

F. W. H. CLAY.
 PROCESS OF MAKING SOUND REPRODUCING RECORDS.
 APPLICATION FILED MAY 23, 1900.

900,706.

Patented Oct. 13, 1908.
 3 SHEETS—SHEET 1.

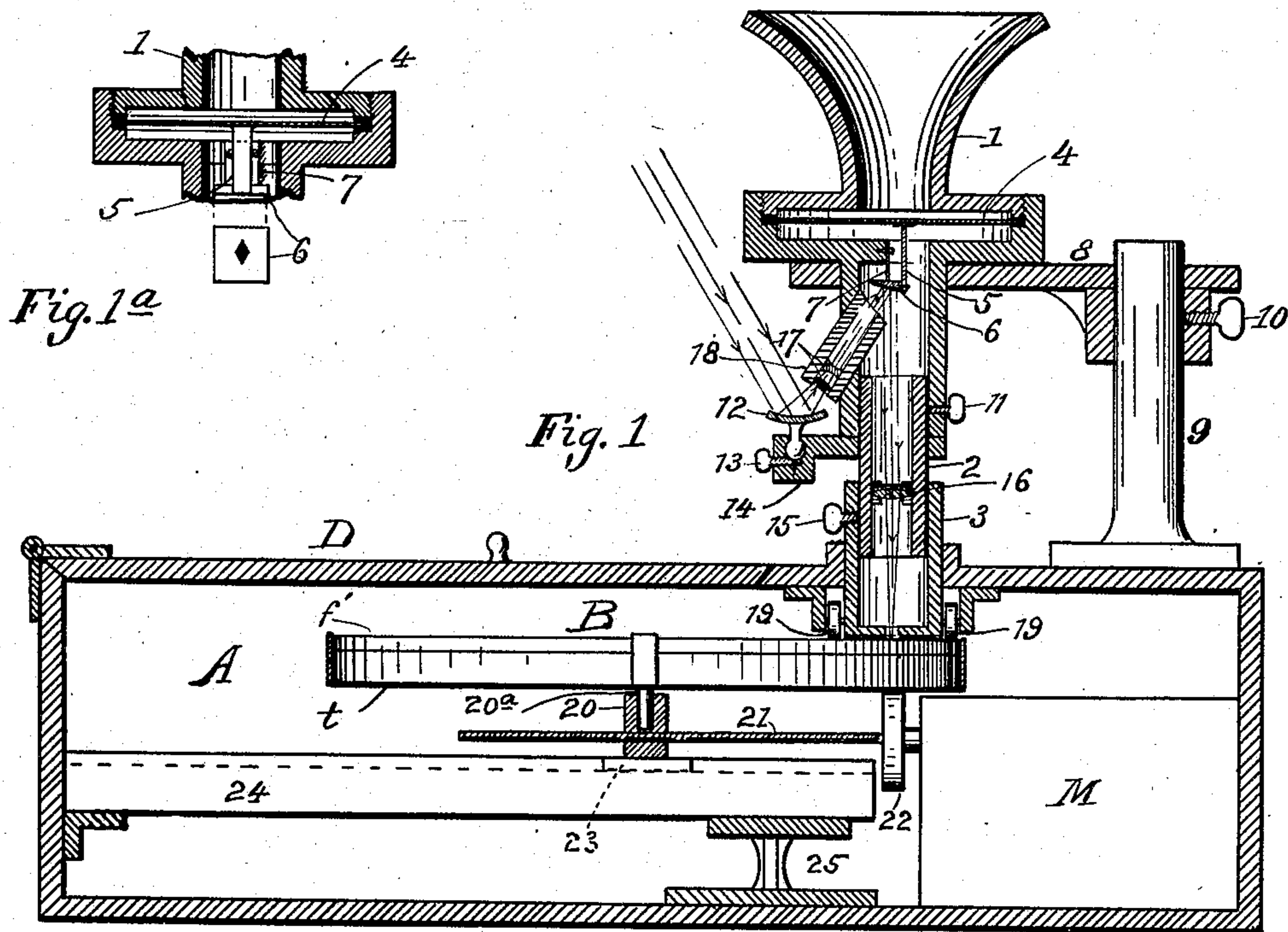
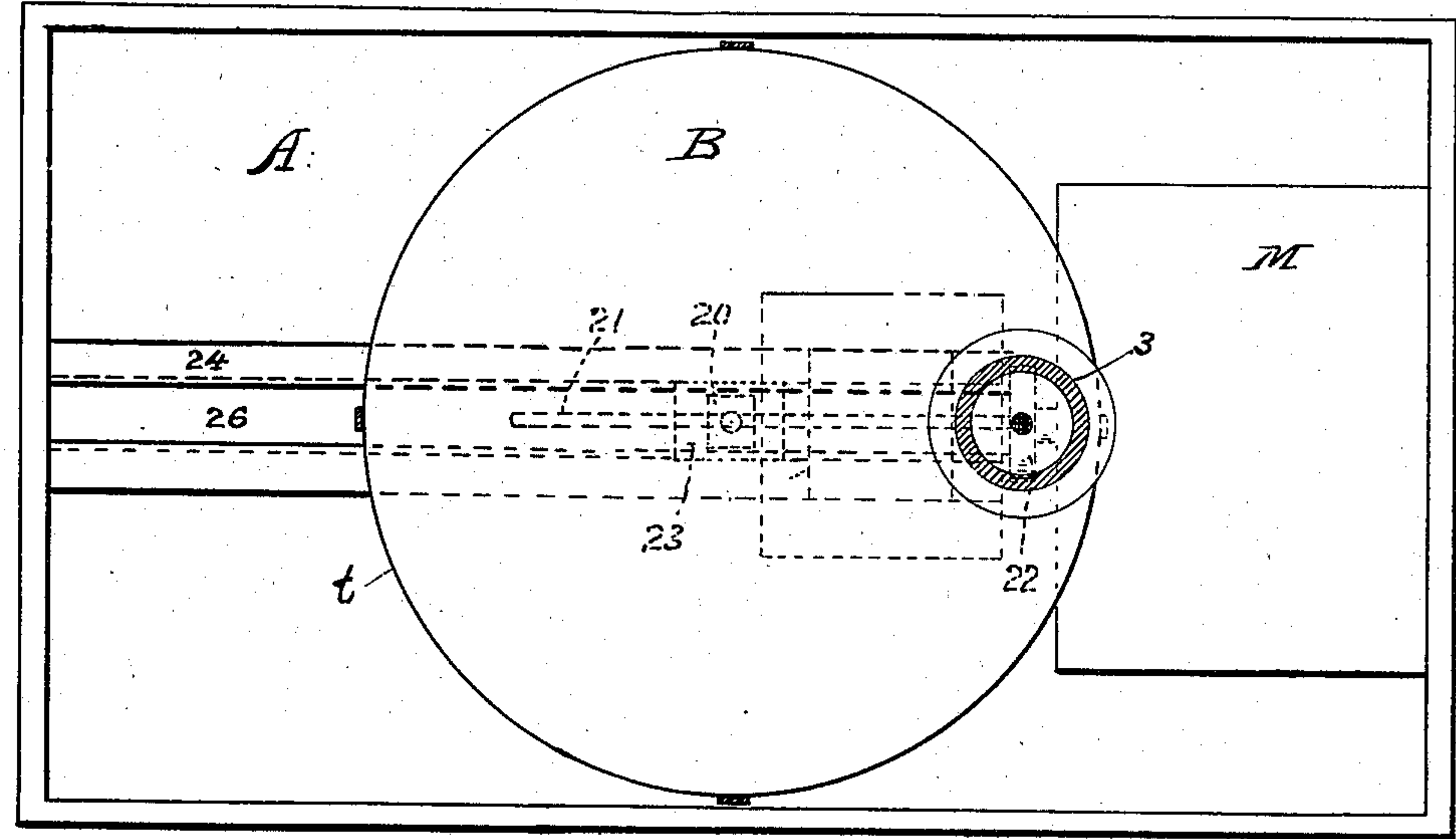


