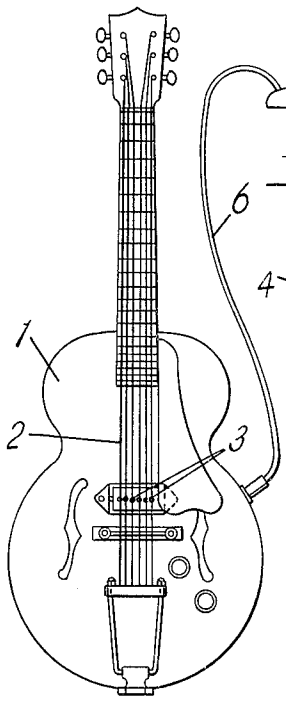
Oct. 19, 1965 G. T. SNODDY ETAL 3,213,181

TONE MODIFIER FOR ELECTRICALLY AMPLIFIED ELECTRO-MECHANICALLY PRODUCED MUSICAL TONES

Filed May 3, 1962



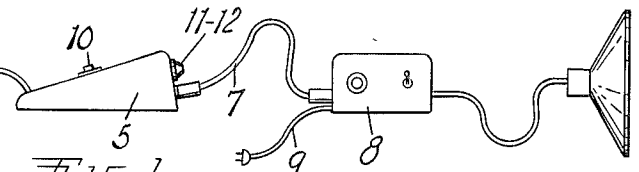


FIG. 1

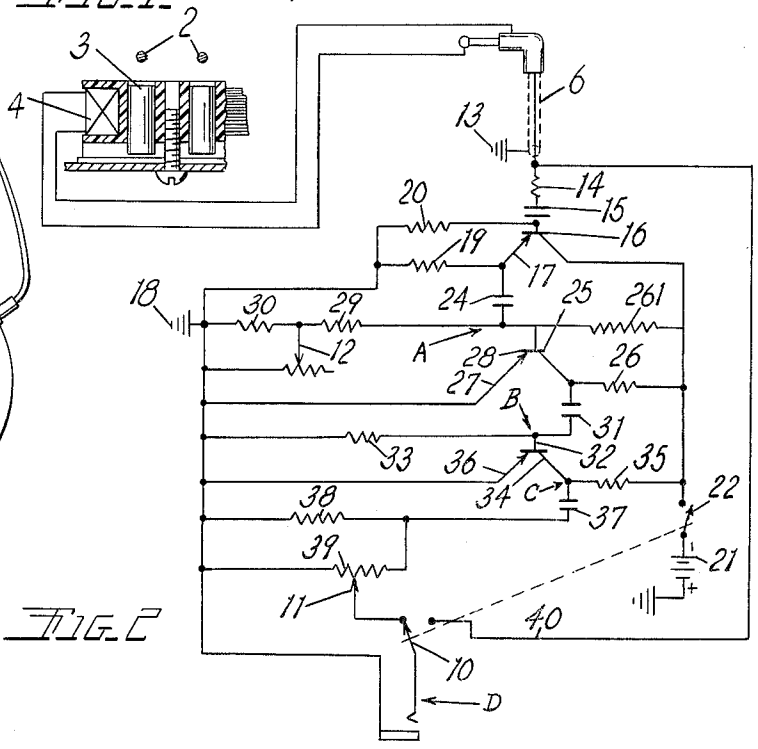


FIG. 2

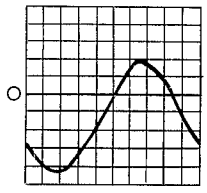


FIG. 3

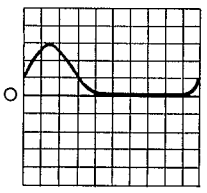


FIG. 4

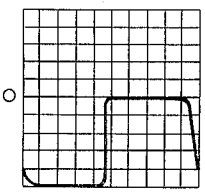


FIG. 5

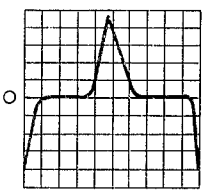


FIG. 6

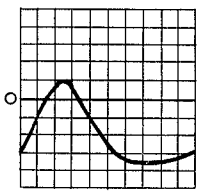


FIG. 7

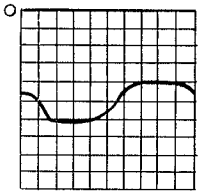


FIG. 8

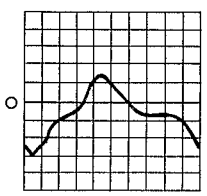


FIG. 9

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United States Patent Office 3,213,181 Patented Oct. 19, 1965



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# TONE MODIFIER FOR ELECTRICALLY AMPLIFIED ELECTRO-MECHANICALLY PRODUCED MUSICAL TONES

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Filed May 3, 1962, Ser. No. 192,202
15 Claims. (Cl. 84—1.19)

This invention relates to improvements in tone modifier for electrically amplified electro-mechanically produced musical tones. The principal objects of this invention are:

First, to provide a tone modifying attachment and circuit for electrically produced signals which will permit stringed musical instruments such as guitars, banjos and string basses to produce electrically amplified and reproduced tones simulating other instruments such as trumpets, trombones and tubas.

Second, to provide tone modifying apparatus that will permit electrically amplified stringed instruments to produce entirely synthetic tones differing from the tones of conventional musical instruments.

Third, to provide tone modifying apparatus for electrically amplified stringed instruments which will permit the musician to vary the type or quality of the tone produced both by pre-setting the controls of the apparatus and by the manner and vigor with which he plays the instrument.

Fourth, to provide a tone modifying attachment for electrically amplified guitars and the like which can be switched into and out of the amplifying circuit at will while the instrument is being played.

Other objects and advantages of the invention will be apparent from a consideration of the following description and claims. The drawings of which there is one sheet illustrate a highly practical form of the tone modifier and circuit applied to an electric guitar.

FIG. 1 is a fragmentary elevational view of the instrument and system with parts of the amplifying and reproducing system shown conventionally.

