

No. 728,867.

PATENTED MAY 26, 1903.

F. W. H. CLAY.

PROCESS OF MAKING SOUND REPRODUCING RECORDS.

APPLICATION FILED FEB. 15, 1901.

NO MODEL.

2 SHEETS—SHEET 1.

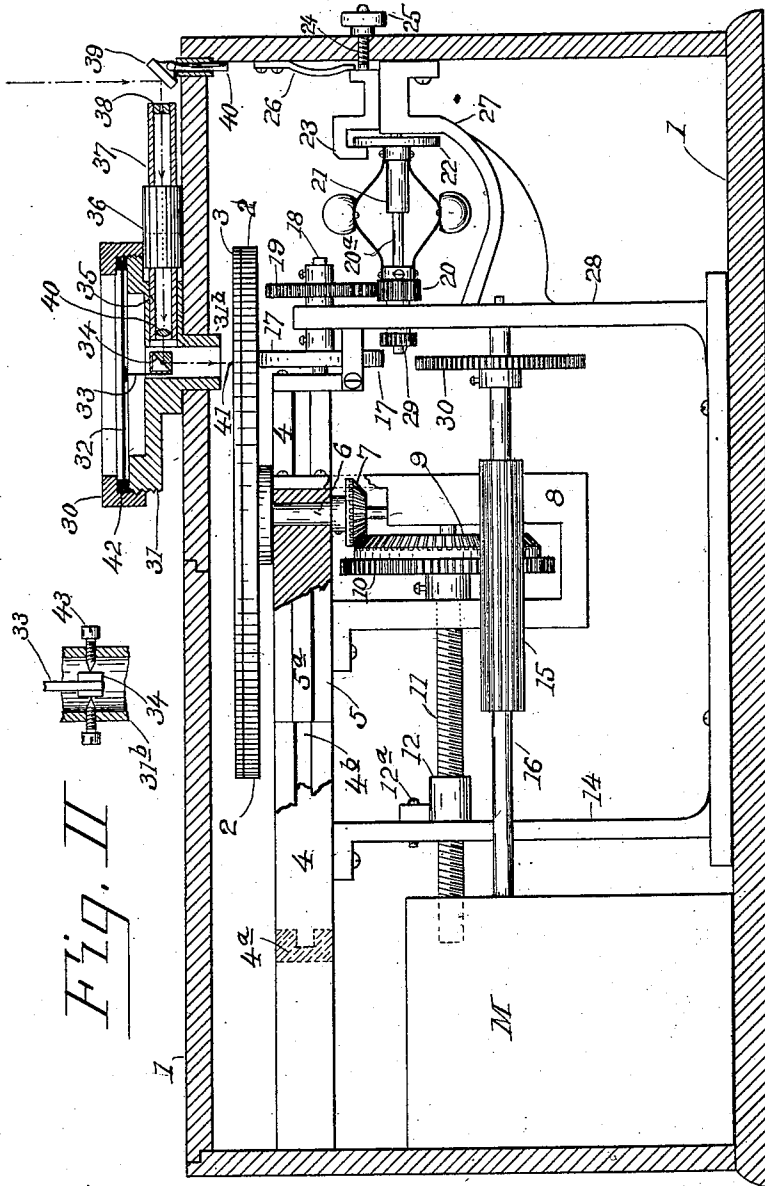


Fig. I

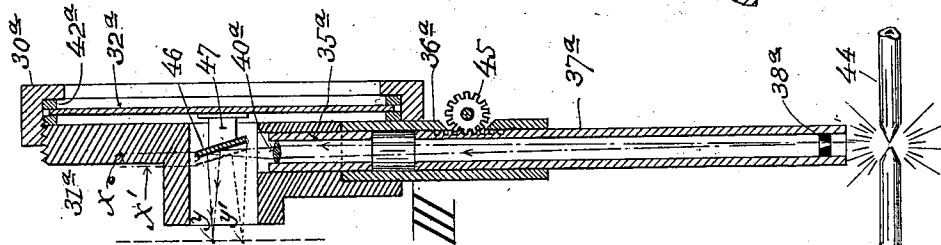


Fig. II

Witness:
Russell A. Wilson
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2 SHEETS—SHEET 2.

