Dec. 17, 1935. E. H. SMYTHE 2,024,609

SOUND PICTURE SYSTEM

Filed Nov. 14, 1933 4 Sheets-Sheet 1

FIG. 1

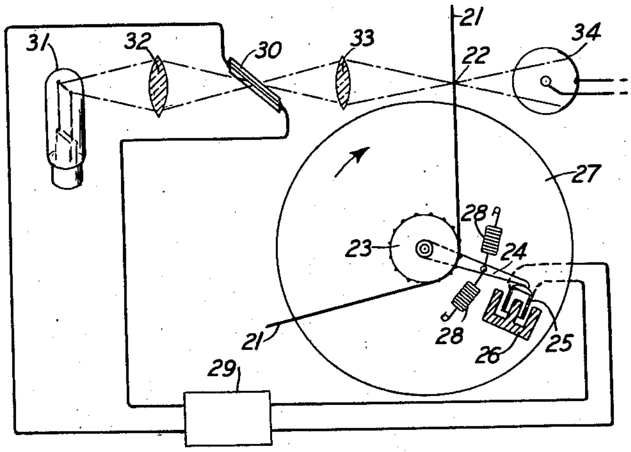


FIG. 2

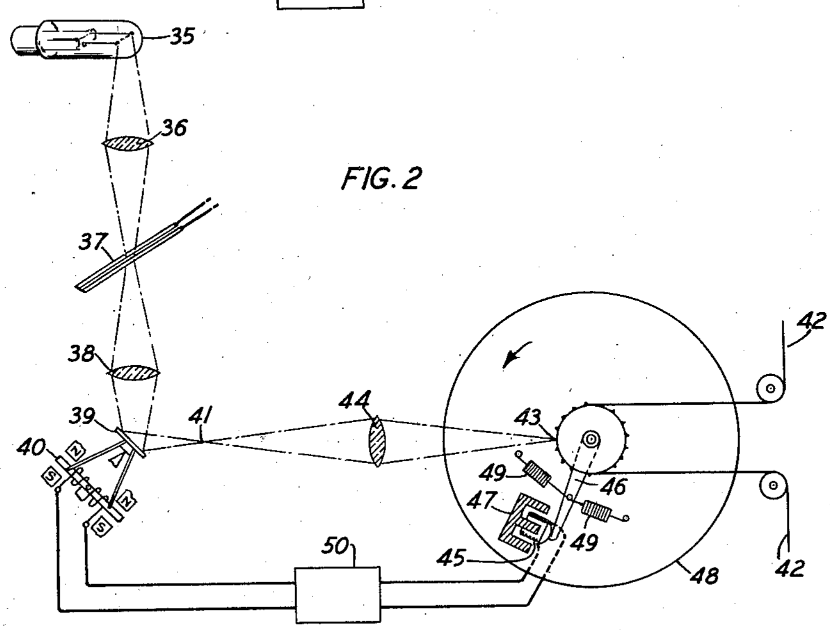
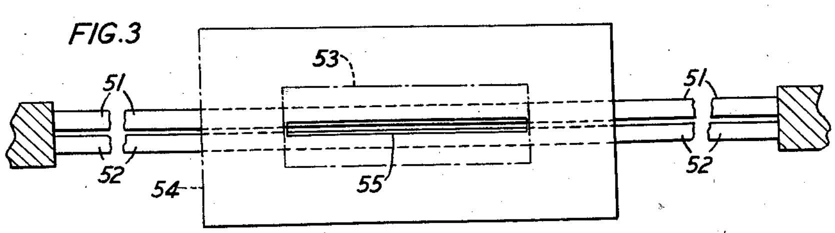


