Aug. 27, 1935. S. C. WHITMAN 2,012,797

PIEZO ELECTRIC CRYSTAL REFLECTING MIRROR SOUND RECORDING SYSTEM

Filed July 13, 1934 2 Sheets-Sheet 1

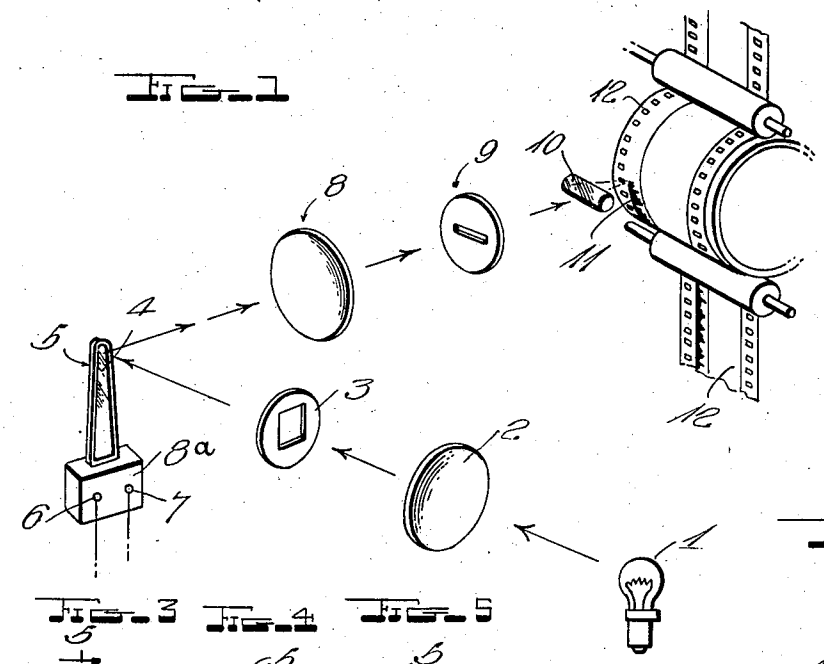


Fig. 1

Fig. 2

Fig. 3

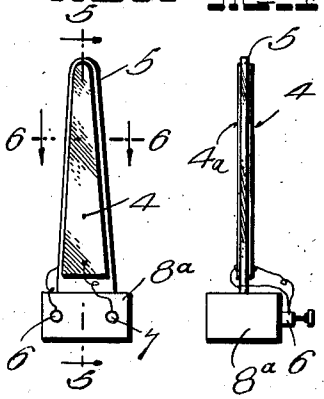


Fig. 4

Fig. 5

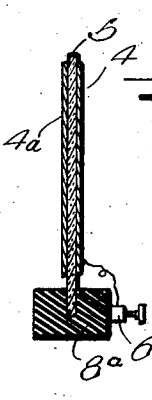
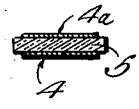


Fig. 6



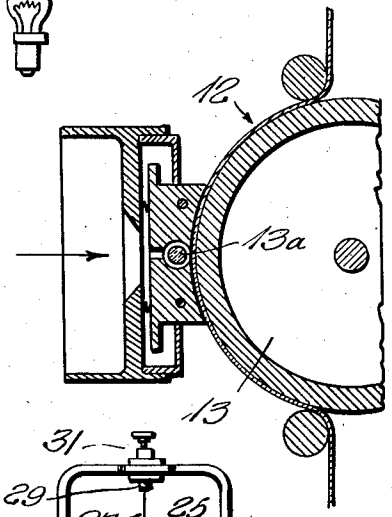


Fig. 7

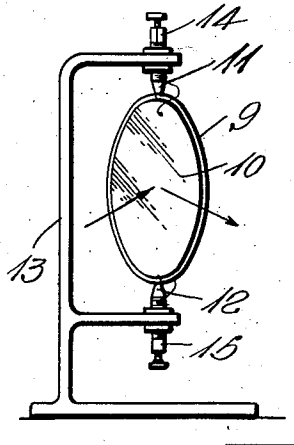
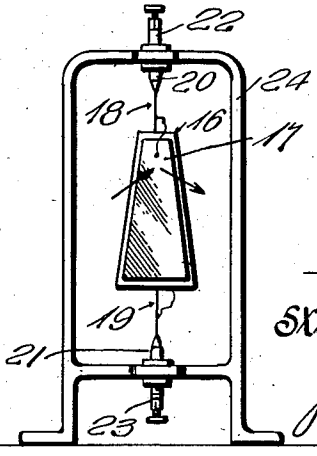


