

[54] **STRINGED MUSICAL INSTRUMENT WITH OPTOELECTRONIC PICKUP SOUND AMPLIFIER**

[76] Inventor: Dennis A. Ferber, 11322 Donovan Road, Los Alamitos, Calif. 90720

[22] Filed: Dec. 30, 1971

[21] Appl. No.: 213,935

[52] U.S. Cl.84/1.16, 84/1.18

[51] Int. Cl.G10h 3/00

[58] Field of Search84/1.14-1.16, 84/1.04, 1.06, 1.18, DIG. 19; 317/235 N

[56] **References Cited**

UNITED STATES PATENTS

3,194,870	7/1965	Tondreau et al.	84/1.16
3,514,522	5/1970	Mussulman.....	84/1.04 X
2,972,922	2/1961	Rhodes.....	84/1.15
3,038,363	6/1962	Miessner	84/1.04 X
3,514,522	5/1970	Mussulman.....	84/1.14 X
2,972,922	2/1961	Rhodes.....	84/1.06 X
3,038,363	6/1962	Miessner	84/1.04 X
3,535,532	10/1970	Marryman.....	317/235 N

OTHER PUBLICATIONS

F. W. Gutzwiller, "G. E., SCR Manual" Page 289, 1967, G. E., Electronics Park, Syracuse 1, N.Y.

Primary Examiner—Richard B. Wilkinson
 Assistant Examiner—U. Weldon
 Attorney—William C. Babcock

[57] **ABSTRACT**

A stringed instrument, such as an acoustical guitar, is provided with a compact, battery powered sound amplification unit attached thereto in an arrangement including cooperating optoelectronic devices situated adjacent the instrument's strings. Each string intersects with a path of a light beam sent from a first light-emitting device toward a second light-detecting device so that vibration of a string modulates the intensity of light from the first device impinging on the second device to produce an electronic signal corresponding to the musical tone associated with any particular string vibration rate.

The unit can be affixed to an acoustical guitar and utilized to drive a speaker or equivalent acoustic transducer situated within the sound box of the guitar so as to cause the transducer to produce amplified musical tones corresponding to the musical notes played on the strings of the guitar. The source of electric power for operating this device shall be situated on or within the guitar to provide a self-contained device that is not dependent on a source of domestic electric power.