Fig. 1a

Fig. 1

Fig. 2



Witnesses:

Thomas H. Sherard.

Henry G. Ginnell

Inventor,

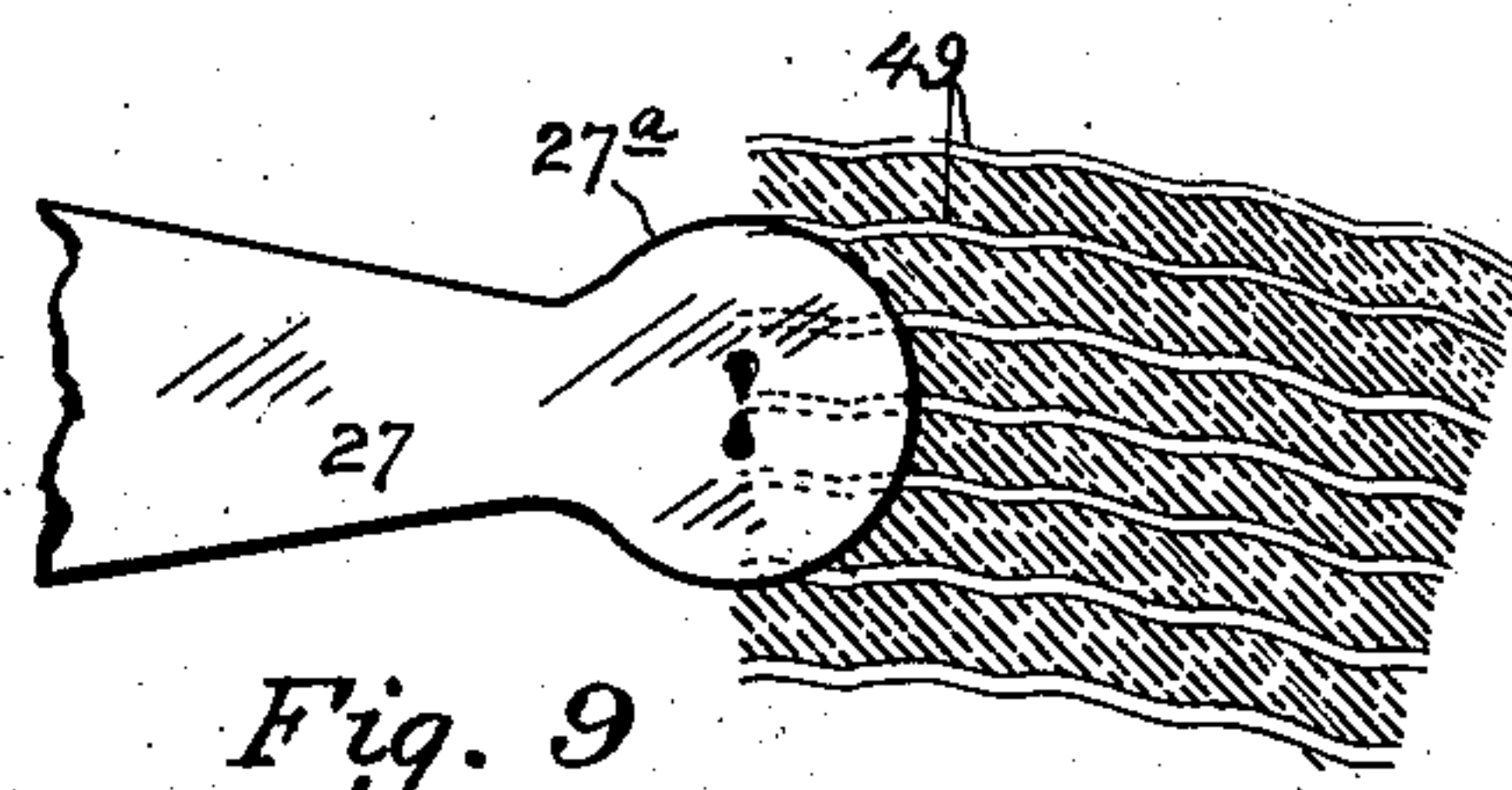