FIG. 2 is a fragmentary view, partially in section and partially in schematic circuit showing the magnetic tone creating or pick-up and electronic tone modifying elements of the system.

FIG. 3 is a graph illustrating a test signal representative of the electro-magnetic signal created by the instrument and impressed on the circuit at point A.

FIG. 4 is a graph illustrating the modified form of signal developed in the circuit at point B in response to the signal in FIG. 3.

FIG. 5 is a graph illustrating the further modified signal developed at point C in the circuit in response to the signal in FIG. 4.

FIG. 6 is a graph illustrating the modified signal developed in the circuit at point D in response to the signal in FIG. 5.

FIG. 7 is a graph illustrating a modified signal developed in the circuit at point B in response to a signal of reduced amplitude or magnitude at point A.

FIG. 8 is a graph illustrating the signal produced at point C in response to the signal in FIG. 7.

FIG. 9 is a graph illustrating the signal produced at point D in response to the signal in FIG. 8.

As stated in the objects, the invention is applicable to stringed musical instrument having electric pick-ups for creating signals in response to and conforming to the vibration of the strings of the instrument as the instrument is played. The pick-up may be electro-magnetic or electro-static and is referred to herein generally as an electric pick-up. The example of the invention illustrated is an electro-magnetic pickup and shows a guitar 1 having strings 2 which are passed over the ends of magnets or pole pieces 3 that create a magnetic field around the string. A coil 4 surrounding the magnets or pole pieces is subject to the magnetic field and develops an electric current and signal in response to variations of the magnetic field by vibration of the strings. This is a well known type of magnetic pick-up for stringed musical instruments. The electric signal from the guitar is transmitted to modifying circuits to be described in the case 5 by the cable 6. The output from the modifier is applied by the cable 7 to a conventional amplifier 8 having a power connection 9. A switch 10 on the top of the case 5 is arranged to be activated by the foot of the musician to selectively by-pass the modifying circuit. A manually settable volume control 11 having a variable tap and variable resistor 12 on the case permit adjustment of the modifier circuit as will be described.