Fig. 8



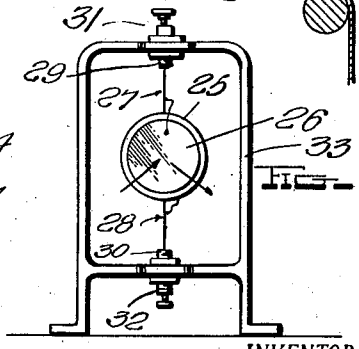


Fig. 9

INVENTOR.
Stewart C. Whitman,
BY
Jacobi & Jacobi ATTORNEYS.

Aug. 27, 1935. S. C. WHITMAN 2,012,797

PIEZO ELECTRIC CRYSTAL REFLECTING MIRROR SOUND RECORDING SYSTEM

Filed July 13, 1934 2 Sheets-Sheet 2.

Fig. 10

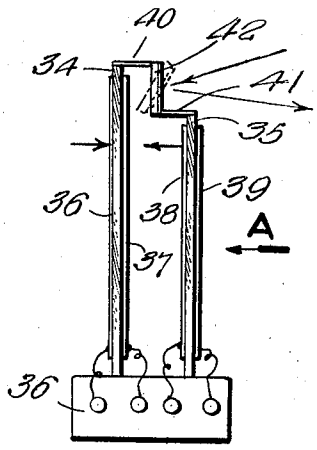


Fig. 11

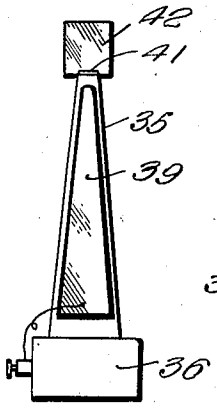


Fig. 12

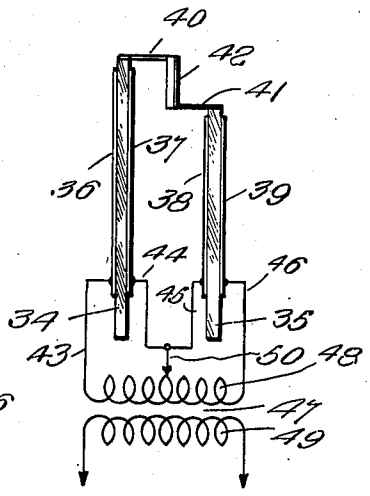


Fig. 13

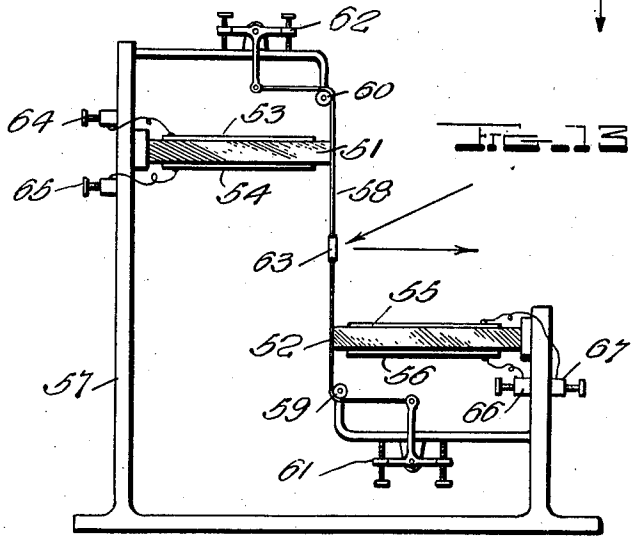


Fig. 14

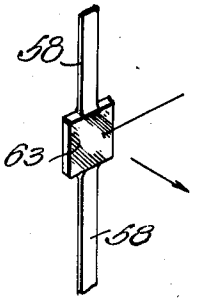
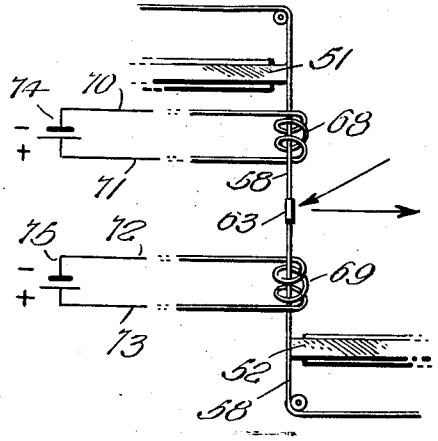


Fig. 15



INVENTOR.
Stewart C. Whitman,
BY
Jacobi & Jacobi
ATTORNEYS.

