April 9, 1935. B. FREUND 1,996,958

METHOD OF AND APPARATUS FOR VARYING THE LENGTH OF SOUND RECORDS

Filed June 19, 1931 2 Sheets-Sheet 1

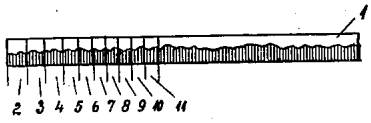

Fig.2.

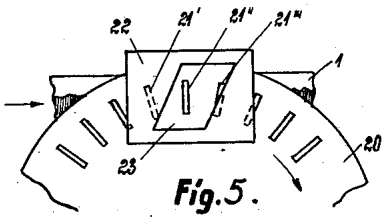

Fig.5.

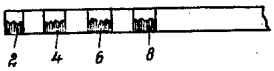

Fig.3

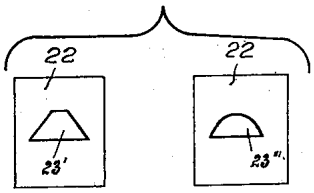

Fig.6.

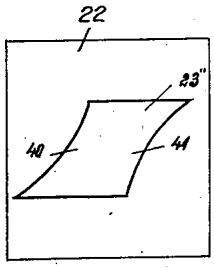

Fig.7

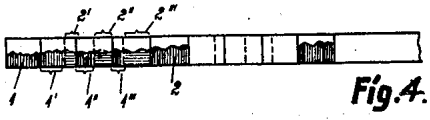

Fig.4.

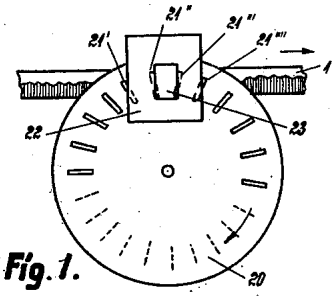

Fig.1.

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Fig. 8.

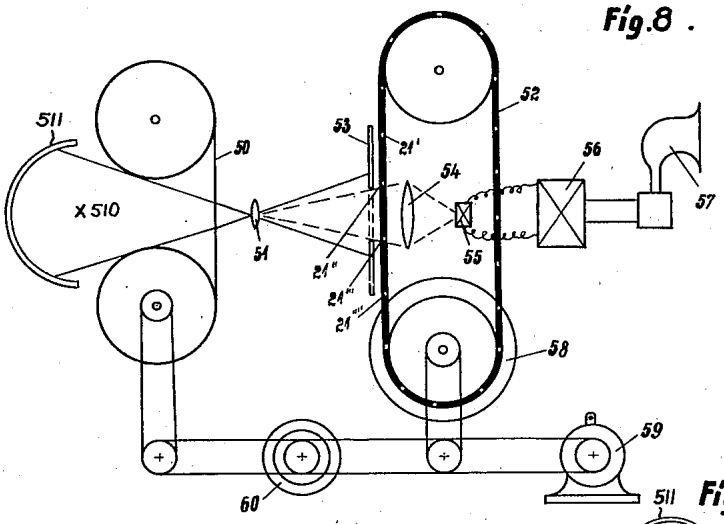


Fig. 10.

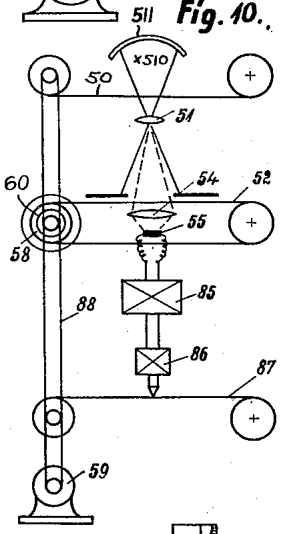
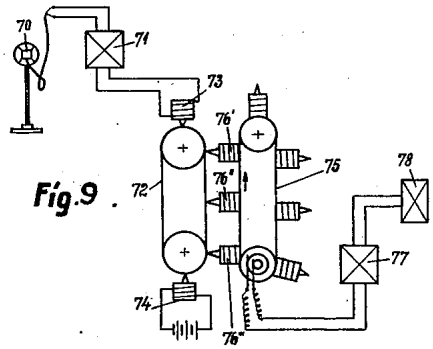


Fig. 9.