The circuit and components of the modifier circuit and by-pass are shown in FIG. 2. The circuit from the coil 4 is grounded at 13 and fed into an impedance transforming or load balancing circuit through the resistor 14 and condenser 15 to the base or control terminal of a transistor 16. The emitter 17 of the transistor is connected to ground at 18 through the load resistor 19. A parallel resistor 20 establishes the impedance of the balancing or load circuit at the desired amount relative to the impedance of the signal generating coil 4. The collector of the transistor is energized from the negative side of the battery 21 through an on-off switch 22. The switch 22 is ganged with the by-pass control switch 10.

The tone modulated current or signal passing through the transistor 16 is coupled through the condenser 24 to a first clipping circuit including the transistor 25. The transistor is fed through the voltage dropping resistor 26 from the battery with its emitter 27 connected to ground 18. A 470 ohm resistor 261 reduces the effect of low temperature on the transistors of the circuit. The control terminal or base 28 of the transistor is connected to ground through the series resistors 29 and 30 with the variable resistor 12 connected from ground to between the two series resistors. The variable resistor varies the intensity or magnitude of the voltage applied to the control terminal 28 of the transistor 25 and may be termed an attack control resistor.

The values of the components of the first clipping circuit are selected so that the transistor 25 is overloaded to clip off or flatten the second or negative peak of the signal developed in the transistor. These may be varied but a practical set of values for a .1 volt input to the balancing circuit are as follows: resistor 14, 100 kilohms; condenser 15, .01 microfarads; resistor 20, 1 megohm; resistor 19, 10 kilohms; condenser 25, 20 microfarads; resistor 29, 2.2 kilohms; resistor 30, 22 kilohms; resistor 30, 0 to 50 kilohms and resistor 26, 1.5 kilohms. With a 3.1 volt battery this provides a minus 1.5 volt bias at the base and the emitter of transistor 16 and minus 3 volt bias at the collector of transistor 25.

The signal in the collector circuit of transistor 25 is coupled through a 20 microfarad capacitor 31 to a second clipping circuit and transistor 32 The base of the transistor and the condenser 31 are connected to ground through a 10 kilohm resistor 33. The collector 34 of the transistor is fed through a 10 kilohm resistor 35 and the emitter 36 is connected direct to ground. This second clipper circuit clips or flattens the leading or positive side of the signal and creates a square wave at point C. with a bias voltage of minus 2.5 volts.

The second clipper circuit is coupled through a .0033 microfarad condenser 37 to a differentiating circuit con-

sisting of the 56 kilohm resistor 38 and parallel variable resistor 39 which is part of the volume control switch 11. The foot operated switch 10 connects alternatively to the volume control switch 11 or a by-pass conductor 40 to cut out the tone modifying circuit.

FIGURE 3, 4, 5 and 6 illustrate the wave form of a test signal as applied to and modified by the circuit at points A., B., C and D respectively. The signals illustrated are representative only of the type of variation of signals that will be created by the more complex signal generated by one of the strings 2. The signals further illustrate the action of the circuit with the attack control 12 set at maximum resistance. The simple sine wave signal shown in FIG. 3 will have a peak to peak value of .17 volts as the result of an input signal of .1 volt R.M.S. The amplification and bias of transistor 16 result in the wave being somewhat negative as shown. This is applied at point A to the first clipper circuit that clips the negative side of the wave and creates a signal at point B as shown in FIG. 4 with peak to peak voltage of 1.5 volts. The differentiating circuit including the volume control switch block portions of the square wave produced at point C and shown in FIG. 5 to produce a signal at point D as shown in FIG. 6. This is with the volume switch set for maximum volume. The peak to peak voltage will be 2.4 volts.