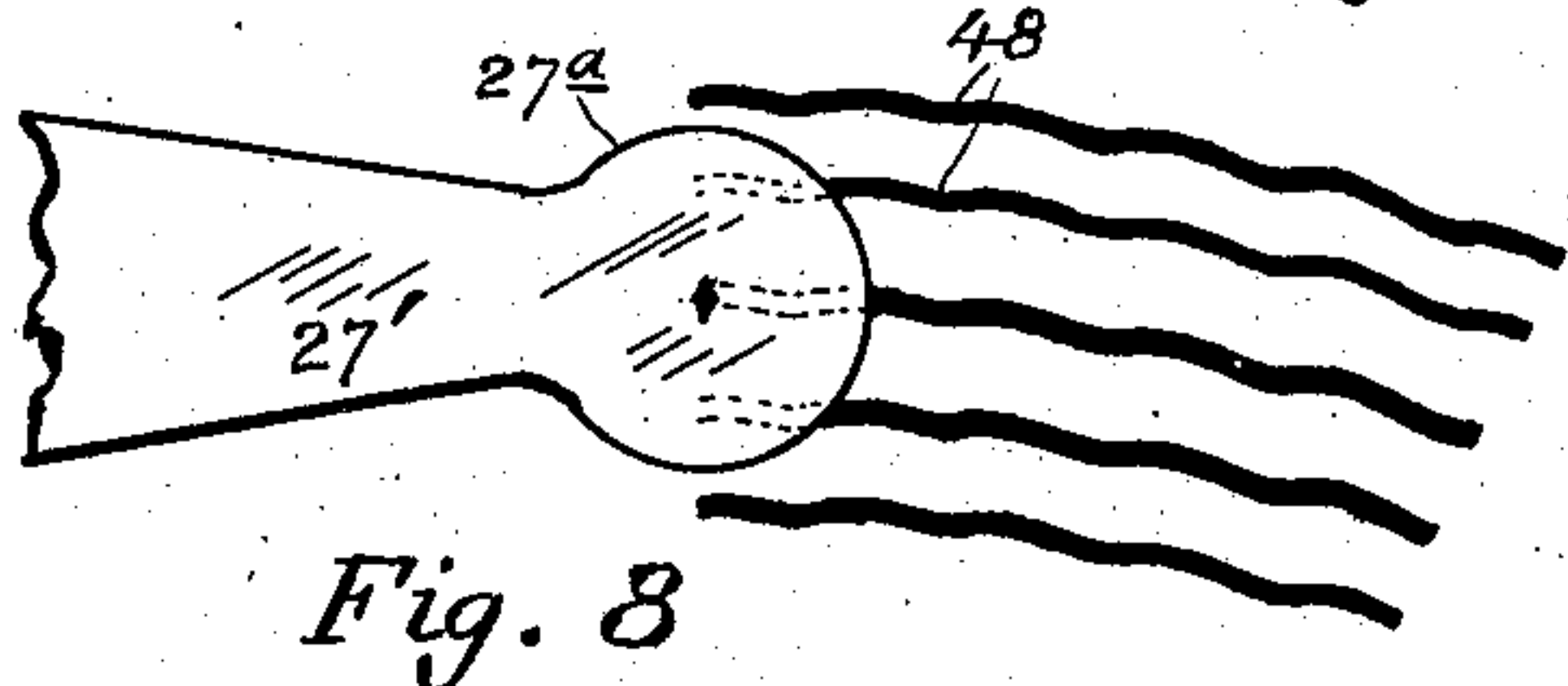
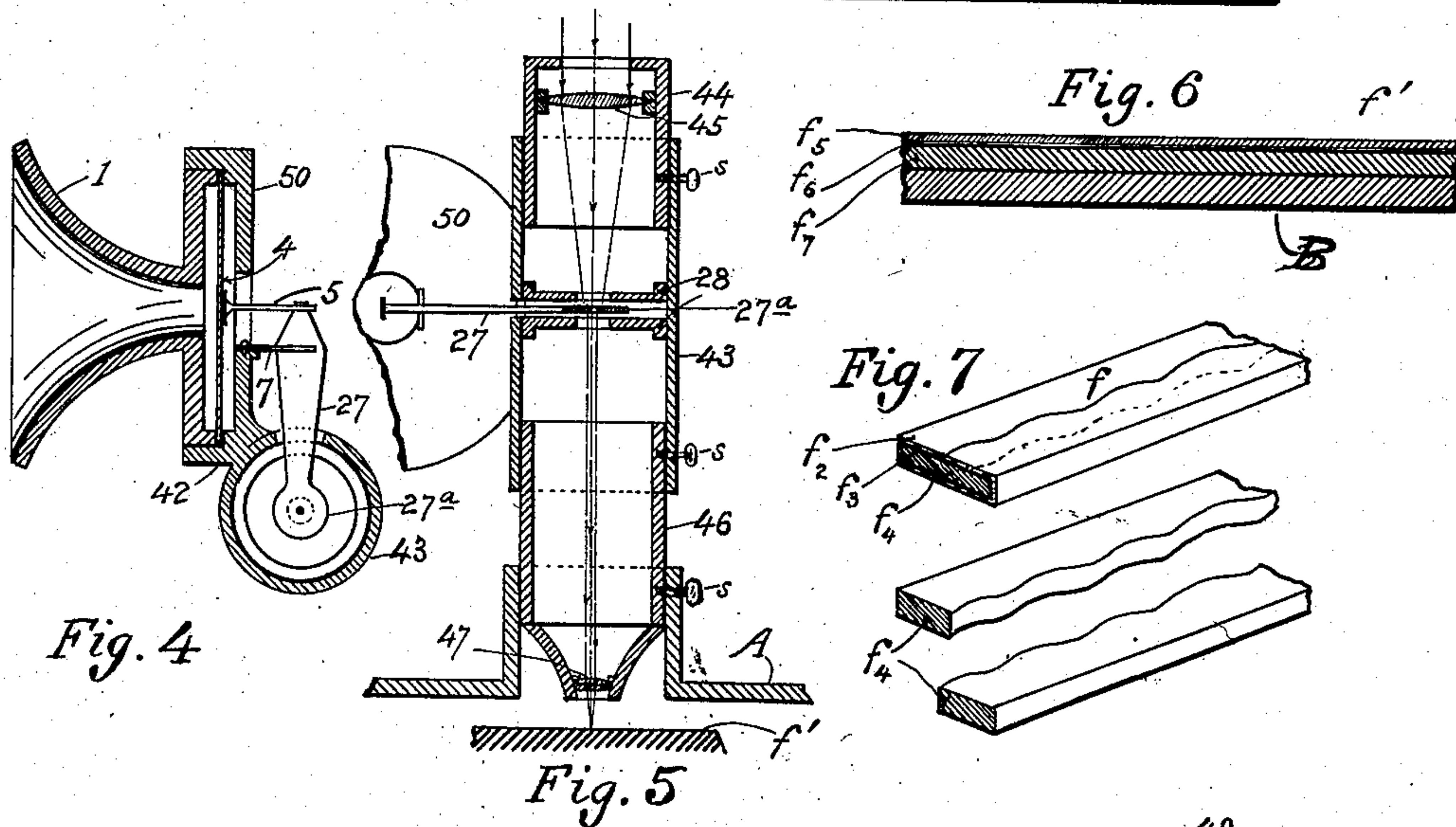
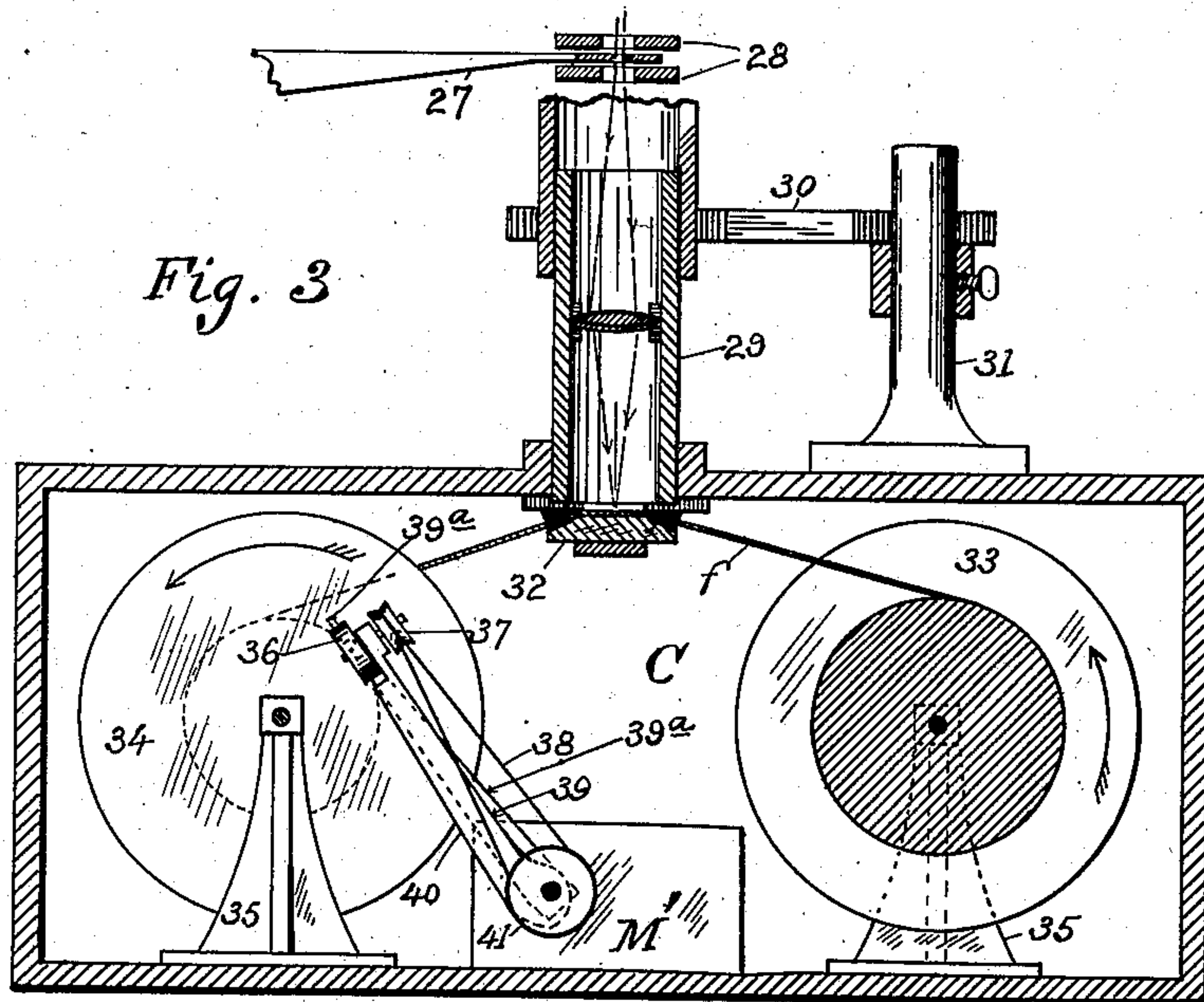
Francis W. H. Clay.