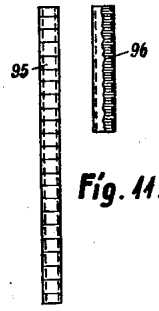


Fig. 11.

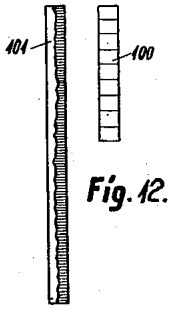


Fig. 12.

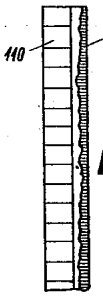


Fig. 13.

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METHOD OF AND APPARATUS FOR VARYING THE LENGTH OF SOUND RECORDS

Berthold Freund, Berlin-Schoneberg, Germany

Application June 19, 1931, Serial No. 545,582
In Germany June 26, 1930

14 Claims. (Cl. 274—46)

My invention relates to apparatus for reproducing sound records which is equipped with means for scanning the record, for moving a record past the scanning means, and for reproducing the scanned sound record.

It is an object of my invention to provide an apparatus in which the difficulty resulting from the necessity of running the sound record at the same low velocity as the picture record with which it is analyzed, is eliminated.

To this end, in my novel apparatus I provide means for varying the relative velocity of the sound record and the scanning means.

A film sound reproducer for analyzing sound film records is old in which means are provided for reproducing repeatedly from a short length of the record for ascertaining its synchronism with a picture film. Obviously, it is desirable to run the picture film slowly so that the operator can study all its details. On the other hand, if the sound record is run at the same low velocity its pitch will be influenced so that, for instance, a woman's voice sounds like a man's in the reproduction, or the pitch may even become so low as to render speech or song unintelligible or inaudible. All this is due to the fact that the pitch of the sound record reproduction is determined by the velocity of the sound record.

According to my invention, the interdependence of the velocity of the sound record and the pitch of its reproduction is eliminated and the pitch of the reproduction is exclusively determined not by the velocity of the sound record but by its relative velocity, i. e., its velocity related to the velocity of the scanning means.

Any suitable means, such as a change-speed gear or the like, may be provided for varying the relative velocity, and by such means the sound record is scanned in what will be referred to as "sections" for the sake of convenience, the sections overlapping each other or being disposed at various relative distances.

It is understood that the sound record is not subdivided into sections, but that the expression "sections" relates only to the areas of the sound record which are subjected to scanning at a given time. The sections or areas are so very small and, even if at a distance from each other, are so near to each other that many of them are always in the range of the same sound and so the reproduction does not become jerky or unintelligible. In fact, the portions or sections which are scanned correspond only to the individual sounds of the record, or even to fractions of such sounds.

By these means, the duration of every individual sound, or fraction of a sound, in the record is protracted while, on the other hand, the pitch of the sounds is not altered even if the record moves quite slowly.

While the object in the old apparatus is to locate a given portion of the film for scrutiny by repeated reproduction or scanning, and at reduced speed if desired, the object of my invention is to scan a film at any desired speed which may be lower or higher than its normal speed, but without varying the pitch of the sounds. Conversely, I may also move a film through my apparatus at normal speed and raise or lower the pitch of the sounds.

In my apparatus the low speed does not involve unintelligible speech. The sounds are only protracted but their pitch remains unaltered.

