Aug. 20, 1935. E. S. HOPKINS 2,012,044

AUTOMATIC SYNCHRONIZING MEANS FOR CINEMATOGRAPHS AND PHONOGRAPHS

Original Filed Dec. 2, 1918

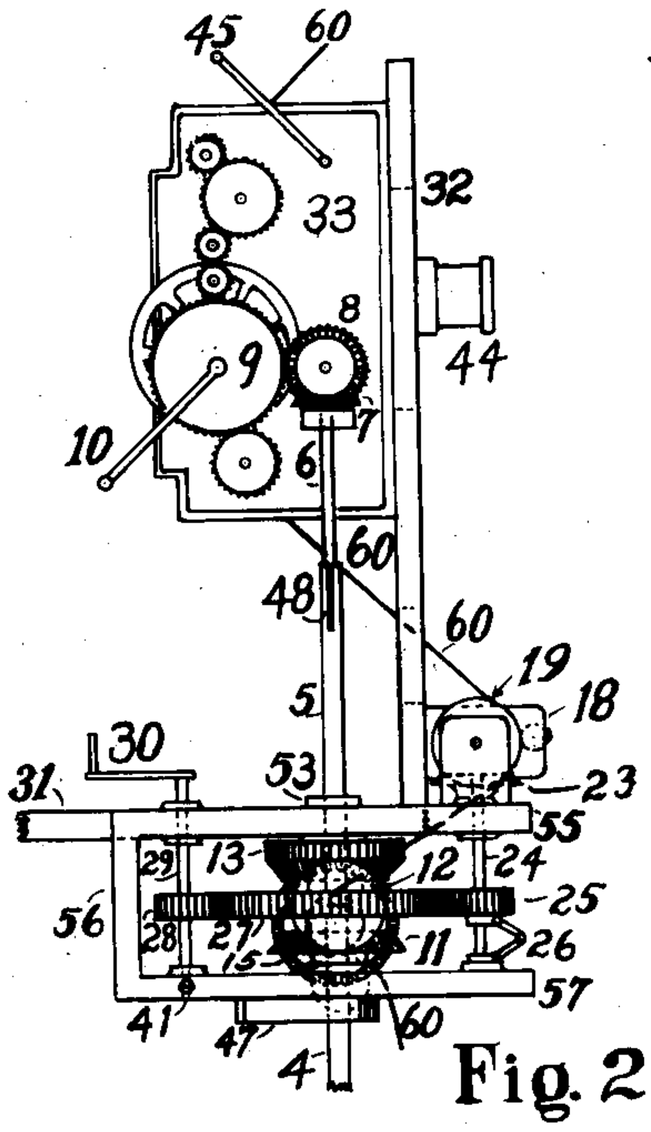

Fig. 2.