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3 SHEETS—SHEET 2.



Witnesses:
Henry Grinnell
Thomas H. Sherrard.

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 3 SHEETS—SHEET 3.

Fig. 10

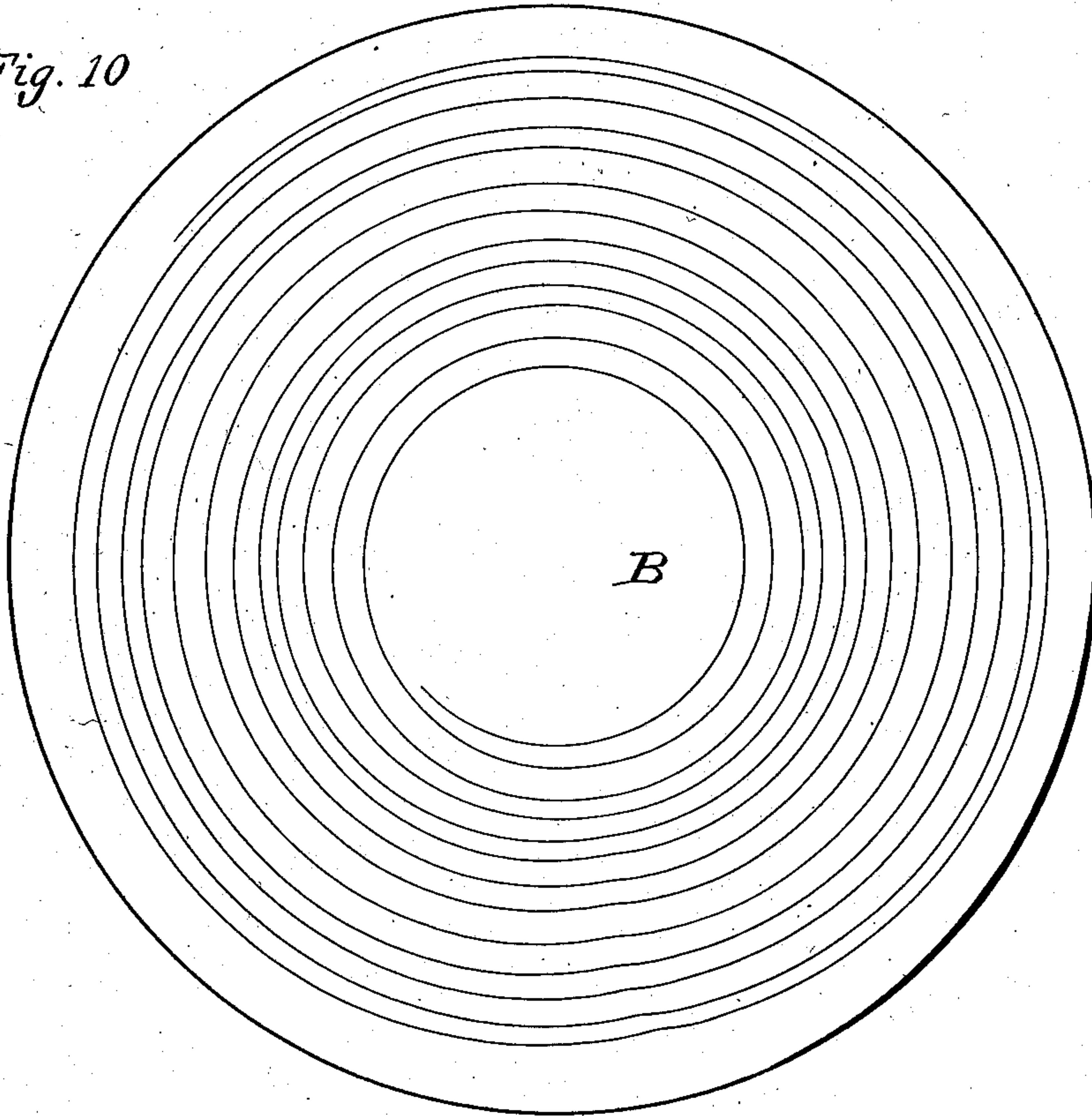


Fig. 11

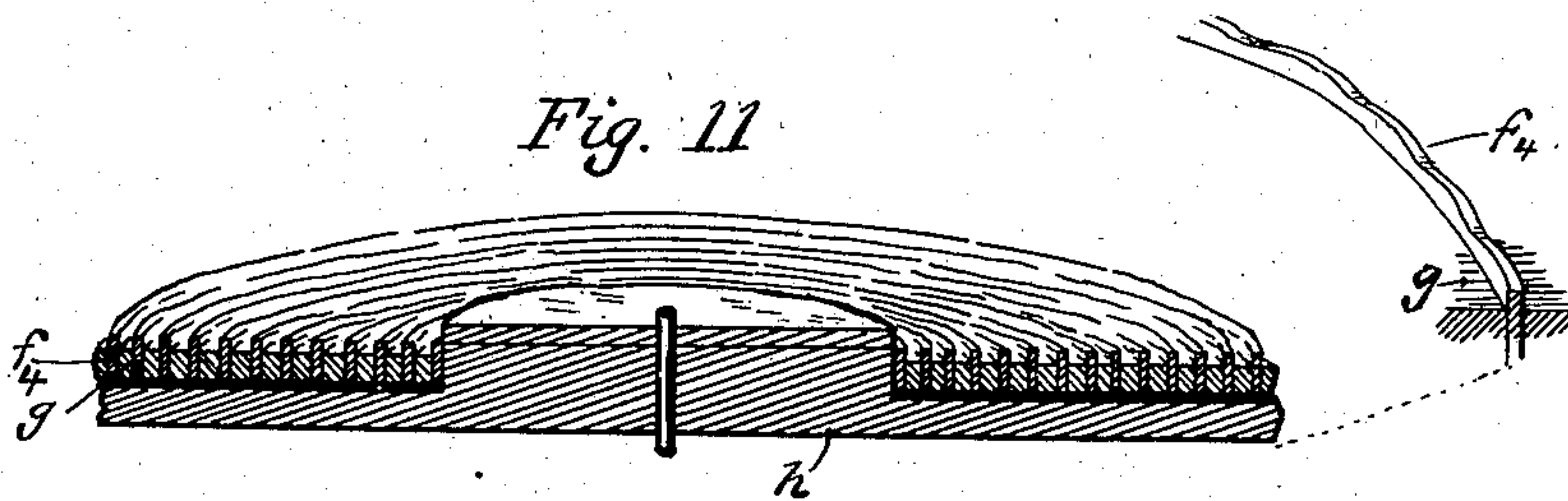
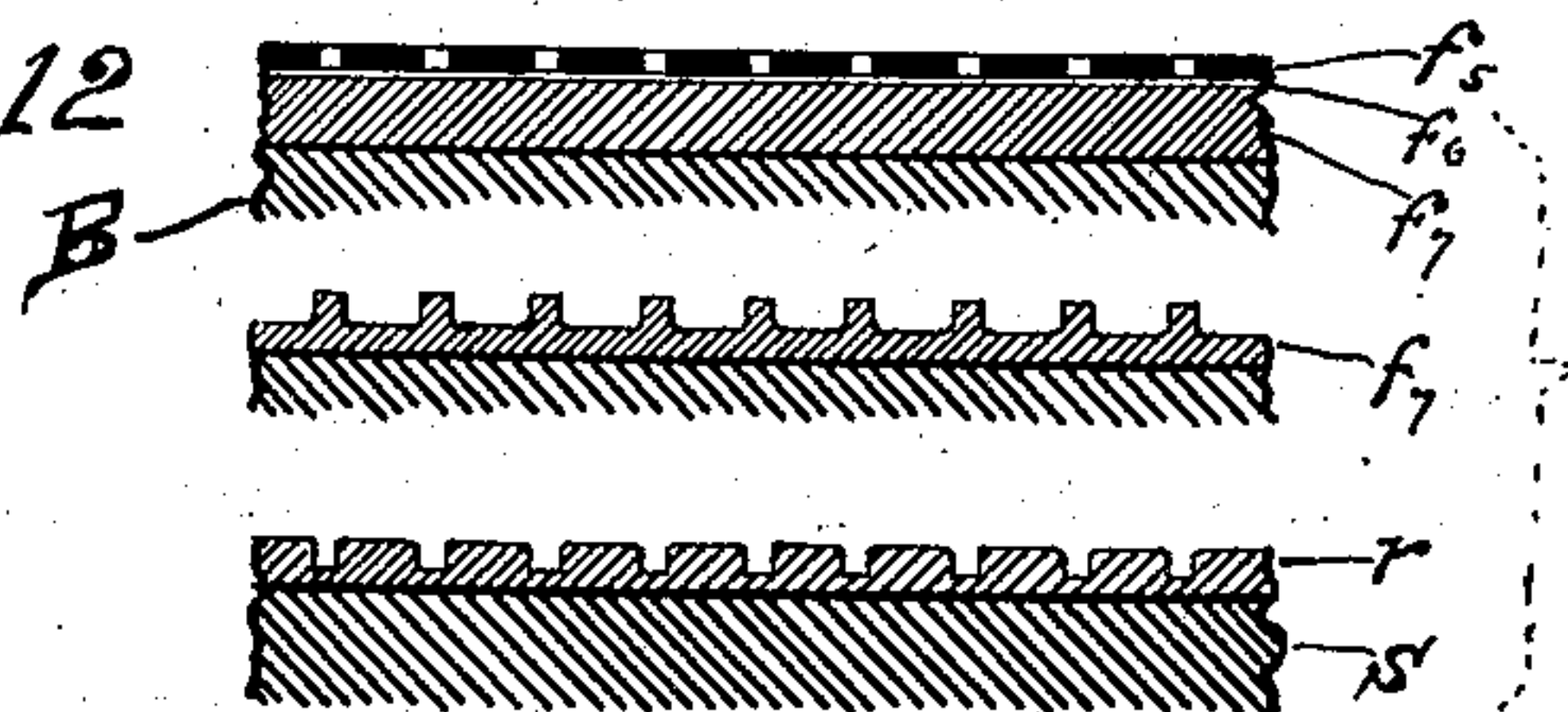


Fig. 12



Witnesses:
 Henry Grimal
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UNITED STATES PATENT OFFICE.

FRANCIS W. H. CLAY, OF WHITEHALL, KENTUCKY.

PROCESS OF MAKING SOUND-REPRODUCING RECORDS.

No. 900,708.

Specification of Letters Patent.

Patented Oct. 13, 1908.

Application filed May 23, 1900. Serial No. 17,773.

To all whom it may concern:

Be it known that I, FRANCIS W. H. CLAY, a citizen of the United States of America, residing at Whitehall, in the State of Kentucky, have invented a certain new and useful Process for Making Sound-Reproducing Records, of which the following is a specification.