FIGURES 7, 8, and 9 show the wave patterns developed at points B, C and D with the attack control variable switch 12 set at a minimum or zero value across resistor 30. It will be noted that similar variations in the wave pattern may be created by the musician striking the string 2 strongly or weakly as this will produce a variation in the intensity or magnitude of the input signal developed in the coil 4.

The pulse signals as shown in FIGURES 6 and 9 when sustained as by the vibration of the string 2 vary in quality or character to simulate the tones of different instruments. For example, the signal of FIG. 6 when amplified and reproduced will simulate the tone of a trumpet while the signal in FIG. 9 will simulate the tone of a bass or tuba. Settings of the controls 11 and 12 in between the maximums cause the tones produced to simulate other instruments such as trombone, saxophone and clarinet.

It is pointed out that the transistors 16, 25 and 32 are used as amplifying electron valves and that vacuum tubes having control grids and plate-cathode circuits can be substituted if the circuit constants are properly selected to drive the tubes beyond the straight line regulating voltages of their control grids. The overdriving of the amplifying devices, either transistors or vacuum tubes creates harmonics of the input signal controlling the amplifier. The extent of overdriving can be measured as a percentage of harmonics in the output signal. For best tonal modification it is preferred to drive the transistors or amplifier devices at over 100% harmonic output but for the purpose of defining the scope of the invention a minimum level of 25% harmonics is arbitrarily selected as a value and limit for the characteristics of the circuit that will produce significant tone modification as distinguished from what might be classed as mere distortion. It is further pointed out that the tone modifying circuit is operative to produce controlled tones only when a single string of the instrument is played. Playing two or more strings at the same time produces unpredictable and unpleasant noise. If two or more tones are desired simultaneously, a complete separate system is required for each tone.

What is claimed as new is:

1. In combination with a stringed musical instrument having an electro-magnetic pick-up and an electronic amplifying and reproducing system,

a tone modifying circuit connected between said pick-up and said amplifier comprising a battery and impedance transforming circuit including a transistor capacitively coupled to said pick-up and having a collector emiter circuit connected to said battery and controlled by said pick-up,

a first clipper circuit including a second transistor having a collector-emitter circuit connected to said battery in parallel with said impedance transforming circuit with a voltage dropping resistor in the collector circuit,

said second transistor having its base capacitively coupled to the emitter of said first transistor with a variable resistor connected between its base and ground to control the second transistor with a minimum of 25% harmonics of the input signal in its output,

a second clipper circuit including a third transistor with a resistor, collector and emitter in series connected from said battery to ground and having its control base capacitively coupled to the collector of said second transistor,

a resistor connecting the base of said third transistor to ground to control the third transistor with a minimum of 25% harmonics of the input signal in its output,

a differentiating circuit including a resistor capacitively coupling the collector of said third transistor and an output circuit connected to said last resistor and including a variable resistor having a variable tap selectively connectable to the input of said amplifier,

a by-pass circuit connected to said pick-up, and

a foot operated switch arranged to alternatively connect said variable tap or said by-pass circuit to said amplifier.

2. In combination with a stringed musical instrument having an electrical pick-up and an electronic amplifying and reproducing system,

a tone modifying circuit connected between said pick-up and said amplifier comprising a battery, an impedance transforming circuit including a transistor coupled to said pick-up and having a collector emitter circuit connected to said battery and controlled by said pick-up,

a first clipper circuit including a second transistor having a collector-emitter circuit connected to said battery in parallel with said impedance transforming circuit,

said second transistor having its base coupled to the emitter of said first transistor with a variable resistor connected between its base and ground to control the second transistor with a minimum of 25% harmonics of the input signal in its output,

a second clipper circuit including a third transistor connected from said battery to ground and having its control base coupled to the collector of said second transistor to control the third transistor with a minimum of 25% harmonics of the input signal in its output,

a differentiating circuiting including a resistor coupling the collector of said third transistor to ground and an output circuit connected to said last resistor and including a variable resistor having a variable tap selectively connectable to the input of said amplifier,

a by-pass circuit connected to said pick-up,

and a switch arranged to alternatively connect said variable tap or said by-pass circuit to said amplifier.