FIG. 3



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SOUND PICTURE SYSTEM

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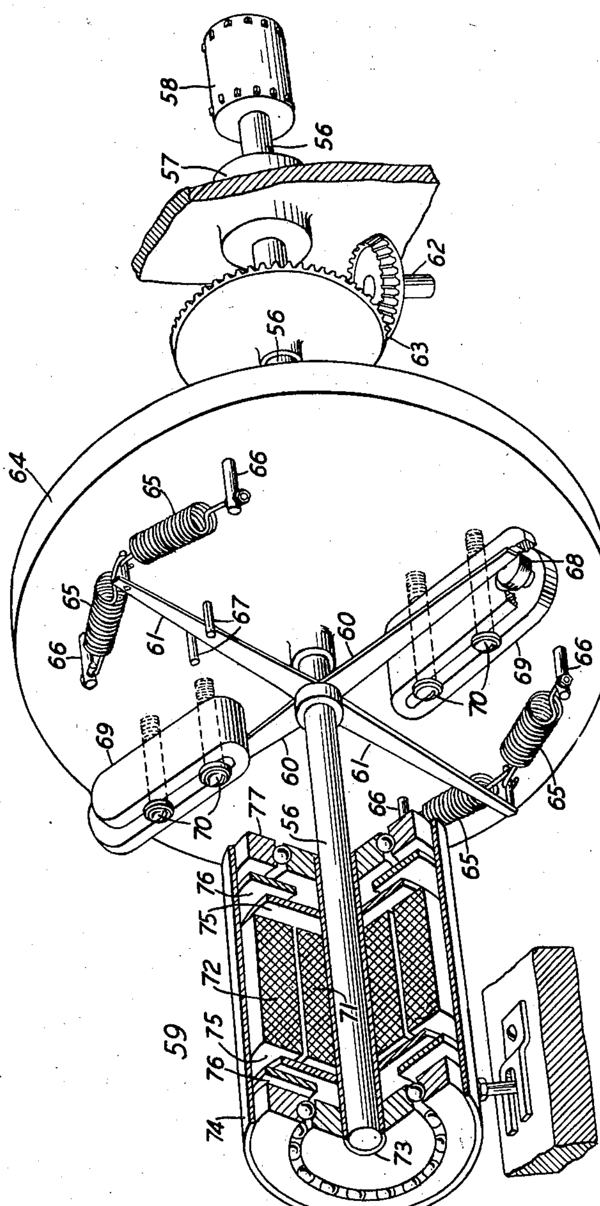

