July 11, 1939. L. DEWAN 2,165,236

METHOD OF AND APPARATUS FOR RECORDING AND REPRODUCING OF SOUND

Filed Jan. 26, 1935

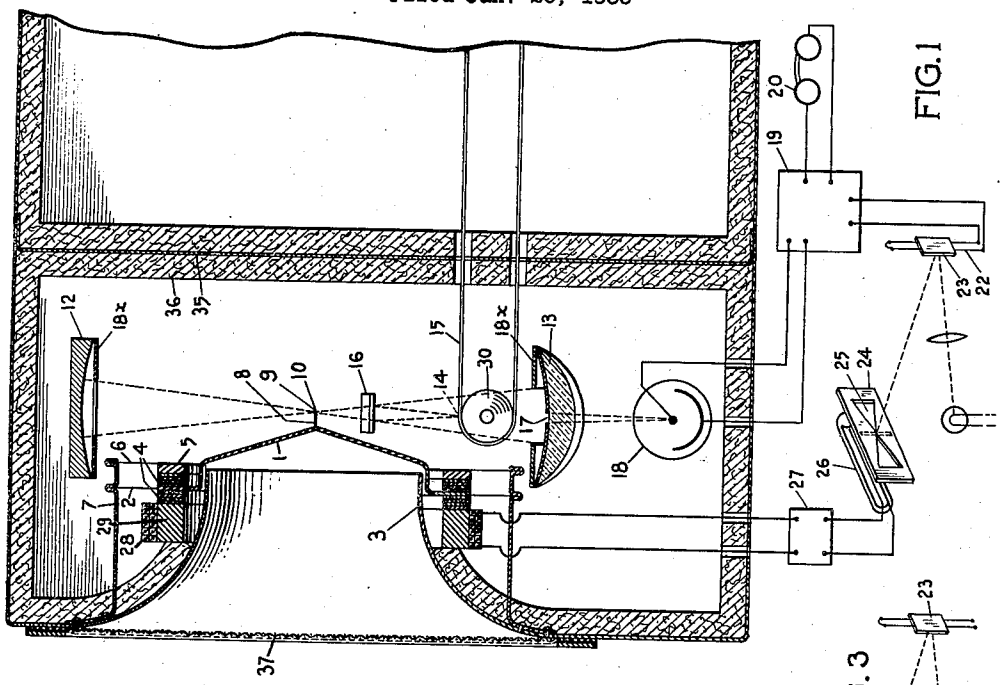

FIG. 1

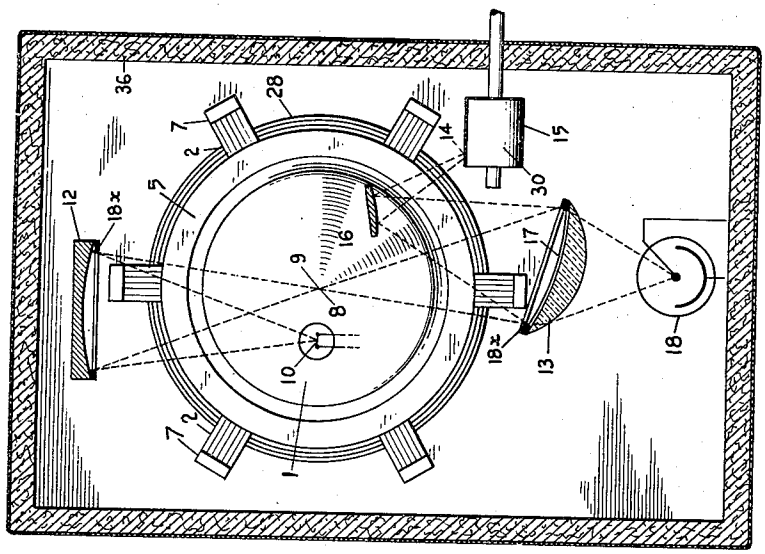

FIG. 5

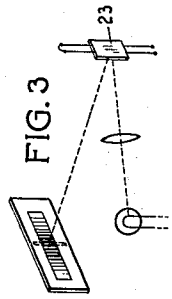

FIG. 3

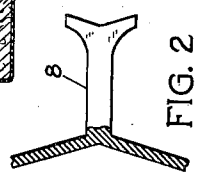

FIG. 2

FIG. 4

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Patented July 11, 1939 2,165,236

UNITED STATES PATENT OFFICE

2,165,236

METHOD OF AND APPARATUS FOR RECORDING AND REPRODUCING OF SOUND

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Application January 26, 1935, Serial No. 3,635

9 Claims. (Cl. 179—100.3)

The object of this system is to improve the sound qualities of the present type of talking motion pictures, particularly with reference to recording and reproducing the higher frequencies and overtones.

