Aug. 9, 1932. E. H. FOLEY 1,870,447

SOUND RECORDING AND RECORDS

Filed July 10, 1930

Fig. 1.

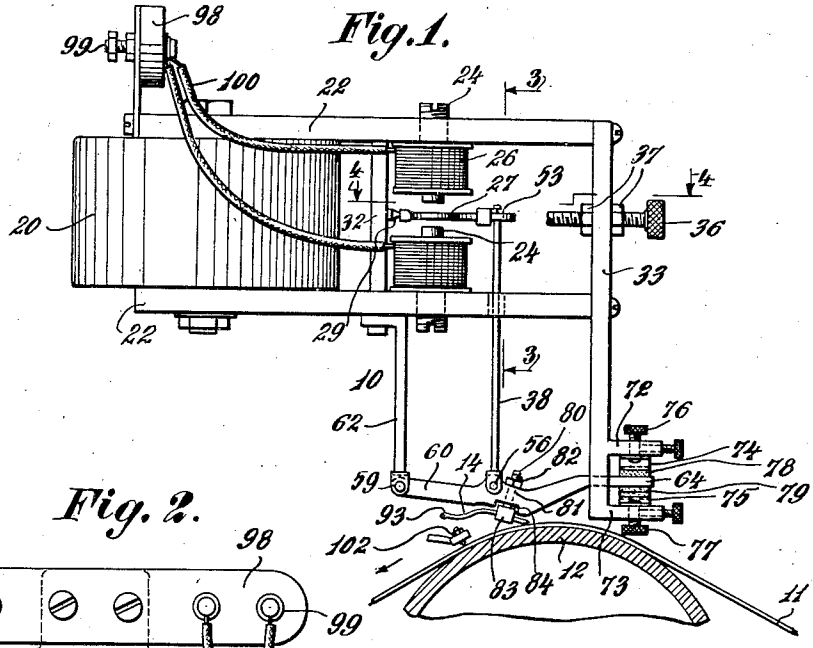


Fig. 2.

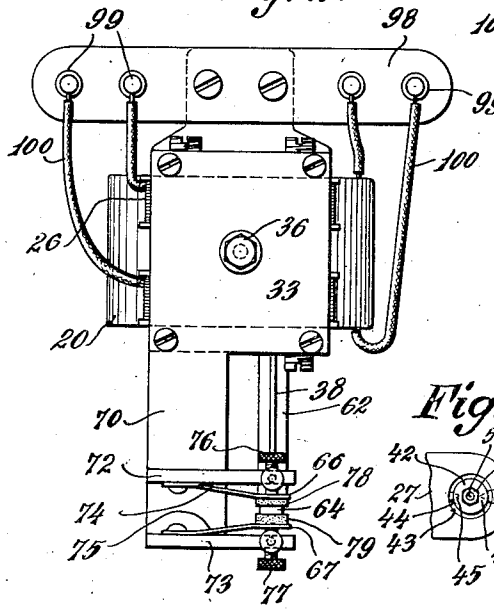


Fig. 3.

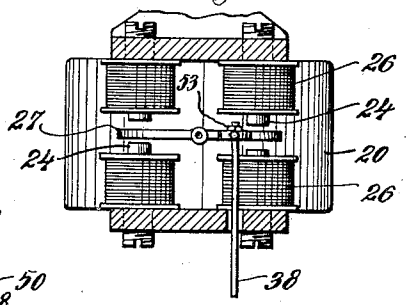


Fig. 6.

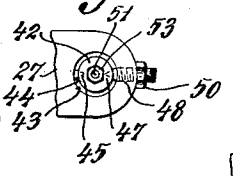


Fig. 4.

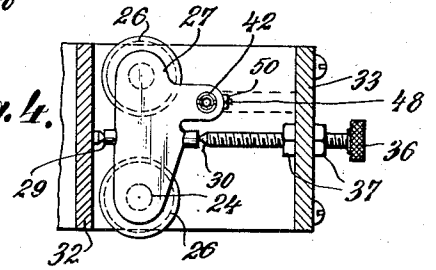
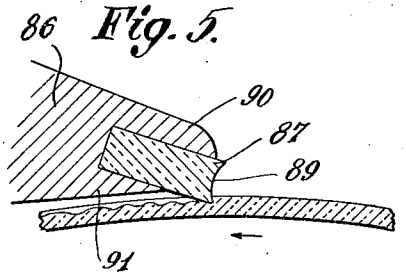


Fig. 5.