FIG. 4

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FIG. 5

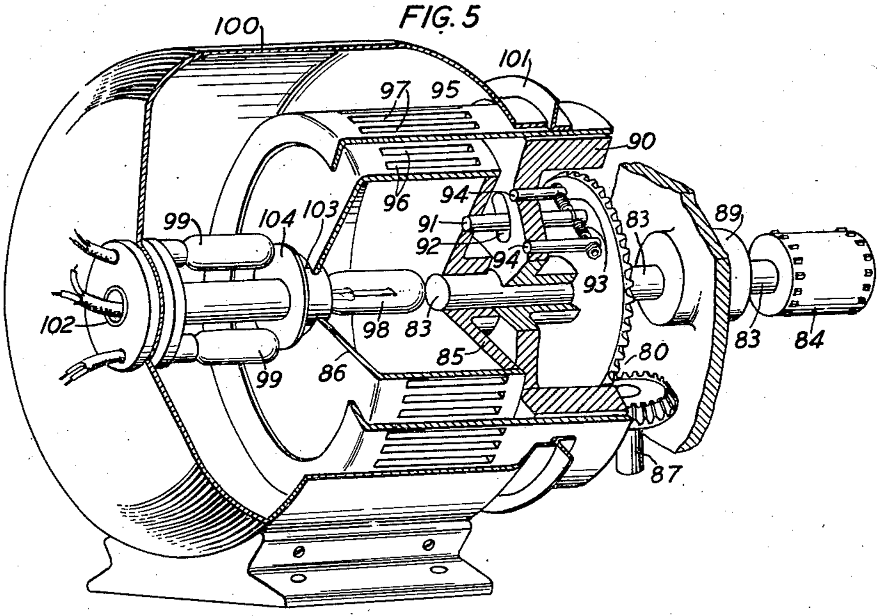

FIG. 6

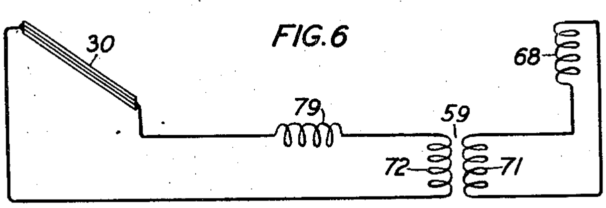

FIG. 7

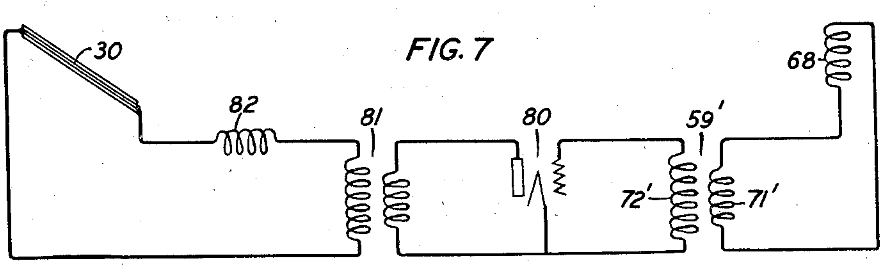

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FIG. 8

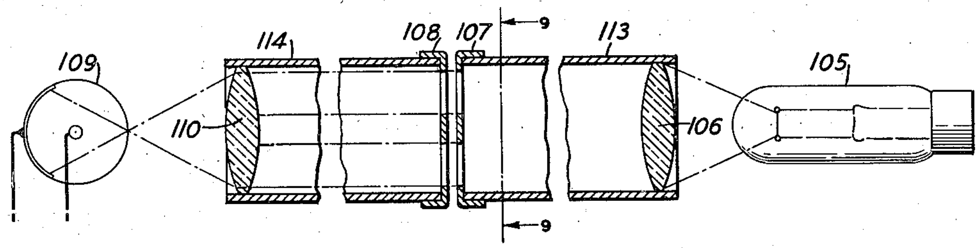


FIG. 9

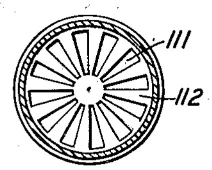
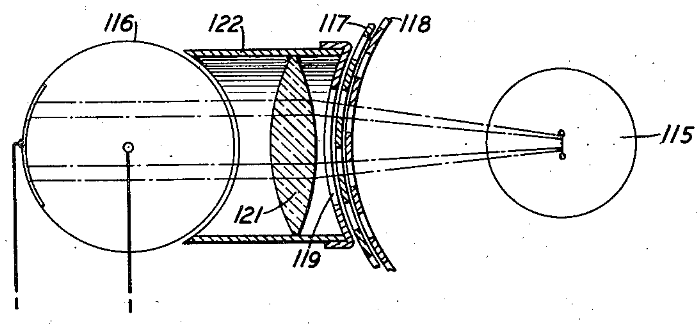


FIG. 10



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UNITED STATES PATENT OFFICE

2,024,609

SOUND PICTURE SYSTEM

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Application November 14, 1933, Serial No. 697,902

25 Claims. (Cl. 179—100.3)

This invention relates to sound picture systems, and more particularly to a method and apparatus for maintaining a constant and uniform velocity of movement of the sound record carrier relatively to the translating point.

In my copending application, Serial No. 697,901, filed Nov. 14, 1933, there is disclosed a photographic sound recording and reproducing system in which irregularities of the sound record movement due to the drive side and load side disturbances are compensated for, and relatively uniform movement of the sound record secured, by converting such irregularities of motion as are ordinarily communicated to the film into forces that operate upon the translating point and continuously shift its position longitudinally with respect to the direction of the film movement and in accordance with these irregularities of motion.

