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REPRODUCTION OF SOUND RECORDS

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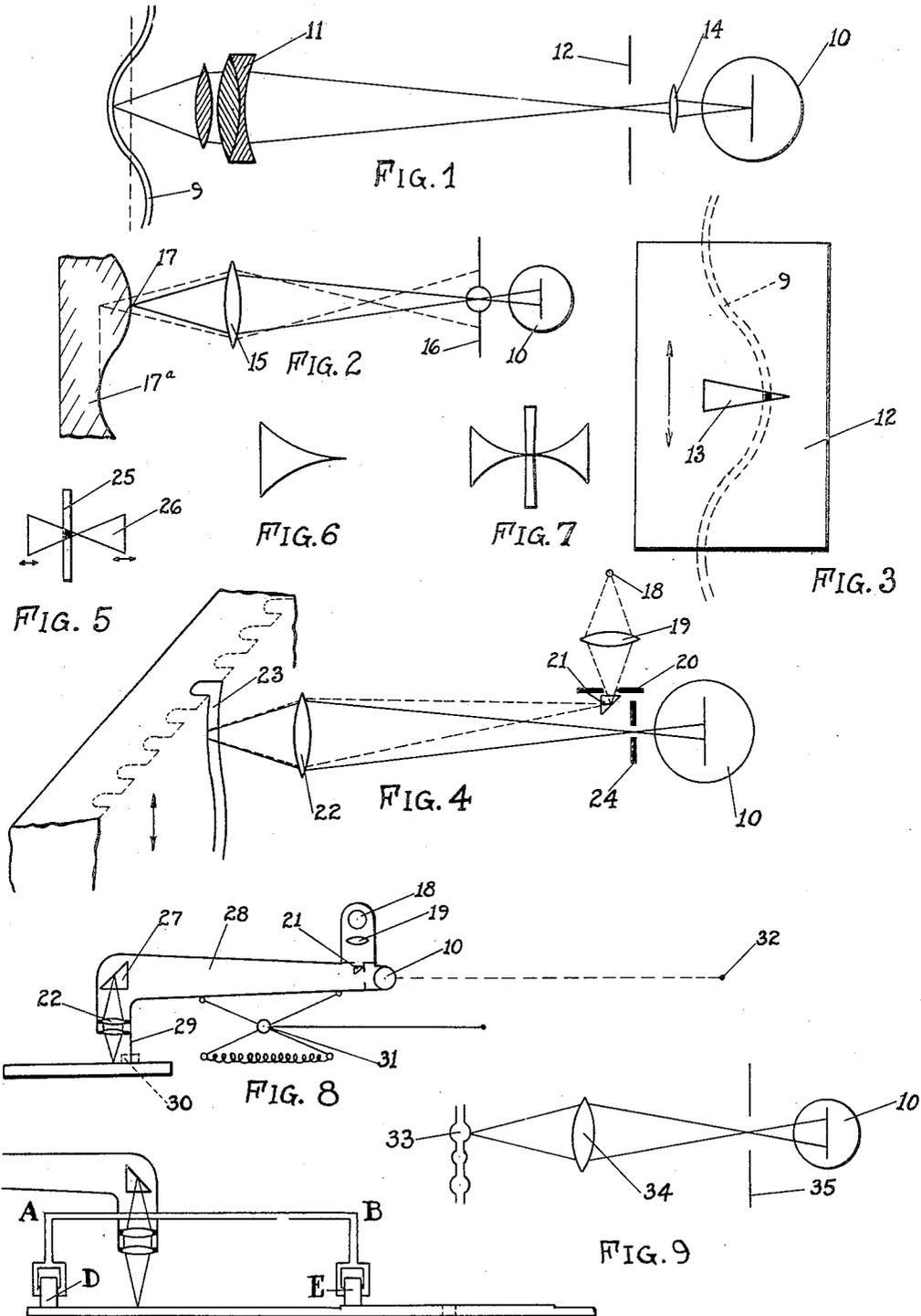


FIG. 10

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REPRODUCTION OF SOUND RECORDS

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This invention relates to a method of and apparatus for the reproduction of sound records.

