Oct. 10, 1944. E. O. THOMPSON 2,359,808

PHONOGRAPH

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Fig. 4a

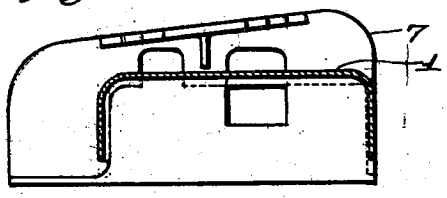


Fig. 1.

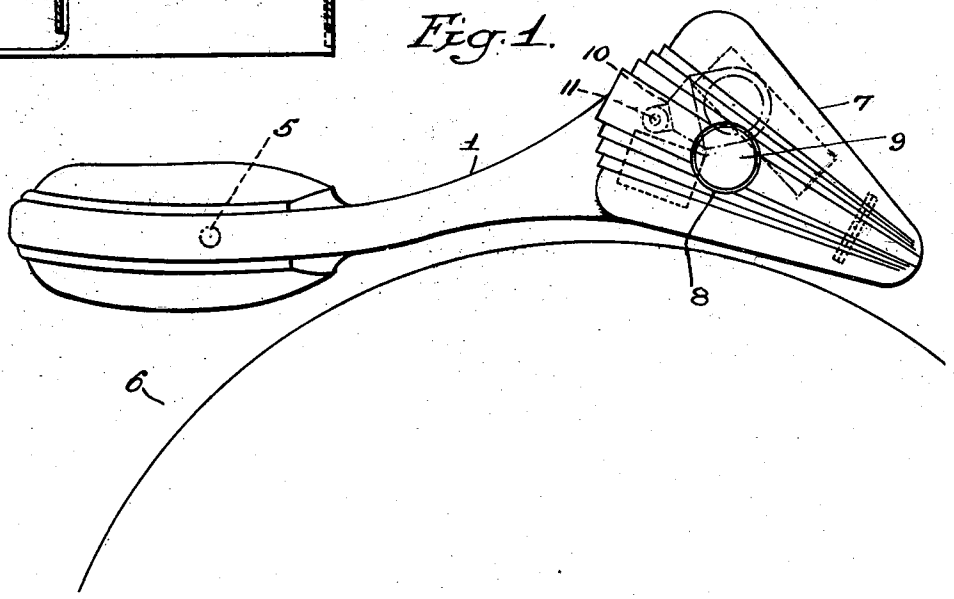


Fig. 4.

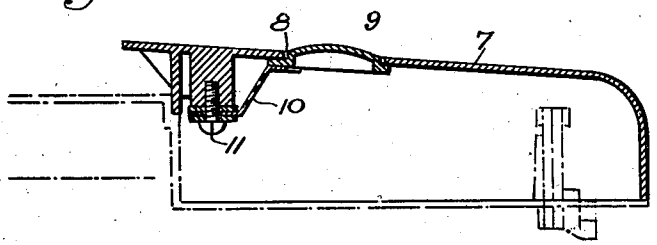
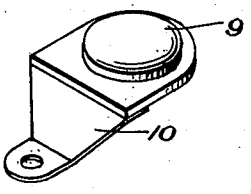