My invention relates to sound recording and reproduction, and has for its object, primarily, to make reproducing records of the motions of sound waves in a more perfect form than has heretofore been attained, and particularly to avoid the rasping imperfections and buzzing sounds incidentally accompanying the sound reproduction from all the present records used by graphophones, gramophones etc.

My object further, is to gain complete control over the loudness and pitch of the reproduced sounds without diminishing in any degree the accuracy and quality of tone of the same.

The said imperfections in the present sound records result from several conditions necessary and inherent in the processes of producing the records,—notably, 1st., the using of metallic or crystalline materials for the records and for working and duplicating them; 2nd., the employment of graving tools, which are necessarily rough and only approximately of the form they are intended to have; 3rd., the mass and inertia of certain moving parts used in making a trace of the movements of a sound-receiving diaphragm. To avoid these imperfections, my process employs amorphous materials in which to record the sound wave lines and to take an impression of the same for reproducing purposes; and further, I use a light ray as the recording agency and chemical or other similar means both for the recording and for the reduction of the record to a permanent material form for use in reproduction. Thus there is no agency employed, between the sounding diaphragm actuated directly by sound waves and the final reproducing record as used in commerce, which involves weight or inertia to overcome, or which has within itself any necessary source of imperfections, as in all present methods.

The process which I have invented consists broadly, in vibrating a ray of light through the agency of a body actuated by sound waves, passing a light sensitive surface across the field of play of the vibrating ray,

to thereby trace thereon a line corresponding to sound waves, and then developing the photographic line into the form of a groove or raised ridge for reproducing purposes, by purely chemical means.

In the photographic arts two general classes of light-sensitive materials are used, which are typified, respectively, in the common silver bromid dry plate and the "bichromated gelatin" used in photo-engraving drawings.

A thin film of gelatinous or albuminous substance carrying in suspension in its mass such a salt as silver bromid, is affected by an extremely short exposure to light, so as to reduce the stability of the salt, when, in the developing of the substance after exposure, the portions of the film that are affected by light become black by a chemical change and supposedly a deposit of metallic silver,—the unexposed portions remaining transparent after the "fixing" bath. A mass of gelatinous or albuminous substance impregnated with such a salt as ammonium or potassium bichromate requires a comparatively long exposure to light before being sensibly affected. The action of the light on the salt in the presence of the suspending medium is of a character which has a sort of tanning action on the medium, rendering it insoluble in several liquids, such as acetic acid, sulfuric acid, hot water, etc., which yet readily dissolve the same material where it has been protected from the action of the light. In view of these facts, I employ as a means for carrying out my process a compound film composed of a thin top layer of gelatin or albumen containing silver bromid or a similar salt and an under layer of gelatin or albumen or glue containing bichromate of ammonium or potassium or a similar sensitizing salt. Also, in order to be able to develop the top layer when it has been exposed without destroying the under layer I cover the under (bichromate) film with a protecting coat of collodion or such substance. In the exposure in recording the motion of the light ray the bichromate film is not affected, owing to the short duration of time exposed; but the bromid film is affected to render it black on developing. The latter is then treated to any of the common developers, when the path of the light ray thereover becomes a black line, the remaining portions being transparent after the fixing bath. The collodian coat protects the bichromate film both

from the developer and the fixer, and all these operations being carried on in the dark, the bichromate film is still light sensitive, and now has superposed upon it a protecting
 5 black coat where the light ray has played over it in recording sound waves. The film is next exposed a comparatively long time (say 5 or 10 minutes) in strong sun or electric
 10 light, and then treated to a bath of the solvent developer, which may be, for example, glacial acetic acid cold. This dissolves away the upper film of gelatin, the collodion coating and the unexposed portions of the bichromate gelatin. The sound record is then
 15 indicated by the difference in the thickness or elevation between the parts of the film which are light struck and those which are not exposed, and if the unexposed portion be all dissolved away the resulting sound record
 20 takes the form of the edge of the film cut along the dividing line between exposed and unexposed parts.

In making sound records in one form hereinafter to be described, I may proceed by
 25 placing the bichromate gelatin directly on the bromid gelatin after the latter has been exposed and developed. Thereupon, the second exposure being made from beneath, the solvent developer being applied to the
 30 outer surface leaves the light struck portion,—*i. e.* the portions under the transparent parts of the bromid film, as raised ridges, superposed on the bromid gelatin.

After the sound photograph has been made
 35 it may be reproduced in relief in gelatin or glue or similar substance by printing in the sun and dissolving out, as is done in photo-engraving.

The form in which the photographic surface is arranged is not material to the process. But I prefer, for cheaper records where accuracy is not the sole consideration, to make the record in the form of a ridge or a
 40 grooved line arranged spirally on a flat plate. For more accurate work I make the compound film in the ribbon form, as illustrated in the accompanying drawing at Figure 7.

For carrying out the process and the manipulation of the film and of the light ray I
 50 have invented the apparatus illustrated in the accompanying drawings, which drawings also illustrate the steps of the process. And the process will be explained in detail in the description of the structure and use of the
 55 apparatus.

Fig. 1 represents my preferred form of exposing box, telescope and actuator, shown in section. Fig. 1^a is a vertical section, at right
 60 angles to that of Fig. 1, through the actuating diaphragm and its housing, showing the support of the mirror. Fig. 2 is a plan inside the dark box, with a plate in position, and a cross section of the telescope. Fig. 3
 65 is a vertical section of an exposing box for recording on the ribbon form of the film.

Fig. 4 is a section through another form of actuator and its telescope. Fig. 5 is a vertical section through the telescope. Fig. 6 is a partial section of the compound film carried on a plate. Fig. 7 shows two perspective and sectional views of the ribbon form of the film, in two stages of development. Fig. 8 illustrates the head of the lever arm for actuating the light ray, and the trace of the light ray, as arranged when it is desired to
 70 produce a groove in the bichromate gelatin. Fig. 9 illustrates the same as arranged to give a raised ridge in the bichromate gelatin, to be used as a patric die in stamping out duplicates. Fig. 10 shows a flat plate with a
 80 sound photograph traced upon it in spiral form. Fig. 11 is a perspective view in section of the disk formed by winding the ribbon of Fig. 7. Fig. 12 shows in section, at two stages of development, the plate form of
 85 the double film, and the reproducing plate stamped out therefrom, below.

Considering the cost of producing duplicate records I prefer the form of the apparatus shown in Figs. 1 and 2.