7 Claims, 8 Drawing Figures

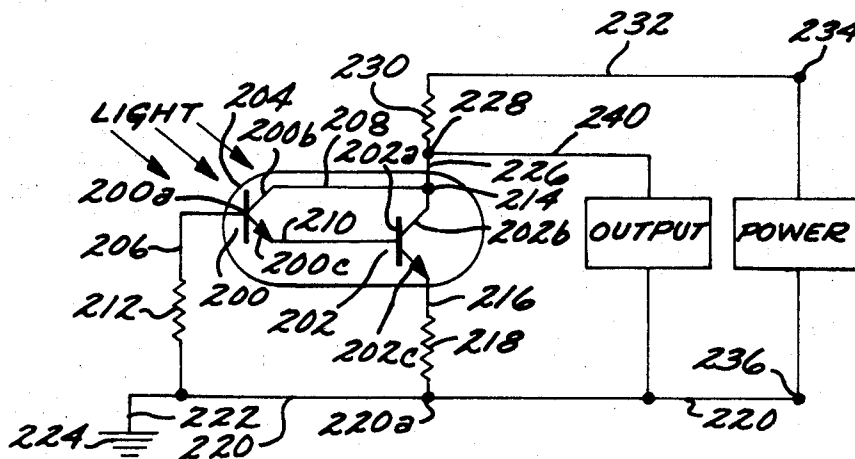


FIG. 1

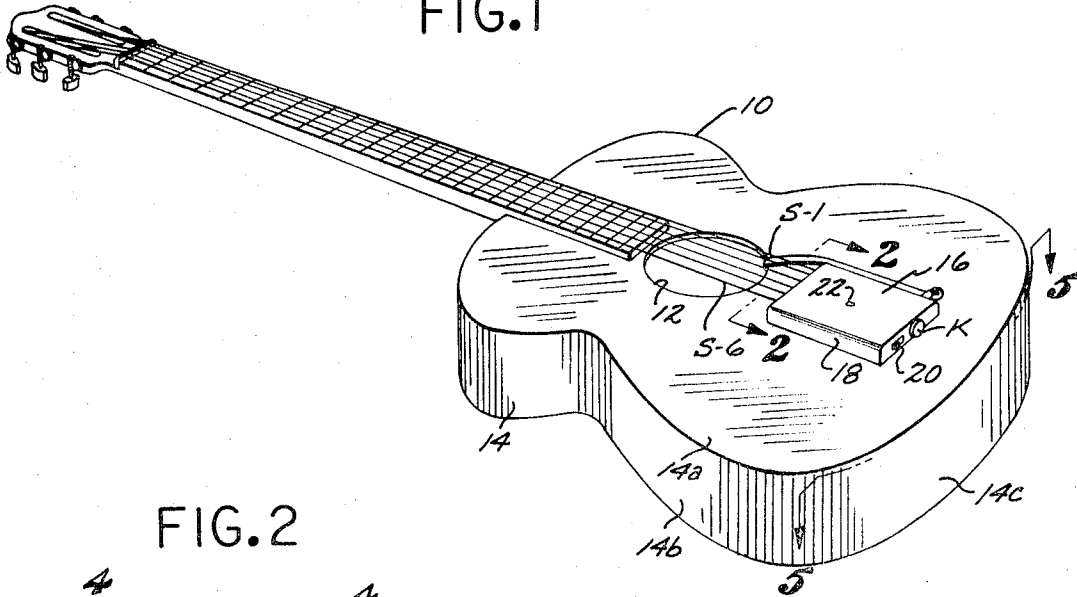


FIG. 2

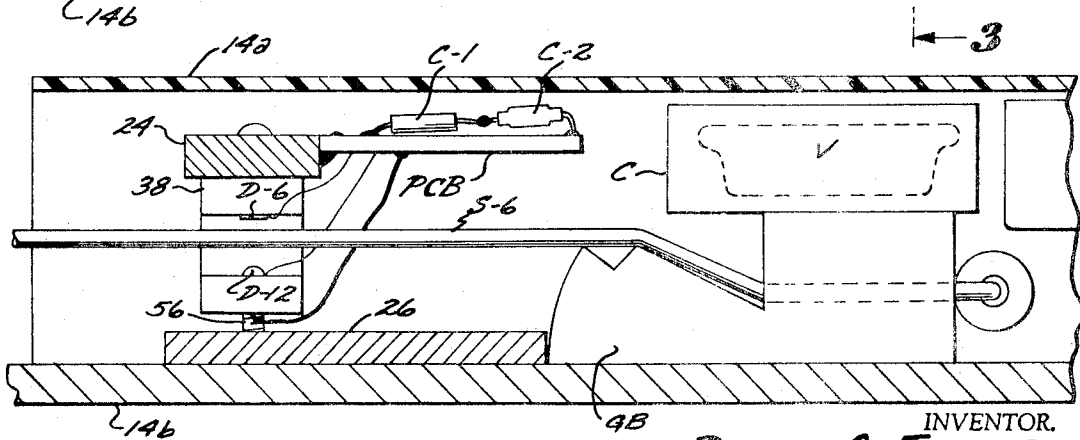
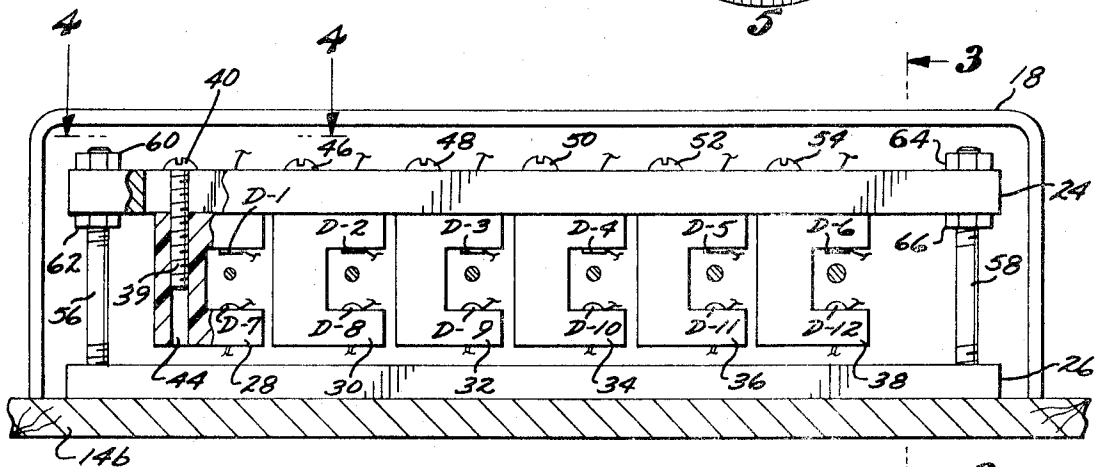


