

Sept. 21, 1937.

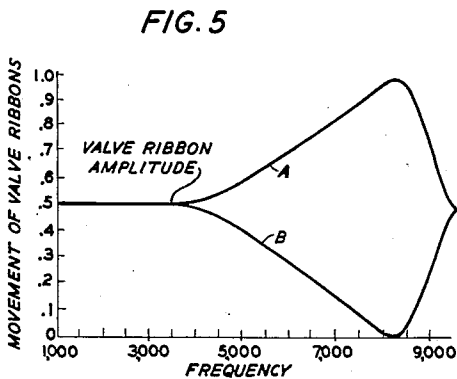
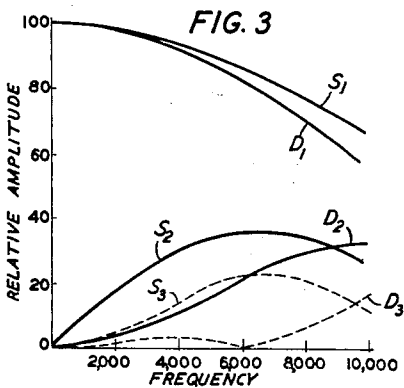
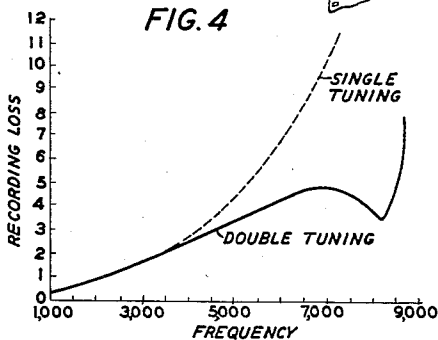
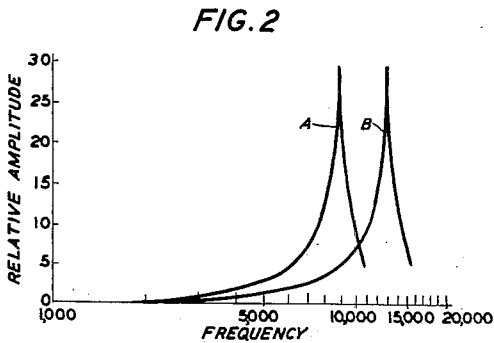
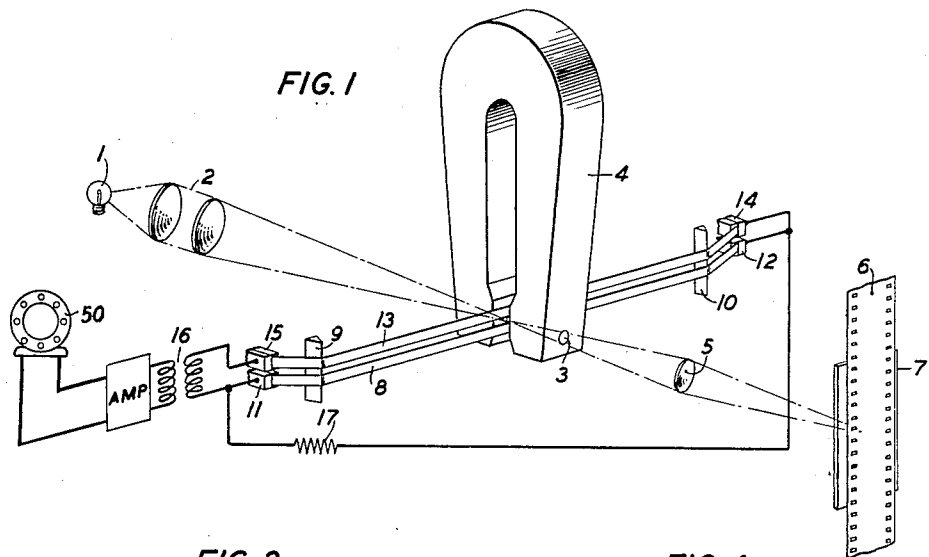
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2,093,674