Fig. 5

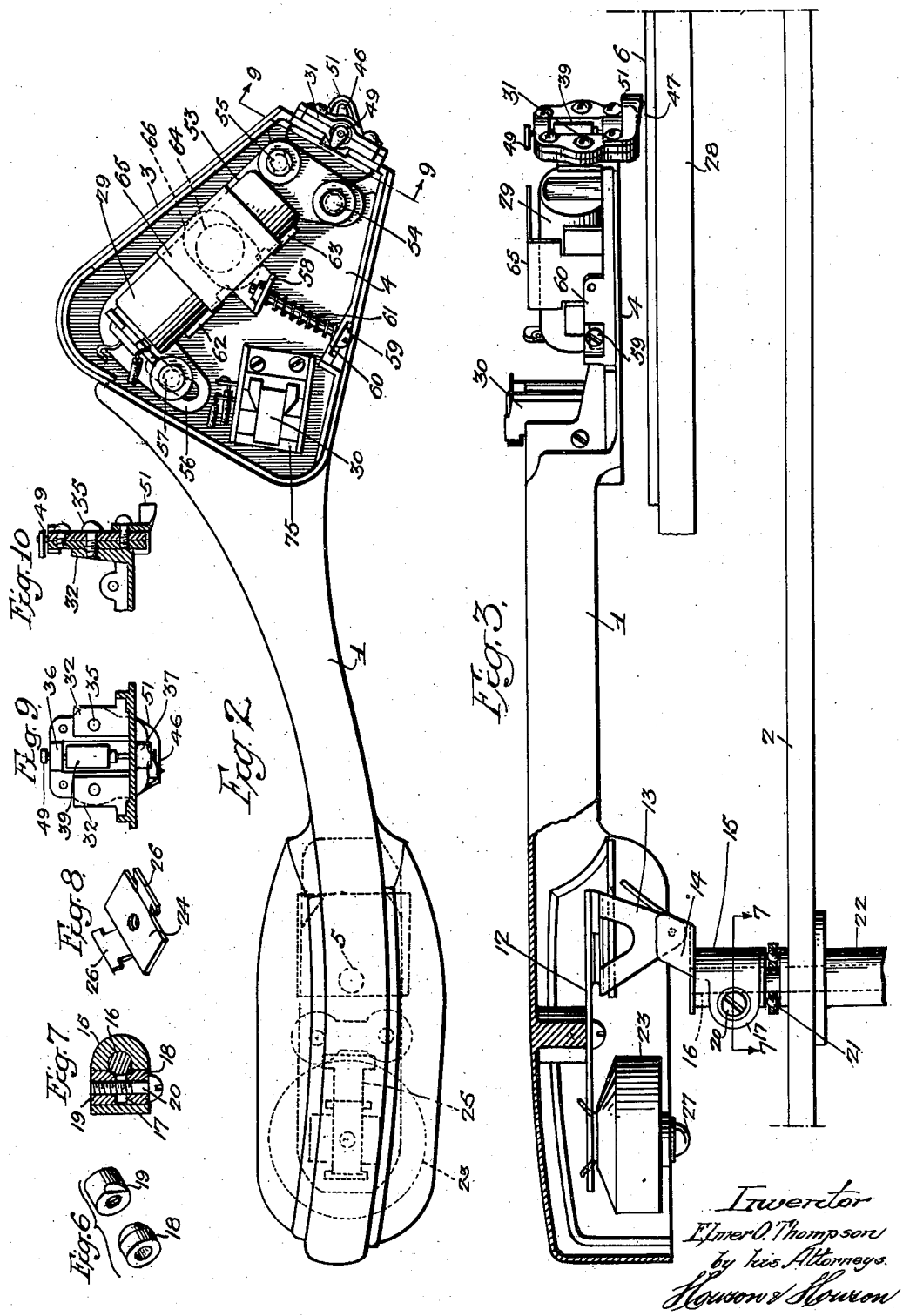


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Fig. 12.

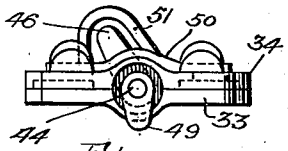


Fig. 17

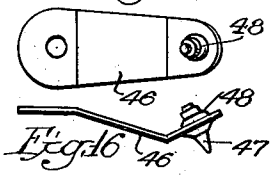


Fig. 16

Fig. 18

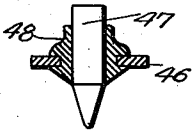


Fig. 11

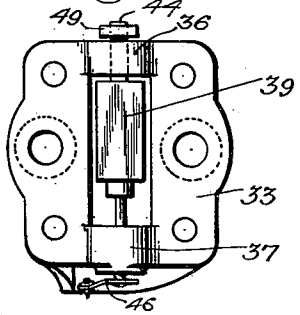


Fig. 13.

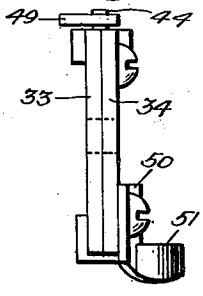


Fig. 14

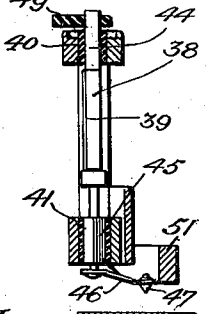


Fig. 19.

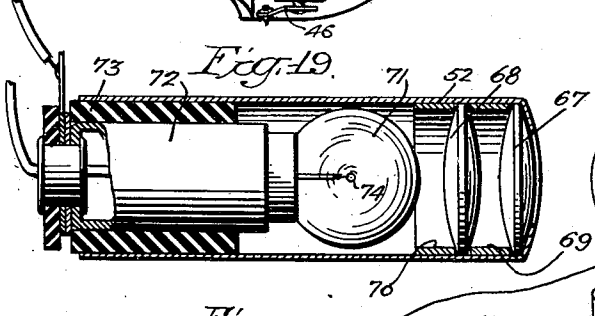


Fig. 20

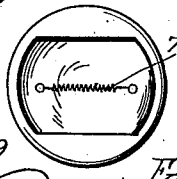


Fig. 23

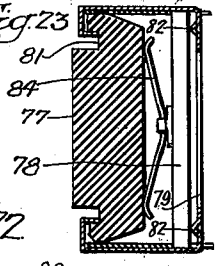


Fig. 22

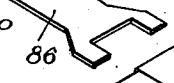


Fig. 15

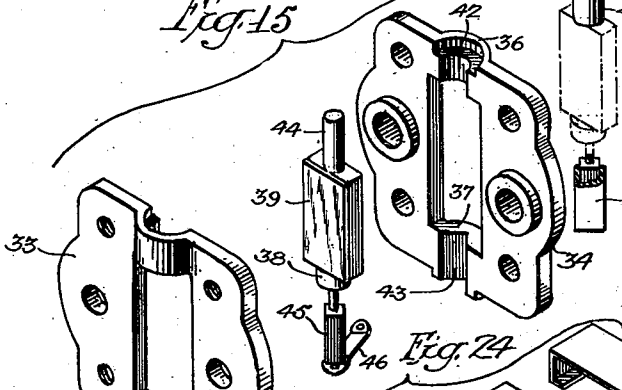
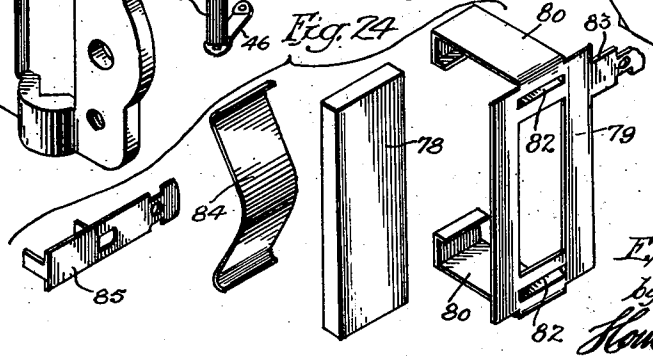


Fig. 21.