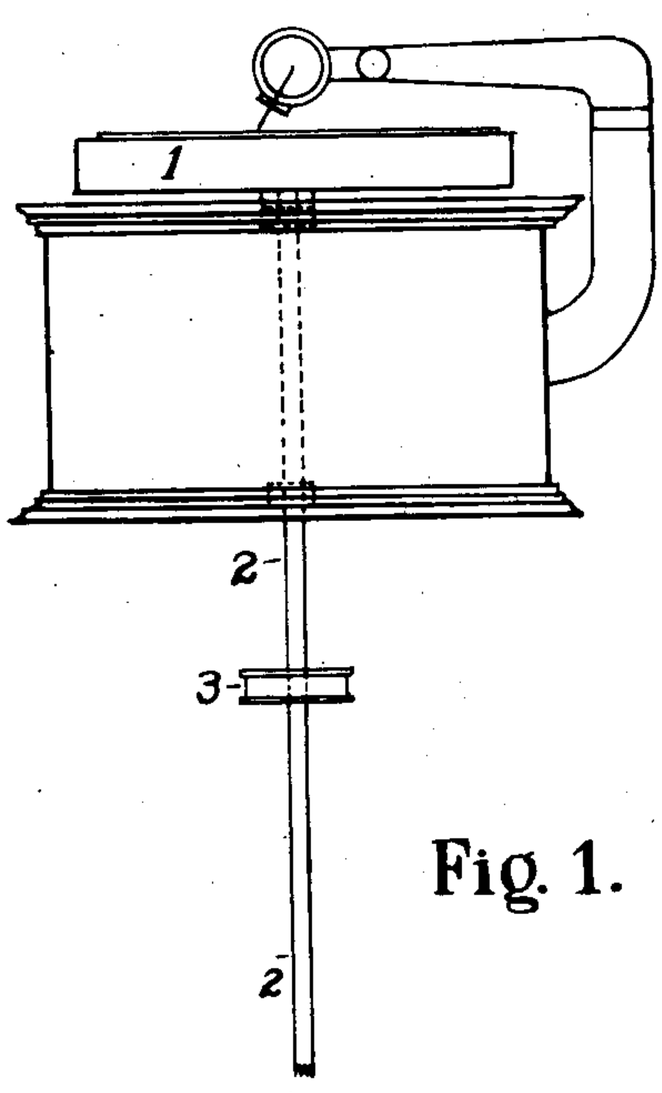

Fig. 1.

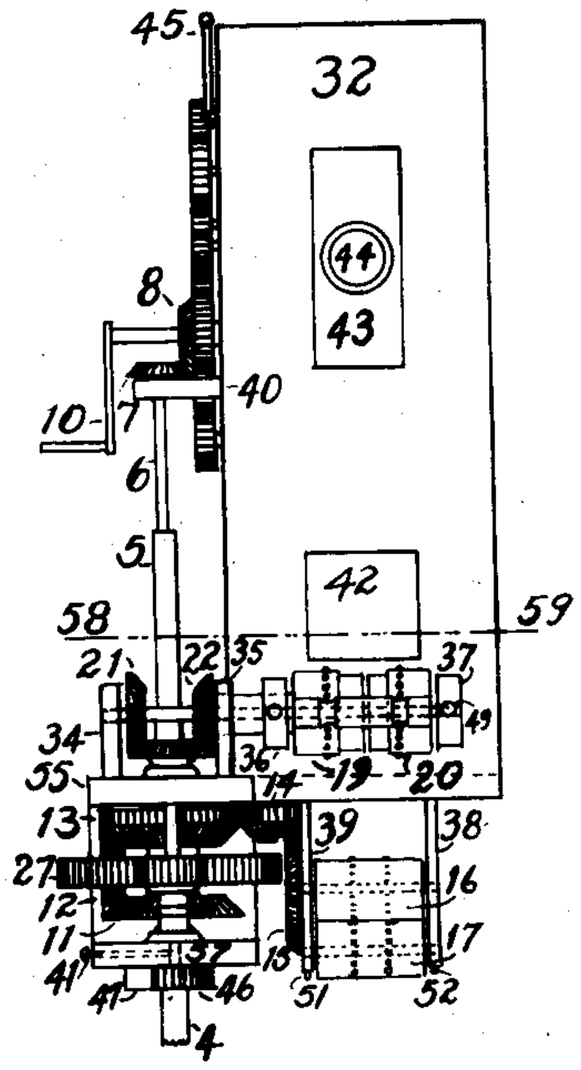

Fig. 3.

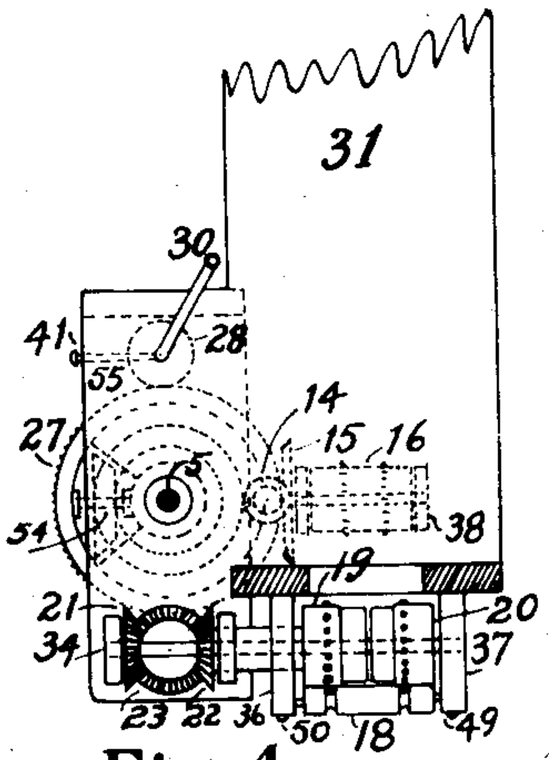

Fig. 4.