An absolutely satisfactory reproduction with my apparatus is not required for the purpose of synchronization and can only be obtained if the sound record curve is substantially uniform, that is, without very prominent peaks. Peaks are present in the sound record curves of practically all words but it has been found that such "normal" peaks are not detrimental to the reproduction and that only the prominent peaks may cause an imperfection in the reproduction which resembles stammering, while the reproduction of music is not subject to such imperfections at all. Prominent peaks correspond to the ejaculated consonants, such as *b, p, d, t, g, k,* etc. These consonants deteriorate the reproduction to some extent, but the major part of the human speech corresponds to a record of substantially uniform curve. Such a curve corresponds not only to the vocals *a, e, i, o* and *u,* but also to the "sounding" consonants, such as *f, h, l, m, n,* etc., and the corresponding record curves can be lengthened and shortened in the reproduction as desired, exactly as they can be protracted in the pronunciation, without altering their pitch to such an extent that the pronunciation becomes unintelligible. Vocals and consonants represented by a substantially uniform record curve behave exactly like musical sounds if reproduced by my apparatus. Only the prominent peaks corresponding to the aforesaid ejaculated consonants, but not the normal peaks disturb the uniformity of the curve and are so short and irregular that the reproduction becomes unnatural upon protraction. As mentioned, however, such consonants are in the minority and the other consonants and vocals are not influenced. In the reproduction at reduced speed in my apparatus, the ejaculated consonants make the impression of the speech of a person

who pronounces defectively the said consonants. It follows that the intelligibility of the sound record is not by any means sacrificed in order to maintain the pitch constant but that, on the contrary, the reproduction of a sound record, which by the manner in which it is scanned is chopped into the aforesaid spaced-apart or overlapping portions, is quite intelligible, apart from the slight imperfections referred to at the reproduction of ejaculated consonants. In particular, the reproduction of a record with spaced-apart portions or "sections" is not jerky as the sections are scanned so as to eliminate the spaces between them. The length of the scanned portions of the record is reduced by this mode of scanning and the pitch is lowered for constant duration of the reproduction. The scanning is never interrupted. In a scanning apparatus as will be described below, a rotary disk with slots therein is moved past an opening in a screen, and the relative distance of the slots is equal to width of the opening in the screen so that when one of the slots has moved past the area of the opening, the next slot enters the area. Nor is the reproduction of a record whose portions or sections overlap subject to confusion, because two or more portions of the record never are scanned at the same time but the individual portions or sections are scanned in succession and repeatedly. If the sections overlap instead of being spaced apart, the scanning operation extends over a longer distance for the same duration of reproduction so that the pitch becomes higher. The difference consequently is that, for spaced-apart sections, the length over which the scanning operation extends is shortened so that the relative scanning velocity is low, the duration of the reproduction being invariable, and the pitch is also low. Conversely, for overlapping sections the said length is increased, resulting in higher relative scanning velocity and higher pitch. But, for the reason stated, and on account of the smallness of the sections, confusion and interference is impossible with overlapping sections.

In the accompanying drawings, apparatus embodying my invention is illustrated more or less diagrammatically by way of example.

In the drawings,

Fig. 1 illustrates an apparatus having a fixed screen with a rectangular opening, and a rotary screen with slots,

Figs. 2, 3 and 4 are diagrams illustrating various operations of the apparatus,

Figs. 5, 6 and 7 show various screens for the apparatus in Fig. 1,

Fig. 8 shows an analyzing apparatus for sound records,

Fig. 9 shows a recording apparatus,

Fig. 10 shows an apparatus for making shortened or lengthened records from normal records,

Fig. 11 is a diagram showing a picture and a sound record for a superspeed camera,

Fig. 12 is a diagram showing a picture record and a sound record which is to be shortened, and

Fig. 13 shows a combined superspeed sound and picture record.

Referring to Fig. 1, **1** is a record bearing medium, such as a film whose record is indicated by the shaded area, **20** is a rotary, and **22** is a fixed screen. The rotary screen **20** has radial slots **21'** . . . and the fixed screen **22** has a single rectangular opening **23**. The width of the opening **23** is exactly equal to the pitch of two radial slots **21'**, as shown for the slots **21''** and **21'''**. By suitably varying the ratio of the speed at which the film moves, to the constant speed at which the slots **21'** . . . move as the screen **20** rotates, i. e., the aforesaid relative velocity, and/or the direction in which the film moves, with respect to the opening in the fixed screen **22**, various effects may be obtained, as will now be described. If the record bearing film **1** is arrested while the screen rotates the section of the record which appears in the opening **23** is scanned repeatedly, and, if the section is small enough, the sound will be continuous and uniform.