A light tight box A contains a motor M having a contact or brush-wheel 22 on a horizontal shaft which has a fine screw extension, 21. This screw works in a block 20 which has a base 23 mortised in and sliding freely in
 90 a groove 26 in a horizontal guide-bar 24 supported as shown at 25. The traveling block 20 has a socket which receives the center pin 20^a of a revolving table *t*. The table *t* carries the plate B having the sensitive film *f*
 95 (shown in Fig. 6). The table and plate are revolved by the brush wheel 22 and are kept in contact therewith by rollers 19. The box A has a door D for introducing the sensitive plate. On top of the box A is stanchion 9
 100 with an adjustable arm 8 which carries the telescope and actuator for the light ray. In the form of this figure, a sound receiver 1 screws into and forms part of a circular housing containing a vibrating diaphragm 4,
 110 which may be of glass or mica, held between elastic rings. At the center of the diaphragm is a thin aluminum strut 5 to actuate a mirror 6. On one side of the lower opening of the housing is attached a thin flat
 115 spring 7 which carries on its outer end a small surface mirror 6 attached at its middle. Thus as the diaphragm 4 vibrates under the influence of sound waves entering the receiver 1 the mirror receives an angular vibra-
 120 tion about its middle as a flexion axis. The face of the mirror has a black or a white spot, preferably diamond-shaped, as shown at Fig. 1^a. (If it is black its image on the plate *f* will make a clear line photographic trace; if
 125 silvered, a black line trace, for a purpose hereinafter set forth. Or, the sectional form of the ray may be controlled by an opening, before striking the mirror.)

The diaphragm housing has a tubular ex- 130

tension below which telescopes over a tube 2 which again slides in a tube 3 set in the top of the box A. All the parts have set screws for adjusting. Through the side of the tube 5 extends a small tube 18 carrying condensing lenses 17 which project rays of light on the center of the mirror 6 and through the lens 16. The sunlight is collected and projected into the tube by the concave mirror 12 held 10 by a universal joint in the head 14 supported by the telescope as shown. The ray of light then is reflected downwards and is focused by a lens 16 to the fine image on the surface of the moving sensitive film f' . It will be 15 plain that by arranging the distance from the mirror to the film f' the movement of the focus point of the ray of light may be given any desired amplitude of vibration, while the lens 16 will reduce the image of the spot on the mirror 6—that is, the cross section of the 20 vibrating ray—to any desired degree or size. Thus both the amplitude of the lateral vibration on the recording surface and the size and brilliancy of the recording beam of light 25 are under complete control. As is clear from the figure, the ray of light will vibrate to and fro in a line radial to the disk B, while at the same time the said disk rotating gives the impinging point of the light ray a resultant sinuous motion with respect to the circumference of the plate B and proceeding in a spiral path over the surface about the center of the plate,—the screw 21 dragging the 30 table and plate laterally under the focus of the telescope as the revolution continues. An illustration of the course over the plate is shown at Fig. 10.

The actuator shown at Fig. 4 will sometimes be used. The small flat spring 7 supported on the diaphragm housing carries an 40 arm 27 of light material as aluminum. At its inner end it is attached to a flexible strut 5 made fast to the diaphragm 4. At its outer end, on the longer lever arm, is a flat 45 head 27^a with a small hole (preferably diamond shaped), and this head and arm extend through a slit in the side of the telescope 43 and play freely between the two disks 28 which are open at the center as shown. The 50 light is collected and concentrated to the desired degree on the vibratory head 27^a by a lens 45 in the tube 44, and after passage through the opening in the head 27^a of the arm 27 the rays are focused by the lens 47 55 on the surface of the moving sensitive film f' .

The plate B and the film f' are shown in partial section at Fig. 6. The bichromate film f' is placed on metal or glass and covered with a collodion film f'' and upon this is placed 60 the bromid film f^5 . The form of the opening in the head of the arm 27 is best shown at Fig. 9, in using which the line left on the plate is unexposed, while the rest of the surface will have been all subjected to the action 65 of light. (See Fig. 12.)

When developed the film f^5 will have a laterally sinuous spiral line left transparent. On exposure to light again the portions of the bichromate gelatin under this will be light struck and become insoluble, so that when 70 the whole is treated to acetic acid the top film f^5 , the collodion coat f'' and the unexposed portions of the bottom (bichromate) film f' will dissolve away, leaving the form shown in section (f^7). This is dried and 75 hardened and then used as a patric die to stamp into softened celluloid for example, as at r , leaving the sound record in the form of a groove spirally arranged on the plate or disk S.

The more accurate form in which to make the record is by the use of a sensitive ribbon, instead of the plate film. This is shown at Fig. 7, and is manipulated by the apparatus of Fig. 3. The dark box C contains a spool 85 or roller 33 carrying the sensitive ribbon, and a spool or roller 34 to receive it. The ribbon passes over a support 32 under the vibrating ray of light and winds on the spool 34, which is driven by a brush wheel 36 carried on a 90 pivoted arm 39 and driven by a pulley 37 and cord 38 from the pulley 41 of the motor M'. The arm 39 is pivoted on the shaft of the pulley 41 and has, integral with it, a finger 39^a which extends inside the spool 34 and 95 rests on the surface of the ribbon already wound thereon. It stands parallel and opposite to the arm 39, so that as the ribbon winds on the spool the arm 39^a rises, carrying also the arm 39 outward, keeping the point 100 of contact of the driving wheel 36 always opposite to the last layer of the ribbon and winding the ribbon on the spool at a constant rate, whatever may be the diameter of the coil on the receiving spool. Either form of 105 telescope and actuator may be used with either form of exposing box and film.

The sensitive ribbon is made similar to the sensitive film on the plate heretofore described, save that it will be more convenient 110 in making to coat both sides of the bichromate film with the collodion and the bromid gelatin.

Referring to Fig. 7: the thick film f^4 is the bichromate gelatin; it is thinly coated with collodion, f^3 , for protection. Outside this is 115 a thin film of the silver bromid gelatin, f^2 . Upon exposure and development the trace of the ray of light (when the form of the actuator head of Fig. 8 is used) results as a fine black line along the middle of the ribbon, as 120 shown. When re-exposed to effect the bichromate film the latter becomes insoluble all except the portion protected by the black medial line, which part readily dissolves in the solvent developer. Consequently, in the 125 bath of acetic acid the bichromate ribbon is severed along the line representing the sound waves by the dissolving away of the protected gelatin. Now one of the halves of the severed ribbon is arranged for sound reproduc- 130

tion as shown in Fig. 11, where the base h is a flat disk having a hub. Around this the ribbon is wound in layers with layers of packing of less width than the ribbon, between them, so that the gelatin ribbon f^4 stands a little above the general surface, forming, when completed, a spiral ridge on the disk h having its upper edge undulatory to correspond to the sound waves. When hardened this may be used as a patrix die to stamp into softened rubber or celluloid for commercial use; or it may be reproduced in various ways.

It is clear that the packing between the layers of the gelatin ribbon might as well be made wider,—i. e., higher from the base disk, than the ribbon itself, so that the whole will present a spiral groove whose bottom is the edge of the ribbon, shaped in correspondence with sound waves.