FIG. 3

INVENTOR.
DENNIS A. FERBER

BY
William G. Babcock
ATTORNEY

FIG. 4

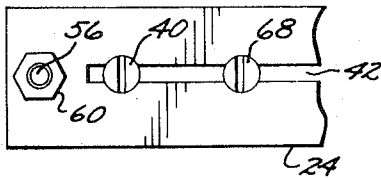


FIG. 5

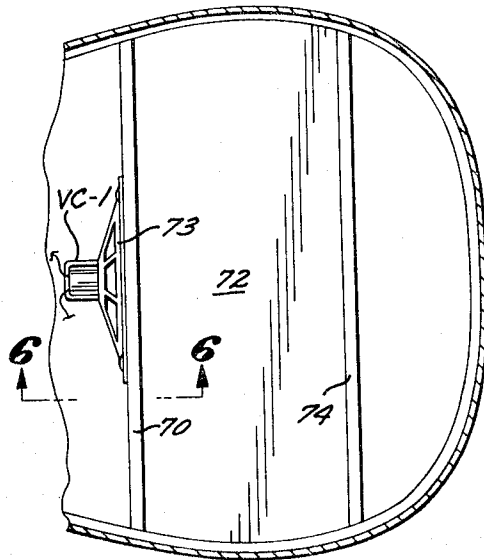


FIG. 6

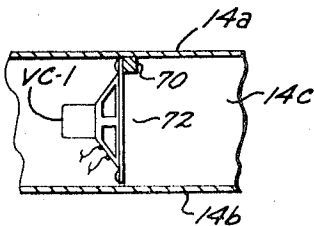


FIG. 7

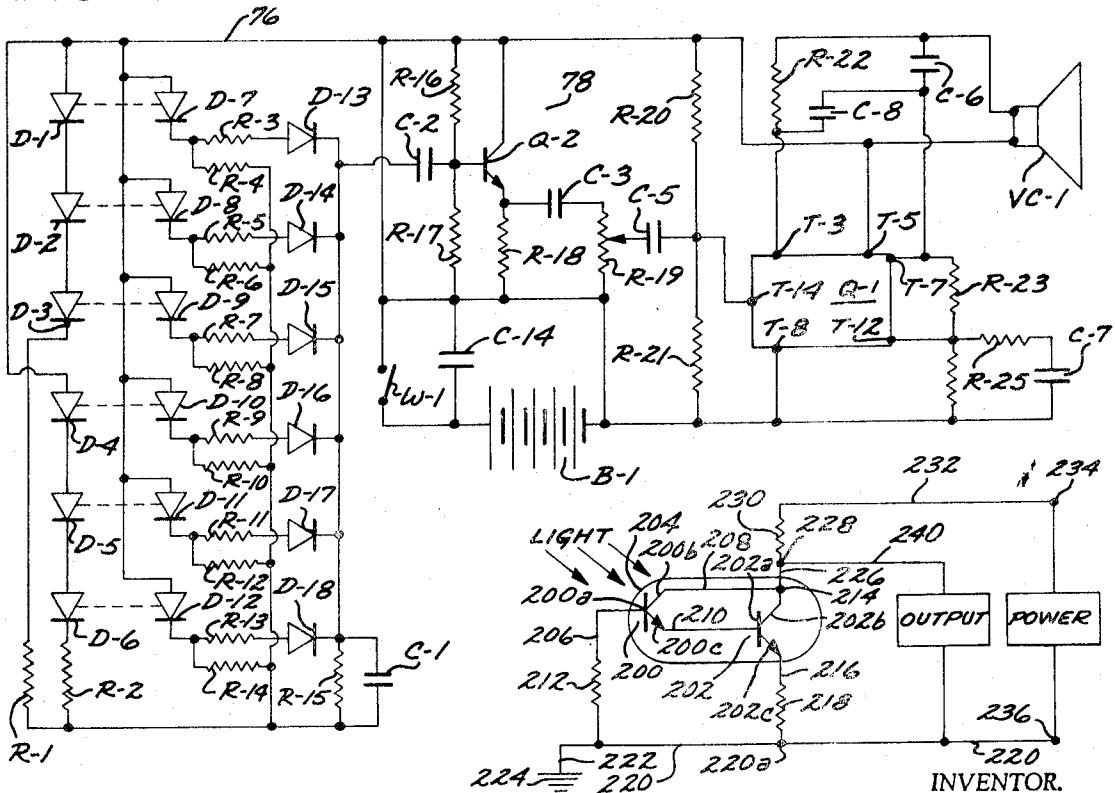


FIG. 8

DENNIS A. FERBER

BY

William G. Bobroch
ATTORNEY

INVENTOR.

STRINGED MUSICAL INSTRUMENT WITH OPTOELECTRONIC PICKUP SOUND AMPLIFIER

FIELD AND BACKGROUND OF THE INVENTION

The present invention relates to an optoelectronic unit utilizable with stringed musical instruments and responsive to string vibrations when the instrument is played in conventional fashion.

The present invention relates also to a sound amplifier system designed so that all of its component parts are situated within a portable stringed instrument such as an acoustical guitar.

The present invention in a detailed sense relates to a pickup device including cooperating optoelectronic devices, electrical amplifier circuitry, and associated speaker in combination with the strings of a musical instrument in an arrangement wherein string vibrations are sensed (picked up) and transduced into corresponding electrical signals that are, in turn, transduced into corresponding audible tones after having been electronically amplified.

Transducer pickups are utilized for transducing sounds produced in playing stringed musical instruments into corresponding electronic signals that can be electronically amplified and fed to a loudspeaker to cause it to produce audible sounds that can be heard from great distances. Modernly, pizeoelectric transducers have found popular usage with such stringed instruments as the electric guitar and the bass fiddle. Pizeoelectric and other kinds of transducer pickups cannot afford precisely the same results and advantages that are afforded by the optoelectronic transducer pickup of the present invention, nor are the former utilizable with all of the various kinds of stringed instruments with which the latter may be utilized.

