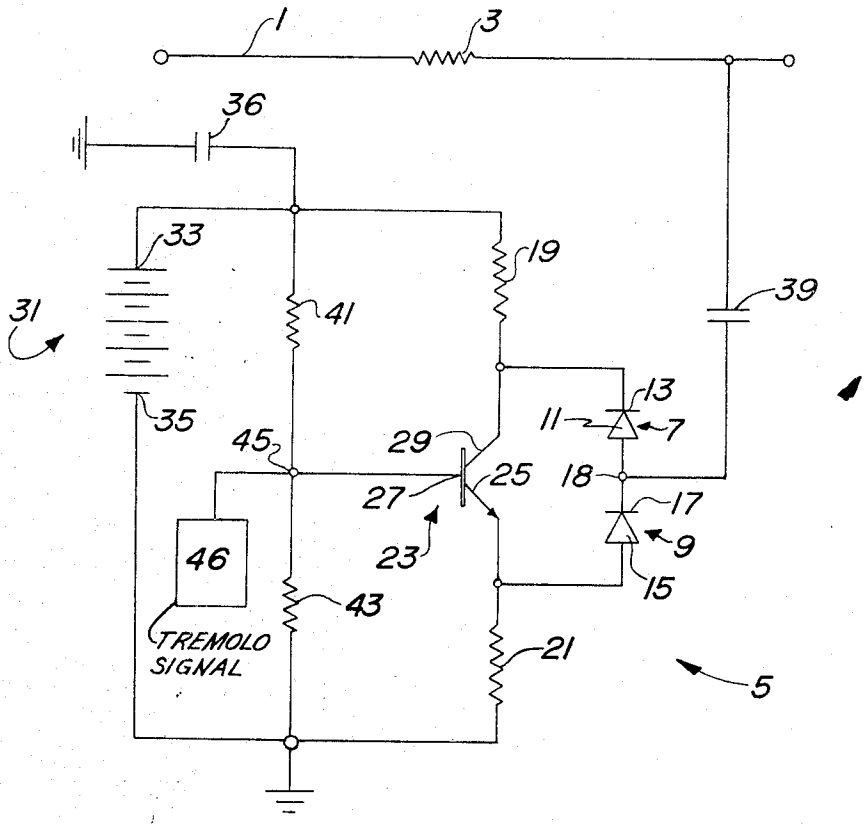
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TREMOLO PRODUCING ARRANGEMENT IN WHICH THE TREMOLO SIGNAL IS ISOLATED FROM THE AUDIO CIRCUIT

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TREMOLO PRODUCING ARRANGEMENT IN WHICH THE TREMOLO SIGNAL IS ISOLATED FROM THE AUDIO CIRCUIT

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ABSTRACT OF THE DISCLOSURE

A tremolo variation is impressed upon an electrical tone signal, without introducing the tremolo signal into the tone signal transmission channel, by utilizing a circuit that provides a variable impedance shunt path for the tone signal. A pair of back-biased series diodes is connected in parallel with a transistor which is the central component of a DC voltage divider. Application of the tremolo signal to the transistor varies the bias of the diodes, and hence the impedance of the diodes with respect to the tone signal conveyed to the juncture point of the diodes, the juncture point being maintained at a constant voltage by the action of the voltage divider.

This invention generally relates to an arrangement for producing a tremolo effect in a musical signal, and more particularly this invention relates to a tremolo producing arrangement for an electrical musical tone signal in which the tremolo signal is isolated from the tone signal channel.

It has long been recognized that a cyclical variation in the amplitude of a musical tone at a low frequency creates a pleasurable listening effect. This effect is generally known as a "tremolo." Prior art arrangements for producing a tremolo effect in electrical musical instruments may generally be broken into two basic approaches: (1) modulation of tone signal amplitude by control of the tone generator or an amplifier; and (2) variable attenuation of a tone signal by using a variable impedance device in the tone signal transmission channel. Both of these approaches have the disadvantage that the tremolo signal is introduced into the tone signal transmission channel. Introduction of the tremolo signal into the tone signal transmission channel can produce distortion and other undesired effects. For instance, if the modulating tremolo signal is not sinusoidal, a "thump" may be produced in the audio output.