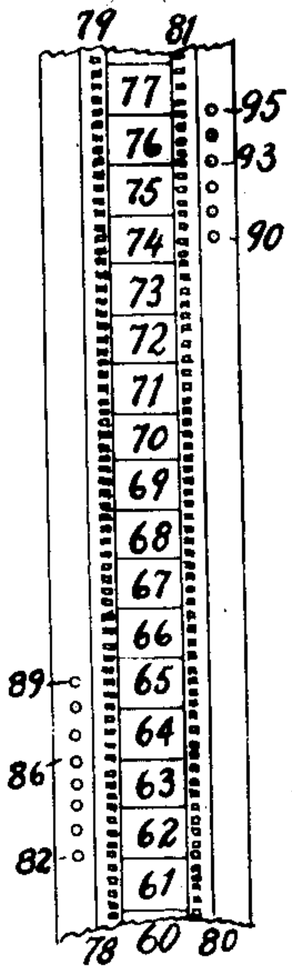

Fig. 5.

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AUTOMATIC SYNCHRONIZING MEANS FOR CINEMATOGRAPHS AND PHONOGRAPHS

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9 Claims. (Cl. 88—16.2)

My invention relates principally to the bringing into unison or synchronism of cinematographic optical effects with corresponding phonographic acoustical effects but it may readily be adapted to synchronize other optical and acoustical effects.

The principles of my invention are as follows:

If a cinematograph film and phonograph record are made simultaneously, the recording apparatus being coupled, the actors cannot move freely about the scene without receding so much from the phonograph recording apparatus as to prevent the making of a serviceable record. But when a film and record are made of different renditions of a scene they will not be synchronous. Exhibited in a cinematograph and phonograph suitably coupled, their effects will at times coincide, but at other times the film will be in advance of the record or vice versa.

I have discovered that by changing the ratio of speed of the cinematograph and phonograph at selected intervals the film and record may be kept in unison and a synchronous relation maintained. This may be accomplished by the manual operation of a form of my apparatus, but as this requires great skill and constant attention I have discovered means of effecting automatically the changes in ratio of speed necessary to effect synchronism.

I find a convenient means of accomplishing the result to consist in providing a speed changing mechanism coupled between the cinematograph and phonograph adapted to be controlled by a strip bearing modifications which are located thereon proportionally to the deviations from synchronous relation of the film and record.

The combination of a cinematograph, phonograph and speed changing means I term a vivigrade. The synchronizing or vivigrading strip is changed with each set of film and record.

A further important principle of my invention lies in incorporating the film with the synchroniz'ng strip. As the phonograph is preferably run at a constant speed the strip-film automatically alters its own ratio of speed as compared with the speed of the phonograph, thus effecting synchronization.

In carrying out my invention I find it generally desirable to employ the herein described apparatus, processes and manufactures, but it is to be understood that less than all of the different means herein described may be employed for some uses, or parts only may be employed, or other means may be substituted which come within the spirit of the invention and the limits of the appended claims, and while the preferred forms embodying my invention are shown, it is to be understood that many of the structural details may be varied and many changes of form resorted to without departing from the scope and spirit of my invention nor do I limit myself to the particular forms shown, although I believe them especially suited to the ends to be attained by my invention.

In the accompanying drawing forming a part hereof, which is largely illustrative and diagrammatical and confines the invention to no one specific arrangement, and in which the same reference letters and numerals indicate the same or corresponding parts, Fig. 1 shows a form of phonograph, Figs. 2, 3 and 4 a form of cinematograph and speed changing device and Fig. 5 a form of strip-film within my invention.

Figs. 1 and 2 are so placed as to illustrate diagrammatically their relation to each other in some uses, the cinematograph projecting pictures from the rear of the auditorium to the screen 96, through which the sounds of the phonograph pass.

Fig. 1 is a form of phonograph reproducing sounds from the spiral groove of a disc record. In this invention rotating record table 1 is ordinarily made much thicker and heavier than the customary table, and preferably of iron or lead, so that it will have a considerable inertia, thereby resisting when in operation, sudden changes in velocity. The usual driving motor of the phonograph is dispensed with in this form of the invention, power being applied by means of pulley 3 to shaft 2 keyed to table 1, and rotating in suitable bearings. The source of power may be an electric motor.