INVENTOR
Earl H. Foley.
BY
ATTORNEY

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UNITED STATES PATENT OFFICE

EARL H. FOLEY, OF ASTORIA, NEW YORK, ASSIGNOR TO FILMTONE CORPORATION, A CORPORATION OF DELAWARE

SOUND RECORDING AND RECORDS

Application filed July 10, 1930. Serial No. 467,093.

This invention relates generally to the recording of sound and more particularly to an improved apparatus and method especially designed for cutting a sound groove in a flexible recording medium. The invention also relates to an improved record body consisting of a flexible medium having a sound record groove thereon.

The recording medium which I preferably employ is a thin film of plasticized material such as the usual motion picture film. I have discovered that a film of this character will permit, by the use of appropriate apparatus, the progressive cutting therein of a sound record groove, which accurately represents the sound waves received by the recording apparatus. Furthermore, such a groove may without further treatment be used for reproduction repeatedly without impairment of the sound produced.

If desired, a single film may have a large number of record grooves thereon, arranged side by side, representing for example a number of separate selections. Also, sound grooves may be formed on both sides of the film, and in one embodiment of my invention I employ as the recording medium an endless or continuous film and cut therein a continuous spiral or helical sound groove along the length of the film, the pitch of the helix being very slight so that the successive turns or laps of the groove are closely spaced side by side and the entire groove covers a large portion of the area of the film as suggested in the sentence beginning line 22, page 6, of my application Serial #21,377, filed April 7th, 1925, on sound recording apparatus. In this manner one film may contain a relatively long selection.

Also, if desired, I may cut the sound groove on the margin of a motion picture film, which is not occupied by the picture and such groove may constitute a record of sound designed to be reproduced synchronously with the picture. This combined picture and sound film has many advantages over the records heretofore employed for this purpose, not only with respect to its durability and efficiency as an instrument for the simultaneous production of sound and picture, particularly under the conditions obtaining in the motion picture art, but also with respect to the economy and simplicity of the method by which such a combined record may be made and the adaptability of such method to present standard practice in the motion picture art, as is more fully explained in my co-pending application Serial Number 453,295, filed May 17, 1930.

In the preferred embodiments of my invention the sound record groove is of the hill and dale type. In forming this groove I make use of an electromagnetic device of improved construction, which is provided with a cutting tool having a cutting point formed of hard material such as diamond or sapphire, this point being especially designed for operating on relatively tough material such as a photographic film. The film is fed over a suitable anvil past the cutting point, the point being held in a direction substantially tangential to and against the motion of the film, and electromagnetic means is provided for vibrating the cutting point in direction substantially normal to the film, in accordance with the sound waves to be recorded. Novel means is employed for securing the requisite leverage for proper actuation of the cutting tool and for providing the requisite damping or terminal impedance for avoiding distortion. The cutting point is specially designed for operating on the film. It has a cutting portion similar in shape to a wood chisel and designed to form the groove by what may be termed a scooping action.

Further advantages and objects of my invention will appear from the following description taken in connection with the accompanying specimen and the annexed drawing, wherein:

The specimen is a strip of film formed with sound record grooves thereon.

Figure 1 of the drawing shows in side elevation one form of electromagnetic recorder constructed in accordance with my invention, together with a portion of the film on which the record is being made, an anvil for supporting the film as it moves by the recording stylus and a pick-up for reproducing the sound from the record groove as it is made.

Figure 2 is an end elevation of the recorder shown in Figure 1.

Figure 3 is a detail sectional view taken on the line 3—3 of Figure 1.

Figure 4 is a detail sectional view taken on the line 4—4 of Figure 1.

Figure 5 is a greatly enlarged sectional view of one end of the cutting tool in cutting contact with the film, showing the mounting of the cutting jewel or point, and

Figure 6 is an enlarged detail sectional view on the line 6—6 of Figure 3, showing the manner of joining the cutting tool operating rod to the armature of the electromagnet.

Figures 1 and 3 show my improved device in actual size except that for clearness of illustration I have shown the spacing of certain parts as somewhat greater than the actual spacing, as will be explained hereafter.

Referring to Figure 1, reference character 10 represents an electromagnetic recording device for making a hill and dale groove record on a film 11 which is fed in the direction of the arrow, over a curved or cylindrical anvil 12.