The modern electric guitar utilizes a pizeoelectric transducer arrangement connected by electrical wires in a cord to a separate amplifier, power source and loudspeaker unit. Such a guitar differs from an acoustical guitar which, unlike the former, has a sound box defined in the body thereof for providing acoustical amplification, via a sound opening in the body, of the musical tones or sounds actually produced by plucking or strumming the guitar strings. In contrast to the foregoing, an actual embodiment of the present invention can be utilized in conjunction with an acoustical guitar, wherein the acoustic transducer makes advantageous use of the soundbox, with all of the components thereof — optoelectronic transducer pickup arrangement, amplifier system, and power system — contained in a detachable unit secured to the acoustical guitar forming a self-contained unit.

OBJECTS OF THE INVENTION

It is accordingly an object of the present invention to provide a compact pickup and amplifier unit, small enough to be affixed to a stringed musical instrument such as an acoustical or electrical guitar.

It is another object of the present invention to provide an optoelectronic transducer pickup system adapted for utilization with stringed musical instruments to produce optoelectronically generated electronic signals corresponding in frequency to the frequency of the musical tones produced by effecting vibration of the instrument's strings at various rates. It is another object of the present invention to provide a battery powered unit of the kind herein described that

is designed to allow for the mechanical adjustment of the relative positions of the instrument's strings in relation to its optoelectronic devices so that the unit can be utilized in conjunction with different, but similar, stringed musical instruments having different spacing between strings and other physical differences.

It is another object of the invention to provide an acoustical guitar or like instrument with an acoustic transducer in the sound box thereof and with a composite optoelectronic transducer, power and amplifier unit affixed to the outside front face of the guitar body near the bridge of the guitar.

These and other further and related objects, advantages, and features of the present invention may be made apparent in light of the following illustrative description of the present invention taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a six-string acoustical guitar provided with an acoustic transducer situated inside the sound box of the guitar body and an optoelectronic transducer/amplifier/power unit removably attached to the outside front face of the body over the guitar bridge at one end of the guitar strings;

FIG. 2 is a view taken generally along line 2—2 of FIG. 1 illustrating an arrangement for photoelectrically sensing vibrations of any guitar string so as to produce corresponding electronic signals that are amplified and then fed to the aforementioned loudspeaker;

FIG. 3 is a view taken along line 3—3 of FIG. 2 showing a single guitar string in relation to a light source manifold and a photodetector and other elements;

FIG. 4 is a plan view taken along line 4—4 of FIG. 2 of a longitudinally slotted bar-shaped member and two threaded bolts. This Figure, together with FIGS. 2 and 3, is illustrative of one way in which the optoelectronic transducers for each string may be arranged relative thereto.

FIGS. 5 and 6 are illustrative views taken orthogonal to each other, showing an acoustic transducer mounted inside the sound box of the guitar and located rearwardly of the guitar's sound opening, with FIG. 5 being taken along line 5—5 of FIG. 1;

FIG. 7 is an electrical schematic of circuitry for photoelectrically sensing string vibrations so as to generate corresponding electronic signals, amplifying such signals, and feeding the amplified signals to an acoustic transducer; and

FIG. 8 is an electrical schematic of circuitry sensitive to light of variable intensity.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring initially to FIG. 1 there is shown an acoustical guitar 10 which is representative of various stringed musical instruments with which device arrangements embodying the present invention may be utilized, and which has six strings. The guitar 10 is conventional and includes a sound opening 12 in the front face of its main portion or body 14 which is hollow between its front and back faces so as to define therein a sound box. The guitar 10, in accordance with the present invention, includes a unit 16 that contains all of the electrical components and circuitry depicted in FIG. 7 with the exception of the sound reproduction device that may be either a dynamic speaker or acoustic trans-

ducer which is preferably mounted within the sound box of the guitar body 14.

The unit 16, as illustrated, includes a casing 18 which, as will be explained in greater detail hereinafter, encloses six sets of optoelectronic devices, amplifier circuitry, and a battery power supply. The casing 18 has four side walls forming an enclosure and is open at its frontmost side and its bottom side which is next to the front face of the guitar body 14. There is a slidable switch button 20 extending from the rearmost side wall of the unit which can be actuated when desired to either turn on or turn off the supply of battery power to the circuitry components disposed within the unit. Two opposite side walls of the casing straddle the guitar bridge, to which one end of each of the six strings is secured. The casing 18 is secured to the body front face in a suitable fashion, as by means of a machine screw 22 threaded into a threaded hole in the top casing wall and extending downwardly between the two middle guitar strings in a threaded hole in the body front face so as to secure the casing to the guitar body in such a way that the casing can be detached readily from the guitar body when desired.

