ABSTRACT: Mirrors are cemented to or suspended by threads from a rubber diaphragm stretched across the face of a loudspeaker in such a way as to trap a volume of air between the diaphragm and the speaker cone. When suspended mirrors are used, the diaphragm slopes slightly forward. A beam of light is directed through a color wheel, and is reflected from the mirrors onto a projection screen or other surface.
MUSIC-RESPONSIVE LIGHT DISPLAY

BACKGROUND OF THE INVENTION

This invention relates to music-responsive light displays, and particularly to a display in which patterns are formed by a beam of light reflected from a mirror which vibrates in response to sound. Oscilloscopes, harmonographs and cycloid generators of the vibrating-mirror-type have been known for a long time. Typically, they involve the vibration of a light-reflecting mirror by a mechanical or electromechanical transducer, the electrical input of which corresponds to the signal to be displayed. The same principle of operation has been used for the purpose of producing a pleasurable sensation as indicated in U.S. Pat. No. 3,048,075, issued on Aug. 7, 1962 to Gilbert M. Wright. In the Wright apparatus, and in other similar devices, patterns of light are produced which move more or less in time with the audio signal and produce a visual representation of the music on a screen.

To produce a visual representation having a recognizable correspondence to the beat of the music is difficult.

SUMMARY OF THE INVENTION

In accordance with this invention, a moving pattern of light is produced, the variation of which has a correspondence to the music producing it which is recognizable by the observer. In addition, special, and particularly pleasing effects are produced by a particular manner of mounting reflecting mirrors on a vibrating diaphragm.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front elevation of a loudspeaker housing showing the diaphragm and a particular suspended mirror arrangement;
FIG. 2 is a vertical section taken on the plane 2—2 of FIG. 1;
FIG. 3 is a front elevation of a speaker housing showing a diaphragm and another arrangement of cemented mirrors;
FIG. 4 is an enlarged section taken on the plane 4—4 of FIG. 3, showing a particular manner of mounting a mirror on the diaphragm;
FIG. 5 is a partially diagrammatic perspective showing the path of light from a light source to a viewing surface, and showing a typical pattern produced by the arrangement of mirrors in FIG. 1; and
FIG. 6 is an elevation of a projection screen showing a typical pattern produced by the arrangement of mirrors in FIG. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring first to FIGS. 1 and 2, there is shown a loudspeaker housing 2 of conventional design, in which there is fastened a baffleboard 4 having a circular opening 6, and having a circular ledge 8 on its forward side for receiving a loudspeaker mounting member. Baffleboard 4 is so arranged that its upper end extends slightly forwardly of its lower end so that a speaker mounted on ledge 8 slopes slightly forward. A removable forward baffle 10 having a circular opening 12, is arranged to abut the forward face of baffle 4 to provide a circular groove for supporting a loudspeaker-carrying element.

A circular baffle 14 having a circular central opening 16 fits into the circular groove provided by members 4 and 10. A loudspeaker 18 is secured to the rearward face of baffle 14 by screws 20. A diaphragm 22, formed by an elastic nonporous material such as rubber or neoprene, is stretched over the forward face of baffle 14, and is bent over the outer edge of baffle 14 and secured to its rearward face by cementing. Diaphragm 22 desirably forms an air-tight closure over the face of loudspeaker 18 so that a volume of air is trapped between the diaphragm and the speaker cone 24. Loudspeaker leads 26 are connected to a suitable terminal strip 28.

Small mirrors 30 are suspended by threads 32, the upper ends of which are cemented at 34 to the forward face of diaphragm 22. Small mirrors 36 are likewise mounted by threads 38. Large mirrors 40 are suspended by threads 42, the upper ends of which are cemented to the diaphragm at 44. It will be seen that, when the mirrors are at rest, they are free to rotate about a vertical axis so that their edges may come into contact with the face of the diaphragm. The term "threads" as used herein will be understood to include not only inextensible woven or twisted suspension members, but also wires and extensible suspension members such as rubberbands and the like.

When the diaphragm vibrates in response to electrical actuation of the loudspeaker and the consequent pressurization of the air trapped between the diaphragm and the speaker cone, the large and small mirrors react differently. The small mirrors are so light in weight that impulses imparted to their edges by the vibrating diaphragm cause them to bounce about quite freely, and in an arbitrary manner. On the other hand, the weight of the large mirrors is such that they do not bounce about, but rather tend to rotate slowly back and forth about a vertical axis, one edge coming into contact with the diaphragm, and then the other. But, because of the elasticity of the diaphragm, a vertical motion is imparted to the mirrors through threads 42 so that they also tend to wobble about a horizontal axis. Once this wobbling motion is begun, it is reinforced by impulses imparted to the upper and lower edges of the mirrors by the face of the vibrating diaphragm.