LIGHT VALVE

Filed Feb. 1, 1935

2 Sheets-Sheet 1



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FIG. 8

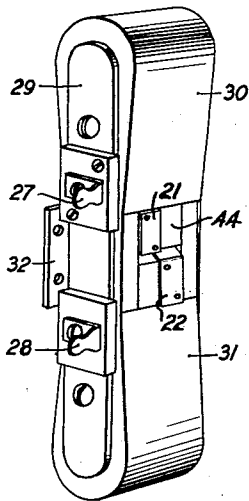


FIG. 6

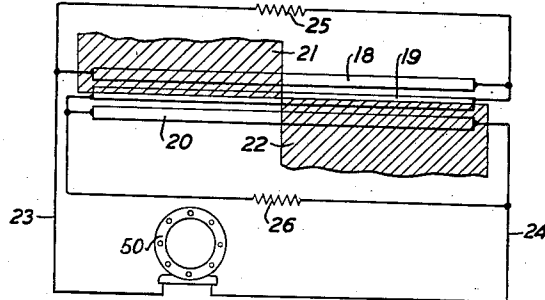


FIG. 7

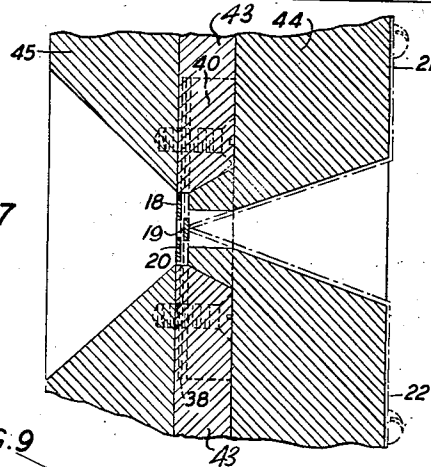
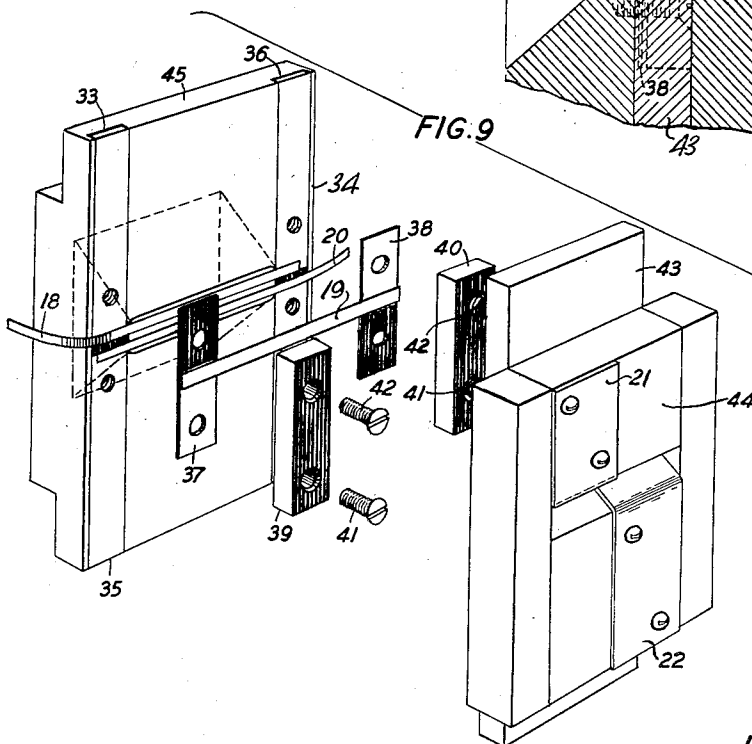


FIG. 9



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2,093,674

LIGHT VALVE

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Application February 1, 1935, Serial No. 4,445
In Great Britain May 11, 1934

8 Claims. (Cl. 88—61)

This invention relates to light valves, and particularly to light valves having a plurality of mechanically resonant elements to define the area exposed to the recording beam.

5 The object of the invention is to increase the recorded amplitude of signals of relatively high frequency; to reduce the distortion produced by the finite height of the recording beam; to make the response of the light valve more nearly uni-
10 form throughout the recorded frequency range; to increase the load carrying capacity of the light valve at relatively high frequencies; and to bring the frequency response characteristic of the valve more under the control of the designer.

15 A feature of the invention is a light valve comprising a plurality of mechanically resonant elements tuned to different resonant frequencies.

Another feature of the invention is an impedance connected in parallel relation with the
20 element tuned to the lower frequency to electrically damp the element at the lower frequencies.

Light valves comprising a plurality of mechanically resonant elements defining the area
25 exposed to the recording beam are well-known. In such light valves, the moving elements have heretofore been tuned to the same frequency.