Shaft 2 is coupled mechanically by means of shafting and gears or otherwise, often extending under the auditorium, with shaft 4 of the cinematograph, Fig. 2, which is consequently driven in unison with the phonograph at a suitable ratio of speed determined by the coupling employed.

Fig. 2 is a side elevation, Fig. 3 a front elevation and Fig. 4 a sectional plan on the line 58—59 of the cinematograph head and speed changing apparatus. The speed changing mechanism is attached for convenience to the cinematograph. Fig. 5 illustrates in enlarged scale a section of the synchronizing strip consolidated with the film. It is shown in position in Fig. 2, but is omitted for the sake of clearness in Figs. 3 and 4.

The head only of the cinematograph, not in full detail, is shown, on vertical frame member

32, supported on horizontal frame 31, which carries frame 55, 56, 57 of the speed changing mechanism.

Shaft 4 is journaled in plate 57 and carries bevel gear 11, which meshes with planetary bevel gear 12, which in turn meshes with bevel gear 13 carried by shaft 5 journaled in plate 55. Shafts 4 and 5 do not meet, but their contiguous ends serve as an axle for the free rotation of spur gear 27, which is the orbital carrier of planetary gear 12, which rotates on a spindle 54 set in orbital gear 27 in the direction of a radial spoke. Normally bevel gear 12 transmits the power from shaft 4 to 5 as a simple bevel gear between bevel gears 11 and 13, but when orbital spur gear 27 is rotated on its axis, it carries 12 around with it in an epicyclic or planetary motion, 12 continuing to rotate on its own axis and thus the ratio of speed of shafts 4 and 5 is altered by the planetary motion of gear 12 as long as 27 continues in rotation orbitally and in proportion to its speed of rotation.

As seen in the plan Fig. 4, shaft 5 rotates clockwise. When gear 27 is caused to rotate clockwise, the velocity of shaft 5 is increased as compared with driving shaft 4, which normally rotates counterclockwise. But when gear 27 is caused to rotate counter-clockwise, the velocity of shaft 5 is decreased as compared with driving shaft 4. If gear 27 rotates with sufficient velocity shaft 5 may be caused to come to a standstill or its direction may even be reversed, but this is not normally necessary. When gear 27 is brought to a standstill shafts 4 and 5 resume their normal ratio of speed. When shaft 5 is caused to rotate acceleratively the ratio of speed may be said to be altered positively, and when retardation of shaft 5 takes place the ratio of speed may be said to be altered negatively. Gear 27 may thus be said to have a positive or negative rotation.

It will be seen that any difference in synchronism of the film and record may be overcome by causing gear 27 to be rotated in one direction or the other, at such velocities and for such durations as may be required to change the speed of the film as compared with that of the record sufficiently, in positive and negative directions as may be, to bring the corresponding optical and acoustical effects into unison.

This is accomplished manually, or automatically, as may be desired.

To accomplish it automatically, a strip is prepared which when fed through the apparatus will cause gear 27 to be rotated one way or the other as required, to whatever duration and velocity may be necessary.

Such a strip, 60, is shown in Fig. 5. It should be of a flexible, non-elastic material. It bears sprocket feed holes in two rows 78—79 and 80—81. Also shown are synchronizing modifications in the form of apertures in two series of lines, unit 82—89 on one side and unit 90—95 on the other, illustrative of its operative effect.

As shown here the synchronizing or controlling strip is consolidated with the cinematograph film, with common sprocket feed holes in rows 78—79 and 80—81, the synchronizing apertures being outside of the sprocket feed holes. They may be placed inside in minute form without encroaching upon the exhibited portion of the film.

The initial portion of the synchronizing strip contains no cinematograph individual pictures for a length corresponding to the distance between the exposure point of the film in line with the lens 44 and the meshing or conjunction of the feed drums 16—17. The activating point, or point at which the strip causes the apparatus to function is at the strip's engagement with drums 19—20 which is reached by any given picture of the film subsequent to its exhibition point at lens 44. The bare portion of the strip preliminary to the portion containing individual pictures controls the film at the outset for a certain interval or until the first individual picture reaches drums 19—20, such interval depending upon the distance of the cinematograph head from the speed changing apparatus, which may be whatever distance is convenient. The synchronizing strip may even be entirely independent of the film, in which case they are started at a common initial point, each in its own mechanism, such initial point corresponding to the initial point of the record.