Hitherto the reproduction of sound records of the gramophone class has been accomplished by a basically mechanical method. This is the case both with the mechanical sound box or with the electrostatic and electromagnetic pick-up and with the more recent method of causing a stylus to vibrate in response to contact with a sound groove, the vibrating stylus being adapted to actuate a shutter whereby the flux of light falling upon a photo-electric cell is made to vary. In all of such cases the primary transmission is in the form of a mechanical vibration in the stylus and the resulting sound effect is greatly dependent upon the dimensions and physical properties of the stylus employed.

The object of the present invention is to provide an improved method of an apparatus for the reproduction of sound records whereby to eliminate mechanical contact with the record surface and with this object in view the invention consists in a method of reproducing sound from a sound record comprising projecting a beam or pencil of light upon the surface of the record, intercepting the light reflected therefrom and converting the light thus reflected into electrical impulses.

The intercepted light is adapted to be directed on to a light sensitive device, for example a photo-electric cell which is adapted to convert the reflected light into electrical impulses, the electrical impulses being thereafter applied to a thermionic amplifier and passed to a loudspeaker or similar device for conversion into sound vibrations.

The invention may be employed in connection with sound records of the lateral cut type or of the hill-and-dale cut type. Furthermore the invention may also be employed to such records in the form of waxes on which the sound vibrations are initially recorded or to either a positive or negative metallic electro plate of the wax master or to the ordinary commercial gramophone record. Furthermore the invention may also be employed in connection with records in the form of a

thread, the actual sound vibrations being delineated by varying thicknesses of the thread.

The invention contemplates the use of shape diaphragms for the purpose of varying the amount or flux of light which is permitted to pass to the light sensitive device, the amount or flux of light being dependent upon the characteristics of the sound record being traversed.

Further features of the invention will hereinafter appear.

In the accompanying drawing:—

Figure 1 illustrates in a somewhat diagrammatic form the invention as applied to a lateral cut type of record,

Figure 2 illustrates the invention as applied to a record of the hill-and-dale type.

Figure 3 illustrates one form of diaphragm employed with the invention.

Figure 4 illustrates a further form of the invention.

Figures 5, 6 and 7 illustrates further forms of diaphragm which may be employed according to the invention, and

Figure 8 illustrates in diagrammatic form a practical embodiment of the invention.

Figure 9 illustrates the invention as applied to a record in the form of a thread.

Figure 10 is a diagram of a modification.

In carrying the invention into effect according to Figures 1 and 3 and as applied to a lateral cut type of record, I arrange a beam or pencil of light to be projected on to the surface of the record by means of a suitable lens system not shown. The focussing power of such system may be employed to differentiate the groove from the remainder of the surface of the record.

The sound groove of the record which is shown diagrammatically at 9 is adapted to reflect an image of the groove and the light thus reflected is intercepted and concentrated by a lens system 11 and directed on to a light sensitive device such as a photo-electric cell 10.

Arranged preferably at the focus of the reflected light is a diaphragm 12 (Figure 1) having a shaped aperture 13 (Figure 3) through which the reflected light is adapted to pass prior to its passage to the light sensi-

tive device 10. The light passing through the aperture may be further concentrated by a lens 14.

The aperture 13 in the diaphragm may be, according to Figure 3, of a triangular or lozenge shape arranged with the base of the triangle substantially parallel to the main track of the groove image.

During traversing of the record the sound groove is adapted to cause a succession of images to be reflected through the lens system 11 on to the surface of the diaphragm and it will be appreciated that such succession of images will traverse the surface of the diaphragm in a linear path and parallel to the short base of the isosceles triangle shaped aperture. The speed and extent to which the images move over the surface of the diaphragm will be dependent upon the amplitude and frequency of the sound recorded. Due to the configuration of the aperture of the diaphragm the amount or flux of light passing through the aperture at one part will vary as compared with the amount of light passing through another part.