Fig. 24



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Fig. 25

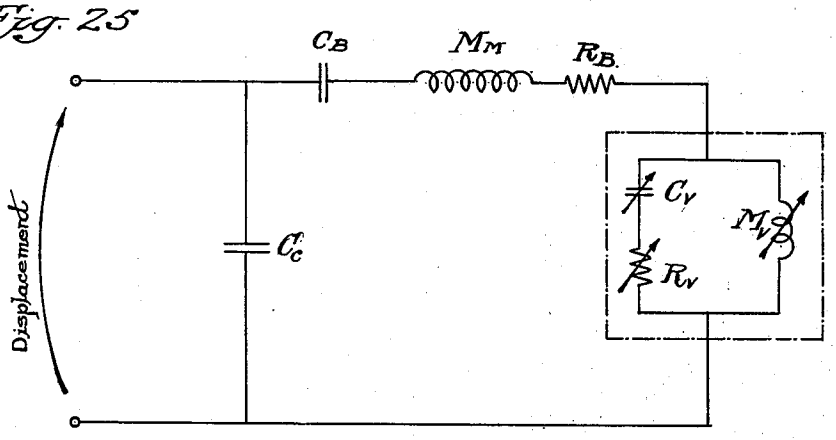


Fig. 26

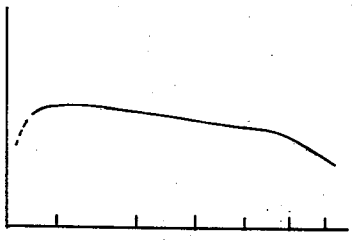


Fig. 27

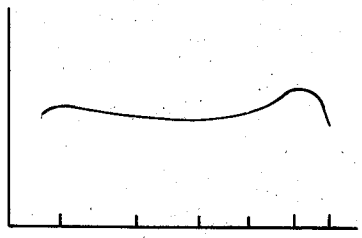


Fig. 28.

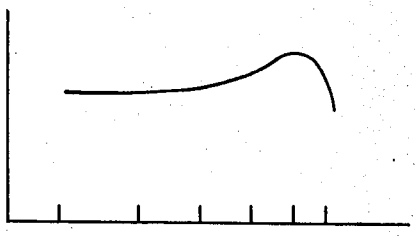
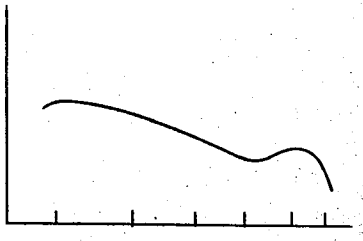


Fig. 29.



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Patented Oct. 10, 1944 2,359,808

UNITED STATES PATENT OFFICE

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PHONOGRAPH

Elmer O. Thompson, Grasmere, N. Y., assignor to Philco Radio and Television Corporation, Philadelphia, Pa., a corporation of Delaware

Application September 18, 1940, Serial No. 357,322

15 Claims. (Cl. 179—100.41)

This invention relates to sound pick-up devices for phonographs, and more particularly to devices of this class which are adapted for use with an electronic amplifier in an audio frequency sound reproducing system. The invention is particularly directed to sound pick-up devices employed for example in radio-phonograph combinations, wherein the audio frequency amplifier of the radio receiver is employed to amplify currents supplied thereto from the pick-up device.

The principal object of the invention is to provide an improved sound pick-up device of the above mentioned character.

A more specific object of the invention is to provide a novel and improved pick-up device of the above type employing a vibratory mirror, a light beam, and a photoelectric cell for translating the motion of the pick-up stylus into signal currents.

Another object of the invention is to provide an improved pick-up device of the above type adapted to greatly decrease record wear.

Another object of the invention is to provide a phonograph pick-up employing a permanent stylus.

Another object of the invention is to provide a phonograph pick-up having a retractable stylus.

Still another object is to provide a phonograph pick-up having a novel and distinctive appearance.

Another object is to provide a phonograph pick-up of the above type which may be easily manufactured, assembled, and adjusted, and in which elements which become worn or defective may be readily replaced at small cost.

Another object of the invention is to provide an improved electro-optical pick-up device comprising a tone arm with a pick-up head at one end thereof, and a translating system completely carried by the said head.

A further object of the invention is to provide an improved pick-up device having novel structural features by which certain desirable resonance characteristics are imparted to the device.

Still another object of the invention is to provide a pick-up device embodying various novel structural features which mutually cooperate to improve the structure as a whole and which impart desirable characteristics thereto.

Other specific objects of the invention will be made apparent hereinafter.

The invention may be clearly understood by reference to the accompanying drawings, in which:

Fig. 1 is a plan view of the device disposed adjacent the outer edge of a record;

Fig. 2 is a plan view of the device with the cover removed from the pick-up head;

Fig. 3 is an elevational view of the device showing the mounting thereof;

Fig. 4 is a detail sectional view of the cover for the pick-up head;

Fig. 4a is a view showing the rear of the cover for the pick-up head;

Fig. 5 is a perspective view of a novel part employed on the said cover;

Fig. 6 is a perspective view of certain mounting elements employed;

Fig. 7 is a detail sectional view taken along line 7—7 of Fig. 3;

Fig. 8 is a perspective view of the slidable carriage for the counterbalancing weight;

Fig. 9 is a sectional view taken along line 9—9 of Fig. 2;

Fig. 10 is a transverse sectional view of the mounting structure for the pick-up element;

Fig. 11 is a face view of the said structure;

Fig. 12 is a plan or top view of the said structure;

Fig. 13 is an elevational view of the same taken from the right-hand side of Fig. 11;

Fig. 14 is a sectional view taken through the center of the said mounting structure;

Fig. 15 is an exploded view showing the parts of the said structure;

Figs. 16 and 17 are elevational and plan views, respectively, of the stylus and its supporting arm;

Fig. 18 is a detail sectional view of the stylus mounting;

Fig. 19 is a sectional view taken longitudinally of the lamp and lens assembly employed;

Fig. 20 is an end view of the same;

Fig. 21 is a fragmentary perspective view of the light cell assembly;

Fig. 22 is a perspective view of a certain part thereof;

Fig. 23 is a sectional view taken through the central part of the light cell assembly;

Fig. 24 is an exploded view illustrating certain parts of the said assembly;

Fig. 25 is an electrical diagram illustrating certain features of the invention by way of electrical analogs; and

Figs. 26 to 29 are explanatory frequency response curves.