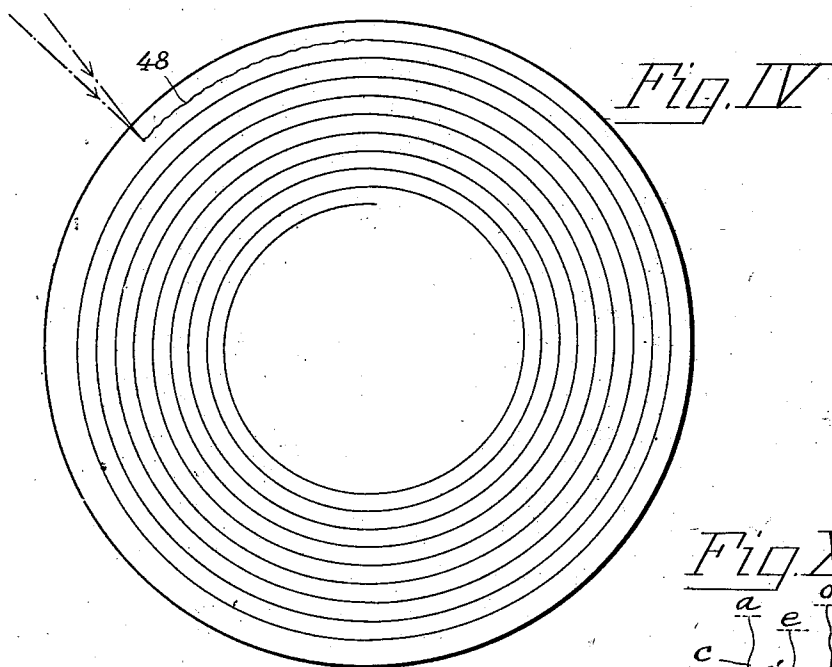


Fig. IV

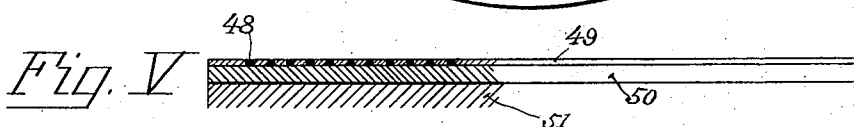


Fig. V

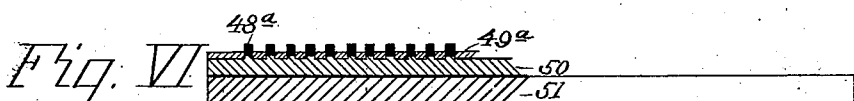


Fig. VI

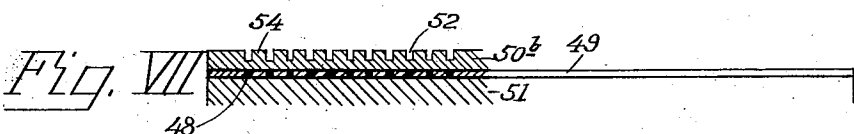


Fig. VII

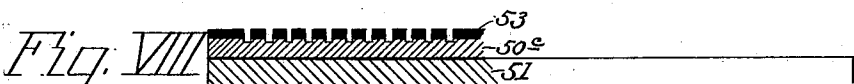


Fig. VIII

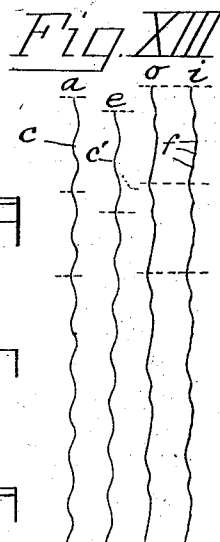


Fig. XIII

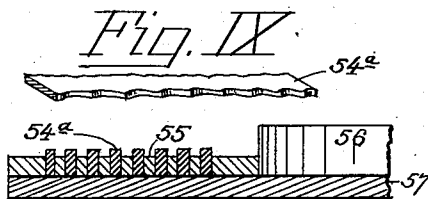


Fig. IX

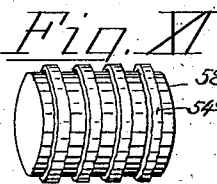


Fig. XI

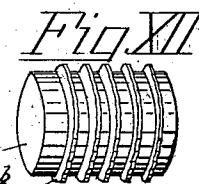


Fig. XII

Witness:
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Fig. X

Inventor,
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UNITED STATES PATENT OFFICE.

FRANCIS W. H. CLAY, OF CINCINNATI, OHIO.

PROCESS OF MAKING SOUND-REPRODUCING RECORDS.

SPECIFICATION forming part of Letters Patent No. 728,867, dated May 26, 1903.

Application filed February 15, 1901. Serial No. 47,389. (No specimens.)