Located within the casing 18 is a mechanical support assembly for six sets of optoelectronic devices which can be seen in FIGS. 2 and 3. The support assembly includes two bar-shaped frame members 24 and 26 held in spaced relation by machine screws extending therebetween. Attached to the topmost frame member 24 and suspended therefrom are six separate support members 28, 30, 32, 34, 36, and 38 that are each generally C-shaped when seen from the view shown in FIG. 2. Each of the support members 28 to 38 are suspended from the frame member 24 in the same way and in a manner that is shown at the left in FIG. 2, wherein a partial cross section is taken through the support member 28 in order to show how it is suspended from the frame member 24. The support member 28, as are the other support members, is suspended in place by the utilization of a first machine screw 39 with a slotted head 40 that passes through a longitudinal slot 42 (partially shown in FIG. 4) into a threaded hole 44 in the support member 28. By loosening the screw 39 with a screwdriver it is possible to loosen the support member 28 from the frame member 24 so that the support member 28 and frame member 24 no longer securely abut one another, to allow the support member to be moved parallel to the longitudinal direction of the frame member 24. In this way the support member 28 may be repositioned relative to string S1 which extends between top and bottom ends of the support member 28 in a direction normal to an imaginary line drawn between the support member ends. This feature, just described, allows the support member to be accurately positioned relative to the string S1 and also adapts the support member and frame member arrangement for utilization with different guitars and other stringed instruments wherein the spacing of the strings of the different instruments may vary to some extent. The other support members 30, 32, 34, 36, and 38 are suspended from the frame member 24 in the same way that support member 28 is suspended by the utilization of respective machine screws 46, 48, 50, 52, and 54.

The frame members 24 and 26 are held in spaced parallel relation by means of two frame machine screws 56 and 58 at opposite ends of the frame members that are each threaded into corresponding threaded holds in

the frame members 24 and 26. A first pair of threaded nuts 60 and 62 and a second pair of threaded nuts 64 and 66 are utilized to determine the spacing of frame members 24 and 26. The nuts 60 and 62 are threaded onto the frame machine screw 56 on opposite sides of the frame member 24 and the nuts 64 and 66 are threaded onto the frame machine screw 58 on opposite sides of the frame member 24 so that by tightening the nuts against the frame member 24 it is possible to maintain the frame member 24 at any desired spacing from frame member 26. FIG. 4 is a plan view of the left end of the frame member 24 showing, for further illustrative purposes, the arrangement of the frame machine screw 56, threaded nut 60, and the heads 40 and 68 of the machine screws 39 and 46 relative to the frame member slot 42.

Referring further to FIG. 2, electrically operated light emitters D1, D2, D3, D4, D5, and D6 are secured to the top ends of the support members 28 and 38 and light detecting sensors D7, D8, D9, D10, D11, and D12 are secured to the bottom ends of the support members 28 to 38 so that the light emitter D1 faces the light sensor photodiode D7, the emitter D4 faces the sensor D10, the emitter D5 faces the sensor D11, and the emitter D6 faces the sensor D12. The light emitter and light sensors D1 to D12 are optoelectronic devices that function in a manner to be explained hereinafter. The emitters D1 to D6 are respectively aligned with the sensors D7 to D12 along respective axes that are transverse to the guitar strings S1 and other guitar strings S2, S3, S4, S5, and S6 so that light rays emitted by each of the emitters D1 through D6 form respective light beams that impinge respectively on the sensors D7 through D12. The strings S1 through S6, being respectively located between the emitters D1 through D6 and the sensors D7 through D12, intersect with the respective light beams to control the amount of light energy from the emitters D1 through D6 reaching the respective sensors D7 through D12 in accordance with string vibrations produced when the strings are plucked or strummed during the playing of the guitar.

When a musical note is played on any of the guitar strings, the string vibrates at a rate or frequency depending upon the particular note played. Each vibrating string moves sideways back and forth in directions generally normal to the light beam passing between the associated emitter and sensor so as to chop the light beam at the same rate as the string vibration rate. The chopping of any light beam produces a signal voltage in the particular photodiode illuminated by the light beam, since the voltage produced in a sensor by impinging light is proportional to the light energy contained in the light ray and such voltage signal is of a frequency corresponding to the vibration rate or frequency of the associated string. The voltage signals produced in the foregoing manner are electronically amplified, as will be explained, and fed to a sound reproducing device, earlier mentioned, mounted on or inside the guitar body, the device broadcasting the musical tones produced when musical notes are played on the guitar strings.

The optoelectronic devices in pairs D1-D7, D2-D8, D3-D9, D4-D10, D5-D11, and D6-D12 respectively function as optoelectronic transducer pickups in that each mentioned pair (e.g., D1-D7) serve to transduce the optical energy of a light beam into an electronic signal. These devices, together with the guitar strings S1

through S6 each constitute a mechanoelectronic or mechano-optoelectronic transducer in that each arrangement of diode, photodiode and string (e.g., D1, D7 and S1) transduce the mechanical motion of a guitar string into a corresponding electronic signal.

Referring now to FIG. 3, there is shown an elevational view taken along line 3—3 of FIG. 2 of the emitter D6 and sensor D12 on the support member 38 as arranged relative to the string S6. The support member 38, as stated earlier, is suspended between the frame members 24 and 26 (which are shown in cross section), the frame member 26 abutting the outside front face of the guitar body therebeneath. The string S6 extends to the right as shown in FIG. 3 into a vertical groove of a guitar bridge GB to an anchoring element A situated to the right of the guitar bridge.