Referring first to Figs. 1 to 3, the phonograph pick-up device provided by this invention comprises generally a tone arm 1 which is adapted for pivotal and swivel mounting on a suitable support 2 and which is formed at its free end to provide a pick-up head, designated generally by reference character 3. An electro-optical translating system, the details of which will be described later, is completely carried by the head 3 and serves to translate the vibrations picked up from a record into electrical currents which are preferably supplied to an amplifying stage or stages prior to the translation of said currents into sound by a sound reproducer or loudspeaker,

The pick-up head 3 includes a generally triangular plate 4 which is formed integrally with the tone arm. The various components of the translating system are mounted on the supporting plate 4, as illustrated in Fig. 2.

The pick-up device as a whole is preferably shaped generally as illustrated most clearly in Fig. 1, the mounting point of the tone arm being disposed at 5. The device is shown adjacent the outer edge of a record 6, and it is to be understood that in operation the free end of the tone arm moves inwardly with respect to the record. The particular shape of the device, and especially the shape and arrangements of the tone arm and head, enables the attainment of certain desirable features to be mentioned hereinafter.

As shown in Figs. 1 and 4, the pick-up head is provided with a removable cover 7 which is preferably formed of a molded light translucent material. In operation, the entire head is illuminated by light emitted from the light source constituting a part of the translating system and mentioned hereinafter. The body of the cover 7 has an opening 8 therein to accommodate a resiliently mounted button 9. This button is also formed of translucent material, but it has a distinctively different light-transmitting characteristic than has the body of the cover, so that the button stands out by contrast. The contrast is preferably obtained by the use of differently colored materials, for example, the body of the cover may be white, while the button may be red. The button is carried by a resilient spring metal piece 10 which is pivotally secured to the cover at 11. By this arrangement, a distinctive and attractive appearance is imparted to the illuminated head during operation and, as will be noted hereinafter, such an arrangement permits adjustment of the pick-up under operating conditions.

Referring now to the tone arm mounting as best illustrated in Figs. 3, 6, and 7, a mounting plate 12 is secured to the tone arm, and serves as a part of the tone arm mounting and also as a support for the counterbalancing weight. A bracket 13 is attached to plate 12 and pivotally carries a second bracket 14. The latter has attached thereto a sleeve 15 which is adapted to be mounted on a rod or shaft 16, as shown in Fig. 7. The sleeve or collar 15 has an extending boss 17 with a transverse opening communicating with the axial opening of the sleeve. The said transverse opening accommodates a collar 18 and a similarly formed nut member 19 which are secured within the said opening by means of a screw 20. As shown in Fig. 7, these members are cut away to conform to the shaft 16, and they grip the shaft so as to mount the tone arm firmly on the upper end of the shaft. The tone arm is thus supported on collar 15 and shaft 16 which in turn, are mounted on the support platform 2 by means of the bearing 21 and the support structure 22. Bearing 21 should preferably be of the ball bearing type so that the tone arm may freely move over the record.

The counterbalancing weight 23 (see Fig. 3) is adjustably mounted on the supporting plate 12 by means of a suspending carriage element 24 (see Fig. 2). The plate 12 is slotted as shown at 25 in dotted outline in Fig. 2, and the extending ears 26 on the element 24 are disposed within the slotted portion of the plate and thus serve to slidably mount the carriage element. The counterbalancing weight 23 is resiliently secured to the carriage element 24 by means of a resilient grommet and a screw 27. By means of this adjustable mounting of the counterbalancing weight, the pressure on the stylus may be varied at will. To minimize the weight required in the counterbalance, most elements in the pick-up are preferably made of a light material such as aluminum. This will be apparent from Fig. 3, wherein the record is again shown at 6 mounted on the usual turn-table 28.

Referring now to the translating system mounted on the pick-up head, (see Fig. 2) this comprises a lamp and lens assembly 29, a light-sensitive cell assembly 30, and a vibratory armature structure 31 which serves to vary the light impinging on the light cell, as will be more clearly understood later. Referring first to the armature structure, this is illustrated in detail in Figs. 9 to 18. At the apex portion of the triangular supporting plate 4, there are two upturned supporting lugs 32 upon which the armature structure is mounted. This structure comprises a pair of frame members 33 and 34 which are rigidly secured to the lugs 32 by means of fastening screws 35. (See Fig. 10.) The upper and lower transverse portions of both of the frame members 33 and 34 are formed to provide yokes 36 and 37 which serve to support the vibratory armature 38. The armature carries a light-reflecting mirror 39 disposed centrally within the frame members, and the end or bearing portions of the armature are supported by bearings 40 and 41. (See Figs. 14 and 15.)

The bearings 40 and 41 serve to support the armature assembly for vibratory movement, and to this end the bearing elements are formed of resilient material held in position in the yokes 36 and 37. The upper bearing member 40 is preferably circular in shape, while the lower bearing member is of square shape. Correspondingly the upper yokes 36 of the supporting frames are provided with a circular recess 42, while the lower yokes 37 are provided with rectangular recesses 43. The upper end of the armature is of cylindrical shape, as shown at 44, while the lower end of the armature assembly is of square formation, as shown at 45. The square end 45 serves, of course, to normally maintain the mirror and crank arm in proper relation to the tone arm. (See Fig. 15.)

At the lower end of the armature assembly there is mounted a semi-resilient arm 46 which extends laterally from the axis of the armature. Further, the arm 46 is bent, as shown clearly in Figs. 14 and 16, so that the free end portion of the arm is disposed below the lower end of the armature. At its free end the arm 46 carries the pick-up stylus or needle 47. The stylus is preferably a sapphire element carried by a metallic mounting rivet 48 which in turn is mounted on the arm 46.

