifier with the associated natural line and the balancing artificial line. This arrangement, however, is expensive and troublesome because of the fine balance which must be provided and maintained.

In the present invention, the expedients hereinbefore mentioned are unnecessary, as an oscillating or singing condition of the amplifiers is prevented by providing means which renders the two amplifiers effective alternately only—both never being effective for signal amplification at the same time. Thus the amplified signal energy, from either amplifier, which is supplied to the input of the other amplifier at the same time that it is supplied to the outgoing line, is unable to pass through the other amplifier because such other amplifier is inoperative at that time.

An important feature of the arrangement is that the two amplifiers are rendered alternately active and inactive at a frequency sufficiently above the signal frequency that the intelligibility of the signal is not interfered with. When the repeater is employed in a circuit used for conversation the frequency will be above that of audition.

Other objects and features of the invention will become more apparent as the description progresses.

Referring now to the accompanying drawing comprising Figs. 1 and 2, it shows the invention applied to telephone, or similar, lines.

Fig. 1 shows diagrammatically the repeater R interconnecting two line sections L1 and L2 included in a two-way conversational path between telephones T1 and T2, while Fig. 2 shows the circuit arrangement of the repeater R of Fig. 1 and its interconnection with the line sections L1 and L2.

Referring first to Fig. 1, let it be assumed that the subscribers at telephones T1 and T2 are conversing over the long-distance line including line sections L1 and L2, by way of the two-way repeater R. Voice currents originating at telephone T1 may pass over line section L1 to the repeater R, being passed through channel CH1 thereof wherein they are amplified and passed to line section L2, and thence to telephone T2. Voice currents originating at telephone T2 pass over line section L2 to the repeater R, whereat they are amplified by being passed through channel CH2 to line section L1, and thence to the telephone T1. The amplified voice currents passing through either of the two channels of the repeater R are prevented from passing back through the other repeater channel to the line on which they originated, to thus set up a singing or oscillating condition, by the previously mentioned arrangement for rendering the two amplifying channels effective alternately one at a time, as will be brought out in connection with Fig. 2.

As shown in Fig. 2, the repeater R includes equipment providing two amplifying channels CH1 and CH2. Channel CH1 is for amplifying voice currents incoming over line section L1 and outgoing over line section L2, while channel CH2 is for amplifying voice currents incoming over line section L2 and outgoing over line section L1.

The equipment included in channel CH1 includes the customary adjustable attenuator pad P1 (or T-pad as it is sometimes called), the input transformer 2, the double triode vacuum tube 3, and the output transformer 4. The transformers 2 and 4 are interconnected with

the two halves of the double-triode tube 3 for what is commonly termed "push-pull" amplification. The equipment for channel CH2 is a duplicate of that of channel CH1 and includes the adjustable attenuator pad P2, input transformer 5, double triode vacuum tube 6, and the output transformer 7. It will be observed that push-pull amplification is employed in channel 2 as in channel 1.

The equipment for rendering the two channels effective, alternately, includes the 20,000-cycle oscillator 16 and the transformer 17. The secondary winding of transformer 17 has its midpoint grounded, and the free terminals thereof are extended respectively to the midpoints of the secondary windings of the input transformers 2 and 5. At all times when the oscillator is placing one potential, through the secondary winding of one input transformer to the grid elements of the associated vacuum tube, it is placing the opposite potential on the grid elements of the other vacuum tube. By this action, amplification is accomplished alternately in the two channels, with no overlapping interval, as will be explained more fully hereinafter.

It will be understood that the heater leads marked H for each of the tubes 3 and 6 are connected to a suitable supply of current for heating the cathodes 9 and 13 through the action of the heaters 8 and 12, and that the terminals marked B+ and connected to the midpoints of the primary windings of the output transformers 4 and 7 are connected to a suitable source of current of a potential positive with respect to ground.