The terms "sound photograph" and "photophonographic record" used herein will be understood to indicate the trace of the vibrating spot of light over the surface of the moving bromid film, after development thereon, when the line referred to is either a black opaque line or else a clear line in the gelatin,—depending on whether the recording spot is lighted or is black.

Now the sound photograph may be reproduced in raised or depressed form in several ways: when it is made as a dark line trace or "negative", I may expose under it directly a common bromid film and make thereby a "positive" or clear line trace. This being developed in oxallate or other non-metallic developer, treated to dilute sulfuric acid, dried thoroughly and then steamed; whereupon the (clear line) trace will swell and form a ridge, which can be baked and hardened and used as a patrix die, from which we may stamp out duplicates in the groove form. Again, I may use a clear line photophonographic record and reverse it over a plate covered with thick bichromated gelatin and after printing thereon dissolve out the unexposed portions of the said bichromate gelatin, leaving the record again in the form of a standing ridge. On using this as a patrix die and stamping out duplicates in celluloid the record will be re-reversed and take the form of a groove in the duplicate, now again in obverse and ready for commercial use.

The ways of duplicating, and of reducing the photophonographic record to a tangible material form for reproducing the sound are given only to illustrate the breadth of my invention, being parts thereof, and while they are alternate forms of procedure in my process I do not limit myself to any one or to all of them.

The apparatus herein described, which forms another part of my invention, I have presented for patent in my application No. 158,311 filed May 22/03, and the same there-

fore forms no part of the invention covered by claims herein, but—

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

1. The process of making sound reproducing records by photographically recording the movements of a sound-actuated body and photo-etching the said graphic record to produce an undulating surface corresponding in form to the sound waves recorded.

2. The process of making sound reproducing records by vibrating a ray of light in consonance with the movements of sound waves, moving a light-sensitive film across the field of play of the said ray and reducing the resulting trace of the said ray by chemical means to material form as an undulating surface in amorphous material.

3. The process of making a reproducing sound record by moving a ray of light in consonance with the vibrations of sound waves, translating a light-sensitive material across the field of play of the said ray, developing, and by chemical means changing the relative elevation of the material along the said trace on the sensitive surface thereof.

4. The process of making sound reproducing records consisting in vibrating a ray of light in consonance with the motions of sound waves over a moving sensitive surface, developing the photographed line thus formed, exposing under the photograph amorphous material capable of being rendered insoluble by the action of light and dissolving out the unexposed and soluble portions of the same, to leave an undulating surface.

5. The process of making sound reproducing records which consists in exposing successive portions of a light-sensitive film to the action of a ray of light vibrated in consonance with the movement of sound waves, developing the same to reduce the trace of the ray to an opaque line, exposing under this film a second film rendered insoluble where light-struck, and dissolving out the unexposed portions of the said second film, whereby an undulating surface in the form of the path of the light ray is produced in the said second film.

6. The process of making sound reproducing records by photographing upon a light sensitive film the movements of a ray of light vibrated by the agency of a sound wave actuated body; developing the resulting photographic trace, exposing beneath it a film capable of being rendered insoluble by the action of light thereon, dissolving away the unexposed portions of the same under the sound record trace, to form an undulating surface, and reproducing the resulting sound wave forms by impressing the same into soft material such as celluloid.

7. The process of making sound reproducing records which consists in vibrating a ray of light by a sound-actuated body, translating a light-sensitive ribbon under the point of incidence of the said ray to trace an undulating photographic line thereon, exposing under this record a ribbon of bichromated gelatin, dissolving away the unexposed portions of the latter, so as to divide the said ribbon into parts having their edges undulating in the form of sound waves.

8. The process of making sound reproducing records which consists in exposing successive portions of a light-sensitive film to the action of a ray of light vibrated in consonance with the movements of sound waves, developing the same to produce an opaque line on the trace of the ray, exposing under this film a second film rendered insoluble where light-struck, dissolving out the unexposed portions of the said second film so that the form of the edge of the path of the ray of light is imparted to an undulating surface representing sound waves, and winding this film about a center so that the said edge is arranged spirally with the volutions of the edge approximately in a plane.

9. The process of making sound reproducing records which consists in vibrating a ray of light by a sound-actuated body, translating a light-sensitive ribbon under the point of incidence of the said ray to trace an undulating photographic line thereon, exposing under this record a ribbon of bichromated gelatin, dissolving away the unexposed portions of the latter to sever the ribbon into parts having their edges in the form of sound waves, and winding the ribbon into a disk with the edge of the ribbon forming a spirally arranged surface with undulations in the plane vertical to the plane of the disk.

10. The process of making sound-producing records which consists in vibrating a ray of light by a sound-actuated body, translating under the point of incidence of said ray a compound sensitive ribbon composed of a top layer of silver bromid emulsion and an under layer of bichromated gelatin the latter being protected by a skin of collodion, developing the top film, re-exposing to effect the under film, dissolving away the top film and the unexposed portions of the under film so as to sever the under film along the line of the trace of the light ray, and winding the resulting wavy-edged ribbon with alternate layers of packing, into a disk with the edge of the ribbon forming a spirally arranged surface on the face plane of the disk, the undulations in the form of sound waves being in a plane vertical to the disk.

11. The process of making sound reproducing records consisting in vibrating a ray of light falling on a sensitive film in consonance with sound waves, developing the photograph thus formed, exposing under the photograph a strip of amorphous material capable of being rendered insoluble by the action of light, dissolving out the unexposed and soluble portions of the amorphous material, winding the strip thus formed into a spiral with the undulating edge corresponding to the sound waves extending in one direction, and impressing in or upon plastic material the said undulating spirally arranged edge of the strip.

12. The process of making sound reproducing records which consists in exposing successive portions of a light-sensitive film to the action of a ray of light vibrating in consonance with the motions of sound waves, developing the same to produce an opaque line, exposing under this film a second film capable of being rendered insoluble by the action of light, dissolving away the unexposed portions of said second film to form the material under the edge of the path of the ray of light into an undulating surface having the shape of the sound waves, winding this film about a center so that the said edge is arranged spirally, lying in approximately a plane, and then impressing the resulting record disk into soft material to make commercial records in the form of a plate having a spirally arranged surface with the undulations in a plane vertical to the plane of the plate.

13. A photophonogram having an undulatory operating surface, the undulations thereof corresponding to sound waves, and composed of amorphous material rendered practically insoluble in water by the action of light.

14. A photophonogram having a continuous spirally arranged undulatory operating surface, the undulations thereof corresponding to sound waves, and composed of amorphous material rendered insoluble by the action of light.

15. A surface of amorphous material rendered insoluble by the action of light having cut therein by tracing with a sound actuated ray of light and a developer a spirally arranged portion having an undulating surface corresponding to sound waves.

In testimony whereof, I hereunder sign my name in the presence of two witnesses.

FRANCIS W. H. CLAY.

Witnesses:

DANIEL WILSON,
CHAS. H. URBAN.