The "sections" which have been shown on the film **1** in several figures, for instance in Fig. 2, are, it will be remembered, not real subdivisions of the record on the film, but their border lines are images indicating the demarcation of areas subjected to the scanning operation at a given time. The relative position of the sections, i. e., their spaced-apart or overlapping relation, is determined by the relative velocity of the film **1** and the scanning means. In the example illustrated in Fig. 1, it has been assumed that the disk **20** rotates at uniform velocity. The velocity at which the film moves is variable. Its velocity may be lower or higher than the velocity at which the slots **21'** move past the opening **23** in the screen **22**. If it is higher, the sections on the film will be spaced apart, as shown in Fig. 3. If it is lower, the sections will overlap, as shown in Fig. 4. A third possibility is that the velocities of the slots **21'** and of the film are equal.

Nor is it necessary that the film should move in the same direction as the slots, as will presently be assumed, for my invention also relates to the relative direction of the scanning means and the film. Assume now that the film **1** moves from the left to the right as indicated by the arrow, and that the rotary apertured screen **20** rotates clockwise, as also indicated by the arrow, the film **1** and the slots **21'** . . . move past the opening **23** in the screen **22** in the same direction.

When the slotted disk **20** of Fig. 1 is stationary, and when the film band **1** is advanced at the same time with the same speed as it was advanced in the course of recording the sound record, the tone pitch remains the same for both renditions, that is, the pitch of the sound record at the reproduction thereof is the same as the pitch of the record at recording. However, when the slotted screen **20** rotates in the course of reproduction in the direction indicated by the arrow in Fig. 1, the relative velocity between the scanning slots **21** and the sound record bearer is less than when the screen is stationary. This results in a lower pitch in the course of the same duration of reproduction. On the other hand, when the slotted screen **20** rotates in a direction opposite to that indicated by the arrow in Fig. 1, the relative velocity between the scanning slots **21** and the record on the record bearer is increased, resulting in an increase in the pitch of reproduction in the case that the advancing velocity of the film is not varied.

In the event that the film is advanced in the direction noted by the arrow in Fig. 1, at a speed which is slower than its rate of advance at recording, while at the same time the slotted screen **20** is rotated in the direction opposite to that indicated by the arrow at such a speed that the relative velocity between the scanning slots and the sound record is the same as that for a normal film speed and a stationary condition of disk **20**, a normal pitch is obtained despite the fact that the duration of the reproduction is lengthened. When the record consists of speech

or song, the individual words are clearly intelligible, although the duration of the reproduction as well as the individual tones are extended. Conversely, a hastened but understandable speech can be obtained when the film is advanced at a faster rate at reproduction than at recording when the disk **20** is rotated in the direction indicated by the arrow in Fig. 1, at such a speed that in this case as well, the relative velocity between the slots **21** and the sound record is the same as that when the film is advanced at normal speed and the screen is stationary.

It will be understood that the pitch is exclusively determined by the relative scanning velocity, being high for high scanning velocity, and low for low scanning velocity.

If the record moves from the right to the left, against the arrow in Fig. 9, while the screen **20** rotates as before, their speeds add, and the pitch is raised. If the speed of the record is less than that of the screen the operation will correspond to that of the diagram Fig. 4. On a photographic film which is exposed to the light traversing the scanned film **1**, the sections will be arranged as shown in the diagrams Figs. 2, 3 and 4, according to the speed ratio at which the scanning operation is performed. If the speeds are equal the half of each preceding section will be duplicated. On a photographic film which is exposed to the light traversing the scanned film **1**, the sections will be arranged as shown in the diagrams **2**, **3** and **4**, according to the speed ratio at which the scanning operation is performed. If the speed of the record becomes higher than that of the screen only a portion of the section is repeated which is less than .5.