The arrangement may be such that for a large amplitude of a sound vibration a greater amount of light is permitted to pass through the aperture than for a relatively small amplitude.

The light passing to the photo-electric cell will therefore depend upon the characteristics of the sound groove being traversed. The light is converted into electrical impulses in the photo-electric cell, such electrical impulses being then applied to a thermionic amplifier and thereafter converted into sound vibrations by means of a loud speaker or the like.

In carrying the invention into effect in connection with a record of the hill-and-dale type as shown in Figure 2, a beam or pencil of light is projected on to the record shown as an enlarged partial section in Figure 2 and concentrated in the groove thereof. The groove is adapted to reflect an image of the groove, which image is intercepted and concentrated by means of a lens system 15 and projected on to a diaphragm 16 which has a small aperture sufficiently large to contain the image of the illuminated part of the hill of the sound groove at 17, the reflected light being then adapted to pass through the diaphragm 16 to the light sensitive device 10.

As the record is traversed the dale 17a will in turn be illuminated and will thus reflect an image which is at a greater distance from the lens system 18 than the image reflected by the part 17.

It will be seen, therefore, that since the reflected image is at a greater distance from the condenser 15 the focus of the image after passing through the condenser is considerably shortened as shown in dotted lines in Figure 2, with the result that, instead of a

fairly concentrated beam being projected on to the surface of the diaphragm 16 as shown in the full lines in Figure 2, a diffused beam impinges on the diaphragm due to the shortening of the focus. It will thus be apparent that the hill part of the groove will cause a greater flux of light to pass through the diaphragm on to the photo-electric cell whereas in the dale part of the record the image is diffused over the surface of the diaphragm so that a less amount of light is permitted to pass through the aperture.

If so desired the arrangement may be reversed so as to permit a greater amount of light to pass for a dale than for a hill part of the sound groove.

A further form of the invention is illustrated in Figure 4 in which an image of a diaphragm is reflected from the sound groove in place of an image of the groove.

A source of light indicated by the numeral 18 is arranged to project a beam on to a condenser 19 which concentrates the beam and projects it on to a diaphragm 20 having an aperture shaped as in Figure 1 or in Figures 5, 6 and 7 hereinafter referred to.

The light transmitted through the diaphragm 20 is totally reflected through a prism 21 on to a lens system 22 which concentrates the beam on to the sound groove indicated at 23. The image of the diaphragm 20 will be reflected by the sound groove back through the lens system 22 and on to a further diaphragm 24 located at or near the focus of the beam prior to its passage to the light sensitive device 10.

The diaphragm 24 is preferably provided with an elongated vertical aperture indicated at 25 in Figure 5.

The succession of images reflected from the groove 23 due to traversing of the record will be displaced laterally depending upon the amplitude of the sound groove and will move over the aperture 25 of the diaphragm 24 in a linear path and it will be appreciated that by virtue of the shape of the reflected image the amount of light permitted to pass to the photo-electric cell 10 will be dependent upon the displacement of the image relatively to the aperture of the diaphragm 24.

In order that the illumination of the shaped aperture 20 may be uniform the aperture may be illuminated by a beam of parallel light by placing the light source 18 at the focal plane of the condenser 19.

Greater flux of reflected light and consequently greater variation in the potential of the photo-electric cell may, if so desired, be obtained by employing an astigmatic lens system.

If so desired, instead of a single triangular shaped aperture as shown in Figure 1 being employed, a double triangular shaped aperture may be provided as shown at 26 in Figure 5, the two triangles being arranged with

their apices in contact so as to constitute a substantially diaboloid shaped aperture.

In some cases the shaped aperture may be made of a suitably non-linear form. For example, the triangular shaped aperture 13 shown in Figure 1 may be provided with curved concave sides as illustrated in Figure 6 or the aperture shown in Figure 5 may similarly be provided with curved sides as shown in Figure 7 while the elongated aperture 25 in Figure 5 may be provided with non-parallel sides as shown in Figure 7.