A case C secured to the guitar bridge GB defines an enclosed space V outline by dashed lines, into which the battery B1 can be inserted. Attached to the frame member 24 is a printed circuit board (PCB), with printed circuit conductors formed on its top and bottom faces. Electrical lead wires interconnect the emitter D6 and the sensor D12 to electrical conductors on the printed circuit board PCB. Disposed atop the printed circuit board PCB are the circuit components of the circuit of FIG. 7, these components being represented in FIG. 3 by the components C1 and C2. The circuit components are interconnected by wires to the printed circuit conductors and also to battery output terminals (not shown) extending from the battery case C.

Referring now to FIGS. 5 and 6, there is shown in each a conventional acoustic transducer VC1 mounted inside the guitar body 14. A dynamic speaker may be used in lieu of the transducer if desired. In FIG. 5 a plan view is shown of the rear end portion of the guitar body 14, corresponding to that portion to the right of the sound opening 12 in FIG. 1, with the front face of the body taken away. The transducer VC1 is shown mounted on one of two internal guitar frame members 70 that transversely extend inside the body of the guitar. These members 70, together with the front wall 14a, back wall 14b and side wall 14c of guitar body 14, formed an enclosed space 72 into which the acoustic transducer portion 73 may broadcast. The broadcasting takes place by moving air in the confined space to take advantage of the acoustical resonance and acoustical amplification that is inherent to the guitar body 14 when the guitar strings are plucked or strummed.

Referring now to the circuitry shown in FIG. 7, the circuitry includes optoelectronic transducer circuitry 76 electrically coupled to a preamplifier circuit 78 that in turn is electrically coupled to a power amplifier circuit Q1 which has its output terminals connected to the loudspeaker VC1. The circuitry has a direct current power source B1, preferably a battery inside the guitar body 14, that supplies direct current thereto when a switch W1, operated by the switch button 20 (see FIG. 1), is closed.

The circuit components shown in FIG. 7 are labelled for identification, and are identified and rated as follows: D1 through D6 are all light emitters; D7 through D12 are all light sensors; D13 through D18 are 1N67 rectifying diodes; R1 through R25 are ohmic resistors; R1 and R2 are 0.50 watt 330 ohm resistors; R3, R5, R7, R9, R11, and R13 are 0.25 watt 100,000 ohm resistors; R4, R6, R8, R10, R12, and R14 are 0.25 watt

1,500,000 ohm resistors; R15 is a 0.25 watt 47,000 ohm resistor; R16 and R17 are 0.25 watt 3,300,000 ohm resistors; R18 is a 0.25 watt 10,000 ohm resistor; R19 is a 500,000 ohm potentiometer; R20 is a 0.25 watt 500,000 ohm resistor; R21 is a 0.25 watt 56,000 ohm resistor; R22 is a 0.25 watt 18,000 ohm resistor; R23 is a 0.25 watt 330,000 ohm resistor; R24 is a 0.25 watt 56,000 ohm resistor; R25 is a 0.25 watt 5,600 ohm resistor; C1 through C8 are capacitors rated in microfarads as follows: C1 is 0.005 microfarads, C2 is 2.2, C3 is 47, C4 is 1,000, C5 is 30, C6 is 500, C7 is 4.7 and C8 is 0.002 microfarads. B1 is a battery supply consisting of 10 series-connected nickel cadmium battery cells. Q1 is a General Electric integrated circuit (PA 237) power amplifier circuit. VC1 is either an acoustic transducer or a dynamic speaker with an 8 ohm voice coil. Q2 is an NPN emitter-base-collector transistor.

The light emitters D1, D2, and D3 are connected in series with the resistor R1, and the light emitters D4, D5, and D6 are connected in series with the resistor R2. The emitters D1, D2 and D3 and the resistor R1 are connected in parallel with the emitters D4, D5, and D6 and the resistor R2. The emitters D1 through D6 are all poled in the same direction so that each is normally forward biased during circuit operation so as to each emit a light beam. The light sensors D7 through D12 are connected in respective series circuits that are parallel to one another and also in series with the resistor R15 that is itself in parallel with the capacitor C1.

The resistor R3 and the diode D13 are connected in series with the photodiode D7. The resistor R5 and the diode D14 are connected in series with the photodiode D8. The resistor R7 and the diode D15 are connected in series with the photodiode D9. The resistor R9 and the diode D16 are connected in series with the photodiode D10. The resistor R11 and the diode D17 are connected in series with the photodiode D11. The resistor R13 and the diode D18 are connected in series with the photodiode D12.

The light sensors and diodes D7 through D18 are all poled in the same direction so as to be normally forward biased during circuit operation. The resistors R4, R6, R8, R10, R12, and R14 are respectively connected in series with the sensors D7 through D12. The sensors D7 through D12 are respectively illuminated by the light rays coming from the emitters D1 through D6. Each illuminated sensor has a voltage induced therein by the light rays impinging thereon.

Sensor D7 and resistor R4, sensor D8 and resistor R6, sensor D9 and resistor R8, sensor D10 and resistor R10, sensor D11 and resistor R12, and sensor D12 and resistor R14, respectively, are connected in parallel with the series circuit including D1, D2 and D3 and resistor R1; and also with the series circuit including diodes D4, D5, and D6 and resistor R2. The light emitters D1 through D6, and light sensors D7 through D12, resistors R1 through R15 and the capacitor C1 are connected together to form the optoelectronic transducer pickup circuit 76.