Referring to Fig. 5, the opening in the fixed screen **22** is rhombic instead of square as in Fig. 1 which results in a more gradual beginning and ceasing of the scanning by the slots **21'** . . . , and the portions at the beginning and the end are partly screened so that constant intensity and uninterrupted sequence of the sections are obtained. The base line of the rhombic opening is equal to the pitch of two slots.

Fig. 6 shows two screens **22**. The screen at the left has an opening **23'** in the shape of a trapezoid, and the opening **23'''** in the screen **22** at the right is semicircular.

Referring to Fig. 7, the sides of the opening **23''** are curved at **40** and **41**, with the object of so determining the intensities that the disturbances in the scanning operation are reduced to a minimum.

Referring to Fig. 8, **59** is a motor, **50** is a record-bearing medium which is wound on two reels one of which is rotated by the motor through the belts or chains indicated, and **60** is a set of pulleys or sprockets intermediate the motor and the reels for reducing the rate at which the reels are driven. **52** is an endless belt which corresponds to the screen **22**, Fig. 1, and has slots **21'**, **21''**, etc., like the screen **22**. The screen or belt **52** is mounted on two pulleys one of which is actuated by the motor **59**, and is equipped with a fly wheel **58**. **53** is a fixed screen having an opening such as shown in Figs. 1, 5, 6 and 7.

510 is a source of light at the left of the medium **50**, **511** is a refector by which the light from the source **510** is projected onto the medium, **51** is a lens projecting a magnified image of the record on the medium **50** on the belt **52** through the opening in the screen **53**, **54** is a lens between the two reaches of the belt **52**, **55** is a photoelectric cell on which the images from the lens **54** act, **56** is an amplifier, and **57** is a sound-reproducing device which may be a loudspeaker as shown, or a head receiver or the like.

In operation the film **50** and the belt **52** are moved at uniform speed and any variations in the sound are indicated by the reproducer **57**. If desired the belt **52** and the film **50** may be moved at two distinct speeds and in the same or in opposite directions, as and for the purpose described with reference to Fig. 1.

Fig. 9 shows an apparatus for making sound records with an intermediate record bearing medium. **70** is a microphone, **71** is an amplifier, **73** is a recording magnet, and **72** is the intermediate record bearing medium. **74** is a putting-out magnet. **75** is an endless chain which moves in parallel with the medium **72**, **76'**, **76''**, **76'''**, etc., are scanning magnets on the chain, **77** is an amplifier under the control of the magnets, and **78** is a sound reproducer connected to the amplifier. The chain **75** with the magnets **76'** etc. is moved in the direction of the arrow, like the belt **52**, Fig. 8, and the record on the medium **72** is scanned.

Referring to Fig. 10, the apparatus illustrated in Fig. 8 is duplicated here as far as the photoelectric cell **55**. **50** is a normal or original record, **87** is the record to be obtained therefrom at a given rate which is determined by the ratio at which the reels for the normal record **50** and the record **87** are driven by a belt, chain or pulley **88**, which ratio is controlled by the set of pulleys **60**. **85** is an amplifier connected to the cell **55**, and **86** is a recorder. The record **87** is moved at a speed which is higher or lower than that of the normal record **50**, and may move in the same direction as the record **50**, or in opposite direction. The sound may be recorded on **87** by any suitable means, such as photographic, mechanical, magnetic means, etc.

Referring now to Fig. 11, **95** is a picture film from a super speed camera, with a considerably increased number of pictures. **96** is a sound record or original which may have been made at normal speed and on a separate medium. In order to obtain from these two films of different lengths a sound and picture record, it is necessary to increase the length of the film **96** until it is equal to that of the picture film **95**. This is effected in the apparatus Fig. 10 by so determining the ratio of the records **50** and **87** that the medium **87** moves faster than the medium **50** while the slotted belt or screen **52** provides for the frequency which corresponds to the pitch of the sound. The two records, being of equal length, may now be combined on a single medium.

Conversely the sound record is shortened if the number of pictures in the picture record is reduced, as shown in Fig. 12 where **101** is the long sound record, and **100** is the short picture record. Here the medium **87** must move more slowly than the medium **50** whereupon the two records may be combined on the same medium.