The device 10, which serves to control the movement of the cutting tool 14, comprises an electromagnet 20 which is adapted to be supplied with constant direct current for producing a permanent magnetic field. Secured to the magnet 20 are frame pieces 22 of magnetic material, to which are adjustably secured pole pieces 24. Four pole pieces are employed, two on the upper frame piece and two on the lower frame piece, as shown in Figure 3. These pole pieces are screw-threaded through the frame pieces so as to be adjustable vertically.

Mounted on each of the pole pieces 24 is a winding 26 adapted to be connected in the output circuit of an amplifier or other system controlled in accordance with the sound vibrations to be recorded. The connections to the windings 26 are such that the talking currents flowing therethrough tend to make the adjacent upper poles of opposite polarity and opposed upper and lower poles also of opposite polarity.

Mounted to rock in the space between the pole pieces 24 is an armature 27 of Norway or similar iron of low retentivity, which is pivotally mounted at its center on pivot bearings 29 and 30, mounted respectively in an inner frame piece 32 and an outer frame piece 33, both formed of brass or other non-magnetic metal. The pivot bearing 29 may be fixed to the frame piece 32 and the bearing 30 screw-threaded through the frame piece 33 and adjustable by turning the knurled head 36. Suitable lock nuts 37 are provided to hold the pivot bearing 30 in position and, if desired, the frame piece 33 may be formed with an internally screw-threaded elongated bushing (not shown) extending toward the armature 27 so as to form an elongated rigid bearing support for the pivot bearing member 30.

Adjustably secured to the armature 27 at one side of the center of the armature is light rod 38 of non-magnetic material such as aluminum. In Figure 6 I show the connection between the rod 38 and armature 27 this connection being designed to permit the rod 38 to maintain its vertical position as it is moved up and down by rocking of the armature 27. This connection comprises a disc or collar 42 which is pivotally mounted in an opening 43 in the armature 27. One side of the opening 43 is formed with an integral tapered pivot bearing 44, which is received in the bearing opening 45 in the disc 42. A corresponding opening 47 at the opposite side of the disc 42 receives the tapered end of a pivot bearing 48 which is screw-threaded into one edge of the armature and carries a locking screw 50. Rod 38 is formed with a screw-threaded upper end which is received in a central opening 51 in the disc 42 and held in position by a lock nut 53. It will be understood that I may if desired employ other forms of connection between the rod 38 and armature which will permit angular movement between rod and armature, such for example as a properly designed ball and socket joint.

Rod 38 is pivotally secured at its lower end at 56 to a lever 60 of light material such as aluminum and which is snugly pivotally secured at 59 to a downwardly extending rigid bracket 62 formed of non-magnetic material. The opposite end 64 of the lever 60 is flattened transversely and is designed to move between upper and lower adjustable cushion or damping devices 66 and 67, respectively.

The cushion devices 66 and 67 are carried by the lower portion of the frame piece, which extends downwardly as indicated at 70 and is formed with lateral supporting ears or lugs 72, 73, as shown in Figures 1 and 2. Suitably secured to the lugs 72, 73 are strips or plates of resilient metal 74, 75, respectively, which are adapted to be engaged by screws 76, 77, respectively, for forcing the outer ends of the strips toward one another. Interposed between the outer ends of the strips and the end 64 of the lever 60 are cushion pads 78, 79. It is to be noted that the upper pad 78 is somewhat thinner than the lower pad 79 and is designed to offer greater resistance to the upward movement of the lever 60 than to the downward movement. In practice the pads may be formed of rubber of the character of the ordinary rubber band, and the lower pad 79 may conveniently be of double the thickness of the upper pad. In practice the screws 76 and 77 are adjusted so as to submit the pads to substantial pressure.

The cutting tool 14 is rigidly secured to

the lever 60 at a point adjacent the pivotal connection 56 of the lever 60 and rod 38. For this purpose, in the form of invention disclosed, I provide a bolt 80 which extends through an inclined hole 81 in the lever 60. The lower end of the bolt 80 is provided with an opening or formed with a collar 83 having an opening, which is inclined to the axis of the bolt and is adapted to receive the cutting tool 14. Tightening of the nut 82 on the bolt 80 serves to clamp the tool lightly against the bottom of the lever 60, the lever being provided with a recess 84 to permit the collar 83 to be drawn upward and the top of the tool forced against the bottom of the lever.

The tool comprises a rod or shank 86 of metal such as brass, in one end of which is secured or embedded the cutting point 87, formed of hard material such as sapphire or diamond. As shown, this point is cylindrical in form with a concave outer end 89. In Figure 5 I show the point in contact with the moving film and it will be seen that the edge of the cutting point which is in engagement with the film is convex downwardly, forming in effect a scoop which cuts a trench having a bottom, curved or circular in section.