A third approach that may be utilized in producing a tremolo effect is to provide a circuit connected from the tone signal transmission channel to ground. This circuit has a variable impedance so that the tone signal may be variably "bled-off" or attenuated. Prior art arrangements that utilize this approach have the same disadvantage as the two aforementioned basic approaches, i.e., that the tremolo signal is introduced into the tone signal transmission channel. This is true because the variable impedance to ground is usually directly controlled by the tremolo signal, so that the voltage level in the tone signal transmission channel is repetitively altered to variably attenuate the tone signal at a tremolo rate. The variation of the voltage level in the tone signal transmission channel results in the tremolo signal actually being introduced into the tone signal transmission channel. This produces a superposition of the tremolo signal upon the tone signal.

To eliminate the undesirable introduction of the tremolo signal into the tone signal transmission channel while producing a tremolo, the present invention was evolved. Briefly, in the preferred embodiment disclosed herein, the subject invention involves a shunt or "bleed-off" path including a tremolo producing circuit connected to the tone signal transmission channel to produce a tremolo effect. In order to produce a tremolo without introducing the tremolo signal into the tone signal transmission channel, the shunt path has a variable impedance for the tone signal, but a constant voltage level is maintained at the point in the tremolo producing circuit to which the tone signal transmission channel is connected. This is achieved by utilizing a tremolo producing circuit that is balanced about a constant voltage point in the circuit.

For example, in the preferred embodiment disclosed herein, a pair of diodes are connected in series, with the common juncture of the diodes (the constant voltage point of the circuit) being connected to the tone signal transmission channel through a blocking capacitor. The series connected diodes are connected in series with and placed between a pair of resistors having equal magnitudes. One of the resistors is connected to a DC voltage source, while the other is connected to ground. The series connected diodes are arranged to be back-biased by the DC voltage. A transistor is positioned in the circuit with its emitter-collector circuit in parallel with the series diodes, i.e., the collector is connected to one side of the series diode arrangement, while the emitter is connected to the other side of the series diode arrangement. The base of the transistor is adapted to receive a tremolo signal.

Since the resistors and diodes are balanced, the voltage level at the common juncture of the diodes (constant voltage point) is always half the magnitude of the applied DC voltage, regardless of the conducting state of the transistor. However, the conducting state of the transistor will determine the voltage appearing across the series connected diodes, thereby setting the bias state of the diodes. As the bias state of the series connected diodes is altered, the impedance of the circuit to the tone signal varies at a rate determined by the frequency of the tremolo signal applied to the base of the transistor. Thus, the amount of the tone signal that is shunted through the blocking capacitor and the tremolo producing circuit varies at a tremolo rate to variably attenuate the tone signal at this rate and to produce a tremolo effect in the audio output. In this manner, a tremolo effect is produced, and the balanced circuit arrangement prevents a change in the voltage level in the tone signal channel, so that the tremolo signal is not directly introduced into the tone signal transmission channel. Therefore, the magnitude of the tone signal is variably attenuated as the signal alternates about a fixed potential level, rather than having a tremolo signal superposed thereon.

Accordingly, a primary object of this invention is to provide a tremolo producing arrangement which does not introduce the tremolo signal directly into the tone signal transmission channel.

Another object of this invention is to provide a tremolo producing arrangement which does not cause distortion or other undesirable effects in the ultimate audio output.

Yet another object of the present invenion is to provide a tremolo producing arrangement which is relatively easy to construct and which utilizes solid state circuitry.

These and other objects, advantages, and features of the subject invention will hereinafter appear, and, for purposes of illustration, but not of limitation, an exemplary embodiment of the subject invention is shown in the appended drawing, the single figure of which illustrates a schematic circuit diagram of a preferred embodiment of the present invention.

In the circuit diagram of the sole figure of the drawing, a tone signal line or transmission channel **1** is schematically illustrated. A series impedance **3** is located in tone signal transmission channel **1**.

A tremolo producing arrangement or circuit 5 is operatively associated with tone signal transmission channel 1. Tremolo producing arrangement 5 includes a pair of series connected diodes 7 and 9. Diode 7 has a plate 11 and a cathode 13, while diode 9 has a plate 15 and a cathode 17. Diodes 7 and 9 are selenium diodes which have a linear portion of their characteristic curve passing through the no-bias point. The common juncture of diodes 7 and 9, where plate 11 of diode 7 is connected to cathode 17 of diode 9, defines a constant voltage point 18.