Referring now to FIG. 5, there is shown a light source 46 producing a beam 48, the width of which, when it reaches the mirrors, is preferably approximately coextensive with the exposed portion of diaphragm 22. Collimated or convergent beams may be used alternatively. A motor driven color wheel 52, which consists of segments 54 of transparent colored glass or plastic, which are sequentially placed in the path of the light beam. A source of audiofrequency electrical signals, such as a radio receiver is indicated at 55, and its output is connected to the loudspeaker through lines 26. The mirrors mounted on the face of the diaphragm reflect portions of the light beam onto screen 50 to produce patterns.

Because of the comparatively violent motion of the small mirrors 30 and 36, reflections from them result in rather arbitrary patterns such as those indicated at 58 and 60. Visual persistence causes the moving spots to appear as lines taking completely arbitrary and continually changing paths. A representative pattern produced by a reflection from one of the mirrors 54 is indicated at 62. Appearance of a reflection from a large mirror is that of a ball bouncing slowly across the screen in one direction, and then in the other. Because of the relatively slow movement of the spot resulting from a reflection from one of the large mirrors, the pattern perceived at any given instant is only a short line such as indicated at 64. The nature of the path is indicated by broken lines at 66.

Referring to FIGS. 3 and 4, an alternate manner of mounting of mirrors on a rubber diaphragm 22 is illustrated. A large mirror 68 is attached to the center of diaphragm 22 by a suitable adhesive or cement indicated at 70. Additional mirrors 72, 74, 76, 78, 80 and 82 are cemented to the diaphragm at various positions and orientations. In the attachment of these mirrors to the diaphragm, pieces of adhesive 84 are located near the edge of each of the mirrors rather than at their centers so that the mirrors reflect light in different directions. If the mirrors were all parallel to the diaphragm, the mirror arrangement would tend to focus light onto several small spots on the screen, which are spaced only by small distances from each other.

In FIG. 4, the manner of mounting mirror 82 is illustrated more clearly. It will be seen when diaphragm 22 vibrates, the upper end 86 of the mirror can separate from the diaphragm, although it will normally be held against the diaphragm except during exceptional violent vibrations.

Mirrors can also be mounted to reflect light in different directions by cementing them to the diaphragm at their cen-
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ters, and tilting the mirrors while the cement hardens. It will be apparent that other methods of mounting mirrors on the diaphragm may be used, including those involving the use of resilient pedestals separating the mirrors from the diaphragm wherein the pedestals are cemented to the diaphragm and the mirrors are cemented to the pedestals. The resilient pedestals provide a greater freedom of movement of the mirror.

FIG. 6 illustrates typical patterns produced by light reflected from the arrangement of mirrors shown in FIG. 3. The patterns are not arbitrary as are those produced by the small mirrors in FIGS. 1 and 2, but rather consist of circles 88, ellipses 90 and "figure-eights" 92. Under certain conditions of input, various other, and more complex, lissajous patterns may be produced.

In accordance with this invention, in both forms illustrated herein, musical beats, tones or rhythms are characterized by sudden expansions of the patterns, the extent of expansions being more or less dependent on the loudness of the beats so that the correspondence between the music and the variation of the patterns is immediately recognizable to an observer. The different method of suspension of mirrors from the diaphragm result in the production of different kinds of patterns, the "bouncing ball" pattern illustrated 66 in FIG. 5 being of particular significance as a special effect produced by reflections from large mirrors 40 suspended by threads from a forward-sloping diaphragm.

I claim:
1. Display apparatus comprising an elastic diaphragm, electromechanical transducing means adapted to receive an audiofrequency electrical input, means coupling the mechanical output of said transducing means to said diaphragm to vibrate said diaphragm in response to said electrical input, at least one mirror, means directing a beam of light to the reflecting surface of each mirror, means having substantial thickness for each mirror, located between said mirror and said diaphragm, fastening a portion of said mirror to said diaphragm so that a part of the edge of each said mirror remote from said fastened portion is in contact with said diaphragm.

2. Display apparatus according to claim 1 in which said coupling means is pneumatic-coupling means.

3. Display apparatus comprising an elastic diaphragm located in a substantially vertical plane, electromechanical transducing means adapted to receive an audiofrequency electrical input, means coupling the mechanical output of said transducing means to said diaphragm to vibrate said diaphragm in response to said electrical input, at least one mirror, means directing a beam of light to the reflecting surface of each mirror, and an elongated flexible suspension means for each mirror fastened at one end to said diaphragm and at the other end to said mirror, each said suspension means having a length such that each said mirror is positioned within the area of the diaphragm and allowed to dangle against said diaphragm.

4. Display apparatus according to claim 3 in which said coupling means is pneumatic-coupling means.

5. Display apparatus according to claim 3 in which the substantially vertical plane in which said diaphragm is located is tilted slightly from the vertical in a direction and to an extent such that the end of each said flexible suspension means where fastened to its mirror is separated from the diaphragm when said flexible suspension means is vertical, but said mirror can rotate into and out of contact with said diaphragm while said suspension means is vertical.

6. Display apparatus according to claim 3 including a plurality of mirrors each of a different size.