Patented Aug. 27, 1935 2,012,797

UNITED STATES PATENT OFFICE

2,012,797

PIEZO-ELECTRIC CRYSTAL REFLECTING MIRROR SOUND RECORDING SYSTEM

Stewart C. Whitman, Sunnyside, Long Island, N. Y.

Application July 13, 1934, Serial No. 735,074

18 Claims. (Cl. 179—100.3)

My invention relates to a novel system for recording sound on film and particularly to a system employing a piezoelectric crystal for impressing sound frequencies on a light beam.

A purpose of my invention is to provide a system for varying a light beam at sound frequencies wherein there is minimum inertia of the moving parts.

A further object of my invention is to provide a system for varying a light beam at sound frequencies while avoiding the employment of the electro-magnetic effect of a current actuating an armature element in a magnetic field.

A still further object of my invention is to provide a piezoelectric crystal actuated mirror element in which the metal laminated electrodes themselves constitute the mirror.

Heretofore in the art there has been employed a regular oscillograph mirror and element through which current is passed to vary a light beam, this being an electro-magnetically actuated arrangement. The moving parts of such a system possess considerable inertia, and being a current operated device, consume considerable power, which requires considerable amplification, which in turn is likely to introduce distortion.

I provide a piezoelectric crystal or other electro-mechanical vibratile element carrying a mirror at a point where such element vibrates with considerable amplitude under the action of an applied voltage of audio-frequency. A beam from a source of light is incident upon such mirror and is thereby reflected through a suitable optical system upon the sound track of a sensitive film. My invention is directed primarily to a light sensitive motion picture film having a sound track.

With these and numerous other objects in view, my invention consists in the novel features of construction, combination and arrangement of parts as will be hereinafter referred to and more particularly pointed out in the specification and claims.

In the accompanying drawings forming a part of this application:

Figure 1 shows a general view of the assembled system for recording sound on film, including the light reflecting piezoelectric crystal element;

Figure 2 shows a sectional view of the cylindrical lens and revolving slot unit herein employable of the type disclosed in my copending application, Serial No. 605,992;

Figure 3 shows a front view of a wedge-shaped type of piezoelectric crystal element mounted at one end;

Figure 4 shows a side elevation of the element of Figure 3;

Figure 5 shows a sectional view on the line 5—5 of Figure 3;

Figure 6 shows a horizontal section on the line 6—6 of Figure 3;

Figure 7 shows a pivotally mounted elliptical form of piezoelectric crystal element;

Figure 8 shows a filarly mounted piezoelectric crystal element in the form of an elongated isosceles trapezoid;

Figure 9 shows a filarly mounted circular form of piezoelectric crystal element;

Figure 10 shows a front elevation of a modification of my invention employing two parallel offset piezoelectric crystal elements with a mirror element mounted between their ends in parallel relation;

Figure 11 shows a side elevation of the arrangement of Figure 10, looking in the direction of the arrow A of Figure 10;

Figure 12 is a general schematic view of the arrangement of Figure 10, including the wiring of the circuit;

Figure 13 shows a further modification of my invention, employing two offset piezoelectric crystal elements and a ribbon provided with a mirror portion maintained in contact with their ends;

Figure 14 shows a detailed view of the ribbon element and its mirror portion of the arrangement of Figure 13; and

Figure 15 shows a modification of the arrangement of Fig. 13 wherein the ribbon element is controlled by a pair of surrounding inductance coils.

I have found that a desirable form of piezoelectric crystal element is Rochelle salt crystals protected with some material such as collodion against deliquescence. It has also been found that a crystal having the shape of an elongated wedge or isosceles trapezoid has desirable frequency operating characteristics. In a preferred embodiment of my invention, I employ electrodes for the piezoelectric crystal element which consist of metallic laminae affixed to the crystal which have high light-reflecting ability, whereby there is avoided the additional inertia of a separate mirror element.