The present invention has particularly to do with an improved method and apparatus whereby the velocity variations in the movement of the sound record or film are converted into corresponding electric currents by the coaction of a uniformly moving part of a reference system with another part which moves with the film or sound record, and which therefore contains in its movement the velocity irregularity components that have been superposed upon the film by the drive and load side velocity-varying forces. The uniformly moving part of the reference system has a uniform velocity which is the same as the average velocity of the part which is operatively associated with the film. As long as the film moves at a uniform velocity, without superposed variations, there is no relative movement as between the uniformly moving part of the reference system and the element or part that has operative association with the film. But any instantaneous velocity variation that occurs in the film movement is reflected in a corresponding relative displacement between the uniformly moving part of the reference system and the film controlled element; and this relative displacement is converted in the preferred embodiments of the invention herein disclosed, into corresponding electric currents. These currents are utilized to shift the position of the translating point in such a way as to compensate for the corresponding irregularities of film movement, thus ensuring a relatively uniform movement of the film with respect to the translating point.

In one of the preferred embodiments of the invention herein disclosed, the compensating currents are produced by the movement of a coil of wire in the strong annular magnetic field of a permanent magnet carried upon the uniformly moving element of the reference system. In another embodiment of the invention herein disclosed a series of apertures in the element that moves with the film is arranged in a partially obscuring relation with a corresponding series of apertures in an element of the uniformly rotating reference system, and the light that passes through these apertures, varying in proportion to the degree of obscuration of one set of apertures with respect to the other, controls the voltage output of a light sensitive cell in accordance with the instantaneous velocity variations of the film controlled element. Other modifications embodying the principles of the invention, which are not herein specifically disclosed, may include the variation of the magnetic flux through a coil surrounding an armature the positional relationship of which with respect to the field of a permanent magnet carried on the uniformly moving part of the reference system is varied by the mechanical connection of the armature with the film controlled element; also an arrangement wherein the resistance of a variable resistance element is varied in accordance with the changes of positional relationship between the uniformly moving element of the reference system and the film controlled element. The foregoing are merely typical of some of the modifications that are possible within the broad principle of the invention herein disclosed.

A further feature of the invention involves the employment of a transformer having axially concentric windings one of which is stationary and the other rotatable, for the purpose of communicating to the compensating circuit, without the use of slip rings, the varying currents generated by the relative movement of the elements carried by the rotating parts.

The invention will be more particularly described in connection with the appended drawings, in which:

Fig. 1 represents schematically the mechanical and electrical arrangement of a photographic sound record reproducer embodying the principles of the invention;

Fig. 2 represents schematically the application of the invention to the photographic recording of sound;

Fig. 3 illustrates portions of the ribbons of a form of light valve which may be used for effecting the compensating shift of the line of light in response to the electric currents set up in the reference system;

Fig. 4 is a perspective view of an arrangement whereby the velocity variations of the sound sprocket are converted into corresponding electric currents by means of a reference system including a coil moving in an annular magnetic field, the currents being carried by means of a rotating transformer winding to the compensating circuit;

Fig. 5 is a perspective view of an arrangement whereby the velocity variations of the sound sprocket are converted into corresponding electric currents or voltages by means of a reference system comprising two series of partially registering apertures that control the amount of light transmitted to a light sensitive element;

Fig. 6 is a diagram illustrating a circuit which may be used for connecting the moving coil or coils of the reference system with the compensating light valve;

Fig. 7 is a diagram illustrating a modified form of circuit connection; and

Figs. 8, 9 and 10 illustrate other forms of reference systems operating by the translation of velocity variations into electric variations through the medium of light.

Referring to Fig. 1, the photographic film **21** bearing the sound record is moved past the translating point **22** by means of a sound sprocket **23**. The sound sprocket **23** is driven at an approximately uniform velocity by any suitable driving mechanism such as is customarily employed in talking motion picture systems. But the usual elaborate precautions employed to prevent any slight departure from absolutely uniform motion are in this case unnecessary.