Fig. 13 shows the two records **110** and **111** combined on a single medium.

In making superspeed records the sound record may be made directly on the picture film or on a second medium moving at higher speed, as described. However, as in this case the speed at which the sound record is reproduced, is small, the pitch of the sound would become too low. This difficulty is overcome by the apparatus Fig. 10 by properly determining the speed of the slotted belt or screen **52**. The normal pitch is rees-

tablished in this manner and the records **50** and **87** move at the same speed.

Suitable change-speed gears may be provided in the apparatus Figs. 8 and 10 like the set of pulleys or sprockets **60** in Fig. 8.

I claim:

1. In an apparatus for reproducing sound records, scanning means, means for moving said scanning means while reproducing the sound record, means for moving the record past said scanning means, and means for varying the relation of the velocity of said record to the velocity of said moving scanning means.

2. In an apparatus for reproducing sound records, scanning means, means for moving said scanning means while reproducing the sound record, means for moving the record past said scanning means, and means for varying the relative direction and the relation of the velocity of said record to the velocity of said moving scanning means.

3. In an apparatus for reproducing sound records, scanning means including a fixed screen with an opening therein and a slotted rotary screen adapted to cooperate with said fixed screen, means for rotating the slotted screen, means for moving the record past said scanning means, and means for varying the relation of the velocity of said record to the velocity of said rotating screen.

4. In an apparatus for reproducing sound records, scanning means, means for moving said scanning means while reproducing the record, means for moving the record past said scanning means, means for magnifying said record, and means for varying the relation of the velocity of said record to the velocity of said moving scanning means.

5. In an apparatus for reproducing sound records, scanning means, means for moving said scanning means while reproducing said record, means for moving a record past said scanning means, means for varying the relation of the velocity of said record to the velocity of said moving scanning means, and means for recording the sounds reproduced from said record.

6. The method of controlling the pitch of a sound record at reproduction which comprises advancing the sound record, scanning the sound record with movable scanning means, and adjusting the relation of the velocity of the sound record to the velocity of the movable scanning means.

7. The method of controlling the pitch of a sound record at the reproduction thereof when the sound record travels at a rate which is different from that at the recording thereof which comprises scanning the sound record with a movable scanning means and adjusting at least the speed of the scanning means to render the relation of the velocity of the scanning means to the velocity of the sound record the same as that between the scanning means and the sound record at the recording thereof.

8. The method of controlling the pitch of a sound record at the reproduction thereof when the sound record travels at a rate which is different from that at the recording thereof which comprises scanning the sound record with a movable scanning means and adjusting the speed and the direction of movement of the scanning means to render the relation of the velocity of the scanning means to the velocity of the sound record the same as that between the scanning means and the sound record at the recording thereof.

9. The method of reproducing a sound record which comprises advancing the sound record, scanning the sound record with movable scanning means, and varying the ratio of the pitch of the sound record and the rate of travel thereof by adjusting the direction and speed of movement of the scanning means relative to the speed of the sound record to obtain scanning sections of definite relative position.

10. The method of reproducing sound records which comprises varying the ratio of pitch and running velocity of the sound records by scanning said records with movable scanning means and adjusting the speed of the scanning means relative to the speed of the sound record to obtain scanning sections of definite relative position.

11. The method of reproducing sound records which comprises varying the ratio of pitch and running velocity of the sound records by scanning said records with movable scanning means and adjusting the speed and direction of the movement of the scanning means relative to the speed of the sound record to obtain scanning sections of definite relative position.

12. The method of varying the ratio of pitch and running velocity of sound records comprising scanning said records by varying the velocity of moved scanning means so as to obtain scanning sections of definite relative position.

13. The method of varying the ratio of pitch and running velocity of sound records comprising scanning said records by varying the velocity of moved scanning means so as to obtain spaced-apart scanning sections.

14. The method of varying the ratio of pitch and running velocity of sound records comprising scanning said records by varying the velocity of moved scanning means so as to obtain overlapped scanning sections.

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