For ordinary purposes, I employ crystals of the order of one-sixteenth inch in thickness. I have found that a system employing crystals of the type here described operates satisfactorily on all frequencies throughout the audio range, wherein the system of my invention has a marked advan-

tage over the system heretofore employed using a conventional oscillograph mirror, which possesses inertia due to the weight of the glass mirror and its supports. Such a conventional oscillograph mirror is essentially a mechanical system, and requires much more energy for its operation than the system of my invention.

The system of my invention employing a piezoelectric crystal element is essentially a voltage operated device, whereas the conventional oscillograph mirror system is essentially a current operated device, and also for that reason requires more energy.

In employing a piezoelectric crystal element, there is available only a comparatively small amount of power, since it is a voltage operated device and it is desirable so far as possible to avoid attaching extraneous mobile elements to the crystal to be actuated by the crystal; for this reason, it is particularly desirable to use the arrangement which I disclose in which optical reflection takes place directly from the metallic reflecting surface of the laminar metallic electrodes which are directly affixed to the crystal itself. The conventional oscillograph mirror type of system heretofore employed has sharp frequency characteristics which limit its usefulness to a comparatively narrow part of the audio-frequency spectrum. When a piezoelectric crystal element is vibrating under the action of an applied voltage, it will often be found that the addition of even a very light mirror element or other slight weight to the crystal will entirely stop vibrations. The crystals which I employ are cut and ground in the shapes which I describe to cover the desired audio-frequency range from the lowest to the highest audio-frequency. A convenient form of electrode which I have employed consists of tin foil, wherein the portion of the electrode upon which the light beam falls is well polished to constitute a good optical reflecting surface. The area of the electrode upon which the light beam is incident should be so located as to be at a point of relatively large displacement of the crystal element during vibration.

In order to increase the relatively small amount of power available from a single crystal element, it is usual to employ a stack of crystals arranged as layers constituting a laminated crystal unit, with the electrodes interleaved. In my invention, the foil constituting the outer electrode is metallically light reflecting.

Referring to the figures in detail, in Figure 1, the light source 1 emits a beam which passes through the condenser lens 2 and the stop 3 and is incident upon the metallic reflecting surface 4 of the piezoelectric crystal element 5 at a point of large displacement thereof. Actuating audio-frequency voltage is applied to the terminals 6 and 7 of the crystal element for controlling its vibrations. The beam of light reflected from the crystal passes through the lens 8 and the diaphragm 9 having a slit of the order of one-sixteenth of an inch, and through the cylindrical lens 10 upon the sound track 11 of the motion picture film 12.

Instead of the simple cylindrical lens element 10 of Figure 1, there may be advantageously employed a specialized form of cylindrical lens with a special revolving slot 13 (Fig. 2) as fully shown and described in my copending application Serial No. 605,992, filed April 18th, 1932, which form has particular advantages for the purposes here in view.

Figure 3 shows an elongated wedge-shaped form of crystal 5 mounted at one end fixedly on the base 8a which may advantageously be of some material such as bakelite. It is desirable to make the free end of this form of crystal element of a rounded shape as shown. The binding posts 6 and 7 mounted on the base 8a are connected to the electrodes in the form of thin metal laminae which occupy substantially the entire area of the crystal faces. Since the free end of this form of crystal will ordinarily be the point of maximum displacement during the vibration, it is desirable to have the electrodes polished adjacent this rounded free end so that the light beam may impinge thereon for reflection.

By making the crystal wedge-shaped, tapered towards the top, an enhanced displacement effect is obtained, since the cross-sectional resistance and piezoelectric response of the crystal increases as the width decreases with increasing height above the base, and a differential effect is produced.

As shown in Figures 4, 5 and 6, the piezoelectric crystal element 5 is provided with the laminar electrodes 4 and 4a which are substantially of equal area and symmetrically disposed on the crystal element.

In Figure 7, there is shown an elliptical form of piezoelectric crystal element having the electrode 10 occupying substantially the entire area of the crystal face. This electrode is also formed of a metallic lamina and is polished in the area of maximum displacement during vibration to have good light reflecting properties. The crystal element 9 is supported by the frusto-conical means 11 and 12 which are attached to the frame 13. The means 11 and 12 may be adjusted by the screw means 14 and 15. One of the means, as 12, engages the crystal 9 tightly so as to hold it rigidly, or at least much more tightly than the other means as 11. The crystal is mounted to move substantially freely pivotally on one of the means, as 11.