This assembly (see Fig. 18) is obtained by first placing the stylus within a soft metal rivet, for example, an aluminum rivet, which has a central hole of slightly larger diameter than the diameter of the stylus. The crank arm may then be placed loosely on the rivet. These elements may now be placed in a mandrel and the rivet may be formed to the shape indicated in Fig. 18. This operation tightly clamps the stylus into the rivet without exerting too great a pressure on any portion of the stylus, which might break the stylus, and it also clamps the rivet into the arm, as illustrated.

The resilient arm 46 acts in the manner of a crank arm and serves to translate the lateral displacement of the stylus by the record into rotary

motion of the armature. In operation, the arm 46 is also subject to a torsional strain and the arm serves as a part of a mechanical resonance system, the other elements of which are constituted by the armature and its bearings. This mechanical resonance feature is an important part of the invention and will be described in detail later. At the upper end of the armature there is preferably employed an auxiliary damping member 49 (see Fig. 14) in the form of a small vane formed of a suitable material, such as viscaloid. This element constitutes an additional component in the mechanical resonance system, as will be described later.

As stated, the arm 46 is semi-resilient. Normally when the tone arm is on the record, the arm and stylus will be in a position generally as shown in Fig. 14. However, should excess weight be placed on the tone arm head, or should the tone arm be accidentally dropped onto a hard surface, the arm 46 will flex.

In order to protect the pick-up stylus, there is provided a guard member 50, which is secured to the lower part of the armature supporting frame on the outer side thereof. This guard member has an outwardly extending portion 51 which surrounds the stylus and serves to protect the same by permitting the stylus to be retracted within the guard when the arm 46 is flexed as above described. For example, in case the tone arm were accidentally dropped, the stylus would recede into the guard and the latter would absorb all shock. Details of the operation of the above described armature will be discussed hereinafter.

Referring now to the lamp and lens assembly—this entire assembly is mounted within a casing or housing 52 (see Fig. 19), which is adjustably supported by a bracket 53, as shown in Fig. 2. At its forward end, the bracket 53 has a slotted extension which is movably secured to the supporting plate 4 by means of rivets 54 and 55 which extend through the slots in the extension. At its other end, the bracket 53 has a slotted extension 56, which is movably secured to the supporting plate 4, by means of the rivet 57. The rivets 54, 55 and 57 are provided with friction washers to aid in holding bracket 53. Intermediate its ends, the bracket 53 has an integral turned-up lug 58 with a threaded aperture thereon to accommodate the end of an adjusting screw 59. The forward end of the screw is loosely supported by a slotted flange 60 at the outer edge of the supporting plate 4. A coiled spring 61 surrounds the shank of the screw between the lug 58 and the flange 60, and serves to maintain the bracket 53 in any adjusted position thereof. By rotating the screw 59, the bracket 53 may be caused to swing about its pivot points, thereby to adjust the position of the lamp and lens assembly relative to the mirror 39 as will be made more clear in the description of the operation of the pick-up. The lamp casing 52 is permanently secured to upturned flanges or lugs 62 and 63 provided on the bracket 53.

The lamp casing 52 has diametrically opposed openings in its upper and lower portions adjacent the normal position of the lamp. These openings are indicated by the dotted circle 64, in Fig. 2. A light-diffusing member 65 of translucent material is carried by the bracket 53 and extends above the upper opening in the lamp casing so as to diffuse the light transmitted through the opening 64 so as to more evenly illuminate the entire translucent cover plate.

The supporting plate 4 has an elongated opening shown in dotted outline at 66 in Fig. 2. This opening is adjacent the lower opening in the lamp casing and serves to emit light downward on to the record. Thus the portion of the record adjacent the pick-up head is illuminated, thereby facilitating the manual positioning of the pick-up element on the record. The openings in the casing 52 and plate 4 also serve in cooperation with suitable openings in the rear wall of the cover 7 to provide for the ventilation and cooling of the lamp (see Fig. 4a).

As shown clearly in Figs. 19 and 20, the forward end of the lamp casing 52 is formed so as to retain the foremost lens 67. A second lens 68 is disposed within the casing in spaced relation to the lens 67, by means of a spacing and retaining collar 69. A second collar 70 frictionally engages the wall of the casing, and serves to maintain the lens assembly in place therein.

The lamp 71 is carried by a conventional socket 72 which is supported by a resilient sleeve 73. The sleeve may be formed by any resilient material, such as soft rubber. It is movably disposed within the open end of the casing and is adapted to maintain its position by virtue of its frictional engagement with the casing wall. Thus, by means of this mounting, the position of the lamp relative to the lens assembly may be adjusted simply by moving the resilient mounting sleeve 73. The electrical connections to the lamp, by means of which it is energized, are of simple conventional form, as shown in Fig. 19, and require no detailed description.

It will be noted that the lamp filament 74 is preferably substantially straight, and by rotating the lamp mounting, this filament may be aligned vertically with the mirror 39. The lens system, together with the filament, provides a light beam of generally rectangular shape. In Fig. 20 the opening in the end of the lamp casing 52 is shown generally rectangular so as to serve as a partial mask so that stray light rays reflected by the base of the lamp and the interior of the casing 52 will be intercepted. This is an important feature since these reflected rays are not properly focused by the lens system and hence would deleteriously affect the operation of the device. Further, for increased life and efficiency, the lamp 71 is preferably of the gas-filled type. In order that the lamp will have no objectionable flicker it is preferably heated by a high frequency power oscillator which may be a part of the accompanying amplifier.

Referring now to the cell assembly, there is rigidly mounted on the supporting plate 4, a bracket 75, which serves to support the entire light-sensitive cell structure. As shown in Fig. 21, this bracket has side portions 76 between which the cell support block 77 is carried. The block 77 is formed of suitable insulating material, and it is recessed to receive the light-sensitive element or cell 78. The cell 78 is preferably a barrier photocell and may be the well known selenium cell, but, of course, any suitable type of cell may be used. A metallic mask 79 is disposed at the front of the cell support, and in addition to serving as a light mask, this member serves also as a retaining means and as a front contact for the light cell. To this end the member 79 has extending resilient hook-like arms 80, which are interlockable with complementary portions 81 of the supporting member 77, as shown in Fig. 23. The mask member 79 also has inturned ribs 82, which afford good electrical contact with the front surface of cell mem-

ber 78. Member 79 also has a laterally extending terminal lug 83 for electrical connection thereto. In order that the arm 80 of member 79 will not engage the end surfaces of the cell 78, insulating members 86, as shown in Fig. 22, are preferably positioned beneath the arms 80.