The preamplifier circuit 78 includes the bias resistors R16, R17 and R18 and the NPN emitter-base-collector transistor Q2. The resistor R18, connected to the emitter of the transistor Q2, serves as an emitter follower resistor, the resistor R16 being connected in parallel with the base and collector of the transistor Q2 serves to reverse bias the base-collector transistor junction when the switch W1 is closed. The resistor R17 is con-

ected in parallel with the base and emitter of the transistor Q2 and the resistor R18 serves as a base resistor for applying a signal voltage to the transistor emitter-base junction to modulate the forward bias thereof when a signal voltage at the cathodes of the diodes D13 through D18 is coupled thereto by the capacitor C2. The capacitor C2 serves as a signal coupling capacitor connected between the output of the optoelectronic transducer pickup circuit 76 and the base of the transistor Q2 of the preamplifier circuit 78. the capacitor C4 connected in parallel with the battery B1 serves to suppress oscillations that might otherwise occur, but for the capacitor C4 in the preamplifier circuit.

The capacitor C3 and the potentiometer R19 are series connected in parallel with the resistor R18 so that amplified alternating current signal voltages impressed across the resistor R18, resulting from the application of signal voltage across the transistor Q2 emitter-base junction, are coupled by the capacitor C3 to the potentiometer R19. The potentiometer R19 has a movable tap terminal for pickup of a selected portion of any voltage impressed on the resistance of the potentiometer R19. The position of the potentiometer tap terminal is adjustable by turning a volume control knob K (see FIG. 1) extending from the casing 18 of the unit 16. The position of this tap terminal determines the volume of sound that can issue from the loudspeaker VC1.

Resistors R20 and R21 are series connected, and together are connected in parallel with the resistors R16 and R17. The capacitor C5 is a coupling capacitor that is connected between the potentiometer tap terminal and the serial junction of the resistor R20 and resistor R21. The resistors R20 and R21 serve as a voltage divider in circuit with the battery B1, and together function to establish a bias voltage level at an input terminal T14 of the power amplifier integrated circuit Q1.

The power amplifier circuit Q1 includes, in addition to the input terminal T14, output terminals T3 and T5 and circuit biasing terminals T8, T7 and T12. The coupling resistor R22 is connected in series with the two loudspeaker terminals between the power amplifier output terminals T3 and T5 to couple the output of the power amplifier circuit to the loudspeaker VC1.

A biasing circuit network, including the resistors R23, R25 and R25 and the capacitors C6, C7 and C8, is interconnected with the power amplifier circuit Q1 and the acoustic transducer VC1. The resistor R23 is connected between the terminals T7 and T12; the resistor R24 is connected between the terminals T12 and T8; and the resistor R25 and the capacitor C7 are series connected across the resistor R24. The capacitor C8 is connected between the terminals T3 and T7. The capacitor C6 is connected between one end of the resistor R22 and the terminal T7. The terminal T5 is connected to the collector of the transistor Q2. Voltage signals applied across the resistor R21 are amplified by the power amplifier circuit Q2 to provide output signals of amplified power at the terminals T3 and T5 that are coupled to the acoustic transducer VC1 by the resistor R22 to drive the transducer.

The acoustic transducer VC1, when driven, broadcasts the amplified sound of the vibrating strings to the confined space 72 to be further amplified as the guitar body 14 acts as a resonator.

From the above description it will be apparent that the strings S1 through S6 must be formed from a material that is less light conductive than air in order that

the vibrating strings will stop the beams of light prior to the latter impinging on the light sensors D6 to D12.

Light of variable intensity resulting from the vibration of the strings S-1 to S-6 may be used to provide an electrical output that is proportional thereto by the device shown in FIG. 8 that is provided for each of the strings. Each of these devices Z includes two NPN junctions 200 and 202. The NPN junctions 200 and 202 are placed in an envelope 204 that is transparent to the extent that a light beam from one of the light emitters D-1 to D-6 impinges on the junctions 200 and 202. The PN junction formed in silicon, which is the basic structural element of the semiconductor diode and transistor, is inherently photosensitive. That is to say that such a junction, when electrically stressed in the reverse polarity passes a current which is dependent upon secondary sources of energy such as heat or light. The greater the amount of light energy irradiating such a junction the greater the current passing through the junction. All PN junctions exhibit this phenomena in varying degrees, and the processes required to enhance this characteristic are clearly understood throughout the semiconductor industry.

The base 200a, collector 200b, and emitter 200c of NPN junction 200 are connected by conductors 206, 208 and 210 to a resistor 212, junction point 214 and base 202a of NPN junction 202. Collector 202b is connected to junction point 214. Emitter 202c is connected by a conductor 216 to resistor 218. Resistors 212 and 218 are connected to a conductor 220 that has a junction point 220a therein that is connected by a conductor 222 to ground 224.

Junction point 214 is connected by a conductor 226 to a junction point 228, which junction point is connected to a resistor 230. Resistor 230 is connected to a conductor 232 that extends to a junction point 234. Connector 220 terminates in a junction point 236. Power is supplied to junction points 234 and 236. The output voltage that is determined by the intensity of the light beam is taken off from conductor 220 and a conductor 240 connected to junction point 228.