In Figure 8, the piezoelectric crystal element 16 is in the form of an isosceles trapezoid having its long dimension in the direction of its non-parallel edges. The electrode 17 occupies substantially the entire area of the crystal face. The surface of the electrodes 17 is also well polished in the area of its maximum displacement during vibration. Wire elements 18 and 19 are fixedly attached to the parallel edges of the crystal at approximately the central point thereof so that the crystal is mounted on its axis of longitudinal symmetry. These wires are tightly attached to the mounting terminal members 20 and 21 which may be adjusted by the screw adjusting means 22 and 23, respectively. These screw adjusting means are in turn carried on the frame 24. One of these wires as 19 is relatively inflexible and stiff, as hard-drawn steel or phosphor-bronze wire, or a stiff ribbon wire. The other wire as 18 is relatively quite flexible and soft-drawn, to permit free movement of the upper end of the crystal relative to terminal member 20. This form of crystal element has been found to have decided advantages in its operating characteristics, particularly as to frequency range. The connections to the electrodes may advantageously be made directly through the wires 18 and 19.

In Figure 9, the piezoelectric crystal element 25 is of substantially circular form, and is provided with the electrodes 26 which occupy substantially the entire area of the crystal face. This electrode is also preferably a thin metallic lamina

and is polished in the area of maximum displacement during crystal vibration. The wires 27 and 28 are fixedly attached to the crystal at diametrically opposite points, so that the crystal is mounted on an axis of symmetry. The wires 27 and 28 are respectively fixedly attached to the terminal members 29 and 30 of the adjustable screw means 31 and 32. These screw means are carried on the frame 33.

One of these wires as 28 is likewise relatively inflexible and stiff, as hard-drawn steel or phosphor-bronze wire, or a stiff ribbon wire. The other wire, as 27, is relatively quite flexible and soft-drawn, to permit free motion of the upper end of the crystal relative to terminal member 29.

The means employed for mounting the crystals in the arrangements shown in Figs. 7, 8, and 9, including the one relatively stiff mounting which is adjustable, provides means for controlling the damping effect and the frequency response of the crystal, so that small adjustments for frequency can be made. By selecting wire of suitable diameter and elasticity, and properly adjusting the tension by the adjusting screws, the frequency response characteristics of the wire can be varied.

Figure 10 shows a modified form of my invention employing two piezo electric crystal elements 34 and 35 which are mounted in substantially parallel relation on the base 36 which may advantageously be of bakelite. The crystal 34 is provided with electrodes 36 and 37, and the crystal 35 is provided with the electrodes 38 and 39. These electrodes occupy substantially the entire area of the crystal faces. The crystal 35 is somewhat shorter than the crystal 34, so that the crystals have an offset relationship. The crystal 34 has a terminal arm or bridge member 40 attached at its free end, and the crystal element 35 has the arm or bridge member 41 attached at its free end. These arms extend toward each other as shown, and should preferably be of as light weight and structure as will serve the purpose, in order to reduce to a minimum the inertia of the moving parts. These arms are called upon to stand compressive stresses without bending, but since these stresses are of comparatively small magnitude, the arms may be constituted of sturdy non-bending wire such as phosphor-bronze wire. Between the free ends of the arms 40 and 41, the mirror element 42 is disposed, and is held in place by the arms 40 and 41. The mirror element 42 should be of as small area and of as light weight and structure as will serve the purposes. This mirror should have high optical reflecting power. As shown, mirror element 42 is advantageously mounted substantially parallel to the long dimension of crystal 34 and with an air space between mirror element 42 and crystal 34, so that mirror element 42 is in heat-insulated relation to crystal 34, which arrangement has particular advantages when a very intense beam of light is to be used with a crystal adversely affected by heat. Under the action of the voltage applied between its electrodes, crystal 34 bends or flexes or buckles and thereby laterally displaces its free end. Likewise, under the applied voltage, crystal 35 bends and laterally displaces its free end. The crystals 34 and 35 are so selected and so connected that under the action of an applied voltage the crystal 35 is displacing its free end toward the left when the crystal 34 is displacing its free end toward the right, as shown by the arrows in Figure 10. Due to this fact, when a voltage is applied, the mirror 42 is tilted through an angle whose amplitude depends upon the applied voltage. The arrangement of the mirror 42 may be clearly seen in Figure 11. Figure 12 shows a general schematic view of this arrangement and also the connections 43, 44, 45 and 46 to the electrodes of the crystal. The transformer 47 has a primary 49 and a secondary 48. The applied audio signal is connected to the primary 49. The secondary 48 is provided with a mid-tap 50 to which the electrode connections 44 and 45 are connected. The terminals of secondary 48 are connected to the other electrodes of the crystal by the wires 43 and 46. This constitutes a push-pull arrangement by which the crystals act in opposition as previously described, and the mirror element 42 is tilted under the action of the applied voltage of the signal.