In accordance with the present invention, one
30 of the elements is tuned to have a frequency of mechanical resonance slightly higher than the maximum frequency of the signal currents which are to be recorded. Another cooperating element is tuned to a frequency of mechanical resonance which is appreciably higher than the first frequency.
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For signal currents of low frequency, both elements cooperate to control the recording beam. For such low frequencies, the effects produced by all the elements are not materially different, though the lower tuned elements will be slightly more sensitive than the higher tuned elements. For frequencies approaching the frequency of mechanical resonance of the lower tuned element, the response of the lower tuned element is so much greater than the response of the higher tuned element that the modulation of the recording beam is very largely due to the movement
45 of the lower tuned element.

50 The sensitivity of all the elements may be exactly equalized at some desired low frequency by connecting a suitable impedance in parallel relationship with the elements tuned to the lower resonant frequency, thus electrically damping the element.

55 For convenience of description, the invention

is shown embodied in a light valve comprising a plurality of stretched ribbons. The invention is not thereby to be limited to the specific type of light valve disclosed but is applicable to any modulating device in which the recording beam is modulated by the conjoint effect of a plurality of mechanically resonant elements. The elements may be mechanically tuned by tension or by a difference in the material of the resilient supports or in the size or weight of the supports.

In the drawings:

Fig. 1 diagrammatically discloses the invention embodied in a two string light valve;

Figs. 2, 3, 4, and 5 show various curves illustrating the effect produced by the invention;

Fig. 6 diagrammatically shows a plan view of a three ribbon light valve;

Fig. 7 diagrammatically shows a sectional view of the ribbons and pole-pieces of the valve shown in Fig. 6;

Fig. 8 shows an elevation of a three string light valve; and

Fig. 9 is an exploded view of the ribbons and supports of the light valve shown in Fig. 8.

The light valve in Fig. 1 is similar to the light valve described in an article "The Principles of the Light Valve" by T. E. Shea, W. Herriott and W. R. Goehner, published in the Journal of the Society of Motion Picture Engineers, Vol. XVIII June 1932, pages 697 to 730. Light from a source
30 is directed by a lens system 2 upon aligned apertures 3 pierced in the pole faces of a magnet 4. The light passing through the apertures 3 is directed by a lens system 5 upon a uniformly moving photographic film 6 through an aperture
35 pierced in the opaque plate 7.

A flat conducting ribbon 8 is stretched over the supports 9, 10 and secured by the clamps 11, 12. The ribbon 8 is stretched so that the frequency of mechanical resonance is a little above the upper
40 limit of the range of frequencies to be recorded. In the case of a light valve used for recording sound, the ribbon 8 may be tuned to say 8,200 cycles per second.

A second flat conducting ribbon 13 is stretched
45 over the supports 9, 10 and secured by the clamps 14, 15. The ribbon 13 is tuned to have a frequency of mechanical resonance appreciably higher than the frequency of mechanical resonance of the ribbon 8. The ribbon 13 may, for example, be tuned to 13,000 cycles per second.

The signal currents from the microphone 50 may be supplied in any convenient manner, such as the transformer 16, and flow through the ribbons 8 and 13 in series. The ribbons 8 and 13 are
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disposed between the pole-pieces of the magnet 4 in such manner as to define the height of the beam of light transmitted through the orifice 3. The magnetic field due to the signal currents flowing in the ribbons 8 and 13 will react with the magnetic field due to the magnet 4 and cause the ribbons 8 and 13 to oscillate toward and away from each other, thus varying the height of the beam of light projected on the film 6.

In Fig. 2, the amplitude of movement of the ribbons 8 and 13, expressed in decibels, has been plotted against the frequency of the applied signal currents. It will be noted that for frequencies less than about 2,000 cycles per second, the amplitude of the two ribbons is essentially equal. For frequencies above 2,000 cycles, the lower tuned ribbon 8, curve A, has a larger amplitude than the higher tuned ribbon 13, curve B. For a frequency of 8,000 cycles, the amplitude of the ribbon 8, curve A, is so much larger than the amplitude of the ribbon 13, curve B, that the valve operates very nearly as a single ribbon light valve. The advantage gained by this change from a double ribbon valve to virtually a single ribbon valve is indicated in Fig. 3, in which a double ribbon valve having both ribbons tuned to the same frequency is compared with a single ribbon valve tuned to the same frequency and having an amplitude of swing double the amplitude of either ribbon of the double ribbon valve. The recorded amplitudes of the fundamental frequency of the signal currents is represented by the curves S and D and it will be noted that the single ribbon valve is slightly more efficient. The recorded amplitude of the second harmonic of the signal frequency is represented by the curves S₂ and D₂. It will be noted that for low frequencies, the single ribbon valve produces appreciably more of second harmonic distortion than the double ribbon valve, but for frequencies near 8,000 cycles, the conditions are reversed. It is in this region, in the present invention, that the light valve changes from the characteristics of a double ribbon valve to virtually the characteristics of a single ribbon valve. Also, the curves S₃ and D₃ represent the third harmonic distortion of the signal frequency and it will be noted again that for the lower frequencies, the double ribbon valve produces less distortion but for the higher frequencies the single ribbon valve produces the same or less distortion.