Another object is to improve the recording and reproducing of the sound track on 16 mm. and 8 mm. which up to the present time has not been accomplished with a fully satisfactory quality within my knowledge.

These and other objects will appear as the description proceeds.

In this system the sound is recorded by allowing the sound waves to impinge upon a very light diaphragm of special design which carries a vane shutter whose vibration modifies the effect of an image of an elongated light source upon a sensitive film. The diaphragm is damped and made to vary its effect on the light level in accordance with sound volume.

Figure 1 is a cross sectional and diagrammatic side view of the recording apparatus.

Figure 2 is an enlarged detail of the vane of Figure 1.

Figure 3 is a perspective view illustrating an alternative method usable in the recorder of Figure 1.

Figure 4 shows one type of sound track that may be produced by the recorder of Figure 1.

Figure 5 is an end view of the recording apparatus of Figure 1 shown diagrammatically and in cross section.

In Figure 1, showing one view of the recorder, the diaphragm 1, in the form of a cone of exceedingly thin duralumin or other suitable material is mounted upon a support 2, which may consist of thin sheet rubber of annular form or of radially disposed strips of thin sheet duralumin. The elasticity of the support 2 is such that if this support alone were used to hold the diaphragm, the natural frequency of the mounting would be below the audibility range (twenty to thirty cycles) despite the extreme lightness of the mounting and especially of the diaphragm whose material may be below .0003" in thickness.

While the diaphragm 1 vibrates free of the heavy metal casing 3, its movements are damped by the ring layers 4 of felt and silk fluff of varying elasticity which layers keep the diaphragm at zero position relative to the vibrations of the sound waves. The ring layers of silk fluff or other damping material which lie immediately adjacent to the rim of the diaphragm 1, are thin and extremely soft and light so that the faintest sound will vibrate the diaphragm unimpededly. The other layers are of gradually stiffer material as they are more distant from the rim so that when the amplitude of the diaphragm movement increases with louder sounds the range of the first layers is exceeded due to the thinness thereof and since the vibration is thereby transmitted to the other stiffer layers the amplitude of the diaphragm will be limited in proportion to the sound volume above a certain medium value and sounds of great volume will be prevented thereby causing excessive amplitude of diaphragm movement. A thin flat sheet iron ring 5 which is suspended by light elastic material 6 from the circular spur 7 of the casing 3, (as is the diaphragm 1) presses very lightly against the rings 4. A small vane 8 which may be of the form shown in Figure 2 with the end cut into a shallow V partly obscures the image 9 of a filament 10 (seen endwise) of an incandescent lamp 11. The diaphragm by vibrating to sound and moving the vane 8 would produce a symmetrical variable area track upon a sensitive film.

The filament 10 and the image 9 are both at the center of spherical curvature of the concave mirror 12. The filament 10, may either be highly tenuous as shown, or may be rather thick if desired providing that its light be concentrated upon a finely apertured mask placed near the vane which would then vary the amount of light passing the aperture or slit, or else a slit in a mask illuminated by the filament may be imaged upon the vane to produce the desired effect. In these cases the diffraction caused by the fineness of the slits or vane edge has no effect in the image thereof produced upon the film 15, because, due to the characteristics of the concave mirror used according to the invention, all parts of the slit edge or vane edge act as point sources of light and because of the absence of chromatic or spherical aberration of the mirror all light leaving the edge is focused on one line in the image. It is therefore possible to use slits of a tenuity far greater than has been hitherto possible. The concave mirror 13 which is formed by silvering the concave face of a meniscus lens concentrates an image 14 of the image 9 upon the sensitive film 15 after reflection from the convex cylindrical mirror 16. The length of the light path from the images 9 and 14 to the concave mirror 13 are equal and the images are at its center of curvature. The cylindrical diverging mirror 16 lengthens the image 14 on the film 15. A slit like area 17 on the mirror 13 is free of silver and permits modulated light to reach the monitor photo cell 18, being concentrated thereon due to the curved

back surface of the mirror 13. The back of the mirror 13, may be either curved very deeply so that the light it reflects to the film 15, through the slit 17, is given a great convergence and dispersed thereby. The back may also be curved concentrically with the silvered face if desired, and a condensing lens be used to concentrate the light upon the photo cell. In either case the slit 17, should be as narrow as consistent with the monitoring requirements.