It is desirable to have a relatively large value of impedance for coupling the crystal to the input circuit, for either recording or reproducing, in order to match the relatively large impedance of the crystal itself, the crystal being inherently a small-current and small-power device.

Figure 13 shows a further modification of my invention employing two piezoelectric crystal elements 51 and 52 which are mounted in offset relationship. The crystal element 51 has the electrodes 53 and 54, and the crystal element 52 has the electrodes 55 and 56. These electrodes occupy substantially the entire area of the crystal faces. These crystals are preferably mounted on a frame 57 by one end of each crystal, in such manner that the free ends of crystals 51 and 52 are in substantially the same vertical plane, the crystals being mounted from opposite directions with reference to such plane. Under the action of the voltage applied to its electrodes, each of the crystals 51 and 52 bends or flexes or buckles and thereby foreshortens and lengthens, and displaces its free end. A ribbon element 58 is held tautly against the free ends of crystals 51 and 52. This ribbon element 58 is preferably a narrow metallic band or ribbon and passes over pulley or similar supporting means 59 and 60, and is held securely in place by adjustable tension means 61 and 62. At a point intermediate crystals 51 and 52, the ribbon 58 is provided with an integral enlarged portion 63 which is highly polished to constitute a good optical reflecting surface. The ribbon 58 may be of chrome-nickel, of dark color, or may be silvered throughout. The ribbon may be about one-sixteeth of an inch in width and may be like the ribbon employed in a ribbon microphone. In any case, the integral portion 63 which is used for light reflection should be silvered or otherwise provided with a very good optical reflecting surface. Figure 14 shows a detail of the ribbon 58 and the reflecting portion 63. The electrodes of the crystal element are respectively connected to binding posts 64, 65, 66 and 67, to which the audio frequency voltage is applied in proper relationship so that crystals 51 and 52 will operate in push-pull relationship, in a manner similar to that shown in Figure 12.

While in Fig. 13, I have shown two crystals mounted offset in opposed relation, it is also possible to use in the arrangement of Fig. 13 only one crystal as 52, and to substitute a rigid fret for the other crystal as 51, and the system will operate but with decreased amplitude.

Figure 15 shows an additional means for securing good control of the modification shown in Figure 13. In Figure 15, the crystals 51 and 52, and the ribbon element 58 with its reflecting portion 63, are substantially as shown in Figure 13. There are, however, provided in addition, the

solenoids or inductance coils 68 and 69 which surround the metallic ribbon element 58. The solenoid 68 is wound in the opposite sense to solenoid 69. The terminals 70 and 71 of solenoid 68, and the terminals 72 and 73 of solenoid 69, are connected to sources 74 and 75 of direct current which are so poled that solenoid 69 has a field of sense opposite to that of solenoid 68. These solenoids therefore apply magnetic fields of constant magnitude in opposite sense to the metallic ribbon 58 which materially assist in controlling the ribbon and holding it in place, and avoiding undesired free vibrations of the ribbon. This materially assists in maintaining the accuracy of the sound track obtained.

I have found that the type of piezoelectric crystal element reflecting system which I have described has important desirable operating characteristics which are not possessed by the types of devices heretofore known in the art, and that very sharp and accurately delineated sound records may be thereby attained.

From the foregoing description of the construction of my improved recording system, the operation thereof and the method of applying the same to use will be readily understood. It will be seen that I have provided a simple, inexpensive and efficient means for carrying out the objects of the invention and while I have particularly described the elements best adapted to perform the functions set forth, it is obvious that various changes in form, proportion and in the minor details of construction may be resorted to, without departing from the spirit or sacrificing any of the principles of the invention.