On the same shaft with the sound sprocket **23** is an arm **24** carrying a member **25** which coacts with another member **26** to generate electromotive forces that instantaneously vary in exact accordance with the instantaneous variations of velocity of the sound sprocket **23** and the film which it moves past the translating point. In the present instance the member **25** is diagrammatically represented as a coil adapted to move in the annular magnetic field of a permanent magnet **26** carried upon a rotating member **27**. The member **27** merely rotates idly as a reference member, being driven from the sprocket shaft by the arm **24** through the medium of the pair of damped coiled springs **28**. The moment of inertia of the reference member **27** and the elasticity and damping of the coils **28** are so proportioned as to give the combination a natural resonance below the lowest disturbing frequency for which it is desired to compensate. The reference member **27** and the magnet **26** that it carries therefore have a uniform rate of rotation which is equal to the average rate of rotation of the sprocket **23** and its driving shaft. But any instantaneous variation in the rate of rotation of the sprocket **23** and its shaft causes the coil **25** to move in the annular field of the magnet **26** and generate a corresponding electric current flow. This current flow, after transformation, correction with respect to phase and amplitude, and, if desired, amplification in the device **29**, is applied to the ribbons **30** of a light valve, which ribbons are caused to move, as will hereinafter be described, to cause a shift of the line of light at the translating point **22** corresponding in phase and amplitude with the velocity variations of the film.

The translating line of light on the film is produced by the filament of the exciting lamp **31** the light from which is concentrated by the condensing lens **32** upon the slit between the light valve ribbons **30**. The image of the brightly illuminated slit is focused upon the sound track of the film **21** at the translating point **22** by the objective lens **33**. The light passes through the film, varied in intensity according to the photographic sound record on the sound track, falls upon a photoelectric cell **34** and is converted by the photoelectric cell and its associated apparatus, in the usual manner, into corresponding electric current variations for the operation of a telephonic loud speaker.

Referring to Fig. 2, this figure illustrates diagrammatically a photographic sound recording system in which velocity variations in the movement of the film are compensated for by a corresponding shift in the position of the line of recording light on the sound track of the film. Light from the exciting lamp **35** is concentrated by means of the condensing lens **36** upon the slit between the two ribbons **37** of a light valve, which ribbons are caused to approach and recede from each other in accordance with the sound modulated electric currents that flow through them. The light that passes through this brightly illuminated sound-current-controlled slit, after passing through the lens **38**, and being reflected from the mirror **39** of the oscillograph **40**, produces an image of the light slit at point **41**. This image, in the form of a brightly defined narrow line of light the thickness of which varies in accordance with the movement of the ribbons **37** of the light valve, is brought to a focus upon the sound track of the film **42** at the translating point **43** by means of the objective lens **44**. The oscillograph **40** may be generally of the type which is illustrated and described in the paper by Dimmick, published in Vol. XV, No. 4, October, 1930 of the Journal of the Society of Motion Picture Engineers. As schematically illustrated, the support of the oscillograph mirror **39**, pivoted on a knife-edge, is connected by light tension ribbons to opposite extremities of an armature pivotally balanced between the poles of a permanent magnet, the movement of the armature being brought about by an energizing coil which surrounds it.

As illustrated, the currents for tilting the oscillograph mirror and effecting the compensating shift of the recording line of light at the translating point **43** are generated, as in the case of the system of Fig. 1, by a moving coil **45** carried on an arm **46** of the sound sprocket shaft coacting with the annular field created by the permanent magnet **47** carried upon the uniformly rotating member **48** of the reference system. The member **48** is driven through the medium of a pair of damped springs **49** which connect it with the arm **46** of the sound sprocket shaft. The variation from uniform velocity in the rotation of the sound sprocket shaft causes corresponding displacements between the moving coil **45** and the annular field of the magnet **47** of the uniform velocity member **48**. The currents resulting from these displacements are transformed, corrected with respect to phase and amplitude, and, if necessary, amplified in the device **50** and passed through the energizing coil of the oscillograph **40**. The tilting of the mirror **39** of the oscillograph causes a shifting of the line of recording light at the translating point **43** that corresponds exactly in phase and amplitude with the variation from uniform velocity in the movement of the film **42**.