To all whom it may concern:

Be it known that I, FRANCIS W. H. CLAY, a citizen of the United States, and a resident of Cincinnati, in the State of Ohio, have
 5 invented a certain new and useful Process of Making Sound-Reproducing Records, of which the following is a specification.

My invention relates to the recording and reproducing of sound; and it consists, primarily, in the process of photographing the
 10 movements of sounding bodies and reducing the photographic record to a form to actuate a reproducer by the employment of chemical agencies.

15 It also consists in the record produced and in certain other features hereinafter set forth.

In the present phase of my process the photorecord is made on a flat film of disk form, and for carrying out the process I have
 20 invented the apparatus illustrated in the accompanying drawings.

Figure I is a vertical section of the exposing-box, showing the recording-machine in side elevation. Fig. II is a vertical section
 25 at right angles to that in Fig. I of the tube containing one form of an actuating-mirror, showing the latter on its pivots. Fig. III is a section of another and more preferred form of the actuating vibrating diaphragm and its
 30 attached mirror and the telescope for the same. Fig. IV is a plan view of the photographed record. Figs. V, VI, VII, VIII are sectional views of the gelatin films in several forms of the development hereinafter specified. Fig. IX is a perspective view of a portion
 35 of gelatin record-ribbon. Fig. X is a sectional view of a form of record made up of the said ribbon for reproduction. Figs. XI, XII are perspective views of two other forms of arranging the ribbon-record for reproduction. Fig. XIII represents some sound-waves.

In the drawings, Fig. I, the dark box 1 contains a circular revolving table 2, upon which is placed the photographically-sensitive plate
 45 or film 3. This table moves in such a way as to cause the point of incidence of a ray of light entering at 41 to travel over the film in a general spiral path. The table 2 has its spindle 6 journaled in a block 5, which slides
 50 and is supported by guide-flanges 5^a in grooves 4^b in the two parallel guide-bars 4, (which latter are of the sectional shape shown at 4^a.)

The sliding block 5 carries the depending bracket 8, in which are journaled the shaft 6
 of the table and a screw and shaft 11, which
 55 carry, respectively, the bevel gear-wheels 7 9 and the spur-wheel 10. The screw 11 engages a split nut 12, mounted on a pivot 12^a on the strut 14, so that it may open and allow the screw 11, and therefore the bracket 8, the block
 60 5, and table 2, to freely slide to and fro. The wheel 10 engages a long pinion 15, carried on the shaft 16, and this latter is driven by the motor M. The table and the film then revolve
 65 and advance under the light-ray as required. This motion for the principal purpose of the process must vary in speed, so that at all times the point under the impinging light-ray
 70 moves at a constant rate. Directly under the point of incidence of the ray 41 is a brush-wheel or friction-wheel 17, mounted on a shaft 18, which carries also the spur-wheel
 19, which impels the pinion 20 of the friction-governor 21 22. The disk 22 of the latter is
 75 in contact with the rubber 23, which is regulated in position by the screw 24 and nut 25, the spring 26 holding it forward against the nut. The path of the light-ray then moves
 at constant speed by the well-known action of the governor. In case it is desired to re-
 80 volve the table 2 at a constant rotary speed the set-screw on the wheel 19 is loosened, and the wheel 30 on the driving-shaft 16 is brought in mesh with the auxiliary pinion 29 to drive
 85 the governor.

The sound-receiving diaphragm 32 is inclosed, in a housing 30 31 between rubber
 cushions 42. At its center is erected a light
 flexible strut 33, which is attached to the inclosing casing of a camera lucida or other re-
 90 flecting-mirror 34, which is mounted on delicate pivots 43, as shown at Fig. II. In the side of the housing 31 is a telescope 35 36 37, having a very small aperture in an end block
 38 and carrying a lens 40 at the inner end.
 95 The focus length of the lens is such that the rays come to a focus on the surface of the film 3 at 41 after reflection from the surface 34. The direct sun's rays or the rays of an
 arc-light are directed on the lens 40 through
 100 the aperture 38 by a reflector 39 on a pivot 40. It will be plain that the vibration of the diaphragm 32 due to sound-waves will oscillate the reflecting-surface 34 and cause the