Having thus described the invention, what is claimed is:

1. In a system for recording sound on film, a source of light, a vibratably mounted piezoelectric crystal, electrodes for said crystal, a laminar mirror element mounted on said crystal flatly on a face of largest area thereof and at a point of relatively large displacement of said crystal and displaceable by the vibrations of said crystal, a light-sensitive film having a sound track and positioned so that light from said source incident on said mirror element is reflected on said sound track, and a source of electric energy of sound frequency connected to said electrodes.

2. In a system for recording sound on film, a source of light, a vibratably mounted piezoelectric crystal element, laminar metallic light-reflecting electrodes affixed to said element, said element being positioned so that light from said source is incident upon one of said light-reflecting electrodes, a light-sensitive film having a sound track and positioned so that light from said source incident on said electrode is reflected on said sound track, and a source of electric energy of sound frequency connected to said electrodes.

3. In a system for recording sound on film, a source of light, a vibratably mounted long wedge-shaped piezoelectric crystal element, laminar metallic light-reflecting electrodes affixed to said element, said element being positioned so that light from said source is incident upon one of said light-reflecting electrodes, a light-sensitive film having a sound track and positioned so that light from said source incident on said electrode is reflected on said sound track, and a source of electric energy of sound frequency connected to said electrodes.

4. In a system for recording sound on film, a source of light, a vibratably mounted piezoelectric crystal element, said element having substantially the shape of an isosceles trapezoid with its longest dimension in the direction of its non-parallel edges, laminar metallic light-reflecting electrodes affixed to said element, said element being positioned so that light from said source is incident upon one of said light-reflecting electrodes, a light-sensitive film having a sound track and positioned so that light from said source incident on said electrode is reflected on said sound track, and a source of electric energy of sound frequency connected to said electrodes.

5. A unit for varying a light beam in accordance with impressed electrical variations comprising a vibratably mounted piezoelectric crystal element, and laminar metallic light-reflecting electrodes affixed to said element and having an optically good reflecting surface at a point of relatively large displacement of said crystal element during vibration.

6. A unit for varying a light beam in accordance with impressed electrical variations comprising a vibratably mounted long wedge-shaped piezoelectric crystal element, and laminar metallic light-reflecting electrodes affixed to said element and having an optically good reflecting surface at a point of relatively large displacement of said crystal element during vibration.

7. A unit for varying a light beam in accordance with impressed electrical variations comprising a long substantially wedge-shaped piezoelectric crystal element, means for fixedly mounting said element on the broader end thereof, said element being freely movable at the wedge-point end thereof, and laminar metallic light-reflecting electrodes affixed to said element and having an optically good reflecting surface at a point of relatively large displacement of said crystal element during vibration.

8. A unit for varying a light beam in accordance with impressed electrical vibrations comprising a substantially elliptical piezoelectric crystal element, means for mounting said element at diametrically opposite points thereof, said crystal being relatively fixedly mounted at one of said points and substantially freely pivotally mounted at the other of said points, and laminar metallic light-reflecting electrodes affixed to said element and having an optically good reflecting surface at a point of relatively large displacement of said crystal element during vibration.

9. A unit for varying a light beam in accordance with impressed electrical vibrations comprising a piezoelectric crystal element having substantially the shape of an isosceles trapezoid with its longest dimension in the direction of its non-parallel edges, means for mounting said element on the parallel edges thereof, on its axis of longitudinal symmetry, said crystal being relatively fixedly mounted on one of its said parallel edges and substantially freely swingably mounted on the other of its said parallel edges, and laminar metallic light-reflecting electrodes affixed to said element and having an optically good reflecting surface at a point of relatively large displacement of said crystal element during vibration.

10. A unit for varying a light beam in accordance with impressed electrical vibrations comprising a piezoelectric crystal element having substantially the shape of an isosceles trapezoid with its longest dimension in the direction of its non-parallel edges, a pair of filar supporting elements fixedly attached respectively to the par-

allel edges of said element at the central points thereof, one of said filar elements being relatively inflexible and the other of said filar elements being relatively highly flexible, supporting means to which said filar elements are fixedly attached, and laminar metallic light-reflecting electrodes affixed to said element and having an optically good reflecting surface at a point of relatively large displacement of said crystal element during vibration.

11. A unit for varying a light beam in accordance with impressed electrical vibrations comprising a substantially circular piezoelectric crystal element, a pair of filar supporting elements fixedly attached respectively at diametrically opposite points of said element, one of said filar elements being relatively inflexible and the other of said filar elements being relatively highly flexible, supporting means to which said filar elements are fixedly attached, and laminar metallic light-reflecting electrodes affixed to said element and having an optically good reflecting surface at a point of relatively large displacement of said crystal element during vibration.