A resistor 19 is connected to cathode 13 of diode 7, and a resistor 21 is connected to plate 15 of diode 9. Resistors 19 and 21 are matching (i.e., identical), as are diodes 7 and 9.

A transistor 23 is connected across the series connected diodes 7 and 9. As illustrated, transistor 23 is of the NPN type and has an emitter 25, a base 27, and a collector 29. Collector 29 of transistor 23 is connected to the junction of resistor 19 and cathode 13 of diode 7, and emitter 25 of transistor 23 is connected to the junction of resistor 21 and plate 15 of diode 9, so that the emitter-collector circuit of transistor 23 is in parallel with series connected diodes 7 and 9.

A DC voltage source 31, indicated schematically as a conventional storage battery, provides a bias voltage for the circuit. The positive side 33 of source 31 is connected to resistor 19, while the negative side 35 of source 31 is connected to ground, as is resistor 21. A capacitor 36 connected to ground from the positive side 33 of source 31 indicates that this side of the source is at ground potential for an AC signal. These connections of DC voltage source 31 are such that diodes 7 and 9 are back-biased, but within the linear portion of the characteristic curve. The balanced arrangement of resistors 19, 21 and diodes 7, 9 causes the applied DC potential to be apportioned in such a manner that point 18 is always at a constant voltage level equal to exactly half the magnitude of the potential supplied by DC voltage source 31. Point 18 (which as previously indicated is located at the common juncture of diodes 7 and 9) is the point at which tremolo producing arrangement 5 is connected to tone signal channel 1 through a blocking capacitor 39. Blocking capacitor 39 passes the tone signal to tremolo producing circuit 5, but prevents DC voltage in circuit 5 from being applied directly to tone signal transmission channel 1.

A bias arrangement for base 27 of transistor 23 is provided by series resistors 41 and 43 connected across DC voltage source 31. Resistor 41 is connected between positive side 33 of source 31 and a point 45, and resistor 43 is connected between grounded negative side 35 of source 31 and point 45. A tremolo signal is applied to the circuit at point 45 from a conventional tremolo signal source 46. Tremolo signal source 46 is any conventional generator of low frequency signals used in tremolo or vibrato producing circuits. A tremolo signal appearing at point 45 is connected to base 27 of transistor 23 to vary the conductivity of transistor 23 at the tremolo rate.

A tone signal appearing on tone signal transmission channel 1 has a frequency such that it will be transformed into a specified audio tone by a suitable converter (not shown), such as a conventional loudspeaker. To produce a tremolo effect, the tone signal is variably attenuated at a tremolo rate. To achieve this effect, the tone signal is connected to point 18 of tremolo producing arrangement 5 through blocking capacitor 39.

Due to the balanced arrangement of diodes 7 and 9 and resistors 19 and 21, the voltage level at point 18 has a fixed value, i.e., one-half the magnitude of the applied potential supplied by DC voltage source 31. This is true in spite of any variations that occur in the conductivity state of transistor 23. For example, if transistor 23 is transferred to a lower conductivity state by the signal applied to base 27, the voltage drop across the emiter-collector circuit of transistor 23 will increase. The increase in the voltage drop across transistor 23 means that the voltage drop across resistors 19 and 21 must be decreased. However, since resistors 19 and 21 are equal, the voltage drops across these resistors will still have the same value, although this value is less than it was before the decrease in conductivity of transistor 23. At the same time, the increase in the potential across transistor 23 increases the voltage drop across the series connected diodes 7 and 9. Since the voltage drop across the complete circuit remains constant at the magnitude of the potential supplied by DC voltage source 31, the decreased voltage drop across resistor 19 (for example) must be exactly equaled by the increase in voltage drop across diode 7. This is true because diodes 7 and 9 are matched so that the voltage drops across these diodes are equal (as is also true of resistors 19 and 21), although the magnitude of the voltage drops vary with changes in the conductivity state of transistor 23. Therefore, the voltage level at point 18 remains constant throughout changes in the conductivity state of transistor 23.