The light valve which effects the compensating movement of the line of light in the reproducing system illustrated in Fig. 1 may be generally of the type disclosed in the article by Perreault, at page 412 of the Aug. 1932 issue of Bell Telephone Laboratories' Record, Vol. X, No. 12. Fig. 3 illustrates portions of the ribbons of such a light valve modified to adapt them for controlling the compensating shift of the line of light. In the form of light valve illustrated, although other dimensions than those given are suitable, it may be assumed that the ribbons 51 and 52 are 2 inches long, 6½ mils wide and ½ mil thick, and that there is a 1 mil separation between their proximate edges. The aperture 53 for the passage of light between the exciting lamp and the sound track, may be assumed to be 120 mils long and 40 mils wide, so that the slit defined by the light valve ribbons is permitted an extreme amplitude of movement of approximately 40 mils before being obscured by the upper and lower edges of the aperture 53. With an optical leverage of 1:1 as between the slit and the film, this permits a corresponding extreme amplitude of compensating movement of the line of light on the film of approximately 40 mils. As the extent of linear displacement of the film at the translating point due to superposed velocity variations ordinarily does not exceed a very small fraction of an inch, even for the lowest periodicity disturbances, this amplitude of movement of the line of light on the film is sufficient for securing the compensating effect.

In order to completely close the aperture 53 for the passage of any light excepting that which passes through the slit defined by proximate edges of the ribbons, an extremely thin and light shield 54 is fastened to the ribbons 51 and 52 so as to move with them. Along its center the shield 54 may be provided with a slit 55 enough broader than the slit between the proximate edges of the ribbons so that the light slit is defined by the edges of the ribbons and not by the edges of the slit in the shield. As the energizing current traverses the ribbons of the compensating light valve in parallel, in order that the movement of both ribbons may be in the same direction, the shield 54 may be of metal, as ½ mil thick duralumin, and may be in metallic conducting contact with the faces of the ribbons without affecting the response of the device to the actuating currents that flow through it. The relatively great length of the ribbons 51 and 52 as compared with their breadth reduces the stiffness factor and enables the valve to be tuned to a low resonance frequency (but one which lies safely above the highest disturbing frequency that needs to be compensated for), and therefore to be actuated by a relatively small amount of electrical energy.

In Fig. 4 there is shown in perspective, with parts broken away, a reference system in which the velocity variations between the uniform velocity and the variable velocity members of the system are converted into corresponding electric currents by means of coils moving in annular magnet fields; and in which the electric currents generated in the movable coils are communicated to the external compensating circuit through the medium of a transformer one of the windings of which is stationary and the other of which is rotatable. Only as much of the structure is illustrated as is necessary to show the relationship between the various elements; and the illustration is largely a schematic rather than an exact mechanical representation of the structure.

The sound sprocket shaft 56, one of the bearings of which is shown at 57, carries on one end the sound sprocket 58 and on the other end the rotating element of the transformer 59. At an intermediate position on the shaft 56 are fixed two sets of radially extending arms 60 and 61. The sprocket shaft 56 is rotated by the driving shaft 62 through the medium of the beveled gears 63. The reference system member 64 is arranged to rotate coaxially with the shaft 56, the member 64 either having a bearing upon the shaft 56, or if desired, having its bearing upon a stationary part of the frame of the machine. Rotary movement is imparted to the member 64 by the sprocket shaft 56 through the medium of the pair of arms 61, at the outer end of each of which arms there is a connection with the member 64 through the medium of the damped coiled springs 65. Each of these coiled springs, damped by felt in a well known manner, is connected at its inner end with the extremity of the associated arm 61, and at its outer end is adjustably connected with a pin or post 66 set in the rotating member 64 of the reference system. Obviously the connection between the sprocket shaft 56 and the rotating reference member 64 may be made in any one of a variety of ways, the essential requirement being that the elasticity of the connection and its damping and the moment of inertia of the member 64 shall be such as to give the system a natural resonance frequency below the lowest of the disturbing frequencies that are to be compensated for, and that the resonance of the system shall have substantially critical damping. The maximum amplitude of relative displacement of the uniform and variable velocity elements of the reference system is determined by the stop pins 67, the connection of the damped springs 65 with their associated pins 66 being so adjusted that in normal operation the arms 61 shall lie midway between their limiting stops 67.