12. A unit for varying a light beam in accordance with impressed electrical vibrations, comprising a pair of piezoelectric crystal elements, electrodes for each of said elements, means for fixedly mounting one end of each of said elements and maintaining said elements in substantially parallel relationship and adjacent each other, one of said elements having its end opposite its mounting end projecting beyond the free end of the other of said elements, a laminar mirror element, and a pair of arms attached to separated points of said mirror element and respectively to the free ends of said crystal elements for maintaining said mirror element in a position approximately parallel to said crystal elements.

13. In a system for recording sound on film, a source of light, a pair of piezoelectric crystal elements, electrodes for each of said elements, means for fixedly mounting one end of each of said elements and maintaining said elements in substantially parallel relationship and adjacent each other, one of said elements having its end opposite its mounting end projecting beyond the free end of the other of said elements, a laminar mirror element, a pair of arms attached to separated points of said mirror element and respectively to the free ends of said crystal elements, a light-sensitive film having a sound track and positioned so that light from said source incident on said mirror element is reflected on said sound track, and a source of electric energy of sound frequency connected to said electrodes.

14. A unit for varying a light beam in accordance with impressed electrical vibrations, comprising a pair of piezoelectric crystal elements, electrodes for each of said elements, a mounting frame whereon one end of each of said crystals is fixedly mounted in such manner that said crystals occupy substantially parallel offset planes, the ends of said crystal elements opposite said mounting ends being free, a ribbon element in contact with the free ends of said crystal elements, and means for maintaining said ribbon element taut and in close contact with the ends of said crystal elements, said ribbon element being provided intermediate said crystal elements with an integrally formed optically reflecting mirror portion.

15. A unit for varying a light beam in accordance with impressed electrical vibrations, comprising a pair of piezoelectric crystal elements, electrodes for each of said elements, a mounting frame whereon one end of each of said crystals is fixedly mounted in such manner that said crystals occupy substantially parallel offset planes, the ends of said crystal elements opposite said mounting ends being free, a metallic ribbon element in contact with the free ends of said crystal elements, means for maintaining said ribbon element taut and in close contact with the ends of said crystal elements, said ribbon element being provided intermediate said crystal elements with an integrally formed optically reflecting mirror portion, a pair of solenoids surrounding said ribbon element and positioned on opposite sides of said mirror portion, and sources of direct current connected respectively to said solenoids, said solenoids being so wound and connected as to apply to said ribbon magnetic fields of opposite sense.

16. A unit for varying a light beam in accordance with impressed electrical vibrations, comprising a piezoelectric crystal element, electrodes for said crystal element, a mounting frame whereon one end of said crystal element is fixedly mounted and carrying said crystal element with its other end free, fret means carried by said mounting frame and extending from said mounting frame substantially parallel to said crystal element, said fret means being positioned in a plane offset from the plane of said crystal element, a ribbon element in contact with the free end of said crystal element and the free end of said offset fret means, and means for maintaining said ribbon element taut and in close contact with the end of said crystal element and the end of said fret means, said ribbon element being provided intermediate said crystal element and said fret means with an integrally formed optically reflecting mirror portion.

17. In a system for recording sound on film, a source of light, a vibratably mounted piezoelectric crystal, electrodes for said crystal, a mirror element attached to and carried by said crystal in spaced relation thereto at a point of relatively large displacement thereof and displaceable by vibrations of said crystal, said mirror element being mounted substantially parallel to the long dimension of said crystal and forming with said crystal an intervening air space, a light-sensitive film having a sound track and positioned so that light from said source incident on said mirror element is reflected on said sound track, and a source of electric energy of sound frequency connected to said electrodes.

18. In a system for recording sound on film, a source of light, a vibratably mounted piezoelectric crystal, electrodes for said crystal applied to and carried on opposite faces thereof, said crystal being provided on one of its faces to which a said electrode is applied at a point of relatively large displacement of said crystal with a light reflecting surface, a light sensitive film having a sound track and positioned so that light from said source incident on said light reflecting surface is reflected on said sound track, and a source of electric energy of sound frequency connected to said electrodes.

STEWART C. WHITMAN.