The consolidated synchronizing strip-film 60 is threaded in the cinematograph head as shown in Fig. 2, feeding downward from a magazine at the top not shown. Emerging from the cinematograph head the strip-film passes through aperture or window 42 in frame 32, over the synchronizing drums 19—20 and down to sprocket feed drum 16, being held in position thereon by idler drum 17, and thence passes into a storage magazine below, not shown.

Synchronizing drums 19—20 rotate on axles journaled in lugs 34, 35, 36 and 37. Drum 19 and bevel gear 22 are keyed to the large spindle journaled in lugs 35—36 while drum 20 and bevel gear 21 are keyed to the small spindle which is journaled in lugs 34 and 37. The small spindle passes through an opening in the large spindle and is independent of the large spindle. Bevel gears 21 and 22 mesh with bevel gear 23 which is keyed to spindle 24 journaled in frame plates 55 and 57. Spur gear pinion 25 is feathered to spindle 24 and engages spur gear 27.

When strip 60 is drawn over drums 19—20 they ordinarily remain motionless. When, however, synchronizing apertures 82—89 engage studs on drum 19, it is caused to rotate clockwise, as viewed in Fig. 2. This rotates bevel gear 23 counterclockwise, as viewed in Fig. 4, and as pinion 25 rotates therewith, gear 27 in mesh with 25 consequently rotates clockwise, as viewed in Fig. 4. This rotation of 27, as hereinbefore shown, accelerates the velocity of shaft 5 and hastens the cinematograph effects. When apertures 82—89 have passed over drum 19, it ceases to rotate and the normal ratio of speed between shafts 4 and 5 is resumed. This continues until synchronizing apertures 90—95 engage studs on drum 20, whereupon drum 20 rotates in a clockwise direction as viewed in Fig. 2, which causes gear 23 to rotate clockwise as viewed in Fig. 4, and as a consequence gear 27 rotates counter-clockwise, which retards the velocity of shaft 5 as compared with shaft 4, and so retards the cinematograph effects.

Deviations from synchronic relation between the film and record are thus corrected. Deviations which necessitate the acceleration of the film may be termed positive deviations while those which require its retardation may be termed negative deviations.

Synchronizing strip 60 is held on drums 19—20 by floating idler roller 18, journaled in lugs 36—37, held in place by adjustable spring screws 49—50. This idler is grooved over the studs and as it floats the strip may ordinarily slide over the studs in places where there are no synchronizing aper-

tures on either side. Its pressure on strip 60 is sufficient to cause the studs to engage the apertures when reached. As apertures are never placed abreast, the edge opposite apertures slides over the studs of the drum on its side, which rotates in the opposite direction at such time. In cases where this movement is found undesirable it is corrected by suitable ratchets in the drums, not here illustrated.

To cause the strip to be fed, bevel gear 13 bears a spur gear portion which engages spur gear 14, journaled on a stud in plate 31. Spur gear 14 carries a beveled gear portion, which meshes bevel gear 15, keyed to shaft of feed drum 16, journaled in lugs 38—39, which also carry idler drum 17, the pressure of which is regulated by spring screws 51—52. Feed drum 16 is fitted with studs which positively engage sprocket feed holes 78—79 and 80—81 of strip 60. Feed drum 16 is accordingly rotated at a fixed ratio of velocity as compared with shaft 5. Shaft 5 receives plunger shaft 6 keyed to bevel gear 7 and feathered to shaft 5. Bevel gear 7 drives bevel gear 8 which has a spur gear portion which engages main driving gear 9 of the cinematograph, ordinarily rotated by crank 10. Head 33 is raised or lowered by lever 45 to frame the pictures.

The plunger relation of shafts 5 and 6 accommodates this motion.

Feed drum 16 has a fixed ratio of speed as compared with the rotating parts of the cinematograph head and consequently as compared to shaft 5. Were it proportional to shaft 4 the film would at times be slack and at other times broken by strains. When, however, the synchronizing strip is not incorporated with the film, it is best fed by a feed drum driven by gear 11 instead of by 13, and is then proportional to shaft 4 instead of shaft 5 in velocity. The location of the synchronizing apertures is ascertained by trial and repetition.