3. In combination with a stringed musical instrument having an electro-magnetic pick-up and an electronic amplifying and reproducing system,

a tone modifying circuit connected between said pick-up and said amplifier comprising a battery a first clipper circuit including a first transistor having a collector-emitter circuit connected to said battery and with a voltage dropping resistor between the battery and the collector,

said transistor having its base capacitively coupled to said pick-up with a variable resistor connected between its base and ground to control the transis-

tor with a minimum of 25% harmonics of the input signal in its output,

a second clipper circuit including a second transistor with a resistor, collector and emitter in series connected from said battery to ground and having its control base capacitively coupled to the collector of said first transistor,

a resistor connecting the base of said second transistor to ground to control the second transistor with a minimum of 25% harmonics of the input signal in its output,

a differentiating circuit including a resistor capacitively coupling the collector of said second transistor to ground and an output circuit connected to said last resistor and including a variable resistor having a variable tap selectively connectable to the input of said amplifier,

a by-pass circuit connected to said pick-up,

and a foot operated switch arranged to alternatively connect said variable tap or said by-pass circuit to said amplifier.

4. In combination with a stringed musical instrument having an electric pick-up and an electronic amplifying and reproducing system,

a tone modifying circuit connected between said pick-up and said amplifier comprising a battery a first clipper circuit including a first transistor having a collector-emitter circuit connected to said battery and,

said transistor having its base coupled to said pick-up to control the transistor with a minimum of 25% harmonics of the input signal in its output,

a second clipper circuit including a second transistor with a resistor, collector and emitter connected in series to said battery and to ground, said second transistor having its control base coupled to the collector of said first transistor to control the second transistor with a minimum of 25% harmonics of the input signal in its output,

a differentiating circuit including a resistor coupling the second transistor to ground and an output circuit connected to said last resistor and including a variable resistor having a variable tap selectively connectable to the input of said amplifier,

a by-pass circuit connected to said pick-up,

and a foot operated switch arranged to alternatively connect said variable tap or said by-pass circuit to said amplifier.

5. In combination with a stringed musical instrument having an electric pick-up and an electronic amplifying and reproducing system,

a tone modifying circuit connected between said pick-up and said amplifying system comprising, a source of direct current,

a first clipper circuit including a first current amplifier having an output circuit connected to said source with a voltage dropping resistor,

said current amplifier having a control element capacitively coupled to said pick-up and having a variable resistor connected between it and ground to control the current amplifier with a minimum of 25% harmonics of the input signal in its output,

a second clipper circuit including a second current amplifier connected to said source and having a control element capacitively coupled to said first current amplifier to control the second current amplifier with a minimum of 25% harmonics of the input signal in its output,

a differentiating circuit including a resistor capacitively coupled to said second amplifier and a variable resistor connected to ground and having a variable tap variably and selectively connectable to the input of said electronic amplifying system,

a by-pass circuit connected to said pick-up,

and a foot operated switch arranged to alternatively



connect said variable tap or said by-pass circuit to said amplifying system.

6. In combination with a stringed musical instrument having an electric pick-up and an electronic amplifying and reproducing system,

a tone modifying circuit connected between said pick-up and said amplifying system comprising, a source of direct current,

a first clipper circuit including a first current amplifier having an output circuit connected to said source,

said current amplifier having a control element coupled to said pick-up and having a variable resistor connected between it and ground to control the current amplifier with a minimum of 25% harmonics of the input signal in its output,

a second clipper circuit connected to said source including a second current amplifier having a control element coupled to said first current amplifier to control the second current amplifier with a minimum of 25% harmonics of the input signal in its output,

a differentiating circuit including a resistor coupled to said second amplifier and a variable resistor connected to ground and having a variable tap variably and selectively connectable to the input of said electronic amplifying system,

a by-pass circuit connected to said pick-up,

and a foot operated switch arranged to alternatively connect said variable tap or said by-pass circuit to said amplifying system.