At the rear of the cell member 78, there is provided a resilient retaining member 84 which serves to hold the cell member 78 in snug engagement with the ribs 82. A terminal lug 85 is secured to the retaining member 84 and constitutes the rear contact for the cell member. Thus, the cell member 78 is firmly mounted by means of the members 79 and 84 and electrical connection is made to the cell member by means of the extending terminal lugs 83 and 85.

In the intended operation of the device, it is desired that the lamp 71 and the bracket 53 be so adjusted that the beam of light reflected by the mirror 39 will fall on the cell assembly in such a manner that a part of the beam falls on one of the side members of the mask 79. Further, the light beam should be so focused as to form a clearly defined spot on the cell assembly. To the end of obtaining these adjustments, the above-described construction has been found most useful. First, the light beam may be focused to give the desired sharply defined and properly aligned spot on the cell assembly by adjusting the lamp relative to the lens assembly by means of the resilient sleeve 73. Then, to properly laterally position the focused spot relative to the mask 79 so that about one half of the spot will fall on the cell proper, the adjusting screw 59 may be utilized. In this connection, the slotted ends 54 and 56 of member 53 cooperate with the rivets 54, 55, and 57, so that, on adjustment of the screw 59, the member 53 will move as if pivoted about the axis of the armature 38 and the mirror 39. With this method of adjustment the sharpness of the light spot on the cell will not be affected by a lateral adjustment of the member 53.

In making the adjustment of the light source and lens assembly by means of the screw 59 it is desirable that all extraneous light, such as daylight, be excluded. The arrangement best shown in Figs. 1, 4 and 5 has been found satisfactory. The button 9 is resiliently and pivotally mounted upon the cover 7 so that it may be readily displaced to the position shown by dotted lines in Fig. 1. With the button in this position a clear view of the light sensitive cell may be had while the adjustment is being made as herein described.

As previously mentioned, the pick-up of this device embodies a novel mechanical resonance system. Mechanical resonance is desirable in pick-up devices of this type because it provides for mechanical amplification of the higher audio frequencies to compensate for the falling off of the response of certain components of the pick-up. Furthermore, the provision of mechanical resonance is a desirable method of attaining a sharp cut-off in the response of the pick-up for the purpose of eliminating noise and needle scratch.

The general functioning of a pick-up of the type above described is relatively simple. As above described, a light beam is focused on the photocell. Then the pick-up is placed on a recording. Since the complete tone arm of the pick-up has considerable mass as compared to the vibratory armature the undulations of the record groove will laterally displace the stylus and rotate the mirror relative to the tone arm. This of course, will vary the area of the photocell which is illuminated by the light beam.

In a light-reflecting device of the type here involved, the change in the illumination on the light-sensitive cell is proportional to the mirror displacement, and with the mirror oscillating at any one frequency the current output of the barrier cell employed will be generally proportional to the change in the illumination. However, for a constant amplitude of mirror oscillation the output of a barrier cell will decrease with increasing frequencies of mirror oscillation, and thus for mirror oscillations having a constant amplitude and variable frequency, the output of the device will decrease seriously at higher audio frequencies. By providing mechanical resonance in the pick-up, the motion of the mirror is caused to increasingly exceed that corresponding to the lateral displacement of the stylus as the frequency increases up to the resonant frequency, above which the motion of the mirror decreases sharply. This resonance characteristic may, therefore, be used to compensate at least partially for deficiencies in the natural response of the pick-up resulting from the use of elements having a non-uniform frequency characteristic over the desired frequency range.

Referring to the physical makeup of the mechanical resonance system embodied in the device, as mentioned above the crank arm 46 acts as a compliance between the stylus and the armature since it is torsionally deflected by the force moment applied to the said arm by virtue of the lower end of the armature being elevated above the driven stylus point. Additional elements include the compliance of the bearings, the mass of the armature, and the damping member.

If desired, the bearing members may be made of special synthetic rubber such as neoprene. The mass of the armature is preferably made as small as is practical. To this end, the armature may be made of aluminum while the crank arm 46 may be phosphor bronze spring material. The operation of this mechanical system and the results obtained thereby may be seen clearly by considering an electrical analogy as depicted in Fig. 25.

Fig. 25 shows an electrical circuit diagram comprising elements generally analogous to the components of the pick-up. In this circuit, current represents velocity and charge represents displacement. M_m is an inductance representing the mass of the vibrating mirror and armature. C_c and C_b are capacitance representing, respectively, the compliance of the crank arm 46 and the compliance of the resilient bearings 40 and 41. R_b is a resistance representing the internal friction of the armature bearings. Similarly, M_v, C_v, R_v represent, respectively, the mass, compliance, and resistance of the viscaloid damping vane 49. It should be noted that all of these last three elements are indicated grouped and variable since the relative values of these elements will vary widely over the frequency range owing to the nature of the material, and further it will be understood that physically the viscaloid is so small as to be important only near the resonant frequency of the system.

In the circuit, the velocity through the several arms will divide inversely as the impedance of the arms, and at a given frequency, the displacement of the components will be proportional to the velocity thereof. Hence, the displacement of the mirror in a resonant system may exceed

the displacement in a non-resonant system; that is when the compliance C_0 is not present.

The response characteristic, over the audio frequency range, of the phonograph pick-up device is illustrated in Figs. 26 to 28.