If, instead of applying the power at pulley 3, it be applied at crank 10, giving driving gear 9 a constant velocity, shaft 5 will rotate without any change in velocity and all changes of ratio of 4 and 5 will be effected in shaft 4, thus producing in the phonograph the necessary changes in velocity to effect synchronization. But changes of velocity in a phonograph are objectionable through producing changes in pitch, so that this, though a possible, is an undesirable method of operation. The apparatus, however, may be driven by crank 10 if the force applied be varied as to velocity to accommodate the changes in the film's velocity, still permitting the phonograph to progress at a practically constant velocity. Where desirable, a ratchet and pawl are provided, 46 and 47, to prevent back lash against the phonograph, in which case synchronization is effected solely by the variations in velocity of the film.

For some uses, and for supplementary purposes the speed changing may be accomplished manually, for which purpose pinion spur gear 28 is provided, keyed to spindle 29, journaled in frames 57—31, meshing with gear 27 and operated by crank 30. Gear 27 may thus be rotated at the will of the operator effecting any needed changes in speed supplementary to those effected automatically, which enables the operator to correct divergences caused by framing or accident. This can only be effected when no apertures on strip 60 are in engagement with drums 19 and 20. A knuckle 26, however, is provided for lifting gear 25 out of engagement with gear 27, thus permitting 27 to be rotated by 28 independently of the automatic action of the strip. An adjustable friction pin 41 against spindle 29 prevents any creep of gear 27 during normal operation. Collar 53 and lug 40 provide journals and thrust bearings for shaft 5—6 so that its weight will not rest on hub of gear 27.

The synchronizing drums 19—20 being placed some distance past the point of exposure of the film, which is opposite lens 44, attached to the head and protruding through window 43 in frame 32, the synchronizing apertures of strip 60 which affect any given portion of the film, must be placed at corresponding distances in advance of the portion to be affected. Thus apertures 82—89 do not affect individual pictures 62—65 alongside of them, but affect the acceleration of a portion of the film not shown, it being further along than individual picture 77, the last shown. Apertures 90—95 serve to retard not the individual pictures 74—76 opposite them but individual pictures still further along. As the film cannot be accelerated and retarded at the same time, synchronizing apertures are never placed abreast. Unit of apertures 82—89 accelerates the film to a greater extent than it is retarded by unit 90—95. The number and location of the apertures is best ascertained by repeated trials. Once a synchronizing strip is produced which effects synchronization between a given film and record duplicates of it may be made to go with duplicates of the film and record without further trial. The initial portion of the synchronizing strip which contains no film is not illustrated, being similar to the portion shown except for the absence of the pictures. It is best to incorporate the film with the strip though it is possible to feed them from the same magazine, one coiled within the other without physically being incorporated. The initial portion not illustrated controls the early portion of the film, in a manner similar to that shown in portion 60 of the incorporated strip-film, and operates on the same principles as a strip entirely unincorporated. An independent strip may be drawn from the same magazine as the film without passing through the cinematograph head where desirable to obviate the widening of certain parts of the cinematograph head commonly in use to accommodate the wider strip-film.

In operation it is preferable to start the phonograph before the cinematograph is threaded, and on reaching an initial point on the record, the apparatus is brought to a stop and the strip-film threaded in position at a corresponding initial point. The apparatus is then started and any accidental deviations may quickly be corrected by the supplementary crank 30 before synchronizing apertures are reached on the strip.

Not only cinematographs and phonographs, but music boxes, pianolas and other automatic instruments may be synchronized by my invention, and the speed changing device and controlling strip are useful in other kinds of mechanism.

One of the uses to which it may be put in this field is that of making cinematograph films synchronous with phonograph records by means of altering the relative speeds of the negative film and the unexposed positive film printed therefrom by contact printing.

In a device of this kind the vivigrading medium is set to agree with the synchronous relation that should exist between a film and a record; that is to say the medium would effect synchronism in operation as described. The sensitive positive film blank is then run at a fixed

speed, being stopped for the printing of each frame in the usual manner, but the vivigrading medium advances the negative or draws it back, through the instrumentality of the apparatus provided therefor of a character similar to the exhibiting apparatus. Thus instead of the light passing through the film onto a screen for exhibition purposes it passes through the negative onto the positive. The negative having been advanced and retarded to agree with the phonograph record, the positive so printed will agree synchronously with the phonograph record when run in coupled machines, without the intervention any more of the vivigrading medium.

This arrangement is one means of producing the film synchronized with the record set forth in my Patent No. 1,286,638 issued December 3, 1918.