7. In combination with a stringed musical instrument having an electric pick-up and an electronic amplifying and reproducing system,

a tone modifying circuit connected between said pick-up and said amplifying system comprising, a source of direct current, a load balancing circuit including a current amplifier coupled to said pick-up and having an output circuit connected to said source controlled by said pick-up,

a first clipper circuit including a second current amplifier having an output circuit connected to said source,

said second current amplifier having its control element coupled to said output circuit of said first current amplifier and having a variable resistor connected between it and ground to control the second current amplifier with a minimum of 25% harmonics of the input signal in its output,

a second clipper circuit connected to said source including a third current amplifier having its control element coupled to the output circuit of said second current amplifier to control the third current amplifier with a minimum of 25% harmonics of the input signal in its output,

a differentiating circuit including a resistor coupled to said second clipper circuit and an output circuit and a variable tap variably connected to said last resistor and selectively connectable to the input of said amplifier,

a by-pass circuit connected to said pick-up,

and a switch arranged to alternatively connect said variable tap or said by-pass circuit to said electronic amplifying system.

8. In combination with a stringed musical instrument having an electric pick-up and an electronic amplifying and reproducing system,

a tone modifying circuit connected between said pick-up and said amplifying system comprising, a source of direct current, an impedance transforming circuit including a current amplifier coupled to said pick-up and having an output circuit connected to said source controlled by said pick-up,

a first clipper circuit including a second current amplifier having an output circuit connected to said source,

said second current amplifier having its control element coupled to said output circuit of said first cur-

rent amplifier to control the second current amplifier with a minimum of 25% harmonics of the input signal in its output,

a second clipper circuit connected to said source including a third current amplifier having its control element coupled to the output circuit of said second current amplifier to control the third current amplifier with a minimum of 25% harmonics of the input signal in its output,

a differentiating circuit including a variable resistor connected to said second clipper circuit and to ground and having a variable tap,

a by-pass circuit connected to said pick-up,

and a switch arranged to alternatively connect said variable tap or said by-pass circuit to said electronic amplifying system.

9. A tone modifying circuit connected in series between the electric pick-up and amplifier of a stringed musical instrument comprising, a source of direct current,

an impedance transforming circuit connected to said source and coupled to and modulated by said pick-up,

a first clipper circuit including a variable resistance connected to ground and to said source and coupled to the modulated output side of said transforming circuit to modulate the current in the clipper circuit with a minimum of 25% harmonics of the input signal in the clipper circuit,

a second clipper circuit connected to said source and coupled to the input side of said first clipper circuit to be modulated thereby with a minimum of 25% harmonics of the modulating signal,

and a differentiating circuit including a variable resistor connected to the input side of said second clipper circuit and ground and having a variable tap to be energized thereby and connected to said amplifier.

10. A tone modifying circuit connected in series between the electric pick-up and amplifier of a stringed musical instrument comprising, a source of direct current,

an impedance transforming circuit connected to said source and coupled to and modulated by said pick-up,

a first clipper circuit including a variable resistance connected to ground and to said source and coupled to the modulated output side of said transforming circuit to modulate the current in the clipper circuit with a minimum of 25% harmonics of the input signal in the clipper circuit,

a second clipper circuit connected to said source and coupled to said first clipper circuit to be modulated thereby with a minimum of 25% harmonics of the modulating signal,

and a variable differentiating circuit including a variable resistor connected to said second clipper circuit and ground and having a variable tap to be energized thereby and connected to said amplifier.