Fig. 26 shows the cell output which would be obtained if the stylus were oscillated at constant amplitude over the audio frequency range in a pick-up having a non-resonant mechanical system.

The curve in Fig. 27 shows the output of the cell which is obtained under the same conditions employing a suitably resonant mechanical system, such as that of the present device.

Fig. 28 is a curve showing the ratio of the angular displacement of the mirror with respect to the angular displacement of the crank arm 46. The curve of Fig. 28 is derived by subtracting the curve of Fig. 26 from that of Fig. 27. This shows how the high frequency response is maintained by the use of mechanical resonance. The importance of this feature will be understood if it is realized that, to obtain a uniform and pleasing response in a pick-up without mechanical resonance, it would be necessary to decrease the low frequency response of either the pick-up or the accompanying amplifier. To do this would, of course, undesirably decrease the output of the system throughout the entire audio frequency range. Thus, the use of mechanical resonance makes possible increased output over the entire audio frequency range of the pick-up with any given amplifier.

In addition, the use of resonance provides for a sharp cut-off of the response characteristic. This cut-off substantially eliminates needle scratch and other undesired high audio frequency noises which might cause cross modulation in the attendant amplifying system to which the pick-up is connected.

However, it will be understood that the above described response curves must be modified when a recording other than a constant amplitude recording is used. For example, most records now in common use are of the constant velocity type. That is, the lateral movement of the needle takes place at a constant velocity independent of frequency. As a result, with these recordings the amplitude of the displacement of the needle decreases with increasing frequencies.

As a result, if the pick-up were used with these recordings the displacement of the needle would not be constant and independent of frequency and the response would not be as shown in Figs. 26 and 27. Instead, the output would decrease with frequency, as shown by Fig. 29. This falling response makes necessary the use of a compensating electrical amplifier connected between the pick-up and the sound reproducing device to restore the overall response of the pick-up and amplifier to that shown by Fig. 27. Nevertheless, the increased output of the pick-up by reason of the employment of the resonant mechanical unit greatly simplifies the problems of amplifier design since any output gained in the pick-up itself need not be compensated for in the amplifier.

Returning again to a consideration of Figs. 1, 2, 11, and 12 it will be seen that the tone arm and head are arranged so that one side of the tone arm conforms generally to the shape of the record edge. Further, the head of the pick-up is offset with respect to the tone arm so that the armature and stylus are brought close to the record edge. This is a desirable and important feature, particularly when the pick-up is used in conjunction with an automatic record changer, for this arrangement materially decreases the rotation of the pick-up about the pivot 5 which is required to position the tone arm clear of the record after the playing thereof. In addition, the arrangement decreases the space required for operation of a record changer using the pick-up.

However the above described arrangement makes necessary the angular relation between the mirror 39 and the crank arm 46 shown in Figs. 11 and 12. That is, the crank arm 46 must be arranged with such a relation to the armature and tone arm that the longitudinal axis of the crank arm will normally pass through the axis of the tone arm pivot 5. When the stylus is on a recording, the friction and drag will cause the crank arm to tend to move so that its longitudinal axis is coincident with the direction of the forces due to friction, and because of the resilience of the armature bearings, the motion of the armature may be sufficient to displace the light beam so as to render the pick-up inoperative. If the axis of the crank arm passes through the tone arm pivot, however, no such trouble will be encountered. Primarily for this reason the arrangement of crank arm and armature shown in Figs. 11 and 12 is to be preferred.

The pick-up as above described greatly reduces record wear as compared with conventional devices for the principal reason that the energy required to vibrate the armature is very small even at the higher audio frequencies. As a result the grooves of a recording are required to provide only a very small driving force. Further, it is possible with this type of pick-up to balance the tone arm so that only a very small pressure need be exerted on the needle. For example, a needle pressure of one ounce or even less has been found satisfactory. With such a low needle pressure, the wear on the stylus is also materially reduced and the normal life thereof is increased about four times.

From the foregoing description, it will be seen that the pick-up device provided by this invention embodies various novel features which mutually contribute to improve the device as a whole. While a single form of the device has been illustrated and described for the purpose of disclosure, it will be understood that various modifications, particularly in the matter of details, may be resorted to without departing from the scope of the invention.

I claim:

1. In a sound pick-up device for phonographs, comprising a tone arm, a head at an end of said tone arm, an electro-optical translating system including a light source and a light-sensitive means responsive to the light from said source all carried by said head, a translucent cover enclosing the elements of the translating system and means for diffusing the light from said source, whereby said light source serves additionally to substantially uniformly illuminate said cover.

2. In a pick-up device for phonographs, comprising a tone arm, a head at one end of said tone arm, an electro-optical translating system including a light source and a light-sensitive means responsive to the light from said source all carried by said head, a translucent cover member enclosing the elements of the translating system, and means for diffusing the light from said source, whereby said light source serves additionally to substantially uniformly illuminate said cover, said head having an opening therein below said light source and positioned to illumi-

nate a recording, said cover member having at least one opening therein, said openings serving cooperatively to provide for the ventilation and cooling of said head.

3. In a phonograph pick-up device comprising a tone arm, a head at one end of said tone arm, an electro-optical translating system including a light source and lens assembly, a light sensitive means, and a vibratory armature arranged to reflect light from said source onto said light sensitive means and to modulate the light supplied to said light sensitive means, the longitudinal axis of said assembly passing through the axis of said armature, and means for adjusting the relative positions of said assembly and said light sensitive means whereby to laterally adjust the reflected light on said light sensitive means, said adjusting means constructed and arranged to rotate said assembly in such manner that the longitudinal axis thereof will continuously pass through the axis of said armature throughout the range of adjustment.