What I claim is:

1. Means adapted for synchronizing cinematograph and phonograph effects comprising a cinematograph and phonograph with means for operating them at a selected ratio of speed, a cinematograph film and a phonograph record of analogous matter to be synchronized not made synchronously; a speed changing mechanism adapted to change the ratio of speed of the cinematograph as related to the speed of the phonograph; and a synchronizing or controlling medium controlling said speed changing mechanism comprising a cinematograph film having artificial modifications adapted to control said speed changing mechanism and thereby effect said changes of speed at predetermined intervals to predetermined extents, and means for causing said changes to be thereby automatically effected, said film thereby adapted automatically to control the said speed changing mechanism, whereby to synchronize its own optical effects with the analogous acoustical effects of the record.

2. The matter of claim 1 when the artificial modifications of the cinematograph film are in the form of two series of apertures along the edges, one along each edge, said apertures placed at selected locations but never abreast, those on one edge adapted to accelerate and those on the other edge adapted to retard the velocity of the film in the cinematograph machine while leaving the phonograph record speed unaffected by the changes in velocity of the film and its apparatus.

3. The matter of claim 1 in which the means for operating the cinematograph and the phonograph synchronously at a fixed ratio of speed includes a source of power, a coupling, and speed changing mechanism adapted to affect the velocity of the cinematograph at selected intervals to selected extents, while the cinematograph and phonograph and intermediate coupling are adapted to operate at the fixed ratio of speed at other times.

4. A speed changing device adapted to be between two moving pieces of apparatus, comprising a driving shaft, a bevel gear attached thereto, a driven shaft in the same line, a bevel gear attached thereto, said bevel gears engaging on opposite sides an epicyclic bevel gear having its axis radially placed within an orbital spur gear the axis of which comprises the free, contiguous ends of the driving and driven shafts between their bevel gears, said orbital gear adapted to cause motion of translation planetarily in either direction of the epicyclic gear as regards the shaft bevel gears; a feed drum driven by gearing communicating with the driven shaft, said feed drum adapted to carry an exchangeable speed changing or controlling medium in the form of a strip with sprocket feed holes at regular intervals and speed changing apertures in two rows linearly at selected locations but never abreast; a pair of selective drums adapted to be driven independently by the speed changing medium one at a time as determined by the location of its rows of selective apertures; a bevel gear connected with each selective drum, engaging an intermediate bevel gear driven in one direction by the rotation of one drum and in the other direction by the rotation of the other drum as they are successively caused to be rotated by said speed changing medium, said intermediate bevel gear adapted to drive the orbital gear through a pinion attached to its spindle, whereby automatically to change the ratio of speed of the driven to the driving shaft acceleratively or retardatively depending upon the selective drum engaged by the controlling medium.

5. In combination, the speed changing mechanism set forth in claim 4, a cinematograph, said mechanism intermediate said cinematograph and its source of driving power, said source of power, and supplementary means of effecting said translation of the epicyclic gear adapted to be manually operated.

6. In combination, a cinematograph and a phonograph adapted to be operated synchronously, and the speed changing mechanism set forth in claim 4 intermediate therewith, adapted to effect changes of speed in said cinematograph at predetermined intervals to predetermined extents without changing said normal speed of said phonograph.

7. In combination, a cinematograph and phonograph adapted for synchronous operation and intermediate therewith the speed changing means as set forth in claim 4, and also supplementary means adapted to be manually operated for effecting the translation of the epicyclic gear, and means adapted to throw out of engagement, manually operable, the automatic speed changing means of controlling the said translation.

8. An apparatus comprising in combination a cinematograph and a phonograph adapted to progress normally at a selected ratio of speed when coupled; means adapted to change said normal ratio of speed comprising an epicyclic gear train arranged to increase or decrease said ratio of speed upon being operated in one direction or the other; a drum arranged upon rotation to operate said epicyclic gear train retardatively, and a drum arranged upon rotation to operate said epicyclic gear train acceleratively; an exchangeable controlling strip bearing two separate series of apertures in linear succession but never having apertures in both series abreast, each of said series interrupted or omitted at selected locations for selected distances, one series adapted to operate said retardative drum and the other series adapted to operate said accelerative drum and means in said apparatus for advancing said strip, whereby to change said ratio of speed at selected intervals to predetermined extents.

9. The apparatus set forth in claim 8 in which said exchangeable controlling strip is incorporated with or is part of the cinematographic film, having a series of apertures of the class described on either edge of said film.

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