Figure 5 shows the disposition of the metal of the rod 86 around the cutting point 87, the metal above extending over the point, as indicated at 90, to form a bracing or strengthening means to withstand the upward thrust of the point and prevent its breaking and the metal below the point being cut away as indicated at 91, so as to leave room for the passage of the film.

Inasmuch as the point 87 is very minute and can only be seen with difficulty, I curve the opposite end of the rod, as indicated at 93, preferably in a direction toward the side or overhanging part 90, so that prior to clamping the rod in position the rod may be turned in the collar 83 to correct position with the cutting point 87 in the position shown in Figure 5.

In Figures 1 and 5 it will be seen that the cutting point is normally directed along a line approximately tangential to the curve of the film as it passes over the anvil 12, also that the thrust of the moving film against the cutting point is largely taken up by the pivotal connection between the lever 60 and bracket 62 which lies almost directly back of the cutting point, this thrust having little or no tendency to change the altitude of the cutting point. It is highly desirable that the feeding of the film past the cutting point should proceed at an even rate and as an aid to this end I preferably drive the film by means of a friction feed (not shown).

In Figure 1 of the drawing I show the cutting point directed away from the pivot 59 of the lever 60 and toward the clamping pads. I may, however, operate the record with the cutting tool reversed, that is, pointing toward the pivot 59. In either case, however, the motion of the film is against the edge of the cutting point.

The varying currents in the coils cause vibration of the armature 27, which is transmitted through the connecting rod 38 to the lever 60 and tool 14. The magnetic forces acting on the armature 27 are increased through the leverage connection between the armature and rod 38 and serve to impart to the cutting point 87 the desired forces for changing the depth of the cutting edge below the surface of the film. Figure 3 shows one spacing of the rod relative to the pivotal center of the armature. In this figure for the purpose of clearness I have shown the coils 26 somewhat farther apart than in actual practice.

While the connections 38 and 60 may be formed of aluminum, I find that to overcome the resistance offered by the film to movements of the cutting tool, these parts should not be of too light a construction, as I preferably utilize the mass or inertia of these parts in overcoming the film resistance, the cushion pads furnishing the desired damping. Also to provide a sufficient actuating force for moving these parts, I employ in the windings 26 currents of relatively high value. With windings of approximately 60,000 ohms impedance, I find a current consumption of approximately 10 watts satisfactory. Inasmuch as it requires more force to press the cutting point deeper into the film than it does to move it in the opposite direction, I preferably adjust the pole pieces 24 toward which the armature swings when the cutting point is moved deeper into the film to a position closer to the armature than the remaining pole pieces. For a similar reason, also the lower cushion pad 79 is made less resistaant to movement than the upper pad 78, as previously described.

Reference character 98 represents an insulated terminal bar which carries the binding posts 99 for connection to the external circuits. Leads 100 connect the binding posts to the several magnetic windings of the device 10.

For the purpose of ascertaining the quality of the sound record produced, I mount a pick-up 102 close to the cutting tool, so that the sound may be reproduced from the groove as fast as the groove is cut. Any variations from the desired quality, volume, etc. can thus be immediately detected and by making appropriate adjustments I can secure the cutting of an accurate sound record.

The accompanying specimen shows a sound record groove cut on a motion picture film. Such films, customarily employed at the present time, are approximately .005 of an inch in thickness and are formed by flowed plasticized material such as nitro cellulose. The particular plastice composition and its treat-

ment is designed to produce a film adapted to hold the photographic emulsion and have the requisite mechanical strength and durability for use as a motion picture film. I find that by the use of the apparatus shown in the accompanying drawing, suitably energized by sound currents, I am able to cut progressively along such a film a groove which forms an accurate sound record, and the grooves in the accompanying specimen were cut in this manner by the apparatus shown. These grooves form sound records of portions of explanatory lectures.

The portion of the film removable by the point 87 is in the form of a clean cut strip shaved off from the film. Such groove may average .001 of an inch in depth with variations from substantially the surface of the film to .002 of an inch in depth. Such a groove does not appreciably impair the strength of the film and I have been able to use such a groove record for reproduction of sound as many as ten thousand times without appreciable impairment of the sound produced. The groove cut by the apparatus shown in the drawing is of the hill and dale type and need not be more than .001 or .002 of an inch in width, and as a result I am able, if I so desire, to place a number of these grooves side by side along the marginal portions of the film without encroaching on the area occupied by the picture to be projected. Sixteen such sound grooves may be placed on the marginal portion of the usual motion picture film outside of the area of the projected picture.