The cathodes 9 of the two halves of the double-triode tube 3 are connected to the slider of the potentiometer 11, whereby a potential positive with respect to ground may be applied to the cathodes, thereby causing the grids of the tube to have a negative bias with respect to the cathodes. Similarly, the slider of the potentiometer 15 places a desired positive potential on the cathodes 13 of the double tube 6, thereby causing the grids of the tube to be negative with respect to the cathode. The condensers 10 and 14 may be employed to maintain the cathode potential substantially stationary with respect to ground during variable current flow through the plate-cathode circuit paths, to ground by way of the potentiometers 11 and 15. It is preferred that potentiometers 11 and 15 be each adjusted so as to make the associated grids slightly more negative (with respect to the cathodes) than the cutoff point of the tube, whereby, with the oscillator 16 not operating, no plate current flows in either of tubes 3 and 6. This arrangement prevents undesirable oscillating or singing through the two channels of the repeater in series in the event of a temporary oscillator failure.

It is further preferred that the voltage of the oscillator be such that, on the peak positive swing of the oscillator with respect to either of the amplifying tubes, the grid potential of the tube reaches substantially the center of the working range of bias, which will be somewhat negative with respect to the cathode, intermediate cathode potential and the normal grid biased potential.

The adjustable pad P1 is preferably so set as to give the desired gain through channel CH1, from line section L1 to line section L2, while the pad P2 may be adjusted to give the desired gain through channel CH2, from line section L2 to line section L1.

The tubes 3 and 6 may each be of a type sold currently as double-triode tube 6SC7.

The double triode tube type 6SC7 has characteristics such that a desirable normal working grid bias is about 1 volt negative with respect to the cathode. The maximum desirable signal range of the grid potential is then from zero (or cathode) potential to about two volts negative with respect to the cathode. The cutoff grid potential is about 2.5 volts negative. In order to insure that peak input signal potential, during a time when the oscillator may be turned off, will not likely return the grid potential to the positive side of the cutoff point, it is preferred that the potentiometers 11 and 15 be set to provide a normal grid bias of, say, 3.5 volts negative with respect to the cathode (by applying a corresponding positive voltage on the cathodes 9 and 13 respectively). Under this condition, the peak oscillator voltage (measured across either half of the secondary winding of the transformer 17) may be 2.5 volts. On a positive half cycle of either half of this transformer, the corresponding grid is brought to the desired 1-volt negative working bias.

For best performance it is believed the oscillator output should have a flat-top wave form approaching what is sometimes referred to as a square-wave form, which can be readily accomplished by a suitable choice and adjustment of the oscillator.

With the repeater conditions adjusted as set forth, and the oscillator 16 operating, channel CH1, for example, is rendered operative for signal transmission and amplification on alternate half cycles of oscillator 16. Each time the grid potential of the two halves of tube 3 is rendered more positive than the cutoff voltage, plate current flows from the associated B+ terminal, through the two halves of the primary winding of transformer 4, through each of the plates of the tube 3, to ground through the cathodes 9 and the lower portion of potentiometer 11.

One-half cycle later, the grid potential of the tube 3 is rendered more negative than the cutoff point of the tube, terminating the flow of plate current through the tube 3. At this time, positive potential is impressed by the other half of the secondary winding of transformer 17, through the secondary winding of input transformer 5, on the two grids of tube 6, bringing these grids from below the cutoff voltage to substantially the desired working voltage of the tube. When this occurs, plate current flows from the associated B+ terminal, through the two halves of the primary winding of output transformer 7, through the plates of tube 6 to the cathodes 13, and thence to ground through the lower portion of potentiometer 15.

At the end of this half cycle the grids of tube 6 are again returned to a more negative potential than the cutoff potential, causing the plate current to cease in the tube 6. At this time, the flow of plate current is resumed in the tube 3 responsive to positive potential impressed on the grids thereof by the transformer 17.

The flow of plate current thus occurs alternately in the tubes 3 and 6, with no overlapping interval.

With no signal being received over either of the line sections L1 and L2, the foregoing operations have no effect on line sections L1 and L2 because of the push-pull connections of the channels CH1 and CH2. For example, the same potential is applied to the two grids of tube 3 through the center point of the secondary winding of transformer 2, with the result that equal

current flows through the two plate circuits of the tube. This plate current flows differentially in the two halves of the primary winding of output transformer 4 whereby the secondary winding of this transformer is unaffected. Channel CH2 passes no signal to the line L1 under this condition for the same reason.