4. In a phonograph pick-up device comprising a tone arm, a head at one end of said tone arm, an electro-optical translating system including a light source and lens asembly, a light sensitive cell assembly and a vibratory armature arranged to reflect light from said source onto said cell and to modulate the light supplied to said cell, and means for adjusting the relative posiitons of said assemblies whereby to laterally adjust the reflected light on said cell, said adjusting means including mounting means for said light source and lens assembly, arranged to rotate in such manner that the longitudinal axis of said assembly will continuously intersect the axis of said armature throughout the range of adjustment.

5. In a sound pick-up device for phonographs, a tone arm having a pick-up head, a cylindrical lamp casing mounted on said head, a lamp within said casing, a plurality of spaced lenses within said casing, lens spacing and retaining collars arranged in operative association with said lenses within said casing, said casing being formed to provide a mask at its light-emitting end, a light-responsive device on said head adapted to receive light from said lamp, a vibratory armature element on said head adapted to modulate the light supplied to said light-responsive device, and means for adjusting said lamp casing to control the amount of light impinging on said light-responsive device without changing the focus of the light beam.

6. In a phonograph pick-up device of the electro-optical type, a light source and lens assembly comprising a tubular member having its light-emitting end formed to provide a mask, a lens disposed within said end, a retaining collar arranged to frictionally engage said tubular member to retain said lens in said member, a light source within said member, mounting means for said light source comprising a resilient bushing adapted to engage said member, whereby said light source may be readily adjusted relative to said lens and whereby said lens and said light source may be readily removed from said member for inspection or replacement, and means for adjusting said member to vary the position of the light beam without changing its focus.

7. In a sound pick-up device for phonographs, a tone arm having a pick-up head, a lamp, and a light-responsive device mounted on said head, and light-controlling means carried by said head in cooperative relation with said lamp and said light-responsive device, said means comprising a support, a vibratory armature carried by said support, an arm extending laterally from the lower end of said armature, a stylus mounted at the free end of said arm, said free end of said arm being deflectible upwardly, and light-reflecting means carried by said armature.

8. In a sound pick-up device for phonographs, a tone arm having a pick-up head, a lamp, and a light-responsive device mounted on said head, and pick-up means carried by said head in cooperative relation with said lamp and said light-responsive device, said pick-up means comprising a support, a vibratory armature carried by said support, resilient bearing means for said armature, a compliant arm extending laterally from the lower end of said armature, a stylus mounted at the free end of said arm to vibrate said armature through said arm, and light-reflecting means carried by said armature, the compliance of said bearing means and said arm and the mass of said armature being so correlated as to effect mechanical resonance over the upper portion of the frequency range of the device.

9. In a sound pick-up device for phonographs, a tone arm having a pick-up head, a lamp, and a light-responsive device mounted on said head, and light-controlling means carried by said head in cooperative relation with said lamp and said light-responsive device, said means comprising a support, a vibratory armature carried by said support, resilient bearing means for said armature, a damping element mounted at the upper end of said armature, a compliant arm extending laterally from the lower end of said armature, and a stylus mounted at the free end of said arm to vibrate said armature through said arm, the compliance of said bearing means and said arm, the mass of said armature, and the compliance and mass of said damping element all being so correlated as to effect mechanical resonance over the upper portion of the frequency range of the device.

10. A self-contained armature unit for a phonograph pick-up device, comprising a pair of juxtaposed open frame members having complemental recesses forming aligned bearing retainers on opposite portions of said members, resilient bearing elements seated in said retainers, an armature supported by said bearing elements, a mirror mounted on said armature within the open frame members, a deflectible crank arm extending from one end of said armature, a stylus carried by said crank arm, a guard for said stylus integral with one of said frame members, and means for removably securing said frame members together and for securing all of the aforesaid elements together as an independent unit.

11. A phonograph pick-up device, comprising a hollow tone arm, a rigid platform at the free end portion of said arm, said platform being of plan form diminishing in width and reaching an apex toward the free end of the tone arm, an oscillatory reflecting armature mounted on said platform at the said apex, a light beam-producing means and a light-responsive means on a wider part of said platform in cooperative relation with said reflecting armature, and a stylus at said apex for actuating said armature to thereby vary the light impinging on said light-responsive means according to undulations of a record groove.

12. A phonograph pick-up device, comprising

a horizontally-extending hollow tone arm having a relatively small vertical dimension, a rigid platform carried by the free end of said tone arm and extending from the lower edge portion thereof, a photoelectric translating system carried by said platform, the component parts of which have a vertical dimension substantially coextensive with the vertical dimension of said tone arm, and a cover enclosing the component parts of said translating system, whereby there is provided a compact and shallow translating unit at the end of the tone arm having a vertical dimension comparable to that of the tone arm.

13. A phonograph pick-up device, comprising a light-weight tone arm, a pivotal mounting for said tone arm which permits movement of a free end portion of the arm relative to a record in playing position, said arm being subject to vibrations which may be transmitted thereto through said mounting, a rigid plate at the free end portion of said arm, a vibratile stylus carried by said plate so as to engage said record, and an electro-optical translating system operable by said stylus and having all of the component parts thereof mounted on said plate, said plate by reason of its rigidity effectively preventing any vibrations in the tone arm from adversely affecting the operation of said translating system.

14. A phonograph pick-up device, comprising a light-weight tone arm, a pivotal mounting for said tone arm which permits movement of a free end portion of the arm relative to a record in playing position, said arm being subject to vibrations which may be transmitted thereto through said mounting, a rigid plate at the free end portion of said arm, said plate being of plan form diminishing in width and reaching an apex toward the free end of the tone arm, a vibratile stylus at said apex, an oscillatory reflecting armature operable by said stylus, a light beam-producing means and a light-responsive means on a wider part of said plate and relatively adjustable crosswise of the plate, said plate by reason of its rigidity effectively preventing any vibrations in the tone arm from adversely affecting the operation of the translating system.

15. In a sound pick-up device for phonographs, a tone arm, a head at the end of said tone arm, an electro-optical translating system including a light source carried by said head, and a cover enclosing the translating system, said head having an opening therein below said light source to illuminate a recording.

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