This application is a continuation in part of my copending application Serial Numbers 235,056, filed November 22, 1927, and 453,295, filed May 17, 1930.

Having now described my invention, what I claim and desire to secure by Letters Patent is:

1. In a device for cutting sound grooves, a vibratory supporting member, a cutting tool having an elongated shank, a clamp for removably securing said shank to said member, a cutting point of hard material embedded in one end of said shank and formed with a cutting edge at one side of said shank and means on said shank for indicating said side, so as to permit proper and ready positioning of said shank in said clamp.

2. In a device for cutting sound grooves, a vibratory supporting member, a cutting tool having an elongated shank, a clamp for removably securing said shank to said member, a cutting point of hard material embedded in one end of said shank and formed with a cutting edge at one side of said shank, said shank being curved at opposite end for indicating said side, so as to permit proper and ready positioning of said shank in said clamp.

3. In a device for making sound grooves, electromagnetic actuating means, a lever connected to said means, a pivotal support for one end of said lever, damping means engaging the opposite end of said lever, and a cutting tool carried by said lever intermediate its ends.

4. In a device for progressively cutting a sound groove in a moving film, the combination with an anvil over which the film is moved, a cutting tool adjacent said anvil and adapted to vibrate in a direction substantially normal to said film, a vibrating member on which said tool is mounted, a damping device engaging said member and operable to resist movement of said tool in a direction away from said film, a second damping device engaging said member and operable to resist movement of said tool in a direction toward said film, said second device offering greater resistance to movement of said tool than said first named device.

5. In a device for progressively cutting a sound groove in a moving film, the combination with an anvil over which the film is moved, a cutting tool adjacent said anvil and adapted to vibrate in a direction substantially normal to said film, said tool having a cutting edge pointing in a direction substantially along said film and against the movement of said film, a vibrating member on which said tool is mounted, a damping device engaging said member and operable to resist movement of said tool in a direction away from said film, a second damping device engaging said member and operable to resist movement of said tool in a direction toward said film, said second device offering greater resistance to movement of said tool than said first named device.

6. In a device for progressively cutting a sound groove in a moving film, the combination with an anvil over which the film is moved, a cutting tool adjacent said anvil and adapted to vibrate in a direction substantially normal to said film, a vibrating member on which said tool is mounted, a damping device engaging said member and operable to resist movement of said tool in a direction away from said film, a second damping device engaging said member and operable to resist movement of said tool in a direction toward said film, said second device offering greater resistance to movement of said tool than said first named device, and means for adjusting the damping effect of each device independently of the other.

7. In a device for cutting a hill and dale sound record in a film, a cutting point movable in directions toward and away from said film, means for supporting said point, a damping device offering relatively low resistance to said movement toward said film, and a damping device offering relatively high resistance to said movement away from said film.

8. In a device for cutting a hill and dale sound record in a film, a cutting point mov-

able in directions toward and away from said film, means for supporting said point, and damping means offering relatively high resistance to said movement away from said film and relatively low resistance to said movement toward said film.

9. In a device for cutting a hill and dale sound record in a film, a cutting point movable in directions toward and away from said film, means for supporting said point, damping means offering relatively high resistance to said movement away from said film and relatively low resistance to said movement toward said film, and electromagnetic means for vibrating said point in accordance with the sound vibrations to be recorded and for biasing said point in said direction toward said film.

10. In an electromagnetic recorder, a permanent magnet, opposed pole pieces in the magnetic circuit of said magnet, operating windings on said pole pieces, a pivoted armature adapted to vibrate between said pole pieces, a cutting tool, a lever on which said tool is supported, a pivotal support for one end of said lever, a damping device in engagement with said lever and an operating rod connecting said lever and armature.

11. In an electromagnetic recorder, a permanent magnet, opposed pole pieces in the magnetic circuit of said magnet, operating windings on said pole pieces, a pivoted armature adapted to vibrate between said pole pieces, a cutting tool, a lever on which said tool is supported, a pivotal support for one end of said lever, cushion pads at the opposite end of said lever in engagement with opposite sides of said other end and an operating rod connecting said lever and armature.

Signed at 50 Broadway, New York city, in the county of New York and State of New York, this 23rd day of June, A. D. 1930.

EARL H. FOLEY.