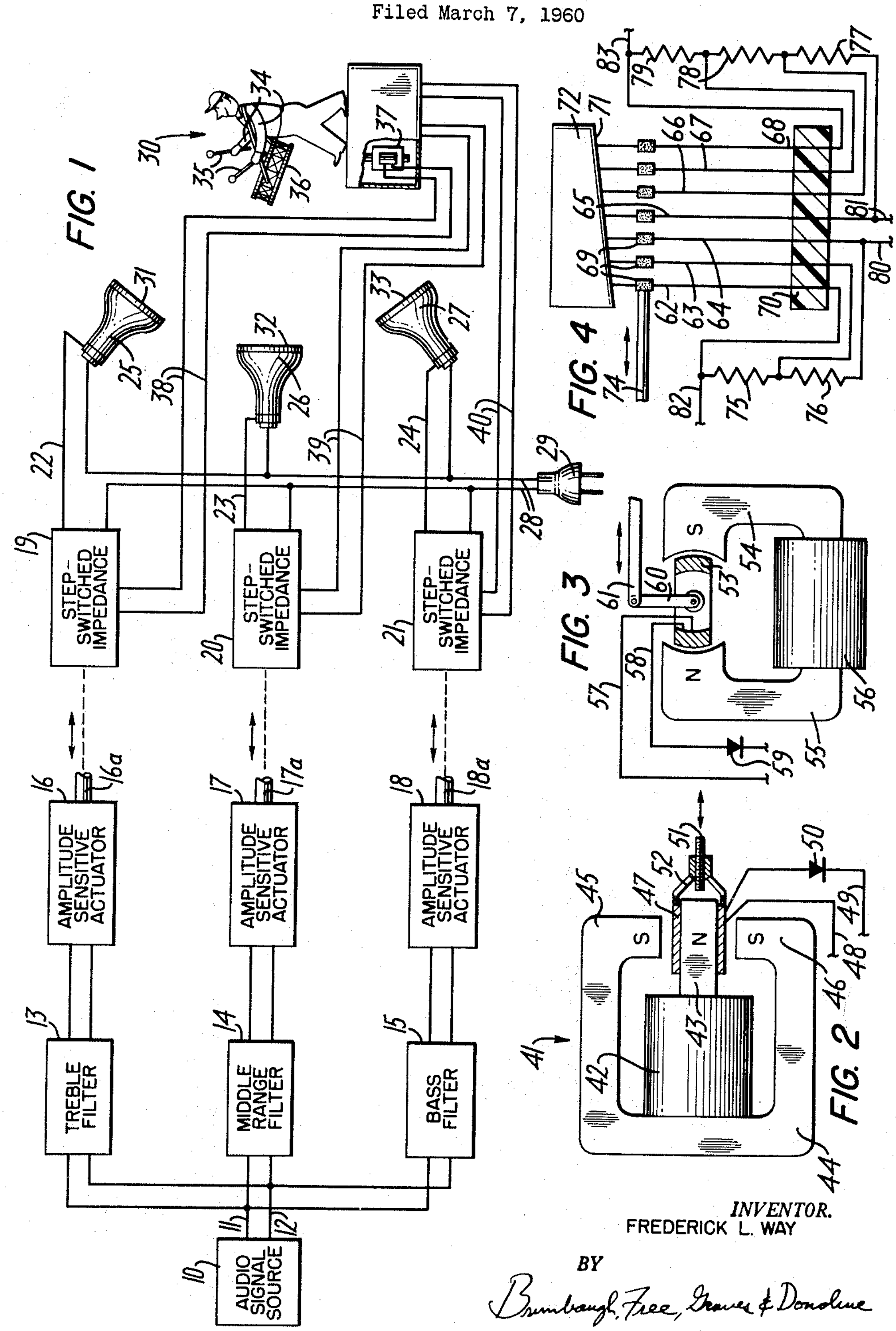
Jan. 30, 1962 F. L. WAY 3,018,683

AUDIO SIGNAL-RESPONSIVE DEVICE

Filed March 7, 1960



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United States Patent Office 3,018,683
Patented Jan. 30, 1962

3,018,683
AUDIO SIGNAL-RESPONSIVE DEVICE

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Filed Mar. 7, 1960, Ser. No. 13,325
10 Claims. (Cl. 84—464)

This invention relates to devices for controlling the quality of light in response to tonal variations in audio signals and more particularly to a high fidelity audio signal device capable of responding accurately to rapid variations in audio signal levels to vary the character of an illuminant and, at the same time, provide mechanical motion or animation in response to such variations.