Recognizing the fact that any transistor is made up of two PN junctions arranged in such a manner that they have an electrically common area (i.e., the "base"), and that under normal operating conditions one of these junctions is reverse polarized (e.g., base-to-collector) while the other is forward polarized (e.g., base-to-emitter), it may be recognized that the photo current is generated within the base-to-collector junction and is passed through the base-to-emitter junction in series with the load circuit (i.e., collector-to-supply-to-emitter). Consequently, it is feasible for the photo-current to forward polarize the base-to-emitter junction without the use of external electrical attachment.

In order to continue this description, it must first be clarified that "forward" polarization of the base-to-emitter junction is "normal" operation, but as is the case with the base to collector junction, the base-to-emitter junction may continue to pass current even when reverse polarized, due to ambient thermal energy. Also, it should be noted that photo current must pass through the base-to-emitter junction in order to be amplified by normal transistor action.

Continuing, by connecting a resistor in the load circuit between the emitter and the reference (i.e., ground) end of the supply, a potential is developed across this resistor that is proportional to the photo-

current and is in phase with respect to changes in illumination when measured with respect to the reference. By connecting a second resistor between the base electrical attachment and the reference (i.e., in parallel with the base-to-emitter junction and emitter to reference resistance) a portion of the photocurrent is diverted around the base-to-emitter junction. This current gives rise to a potential of the same polarity and phase as the potential across the emitter-to-reference resistor. The difference between these two potentials is the base-to-emitter junction polarization potential, and will be self-adjusting. That is to say that the photocurrent will divide between the two available paths in such proportions as to establish quiescent equilibrium under all ambient conditions.

It should be clear at this point that connection of the resistance between the base electrical attachment and the reference has given rise to a biasing current that is directly proportional but 180° out of phase with photocurrent (i.e., illumination). This technique of "negative" current feed-back has all of the advantageous effects of negative feed-back as used in more conventional circuitry. Specific areas of improvement include (1) gain stabilization device-to-device as well as with changes in ambient conditions, (2) extended bandwidth, (3) reduced distortion, and (4) improved isolation of the collector-to-battery (i.e., output) circuit.

I claim:

1. In combination with a musical instrument having a sound box in which an opening is formed over which a plurality of parallel, laterally spaced, tensioned strings extend that are formed from a material that is less light conductive than air, an assembly operatively associated with said musical instrument for amplifying the sound from said strings when the latter are vibrated, said assembly including:

- a. electrically operated, sound reproduction means;
- b. a source of electric power;
- c. electric amplifier circuit means that connects said sound reproduction means and said source of electric power; and
- d. a plurality of electrically operated light emitting and light sensing means located on opposite sides of said strings and connected to said electric amplifier circuit means, with said strings so situated as to at least partially obstruct the beams of light between said light emitting and light sensing means, said strings when vibrating cooperating with said light emitting means to subject said light sensing means to a plurality of spaced pulses of light of the same frequencies as those at which said strings vibrate, and said light sensing means imparting electric signals to said electric amplifier circuit means to cause said sound reproduction means to reproduce the sounds of said vibrating strings at an amplified level, with said light sensing means including:

1. first and second NPN junctions that each includes a base, collector and emitter;
 2. first, second and third resistors;
 3. a first plurality of conductors that connect the base of said first NPN junction to said first resistor, the emitter of said second NPN junction to said second resistor, the collector of said second emitter to said third resistor, the collector of said first NPN junction to the collector of said second PN junction, and the emitter of said first NPN junction to the base of said second NPN junction;
 4. a second conduit that connects said first and second resistors to the ground;
 5. a third conductor connected to said third resistor, with said second and third conductors connected to said source of power; and
 6. a fourth conductor connected to said collector of said second NPN junction, and said signal being emitted by said third and fourth conductors.
2. An assembly as defined in claim 1 in which said instrument is an acoustic guitar, and with said sound reproduction means so positioned within said sound box as to direct the reproduced sounds of said strings away from said opening, and said sound box acting as a resonator to further amplify the reproduced amplified sounds of said strings from said sound reproduction means.
3. An assembly as defined in claim 2 in which said sound reproduction means is an acoustic transducer.
4. An assembly as defined in claim 2 in which said sound reproduction means is a dynamic speaker.
5. An assembly as defined in claim 1 which in addition includes:
- e. means for effecting relative lateral adjustment between said strings and said light emitting and light sensing means whereby said strings obstruct at least portions of said beams of light prior to the latter impinging on said light sensing means.
6. An assembly as defined in claim 1 in which said musical instrument includes a bridge over which said tensioned strings extend, and said assembly in addition including:
- e. a plurality of laterally adjustable supports mounted on said sound box adjacent said bridge, with each of said supports having one of said light emitting means and light sensing means mounted in spaced relationship thereon, and each of said supports being movable relative to one of said strings to a position where said string obstructs at least a portion of the beam of light from said light emitting means when said string is stationary.
7. An assembly as defined in claim 1 in which said source of electric power is at least one battery removably situated at a fixed position relative to said sound box.

* * * * *