11. A tone modifying circuit connected in series between the electric pick-up and amplifier of a stringed musical instrument comprising, a source of direct current,

an impedance transforming circuit connected to said source and coupled to and modulated by said pick-up,

a first clipper circuit coupled to said transforming circuit to modulate the current in the clipper circuit with a minimum of 25% harmonics of the input signal in the clipper circuit,

a second clipper circuit connected to said source and coupled to said clipper circuit to be modulated thereby with a minimum of 25% harmonics of the modulating signal,

and a differentiating circuit including a resistance connected to said second clipper circuit and to ground



to be energized thereby and connected to said amplifier.

12. A tone modifying circuit connectable in series between the electric pick-up and amplifier of a stringed musical instrument comprising, a source of direct current,

an impedance transforming circuit connected to said source and arranged to be coupled to and modulated by said pick-up,

a first clipper circuit including a variable resistance connected to ground and to said source and coupled to said transforming circuit to modulate the current in the clipper circuit with a minimum of 25% harmonics of the input signal in the clipper circuit,

a second clipper circuit connected to said source and coupled to said first clipper circuit to be modulated thereby with a minimum of 25% harmonics of the modulating signal,

and a variable differentiating circuit including a variable resistor connected to said second clipper circuit and ground and having a variable tap to be energized thereby and connectable to said amplifier.

13. A tone modifying circuit connectable in series between the electric pick-up and amplifier of a stringed musical instrument comprising, a source of direct current,

a first clipper circuit connected to said source and connectable to said pick-up to modulate the current in the clipper circuit with a minimum of 25% harmonics of the input signal in the clipper circuit,

a second clipper circuit connected to said source and coupled to said first clipper circuit to be modulated thereby with a minimum of 25% harmonics of the modulating signal,

and a variable differentiating circuit including a variable resistor connected to said second clipper circuit and to ground to be energized thereby and having a variable tap connectable to said amplifier.

14. A tone modifying circuit adapted to be connected between the electric pick-up of a stringed musical instrument and an amplifier comprising, a source of direct current, an impedance transforming circuit connected to said source and including a current amplifier adapted to be coupled to said pick-up and having an output circuit controlled by said pick-up,

a first clipper circuit connected to said source and including a second current amplifier having an output circuit,

said second current amplifier being coupled to the output circuit of said first current amplifier and connected to ground to control the second current amplifier with a minimum of 25% harmonics of the input signal in its output,

a second clipper circuit connected to said source and including a third current amplifier coupled to the input circuit of said second current amplifier to control the third current amplifier with a minimum of 25% harmonics of the input signal in its output,

a differentiating circuit including a resistor coupled to the input circuit of said third current amplifier and connected to ground, and an output circuit including a variable resistor having a variable tap connected to said last resistor and to ground,

a by-pass circuit connected to the input end of said transforming circuit,

and a switch arranged to alternatively connect said tap or said by-pass circuit to said amplifier.

15. A tone modifying circuit adapted to be connected between the electric pick-up of a stringed musical instrument and an amplifier circuit comprising, a source of direct current, an impedance transforming circuit connected to said source and including a current amplifier adapted to be coupled to said pick-up and having an output circuit controlled by said pick-up,

a first clipper circuit connected to said source and including a second current amplifier having an output circuit,

said second current amplifier being coupled to the output circuit of said first current amplifier to variably control the second current amplifier with a minimum of 25% harmonics of the input signal in its output,

a second clipper circuit connected to said source and including a third current amplifier coupled to the circuit of said second current amplifier to control the third current amplifier with a minimum of 25% harmonics of the input signal in its output,

a differentiating circuit including a resistor coupled to the circuit of said third current amplifier and to ground with a tap on the opposite side of the resistor from ground,



a by-pass circuit connected to the input end of said transforming circuit,

and a switch arranged to alternatively connect said tap or said by-pass circuit to said amplifier circuit.

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GEORGE N. WESTBY, *Examiner.*