Although many types of light-controlled instruments responsive to music or sound have been devised, thus far none has been sufficiently sensitive to produce an accurate visual rendition of audio information. Moreover, heretofore all such devices have lacked complete visual representation in that they have been designed merely to control illumination and have not been capable of imparting mechanical actuation to an object.

Accordingly, it is an object of this invention to provide a new and improved audio signal-responsive device which responds to signal variations to produce corresponding visible variations with high fidelity.

Another object of the invention is to provide a signal-responsive device of the above character arranged to control mechanical actuation of an object.

A further object of the invention is to provide a simple and attractive device for representing audio information by actuating animated characters or other objects and varying the quality of the illumination incident on the characters.

These and other objects of the invention are attained by providing a moving coil transducer mechanism responsive to changes in the signal level in a selected portion of the audio frequency range. Mechanical motion of the transducer is applied to a step-switch device arranged to vary the magnitude of an impedance connected in series with a light source by a selected value at each step, the value being representative of the change in current necessary to produce an illumination change equivalent to the corresponding change in audio signal level.

One or more portions of the series impedance may comprise an electromechanical converter responsive to current to actuate a mechanical device in an object illuminated by the light source. Preferably, three or more devices responsive to changes in audio signal level in different portions of the audio frequency range are connected to control separate light sources, each source being filtered to project a different colored light.

Further objects and advantages of the invention will be apparent from a reading of the following description in conjunction with the accompanying drawings, in which:

FIG. 1 is a block diagram representing a typical system for providing visual representations of audio signals in accordance with the invention;

FIG. 2 is a view illustrating one form of amplitude-sensitive actuator adapted for use in the system of FIG. 1;

FIG. 3 is a view of another form of actuator; and

FIG. 4 shows the arrangement of a step-switched impedance useful in the system of FIG. 1.

I the representative embodiment of the system shown in FIG. 1, audio signals from a source 10, which may be a radio or a phonograph or the like, are carried by two conductors 11 and 12 to three conventional band pass filters 13, 14, and 15. These filters are selected to pass the treble, the middle range, and the bass frequencies of the audio signal spectrum, respectively, to three amplitude-sensitive mechanical actuating devices 16, 17, and 18.

Preferably, the treble filter 13 is designed to pass only the audio signal information above a frequency of about five hundred cycles per second and the bass filter 15 transmit audio signals below about one hundred twenty-eight cycles per second, while the middle range filter 14 transmits only those signals having frequencies between these two values. In order to provide an accurate response to changes in the signal level within each band, the amplitude-sensitive actuators are arranged in the manner described hereinafter to impart linear motion to an actuator member *16a*, *17a*, or *18a*, in sensitive response to the amplitude level of the signal and in direct proportion to changes in the level.

Each of the actuator members *16a*, *17a*, and *18a*, transmits motion to a corresponding step-switched impedance device 19, 20, and 21, connected by conductors 22, 23, and 24 in series with an associated light source, such as one of the floodlamps 25, 26, and 27, shown in the drawings. Power is supplied to these circuits through a line 23 having a plug 29 adapted for connection to any conventional electrical outlet. Within each of the devices 19, 20, and 21, a selected group of series-connected impedance elements is arranged to be shunted successively by the operation of the actuator member so that the total impedance is varied in steps of predetermined magnitude in accordance with the motion of the corresponding actuator member. In order to provide uniform changes in illumination from the corresponding floodlamp 25, 26, or 27, the impedance elements in the group are selected and arranged so that the intensity of illumination from the lamp changes in direct relation to the corresponding signal amplitude variations.