The masks 18X have oblong apertures whose length in the plane of the sound track width exposes the whole width of the concave mirrors 12 and 13, but masks the upper and lower portions thereof. Thus the concave mirror 13, for example produces a light bar on the film by means of a beam whose convergence in the lateral plane of the sound track is less than the convergence in the longitudinal plane. The result is that small variations of distance between the mirror 13 and the film emulsion do not cause a great broadening of the light bar in the longitudinal plane where there is a great necessity of sharp image resolution to scan the sound waves. At the same time a sufficient amount of light is gathered by the breadth of the exposed portion of the mirror in the lateral plane. The great convergence of the beam in the lateral plane causes a greater confusion therein with "in and out of focus" effects, but this does not affect the image sharpness longitudinally. This feature enables the concave mirror to be brought close to the light source and film and a large aperture or hemisphere of the light source can be collected and concentrated on the film without impairing the sharpness of the image in the scanning plane.

The photo cell amplifier 19 actuates the monitor phones 20 and the oscillograph 21 which may be of a type wherein an iron armature 22 carrying a mirror 23 is freely pivoted and its movement damped by felt packing. The oscillograph mirror 23 reflects a thin vertical elongated light spot on a screen 24 which may have two triangular openings 25 or a glass screen as shown in Figure 3 which is opaque at the center and graduating to transparency at the edges. A selenium cell 26 actuates an amplifier 27. It will be seen that since the oscillograph responds to the amount of light on the photo cell 18, and consequently to the incoming sound. The amplitude of the movement of the light spot on the screen 24 will determine to what extent the selenium cell 26 shall be activated since at zero sound the light spot rests in the middle of the space between the two openings 25. It is known that while selenium responds quickly to light increase, it responds much more slowly to a light decrease and therefore if it is activated by light variation of high frequency its resistance and output would practically represent the average light and be little affected by the high frequency modulation. The result is that while its output would respond quickly to every increase of light and therefore follow each upward surge of volume, its sluggishness to light decrease retards its response to the valleys of the sound waves. Therefore the output of the selenium cell or the amplifier 27 requires very little filtering in order to furnish a biasing current representing the average sound volume. This output is applied to a magnet winding 28 which causes the circular iron core 29 to attract the ring 5 in proportion to the sound volume. The current in the windings 28 during silence is very small or at zero.

At silence, the normal position of the vane 8 is such that only a small portion of the center of the sound track as shown in Figure 4 is illuminated. With sound, not only does the diaphragm vibrate, but it is drawn back by the ring 5 in proportion to the volume of the incoming sound so that a greater average area of illumination results and room is provided on the track for the amplitude of the sound waves. The diaphragm is automatically damped in proportion to the sound volume so that excessive volume will not cause overshooting, and a great volume range can be handled. It is thus possible to mount the diaphragm with exceeding delicacy so that the faintest sounds are registered without fear of spoiling the record when great volume occurs. Furthermore, due to the inertia of the oscillograph and selenium cell 26 which respond more readily to lower frequencies, the damping action on the diaphragm 1 is greater for sounds of low frequency than high frequency, so that excessive amplitude response of the diaphragm to low frequency sounds is corrected. The selenium cell also presents the advantage that the delay with which it responds to light or volume decrease reduces the distortion due to the interaction of the biasing component with the volume envelope frequency of the recorded sound and prevents the biasing from responding to the outlines of the low frequency sound waves. A low pass filter consisting as known in the art of an inductance in series and a capacity in parallel with the output of the amplifier 27 may be used to suppress any remaining voice frequency ripples in the biasing current.

The film 15 travels over a sound filtered roller 30 which is mounted to revolve as smoothly and quietly as possible. The film runs back through the sound insulated portion 31 to the film drive (not shown). Alternate layers 36 of various sound absorbent materials line the interior of the casing 3 so that any sound entering the casing is destroyed. Several folds of loosely stretched silk 37 prevent air currents from affecting the diaphragm. The silk surface may be damped by felt wads mounted on the metal screen 38 to prevent vibration thereof.

Figure 5 shows the recorder mounting endwise. Although variable area sound track recording is shown it is obvious that variable density track may be produced by causing the edge of the vane 8 to be straight instead of V shaped, in which case a reducing lens may be substituted for the concave mirror 13, and the film roller 30 may then be far below the diaphragm 1.