As pointed out above, although the potential at point 18 remains constant, the potential across diodes 7 and 9 will vary with changes in the conductivity state of transistor 23. Thus, the biasing of diodes 7 and 9 varies with changes in the conductivity state of transistor 23. For example, if the voltage across the emitter-collector circuit of transistor 23 is v volts, the voltage drop across each of the diodes 7 and 9 will be $v/2$. This sets the operating characteristics of the diodes at a specified point on the linear portion of the characteristic curve corresponding to a bias of $v/2$. Positive portions of the tone signal will be bled to AC ground (as symbolized by capacitor 36) through diode 7 and negative portions of the tone signal will be bled to ground through diode 9. At the chosen operating point diodes 7 and 9 will have a predetermined impedance to the respective portions of the tone signal. As the operating point is varied up and down the linear portion of the characteristic curve, the impedances will vary correspondingly. Due to operating on the linear portion of the characteristic curve, the tone signal is not distorted by the variable impedance path.

By varying the conductivity of transistor 23 at a tremolo rate, the attenuation of the tone signal in the tone signal transmission channel 1 may be varied at a tremolo rate to produce a tremolo effect in the audio output. However, the balanced arrangement maintains a constant potential at point 18 so that the tremolo signal applied to transistor 23 is not directly introduced into tone signal transmission channel 1. In this fashion, the tremolo effect is produced without incurring the problems that are encountered when the tremolo signal is introduced into the tone signal transmission channel 1.

It should be understood that the embodiment described is merely exemplary of the preferred practices of the present invention and that various changes, modifications, and variations may be made in the arrangements, operations, and details of construction of the elements disclosed herein, without departing from the spirit and scope of the present invention, as defined in the appended claims.

What is claimed is:

1. A tremolo producing arrangement for an electrical tone signal appearing on a tone signal transmission channel comprising:

a source of tremolo signal;

variable impedance circuit means located outside the tone signal transmission channel to provide a shunt impedance for the electrical tone signal, said shunt impedance being varied in response to said tremolo signal;

control means in said variable impedance circuit for maintaining a point in said variable impedance circuit at a constant voltage independently of circuit impedance changes therein; and

coupling means for connecting said constant voltage point to the tone signal transmission channel,

whereby the electrical tone signal may be variably attenuated at a tremolo rate without introducing said tremolo signal directly into the tone signal transmission channel.

2. An arrangement as claimed in claim **1**, wherein said control means comprises:

a DC voltage source;

a pair of unidirectional conducting devices connected in series, with said constant voltage point located at the common juncture of said series connected unidirectional conducting devices;

tremolo signal controlled means connected in parallel with said series connected unidirectional conducting devices to vary the impedance thereof at a tremolo rate; and

a pair of matched resistors connected in series with and on opposite sides of said tremolo signal controlled means, said DC voltage being applied across the series combination comprising said tremolo signal controlled means and said pair of matched resistors.

3. An arrangement as claimed in claim **2**, wherein said series connected unidirectional conducting devices are matched solid state diodes arranged to be back-biased by said DC voltage source.

4. An arrangement as claimed in claim **2**, wherein said tremolo signal controlled means comprises a transistor having base, emitter and collector electrodes.

5. An arrangement as claimed in claim **4** wherein:

said source of tremolo signal is connected to said base electrode of said transistor;

said series connected unidirectional conducting devices are matched solid state diodes having plate and cathode terminals and are connected in series between said emitter and said collector electrodes of said transistor, with the cathode of one of said diodes being connected to the plate of the other of said diodes at said constant voltage point, the cathode of the other of said diodes being connected to said collector electrode of said transistor, and the plate of said one of said diodes being connected to said emitter electrode of said transistor;

the positive side of said DC voltage source is applied to the one of said pair of matched resistors connected to said collector electrode of said transistor; and

said coupling means comprises a capacitor connected between said constant voltage point and said tone signal transmission channel.

6. An arrangement as claimed in claim **1**, wherein said control means comprises:

a DC voltage source;

a voltage divider including a variable impedance element the impedance of which varies in response to said tremolo signal, said DC voltage source being connected across said voltage divider; and

a variable impedance device connected in parallel with said variable impedance element and including said constant voltage point.

7. An arrangement as claimed in claim **6** wherein said variable impedance element is a transistor having said tremolo signal applied to the base electrode thereof.

8. An arrangement as claimed in claim **7** wherein said voltage divider further comprises matched resistors, one on either side of said transistor.

9. An arrangement as claimed in claim **6** wherein said variable impedance device comprises a pair of diodes connected in series, said constant voltage point being located at the juncture of said diodes.

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