As illustrated in FIG. 1, the three lamps 25, 26, and 27 are oriented to illuminate the same object 30 and in order to provide color variations in accordance with changes in the tonal quality of the audio signal from the source 10, selected color filters 31, 32, and 33 are mounted in front of the lamps. Preferably, these filters transmit the three primary colors, blue, green, and red, and in a typical example the filter 31 in front of the lamp 25 responsive to treble audio signals passes red light, the middle range filter 32 transmits green light, and the bass lamp filter 33 transmits blue light. As a result, the illumination of the object 30 constitutes an accurate visible representation of the changes in quality and intensity in a group of audio signals, such as a musical passage, for example.

Moreover, in order to provide an even more effective visible representation, the object 30 may constitute one or more animated characters, such as the drummer illustrated in FIG. 1. In this case, the drummer has movable arms 34 carrying drum sticks 35 arranged to beat a drum 36 in response to energization of a solenoid device 37 having a plunger which is mechanically linked to the arms. Two conductors 38 connect the solenoid to one of the impedance devices, for example, the device 19, so that the impedance of the solenoid constitutes one of the steps in the series impedance while other solenoids (not shown) for actuating different mechanical members in the object 30 are connected to the devices 20 and 21 through corresponding pairs of conductors 39 and 40, respectively. Moreover, if desired, several solenoids cans be connected to each of the devices 19, 20, and 21 so as to constitute different steps in each group of series-connected impedance elements. In this way, an entire orchestra, for example, may be activated by changes in the quality and amplitude of an audio signal.

In FIG. 2, the details of one form of amplitude-sensitive actuator for use in the system of FIG. 1 are illustrated. This actuator comprises a moving coil transducer 41 of the same general type utilized in conventional loud speakers having a magnet element 42, which may be either an electro-magnet or a permanent magnet, a central pole piece 43 projecting axially from one end of the magnet and another U-shaped pole piece 44 extending from the opposite end of the magnet and having poles 45, 46 on opposite sides of the pole piece 43. A coil member 47 slidably supported for relative axial motion on the pole piece 43 has two lead wires 48 and 49 which are connected to receive the audio signals passed by the corresponding filter 13, 14, or 15, a diode rectifier element 50 being inserted in one of these lead wires. As a result, the coil member 47 is driven axially on the pole member 43 by a force proportional to the amplitude of the audio signal. To transmit axial motion of the coil member 47 a shaft 51 is supported from the coil by a spider 52, the shaft 51 being connected to the actuator member *16a*, *17a*, or *18a* of FIG. 1.

Another form of actuator shown in FIG. 3 utilizes a structure similar to the usual type of meter movement wherein a coil member 53 is rotatably supported between the spaced ends of two adjacent pole pieces 54 and 55 of a magnet 56. Two lead wires 57 and 58, one including a diode rectifier element 59, supply the audio signal to the coil member 53. Consequently, the coil is rotated by a force having a magnitude proportional to the amplitude of the audio signal so that an arm 60 carrying a pivotally mounted shaft 61 transmits the coil motion to drive the actuator member *16a*, *17a*, or *18a* of FIG. 1 longitudinally in proportion to the input signal level.

In FIG. 4 a typical step-switched impedance for use in the system of FIG. 1 is illustrated. This device comprises a series of resilient contact fingers 62–68 supported in closely spaced parallel relation and carrying adjacent contact elements 69 which may be small silver blocks, for example. Preferably, one end of each of the fingers is embedded in a support member 70 while the other end rests against the inclined side 71 of a wedge block 72, the fingers in the series having progressively greater length so that they normally are held in spaced parallel relation by the wedge block. An actuator element 74, which is connected to a corresponding actuator member *16a*, *17a*, or *18a* of FIG. 1, rests against the outer side of the contact element 69 of the shortest finger 65 so that the resilience of the finger provides a restoring force for the element 74, the actuator member, and the moving coil of the actuating device. In a typical case, the resilience of the fingers is selected to provide a total restoring force of about fifteen grams when the actuator element 74 has moved sufficiently to close all the contacts and the spacing between the contact elements is arranged so that the total travel of the actuator is approximately one-eighth inch.