It will be seen, therefore, that with the above arrangements the light passed to the photo-electric cell is not directly proportional to the displacement of the image relatively to the aperture but increases more than in proportion to the displacement. By suitably choosing the shape of the aperture any desired displacement response curve may be obtained.

The shaped diaphragm referred to above may form an integral part of the photo-electric cell, (which latter may, for example be of the anode plate type), and in place of the particular shapes shown, the diaphragm may be furnished with one or more apertures of any suitable shape.

In some cases for the illumination of the record surface I may employ a system comprising a mirror or reflecting prism covering a part of the objective through which the light from a suitable source is projected onto the record, and the light reflected from the record is transmitted through that part of the objective which is not so covered. The part of the lens system for projecting the light onto the record need not be so highly corrected as the other part and may in consequence be a wider aperture system so as to secure a greater intensity of illumination of the record groove or other part. Such a system may be employed with either one or two shaped aperture diaphragms.

It is important that the distance between the lens system and the record be maintained constant. For this purpose the optical system may be arranged as shown in Figure 8 which system corresponds generally to the system shown in Figure 4 with the exception that a further prism 27 is provided for reflecting the light from the source on to the groove of the record. The system may be arranged within a casing or arm 28 as shown conveniently mounted adjacent to the turntable of the machine and which may be arranged similarly to the usual tone-arm.

The distance between the lens system and the record may be kept constant by means of an arm 29 provided with a small roller 30 which is adapted to run in an adjacent groove of the record. If desired the arm 29 may be replaced by a flexible stylus with or without a small wheel at the end or the arm 28 may carry a pin or projection arranged to be con-

trolled by a light spring and located in a part of the arm which rides on the surface of the record, the pin or projection riding in the record groove.

If the record should not rotate truly in one plane the optical system will likewise move but may still be kept parallel to the record by the linked movement illustrated diagrammatically at 31. Should the record errors be not great it may be sufficient to hinge the apparatus on a fulcrum at 32.

The alignment of the record groove with the optical system is secured by means of the arm 29 which not only maintains the vertical height above the record at the correct value but also maintains the tracking or the horizontal alignment of the record groove and the optical system.

It will be appreciated that the arm or stylus 29 does not communicate any vibration to the optical head so that wear upon the record is reduced to a minimum.

If so desired, the arm or stylus 29 may be arranged to travel in a plain or uniform groove arranged alongside the record groove so that wear upon the actual record groove is reduced to zero.

According to a further form the correct traversing of the record by the optical system or vice versa may be obtained by employing a system of cams, levers or gear arrangements so that the working head traverses or is traversed by the record at the desired rate.

In order to keep the record at the correct distance from the lens system, the arm carrying the latter may rest on and slide over a bar A B (Figure 10) which is kept at a fixed distance from the record by means of rollers D and E, which are adapted to roll on plain or ungrooved portions of the record.

The lateral eccentricity of record can be corrected for by means of another roller running on a raised projection or groove at the edge of the record. It is arranged that this roller gives a small spring controlled lateral displacement either to the record, or to the traversing screw or the nut guiding the alignment of the optical system and its groove. Alternatively the turntable carrying the record may have a more or less flexible support so that the essential grooves of the record are maintained in the correct position by the fixed arrangement of rollers or wheels so that relative to the optical system the record is free from errors of eccentricity and warping of the discs.

The invention is of particular service for use in the initial recording of the sound vibrations upon wax masters and the difficulties of focussing and tracing in the case of wax are eliminated by mounting the optical system as an integral part of the head of the record cutting tool. The action of the latter can be electrically controlled by listening to the reproduction from the optical reproduc-

ing system mounted immediately behind the cutter.

The records employed in accordance with the present invention may as previously mentioned be of any suitable form and such may be metallized to afford a better reflective surface by any convenient process such as chemical deposition or cathodic spluttering or any other method so that the metal film lies either in the record grooves or on the other parts or both.

It will be appreciated, of course, that it may not be necessary to metallize the surface of the record since in some cases the ordinary record surface may be suitable and have a sufficiently reflective surface so as to obviate the necessity of metallizing the record.