Repeating and amplifying

Assume now that voice currents arrive over line section L1, to be amplified and repeated to line section L2. Assume further that the voice-current frequency being received is 1,000 cycles, for example. During a given half cycle of the voice current received over line L1, the potential on the upper grid of tube 3 becomes more positive than the center tap of the secondary winding of the transformer 2, while the potential on the lower grid of the tube becomes more negative than the center tap potential. While this half cycle of voice current is being received, the plate current in tube 3 starts and stops a number of times due to the previously described action of the oscillator 16. During each brief interval that the plate current is allowed to flow, the more positive potential on the upper grid of tube 3 causes an increased plate current in the upper plate circuit, while the more negative potential on the lower grid of the tube 3 causes a decreased current in the lower plate circuit of the tube. As a result, the secondary winding of output transformer 4 is affected because of the unbalanced plate current through the primary winding. An amplified portion of the positive half cycle of voice current is thus transmitted to line section L2 each time plate current flows in tube 3. These intermittent portions of the positive half cycle of voice current pass out over line section L2 to the telephone T2 of Fig. 1.

During the next succeeding half cycle of the incoming voice current, the upper grid is rendered more negative than it normally is, while the lower grid is rendered more positive than it normally is. Therefore, during this half cycle of voice current flow, each time channel CH1 is rendered operative by the described action of the oscillator, the reversed unbalanced current flow which occurs through the primary windings of transformer 4 causes reversed impulses of current to flow in the output winding of the transformer, which are passed on over the line section L2 to the telephone T2. The operation is repeated from the succeeding cycles of voice current incoming from line L1.

These repeated impulses of voice current in line section L2 pass readily through input transformer 5 to the grids of tube 6 in channel CH2, but they cannot proceed further through channel CH2 to line section L1 to cause a singing condition, because the oscillator 16 maintains the tube 6 of channel CH2 inoperative to transmit voice frequency throughout the time that channel CH1 is operative.

The voice currents received over line section L2 from the telephone T2 of Fig. 1 are similarly amplified and passed through channel CH2 to the line section L1 and thence to the telephone T1 of Fig. 1, passing through the channel CH2 of the repeater R intermittently in sections, each such section passing through channel CH2 at the instant when channel CH1 is in an inoperative condition. Therefore, the amplified signals reaching line section L1 through channel CH2 from line section L2 cannot pass back to the originating line section L2 to cause an oscillating or singing operation of the repeater, because each of the channels CH1 and CH2 is inoperative to repeat and amplify at the moment when the other channel is repeating and amplifying.

In operation, it has been found that the repeater R, as illustrated in Fig. 2, can provide a gain in signal strength in each direction of about fifteen decibels, with no singing or other observable feeding-back occurring.

It has been found that the audibility and fidelity of the amplified and repeated signals is not affected to any detectable degree by the high-frequency interruptions thereof under control of oscillator 16. The explanation for this is that an interruptnig frequency of 20,000 cycles is inaudible to most human ears.

It will be understood, of course, that signals other than voice-current signals may be transmitted over the two-way repeater R from one interconnected line section to another, and that signal frequencies lying outside the range of audibility may be used. It will be understood also that the 20,000-cycle frequency of the oscillator is given only by way of example, and that higher and lower oscillator frequencies may be used. It is preferred, however, that the oscillator frequency be higher than the signal frequency in any case in order that the character of the signal be not disturbed, from the standpoint of the receiving station, by its passage in disconnected sections through the repeater R.

Arrangements specifically different from the one herein disclosed will suffice. For example, two separate triodes may be used in place of either of the double triodes, and other forms of amplifier tubes (such as those with screen and suppressor grids) may be employed.

I claim:

A repeater comprising two amplifying channels interconnected with a common signal line, each channel including a separate amplifying tube having a cathode and an anode, potential means for driving space current through each tube by way of its cathode and anode, means for applying signal potentials to the space between each cathode and its associated anode pursuant to amplifying received signals by varying the associated space current, means for applying a blocking potential continuously to each said space, and means for applying an unblocking potential intermittently to each said space, said unblocking potential being applied alternately to the two said spaces, said blocking potential being sufficient to block the flow of space current when no signals are being received and additionally sufficient to block such flow when signals are being received, and said unblocking potential being sufficient to reestablish the space current at such a value that the space current responds faithfully to the applied signal potentials during such time as the unblocking potential is applied.

HARRY J. DONALDSON.