Connected between each adjacent pair of fingers 62–68 is an impedance element which may be one of a group of resistors 75–79 or may comprise the winding 37 of an actuating solenoid of the type described above which, as shown in FIGS. 1 and 4, is joined to the fingers through conductors 80 and 81 and the lead wires 38, 39, or 40. Accordingly, the individual impedance elements in the group are shunted out successively as the actuator element 74 moves in response to signals of increasing amplitude.

At one end of the series of elements 75–79 a lead wire 82 is connected to one of the power lines 28, shown in FIG. 1, while a conductor 83 at the other end of the series leads to the lamp 25, 26, or 27, thus connecting all the impedance elements in series with the lamp. Although only seven resilient fingers form the step switch illustrated in FIG. 4 and the impedance comprises but six separate elements, it will be readily apparent that any number of impedance elements may be utilized if the number of resilient fingers is correspondingly increased.

In order to provide an immediate response to switch actuation the total series impedance of the elements 75–79 and the actuating solenoid 37 is selected to maintain the corresponding lamp at an operating level just below that sufficient to cast a perceptible amount of light through its color filter onto the object 30 when power is applied and none of the contacts 69 is closed. Moreover, the values of the various impedance elements are selected in accordance with the characteristics of the lamp to decrease the series impedance as the corresponding contacts are closed by the amounts necessary to generate uniform changes in light intensities at all operating levels. For a 120 volt, 150 watt lamp transmitting light through a typical blue filter, the total series impedance required is about 600 ohms and the individual impedance elements in a twenty-element group should have values in decreasing progression from about 100 ohms for the first element shunted, 90 ohms for the next element shunted, and so on down to about 4 ohms for the last element in the series. The precise impedance values required to provide uniform steps for any specific light source can be readily determined from a graph of light intensity of the desired color plotted against impedance in series with the lamp. Also, inasmuch as conventional incandescent lamps produce a relatively high proportion of green light and an even higher proportion of red light as compared with the blue light, a 40 watt lamp may be used as the red light source and a 75 watt lamp for the green light source where the blue light source is a 150 watt lamp.

In operation, audio signals from the source 10 are divided into three separate channels according to frequency by the filters 13, 14, and 15. In each channel the amplitude-sensitive actuator 16, 17, or 18 moves its actuating member *16a*, *17a*, or *18a* in accordance with the amplitude level of the signals within the corresponding frequency range and this motion is transmitted to the actuator element 74 (FIG. 4) of the corresponding step-switched impedance device. Because the resilience of the finger elements 62–68 provides mechanical damping for the actuator unit, the system responds only to changes in amplitude level and not to each cycle of oscillation of the audio signals.

In response to actuator element motion the impedance elements 75–79 of the impedance device are shunted successively by the contacts 69 in accordance with increases in the amplitude of the audio signal, thereby decreasing the total impedance in series with the lamp 25, 26, or 27. At the same time, current passing to the lamp through the impedance elements flows through the solenoid winding 37, actuating the arms of the animated object 30 of FIG. 1 for as long as the contacts on the fingers 64 and 65 remain separated. When these contacts close as the signal amplitude increases, the solenoid is de-energized, moving the arms to their inactive position, while the reverse motion takes place when the contacts open on decreasing signal amplitude. In this way, the system provides an accurate and complete visible representation of the quality and intensity of variations in audio signal levels.

Although the invention has been described herein with reference to specific embodiments, many modifications and variations therein will occur readily to those skilled in the art. Accordingly, such variations and modifications are included within the intended scope of the invention as defined by the following claims.