According to a further form of the invention I may employ a record in the form of a thread, the actual sound vibration being delineated by varying thicknesses of the thread.

As shown in Figure 9 a record in the form of a thread is indicated at 33 and is arranged so that light may be reflected therefrom through a condenser 34 on to a diaphragm 35. The operation of the device shown in Figure 9 is similar to that described in connection with the hill-and-dale type of record illustrated in Figure 2.

According to a further form the light may be reflected from a mirror placed immediately behind the thread record and the aperture employed with either a parallel or focussed beam of light.

If desired in place of the shaped diaphragm referred to above I may employ a neutral tinted wedge for the purpose of varying the amount or flux of light which may or may not be combined with clear glass wedge for compensating the natural deviation in the neutral tinted wedge.

In some cases I may provide suitable means for varying the intensity of the light reflected from the record for the purpose of varying the volume of sound reproduced.

It is to be understood that I am not to be limited to the above details of constructions since I may vary the arrangement of lens system, the particular disposition and arrangement of the apertures depending upon any practical considerations that may have to be fulfilled.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. Apparatus for reproducing sound from a sound record, said apparatus including means for projecting a beam of light upon a record, means for intercepting the light reflected from the surface of the record, a light sensitive device for converting the reflected light into electrical impulses, a diaphragm having an aperture, means for projecting an image of said aperture onto the

surface of the sound record, a diaphragm in front of the light sensitive device, and said second diaphragm having an aperture for the passage of light rays.

2. Apparatus for reproducing sound from a sound record, said apparatus including means for projecting a beam of light upon a record, means for intercepting the light reflected from the surface of the record, a light sensitive device for converting the reflected light into electrical impulses, and means for compensating for any irregularity of movement of the record.

3. Apparatus for reproducing sound from a sound record, said apparatus including means for projecting a beam of light upon a record, a lens system for intercepting the light reflected from the surface of the record, a light sensitive device for converting the reflected light into electrical impulses, said lens system arranged to direct the intercepted light onto the light sensitive device, an arm, rollers engaging the portions of the record, a bar supported by said rollers in spaced relation to the record, and said lens system slidable on said bar and maintained at the correct distance from the record thereby.

4. A method of reproducing sound from a record having a sound groove therein comprising projecting light upon the surface of the record, intercepting and concentrating the light reflected from the record groove, passing the light thus concentrated to a light sensitive device for conversion into electrical impulses, and varying the amount or flux of light passed to said light sensitive device in accordance with the characteristics of the sound groove.

5. Apparatus for reproducing sound from a sound record having a sound groove therein, a source of light, means for projecting a pencil of light from said source into the sound grooves, means for intercepting the light reflected from the sound groove, a light sensitive device, means adapted to pass said intercepted light to said sound sensitive device, said sound sensitive device adapted for converting the reflected light into electrical impulses, and means for varying the light or flux of light projected to said record groove depending upon the characteristics of the record groove.

6. Apparatus for reproducing sound from a sound record having a sound groove therein, a source of light, means for projecting a pencil of light from said source into the sound grooves, means for intercepting the light reflected from the sound groove, a light sensitive device, means adapted to pass said intercepted light to said sound sensitive device, said sound sensitive device adapted for converting the reflected light into electrical impulses and means for varying the amount or flux of light passed to said light sensitive

device depending upon the characteristics of the record groove.

7. Apparatus for reproducing sound from a sound record comprising means for projecting a beam of light upon a record, means for intercepting the light reflected from the surface of the record, a light sensitive device for converting the reflected light into electrical impulses, and a diaphragm having a triangular shaped aperture through which the light reflected from the record is adapted to pass.

8. Apparatus for reproducing sound from

a sound record comprising means for projecting a beam of light upon a record, means for intercepting the light reflected from the surface of the record, a light sensitive device for converting the reflected light into electrical impulses, a diaphragm having an aperture through which the light reflected from the record is adapted to pass, and said aperture being triangular shaped and having curved sides.

Signed at London, England, this 2nd day of January A. D. 1930.

WILLIAM EWART WILLIAMS.

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