point of incidence 41 of the focused light-rays to move radially to the revolving table and film a distance precisely proportioned to the said vibration of the diaphragm, for the angular vibration of the mirror is the antitangent of the rectilinear vertical motion of strut 33, while the lateral play of the ray at 41 is the tangent of the same angle multiplied by the distance of the mirror therefrom, which is a constant. It is also plain that the amplitude of lateral vibration of the point of incidence may be regulated at will by changing the said distance of the mirror from the film. The thickness of the photographed line is regulated by the size of the aperture at 38. If the mirror or camera lucida 34 be nicely balanced at its center of gravity, it is found that in the more rapid vibrations the mirror will oscillate about its own gravity-axis, and therefore is absolutely accurate, whatever retarding is occasioned by its inertia occurring in both phases of the vibration; but in slower vibrations the inaccuracy in the pivot-points may effect the light-ray's motion. Therefore I prefer the form of actuator shown at Fig. III. In this instance a rigid strut 47, mounted at the center of the diaphragm 32^a, carries a surface-mirror 46, set an angle less than forty-five degrees to the line from the source of light. When this reflector moves forward from the position X to the dotted-line position X', it is plain that the focus-point $y y'$ of the reflected rays will move sideways a greater distance, as indicated. This obtains any desired amount of exaggeration in the vibration, depending on the angle at which the mirror is set, and it is absolutely accurate in recording the motion of the diaphragm. The resulting "sound-photograph" is illustrated at Fig. IV. After the ordinary development, as in the case of a common dry-plate, the photograph becomes a laterally-undulating black or opaque line proceeding in a generally spiral path on the surface and consisting of a fine powder of metallic silver suspended in the outer portion of the film. This line is to be formed directly into a groove or a ridge—that is, the color form is to be made into a material shape to actuate a reproducing instrument. In order to attain this end, I use any thick gelatinous material, such as gelatin, which when sensitized by ammonium or potassium bichromate has the property of becoming insoluble when acted on by light. This may be done in several ways.

First. I use in the recording the specially-prepared plate shown at Fig. V. On a base 51 is placed a thick sheet of pure gelatin 50, and on this a sensitive silver-bromid emulsion 49. After the photograph is made, developed, washed, and well dried this double film is placed in a potassium-bichromate solution and sensitized. After drying in the dark it is exposed to light with the photograph side up. Thereupon the gelatin, which is transparent, becomes insoluble, while that

part having the black precipitate in it and the gelatin under it are protected and are still soluble. Now if we treat this film to a bath of acid the lime is entirely dissolved except that part containing silver, and this part is dissolved also, with the exception of the outer skin on the photograph. (It is even possible to dissolve the entire substance containing the silver.)

Second. If instead of the acid-bath we place the double film in a bath of hot chrome-alum, the black portion and the gelatin under it will swell, while the hardened portions, which have been in the clear, will not absorb water, and the result will be a high ridge along the line, as at 48^a in Fig. VII. Now pour upon this a plastic material and allow it to set. It forms a plate having the groove ready for commercial use for reproducing.

Third. By originally sensitizing the thick part of the film 50 with bichromate, then covering it with a thin coat of collodion before superposing the silver film 49, I may proceed by developing and drying in the dark and then re-exposing to affect the thick part 50, after which I develop the whole in pure acetic acid, which will dissolve away the whole top film 49, the collodion coat, and the unexposed parts of the under film 50. This makes the most accurate record. It may be duplicated by using it as a matrix-die to form a matrix for making duplicates for commercial use.

Still another method of reproducing is to dissolve the under film entirely through in the acid-bath when the result is to separate the gelatin along the record-line into a narrow ribbon. This has on its edge the sound-record and is arranged for reproduction in the manner indicated in Figs. IX, X, XI, or XII. The form of Fig. X is made by winding the ribbon 54^a about a central hub 56 with its edge seated on the plate 57 and having between its layers a packing 55, so that the record-ribbon forms a spiral ridge with the operating-surface practically all in a plane, or if the filling 55 be wider than the ribbon 54^a of course the resulting record-surface forms the bottom of a groove instead of the top of a ridge. This may be used as a die. However, I am not limited to the mode of treating the sound-photograph. The treatment to alter the elevation of the record-line may be varied in other ways still, and I have shown and claimed a more direct way in my copending application, Serial No. 109,513, which comes under the broad process as herein set forth.