The thin diaphragm may be produced by deposition by well known methods either in air or in a vacuum, of aluminum or duralumin upon a hollow form which may later be dissolved away in a liquid which does not affect the deposit. This form may be of a cone like shape with concentric or radial corrugations therein as the case may be.

The advantage of using a separate carbon microphone for example is the large amount of power easily obtained thereby without great amplification which causes delay. Furthermore this type of microphone may be simple and inexpensive while a good quality of sound is not a factor in deriving the biasing current. It is understood that this method of amplitude levelling or regulation may also be applied to other systems of recording wherein the movable diaphragm type of microphone is used, by having a damper ring such as rings 4 and 5 of Figure 1 act variably upon the diaphragm in accordance with sound vol-

ume. For example, in a condenser microphone the stretched diaphragm may be placed closer to the back plate than is usual in practice, and the damper ring is pressed against the diaphragm from the rear when sound occurs to increase the distance separating the condenser plates with increased sound volume. When this method is applied to the case of a carbon microphone, the contact pressure between the diaphragm and carbon button may be increased with increased sound volume.

What is claimed is:

1. In an apparatus for recording sound, a light source, a diaphragm actuated by sound waves in air in accordance with the instantaneous value of the sound, a light modulator coupled to and operated by the diaphragm, a photographic film to receive a sound track, a main support for holding said diaphragm at a tension resulting in a sub-audible natural period of vibration of said diaphragm, and additional means comprising a cushion support intermediate of the main support and the center of the diaphragm for yieldably holding the diaphragm at zero position in the plane of vibration.

2. In a sound recording system, a diaphragm actuated by sound waves in air in accordance with the instantaneous value of the sound, cooperating light modulating means coupled to and mechanically operated by the diaphragm, and means acting on the diaphragm and controlled by said sound waves for modifying the action of the diaphragm in accordance with the average volume of the sound being recorded whereby the vibrational response of the diaphragm to the sound waves impacting thereon is limited, the limiting force being increased with increasing sound volume and decreased with decreasing sound volume.

3. In a sound recording system, a diaphragm actuated by aerial sound waves in accordance with the instantaneous value of the sound, a light modulator coupled to and operated by the diaphragm, and automatic means to vary the zero position of the diaphragm in proportion to the volume of the sound waves actuating the diaphragm.

4. A sound recording system for producing a photographic sound track including means for producing a beam of light converging to a focal point and diverging therefrom to a light collector, means for modulating the light comprising a shutter disposed adjacent to and active at the focal point of the light beam, a diaphragm adapted to be vibrated by air waves and of generally conical form to be substantially parallel to the angle formed by the light beam, the apex of said diaphragm being connected to said shutter.

5. A diaphragm actuated by sound waves in air in accordance with the instantaneous value of the sound, a light modulator operated directly by the diaphragm, and means actuated by the sound being recorded for varying the relation between the diaphragm and the modulated light beam in accordance with the volume of the sound being recorded.

6. In a sound recording system, the combination of a diaphragm actuated by sound waves in air in accordance with the instantaneous value of the sound, an electrical circuit including a source of current modulated in accordance with the volume component of the sound, and electromagnetic means associated with the diaphragm and influenced by said modulated current for varying the zero position of the diaphragm by and in accordance with the volume of the sound waves acting upon the diaphragm.

7. The combination of a diaphragm actuated by sound waves in air in accordance with the instantaneous value of the sound, a support for said diaphragm, an electromagnetic clamp for stiffening the opposition of the diaphragm to the sound waves impacting thereon, and means for varying the tension of the clamp on the diaphragm in accordance with the volume of the sound whereby the tension will increase with increasing sound volume and decrease with decreasing sound volume.

8. A diaphragm actuated by sound waves in air in accordance with the instantaneous value of the sound, cooperating means for recording the sound, and means operated by the sound being recorded for stiffening the opposition of the diaphragm to the impact of the sound waves thereon whereby said stiffening is increased with increasing sound volume and decreased with decreasing sound volume.

9. A diaphragm actuated by sound waves in air in accordance with the instantaneous value of the sound, cooperating means for recording the sound, a support for the diaphragm, means for grasping the diaphragm and means controlled by the sound being recorded for varying the hold of the grasping means on the diaphragm in accordance with the volume of the sound whereby the hold increases with increasing sound volume and decreases with decreasing sound volume.

LEON DEWAN.