I claim:

1. A device for producing high fidelity visual representations of audio signals comprising electric light source means, circuit means for connecting the light source means to an electrical energy source, impedance means connected in series with the light source means having a value selected to maintain the light source means at a threshold operating condition, mechanical switch means for reducing the impedance of the impedance means in selected steps to provide substantially uniform changes in light intensity, and electromechanical actuator means com-

prising fixed magnet means, coil means supported for oscillatory motion in the magnetic field of the fixed magnet means connected to an audio signal input, and linking means mechanically linking the coil means to the switch means, to activate the switch means in accordance with changes in audio signal amplitude.

2. A device for producing high fidelity visual representations of audio signals comprising a plurality of electric light source means, color filter means for each light source means transmitting light rays of a selected color, circuit means for connecting each light source means to an electrical energy source, impedance means connected in series with each light source means having a value selected to maintain the light source means at a threshold operating condition, mechanical switch means for each impedance means for reducing the impedance in selected steps to provide substantially uniform changes in light intensity, electromechanical actuator means for each switch means comprising fixed magnet means, coil means supported for oscillatory motion in the magnetic field of the fixed magnet means connected to an audio signal input, and linking means mechanically linking the coil means to the switch means, to actuate the switch means in accordance with changes in audio signal amplitude, and a plurality of electrical filter means each connected to one of the actuator means and adapted to transmit a selected audio frequency range thereto from an audio signal source.

3. A device for producing high fidelity visual representations of audio signals comprising electric light source means, circuit means for connecting the light source means to an electrical energy source, impedance means connected in series with the light source means having a value selected to maintain the light source means at a threshold operating condition, mechanical switch means comprising a plurality of spaced resilient conducting members electrically connected to selected points in the impedance means to shunt the impedance means in predetermined steps when adjacent conducting members are joined, the points being selected in accordance with the operating characteristics of the light source means to provide substantially uniform changes in light intensity as the resilient elements are joined successively, and electromechanical actuator means comprising fixed magnet means, coil means supported for oscillatory motion in the magnetic field of the fixed magnet means connected to an audio signal input, and linking means mechanically linking the coil means to the switch means, to actuate the switch means in accordance with changes in audio signal amplitude.

4. A device according to claim 3 wherein the linking means comprises shaft means longitudinally movable in response to coil motion to displace the resilient conducting members laterally and urge adjacent members successively into contact.

5. A device according to claim 1 wherein the magnet means includes a longitudinal pole piece and the coil means is movable longitudinally on the pole piece.

6. A device according to claim 1 wherein the magnet means includes a pair of opposed pole pieces and the coil means is rotatably supported between the pole pieces and carries an arm pivotally linked to the linking means.

7. A device according to claim 3 including an object having a movable member actuatable by electromechanical drive means, and electromechanical means for operating the movable member having a selected electrical impedance connected to form a portion of the impedance means.

8. A device according to claim 7 wherein the object is positioned to be illuminated by the light source means.

9. A device for producing high fidelity visual representations of audio signals comprising a plurality of electric light source means, color filter means for each light source means transmitting light rays of a selected color, circuit means for connecting each light source means to an electrical energy source, a plurality of electrical impedance elements of progressively decreasing value connected in series with each light source means and having a total impedance selected to maintain the light source means at a threshold operating condition, mechanical switch means for each plurality of impedance elements comprising a plurality of spaced resilient conducting members electrically connected to the junctions between adjacent impedance elements in the series to shunt the elements in sequence when adjacent conducting members are joined, electromechanical actuator means for each switch means comprising fixed magnet means, coil means supported for oscillatory motion in the magnetic field of the fixed magnet means connected to an audio signal input, and linking means mechanically linking the coil means to the switch means, to join the resilient fingers successively to shunt the corresponding impedance elements, starting with the element having the highest value, and a plurality of electrical filter means each transmitting selected portions of the audio frequency range to one of the actuator means.

10. A device according to claim 9 including an object having a movable member, and solenoid means for actuating the movable member having a winding constituting one of the impedance elements in one of the pluralities of impedance elements.

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