In all these forms the essentials of the process are the same—namely, the making of a line-record by the use of a vibrating means having no inertia and the forming of this line into an undulating surface directly in an amorphous material and without the use of any tools or other instrumentality than chemical agents. This results in a record made with absolute accuracy, not affected by any

transferring of the line from one surface to another, and being formed in a material which of its own nature necessarily takes a fluid form having no granular, striated, or crystalline structure even of the minutest dimensions. The sound-waves represented in Fig. XIII represent the relative times and intensities of the several distinct impulses in a cycle of changes felt on the receiving-diaphragm and caused by the sound-waves in air. The curve being made up always of one fundamental impulse-cusp and various overtone impulse-cusps $c c' f$, intermingled regularly at shorter intervals, it is evident that the record will not be faithful if the recording agency be retarded in one direction more than in the other or be retarded constantly enough to cause the omission of the overtone-cusps. Also if the operating-surface formed from the line-record has any roughness this must appear in the reproduction, and hence there can be no perfect reproduction of sound-waves where the record-line is transferred or where it is originally made by a graving-tool or made in a metal by acids, since all metals are crystalline in their minutest construction and are left in that form by the action of acids.

It will be understood that by the use of the terms "gelatin" or "bichromated gelatin" herein I mean any substance which has the described property of becoming insoluble in the presence of light by that agency of any salt.

The apparatus herein described and the novel double film of gelatin used in the process and herein described I do not claim herein; but the same will be claimed in other applications, and the phase of the process resulting in the ribbon form and the made-up disk-record, as illustrated in Fig. 10, I do not claim herein; but the same is claimed in my copending application, Serial No. 17,773, filed May 23, 1900.

What I claim herein, and desire to protect by Letters Patent, is the following:

1. The process of making sound-records by photographing the movements of a pencil of light actuated by sound-waves and caused to impinge on, and proceed in a general spiral path over, a sensitive film, and developing this phototrace to produce a groove of uniform width having lateral undulations, in the said film.

2. The process of making sound-records which consists in vibrating a pencil of light in consonance with the movements of a body actuated by sound-waves, moving an amorphous sensitized film under the point of incidence of the pencil so that it travels over a spiral path, developing this trace of the light on the film into an undulating surface in the film by chemical means.

3. The process of making sound-records by photographing the vibrations of a sound-actuated pencil of light impinging on the surface of a double film of amorphous material,

developing this trace of the light into a color form as an opaque line on the upper part of the film, resensitizing the double film, re-exposing to harden the clear parts of the film, and then by chemical means altering the relative elevation of the film along the said trace, to form a rilievo in the said film for the purpose of actuating a reproducing-stylus.

4. The process of making a sound-reproducing record by photographing the motions of a sound-actuated pencil of light on a double gelatin film having a part sensitized to quick action of light, developing to render the resulting trace opaque, sensitizing the film anew in bichromate of potash, re-exposing the film to harden the clear portions of the same, chemically developing to alter the relative elevation of the film along the said trace, and taking a cast of the resulting form-line on the film, for commercial use as a reproducing-record, as described.

5. The process of making sound-records by photographing the trace of a sound-actuated pencil of light moving in a general spiral path, on the upper surface of a double film composed of silver-bromide gelatin and bichromated gelatin, developing the trace into a black line on the upper film, re-exposing to affect the under film, and dissolving out the parts protected from light by the said line in the compound film, to form a groove in the said compound film.

6. A sound-record consisting of a line photographically traced and chemically developed into a groove in an amorphous material by chemical means, the said line being of uniform width and depth and having lateral undulations.

7. A sound-record consisting of a spiral path having lateral undulations and constant width and elevation, traced on the surface of an amorphous material by the action of light and chemically changed in elevation from the original surface of the said material, as described.

8. A photophonogram having an undulatory operating-surface corresponding to sound-waves and composed of an amorphous material rendered insoluble by the action of light and formed by tracing with a pencil of light and dissolving out the exposed portions of the said trace to form a groove.

9. A photophonogram having a spirally-arranged undulatory operating-surface in the form corresponding to sound-waves and composed of an amorphous material rendered insoluble in the portions surrounding said undulating surface by successive exposures to the action of light.

10. A sound-record consisting of a double film of gelatin having a photographically-traced line of undulating form and constant width thereon, the surface along said line being dissolved out to form a groove in the gelatin, by rendering the other parts of the gelatin insoluble by the action of light.

11. A sound-record consisting of a spirally-

arranged laterally - undulating groove in a
compound sheet of gelatin, the upper surface
of said sheet being blackened by the action
of light on silver bromide and the gelatin
5 under the same being dissolved out while the
rest of the sheet is rendered insoluble by the
action of light.

In testimony of the foregoing I hereunder
sign my name in the presence of two wit-
nesses.

FRANCIS W. H. CLAY.

Witnesses:

BERTHA O. ROSS,
CHAS. H. URBAN.