In Fig. 4, the recording loss in decibels indicated by the curve D₁ in Fig. 3 is plotted in dotted lines against the frequency of the signal currents. The solid line curve shows the result of actual measurements made on the same valve when the ribbons were tuned respectively to 8,200 and 13,000 cycles. The reduced loss at the higher frequencies is apparent.

As shown in Fig. 2, the lower tuned ribbon, curve A, has an appreciably larger amplitude than the higher tuned ribbon, curve B, even at 3,000 cycles per second. This difference in sensitivity does not confer any benefit and may be corrected by connecting an impedance in parallel relation with the lower tuned ribbon, as shown by the impedance 17 in Fig. 1. This impedance may have the form of a resistance equal to the direct current resistance of the ribbon 8. When such an impedance is used, the ribbons will have substantially equal amplitudes of oscillation up to nearly 4,000 cycles. In Fig. 5, the amplitude of oscillation of the ribbons of a light valve is plotted. The normal spacing of the ribbons is one mil inch (.001 inch); one ribbon is tuned to

8,200 cycles per second and connected in parallel relation with an equal resistance, the other ribbon is tuned to 13,000 cycles. The curve A shows the amplitude of oscillation of the lower tuned ribbon, while curve B shows the amplitude of oscillation of the higher tuned ribbon. It will be noted that as the frequency of the signal currents approaches 8,000 cycles, the valve approaches very nearly to the operation of a single ribbon light valve.

In certain known recording systems, separate records of the alternate half-waves of the signal currents are produced. In Figs. 6 and 7, a three ribbon light valve suitable for use in such systems is disclosed. The ribbons 18, 19, and 20 are disposed parallel to each other in the recording beam. A pair of masks 21 and 22 limit the area of the beam transmitted past the ribbons. For clearness of description, the ribbons have been shown widely separated but, in regular use, the ribbon 18 is close enough to the ribbon 19 that the recording beam is virtually cut off when no signals are being recorded. The ribbon 20 may be similarly placed close to the ribbon 19. The signal currents from the microphone 50 flow along wire 23, ribbons 18, 19, and 20, and out by wire 24. In accordance with the present invention, the ribbons 18 and 20 are tuned to have a different frequency of mechanical resonance than ribbon 19. If the ribbons 18 and 20 are tuned to a lower frequency than the ribbon 19, they may be respectively connected in parallel relationship with the impedances 25 and 26.

In order that the ribbon 19 may move freely with respect to the ribbons 18 and 20, as shown in Fig. 7, the ribbon 19 may be disposed in a different plane to the ribbons 18 and 20. The masks 21 and 22 may be attached as shown to the pole-pieces of the light valve.

The complete light valve may, if desired, have the general form of the light valve described in United States Patent 1,914,186, patented June 13, 1933 by E. C. Wente, modified as shown in Figs. 8 and 9. Only the essential parts of the light valve have been indicated, as the less important details are clearly shown in the above patent.

The light valve comprises a frame 29 spacing two permanent magnets 30 and 31 and supporting the pole-pieces and other details shown in Fig. 9. The complete light valve may be supported in the recording beam by screws passed through the bracket 32.

The signal currents are brought to the terminal 27 (Fig. 8), thence along wire 23 (Fig. 6) to a conducting strip 33 (Fig. 9), thence through the ribbons 18, 19, and 20 to a conducting strip 34 (Fig. 9), and through wire 24 (Fig. 6) to terminal 28 (Fig. 8).

The conducting strips 33, 34 are mounted on and insulated from the support 45 into which the pole-pieces of the magnets 30, 31 may be inserted. The strips 33 and 34 are less than one-half as long as the support 45. Intermediate strips 35 and 36, insulated from the strips 33 and 34, form a plane surface for the connectors 37, 38. The connectors 37, 38 are covered with an insulating material on the shaded areas, the remainder of the connectors 37, 38 being conducting. The connectors 37, 38 are clamped on the conducting strips by the insulating blocks 39, 40 which are retained by the screws such as 41, 42 passing through insulating bushings in the connectors 37, 38 into the conducting strips.

The signal currents will flow from the conduct-

ing strip 33 through ribbon 18, strip 36, upper half of connector 38, ribbon 19, lower half of connector 37, strip 35, ribbon 20 to strip 34. The ribbons 18, 19, and 20 are stretched to the proper tension in an auxiliary tool and clamped in place then cut off at the edge of the strips 33, 34.

The spacing member 43 carrying the pole-piece 44 is then suitably attached to the support 45 in the frame 29.

The masks 21, 22 may conveniently be attached to the pole-piece 44 by screws which permit the masks to be accurately adjusted.

What is claimed is:

1. In a device for recording signal currents extending over a range of frequencies, a supporting frame, a magnetic system associated with said frame, a plurality of conducting ribbons supported by said frame and disposed between the poles of said magnetic system to define a light transmitting slit, said ribbons being tensioned to a frequency of mechanical resonance slightly higher than the highest frequency of said signal currents, one of said ribbons being disposed in a different plane and tensioned to a frequency of mechanical resonance approximately fifty per cent higher than the frequency of the other ribbons, and means for supplying signal currents to said ribbons whereby for lower frequencies all of said ribbons oscillate to produce a record and for higher frequencies said one ribbon is substantially ineffective to produce a record.

2. In a light valve, a supporting frame, a magnetic system associated with said frame, a plurality of conducting ribbons supported by said frame and disposed between the poles of said magnetic system to define a plurality of light transmitting slits, said ribbons being tensioned to a frequency of mechanical resonance slightly higher than the highest frequency to be recorded, one of said ribbons being tensioned to a frequency of mechanical resonance approximately fifty per cent higher than the frequencies of the other ribbons, and masking means limiting the length of said light transmitting slits.

3. The combination in claim 1 with impedance elements connected respectively in parallel relationship with the ribbons tuned to the lower frequencies to produce the same sensitivity at low frequencies as the ribbons tuned to the higher frequencies.

4. The combination in claim 2 with impedance elements connected respectively in parallel relationship with the ribbons tuned to the lower frequencies to produce the same sensitivity at low frequencies as the ribbons tuned to the higher frequencies.

5. In a light valve, a supporting frame, a magnetic system associated with said frame, a pair of serially connected conducting ribbons supported by said frame and disposed between the poles of said magnetic system to define a light transmitting slit, one of said ribbons being tensioned to a frequency of mechanical resonance slightly higher than the highest frequency to be recorded and the other ribbon being tensioned to an appreciably higher frequency, and a resistor connected in parallel relation with said lower tuned ribbon to equalize the sensitivity of said ribbons at low frequencies.

6. In a light valve, a supporting frame, a magnetic system associated with said frame, three serially connected conducting ribbons supported by said frame in two planes and disposed between the poles of said magnet to form two light transmitting slits, the coplanar ribbons being tensioned to a frequency of mechanical resonance slightly higher than the highest frequency to be recorded, the other ribbon being tensioned to an appreciably higher frequency, a pair of resistors respectively connected in parallel relationship with said coplanar ribbons to equalize the sensitivity of said ribbons at low frequencies, and a pair of masks screening alternate portions of said light transmitting slits.

7. In a device for recording a range of signal frequencies, a supporting frame, a magnetic system associated with said frame, a plurality of ribbons supported by said frame in the field of said magnetic system and tensioned to a degree to provide for a vibration of all of the ribbons at lower frequencies and for a vibration of one of said ribbons at higher frequencies that is ineffective to produce a record and a vibration of the other ribbon at higher frequencies to produce the required record, and means for supplying signal energy to said device to cause said ribbons to vibrate.

8. In a light valve, a supporting frame, a magnetic system associated with said frame, a plurality of serially connected conducting ribbons supported by said frame and disposed between the poles of said magnetic system to define a light transmitting slit, said ribbons being tensioned to a degree to provide for a vibration of all of said ribbons at lower frequencies and a vibration of one of said ribbons at higher frequencies that is ineffective to produce a record and a vibration of the other ribbon at higher frequencies to produce the required record.

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