At each end of the two arms 60 is rigidly attached a coil of wire 68 (only one of which is shown in the perspective drawing), which coils are adapted to move in the annular fields between the poles of the two permanent magnets 69. The magnets are carried upon and rigidly fastened to the reference system member 64 by means of the bolts 70. The arms 60 that carry the moving coil 68 are light, but rigid with respect to frequencies within the range of velocity variation frequencies that are to be communicated to the coils that they carry.

The moving coils 68 are electrically joined together in aiding relation and are connected with the inner or rotating winding 71 of the transformer 59. The outer or stationary transformer winding 72 is connected, as has been described, with the compensating circuit that includes the light valve or oscillograph.

The transformer 59 may form a unit adapted to be slipped onto the protruding end of the sound sprocket shaft 56. In the embodiment illustrated in Fig. 4, the transformer includes an inner sleeve 73 and an outer shell 74, preferably of material of high magnetic permeability, such as permalloy. The inner or rotating winding 71 is carried upon the inner sleeve 73, and the outer or stationary winding is secured upon the inner surface of the outer shell 74. To complete the magnetic circuit of the transformer there are two pairs of discs or washers, laminated, if desired, and of high magnetic permeability, at the ends of the windings 71 and 72. The pair 75 fits tightly upon the inner sleeve 73 and clears the inner surface of the outer shell 74, and the other pair 76 is tightly fitted within the inner surface of the outer shell 75 and clears the outer surface of the inner sleeve 73. These sets of discs or washers are so placed that their juxtaposed surfaces are as close together as possible consistent with clearance, say, a 5 mil separation. In this way the reluctance of the magnetic circuit is reduced and the leakage flux kept low.

To properly hold the parts of the transformer in rotatable but substantially unvarying relation with each other, the ball-bearings 77 and 78 are employed, the outer periphery of each bearing being secured to the shell 74 and the inner periphery being secured to the sleeve 73. As the magnetic circuit of the transformer is provided for by the sets of discs and washers 75 and 76, it is substantially independent of the path by way of the ball-bearings 77 and 78. A transformer thus constructed is adapted to transmit with only slight loss the velocity variation currents generated by the moving coils 68 of the reference system. These velocity variation currents may have frequencies that lie within the range of from 1 to 100 cycles per second.

The connection of the moving coil or coils of the reference system with the compensating light valve ribbons may be in the manner shown diagrammatically in Fig. 6 of the drawings. The moving coil 68 has connection with the rotating primary winding 71 of the transformer 59; and the stationary secondary winding 72 of the transformer is connected with the light valve ribbons 30, the connection including a reactance 79 to introduce the necessary amplitude correction. The transformer windings 71 and 72 are preferably of high impedance, with many turns, and the coil 79 preferably has a reactance impedance greater than the impedance of the light valve 30 and less than the reactive impedance of the associated transformer winding. Of course, the transformer 59 may, if desired, be so constructed that the required reactance in the light valve circuit may be due entirely to the leakage reactance of the transformer.

The circuit shown in Fig. 6 is upon the assumption that the electrical energy generated by the movement of the coils 68 in the reference system is sufficient without amplification to effect the desired magnitude of movement of the compensating light valve ribbons. But if it is desired to have more energy available for the movement of the compensating ribbons, an amplifier may be introduced as shown diagrammatically in Fig. 7. In this case the moving coil 68 of the reference system is connected with the rotating primary winding 71′ of the transformer 59′, and the stationary secondary winding 72′ is connected with the input circuit of the amplifier 80. The output circuit of the amplifier 80 includes the primary winding of a transformer 81 the secondary winding of which is included with a reactance coil 82 in the energizing circuit of the compensating light valve 30. In this case the transformers 59′ and 81 are wound to match the impedances into which they work, and the rotating transformer 59′ is so constructed, as, for instance, by employing axially longer windings, that the reactance due to the leakage flux is reduced. As in the case of the circuit illustrated in Fig. 6, the reactance coil 82 may be dispensed with by deriving the required correcting reactance in the light valve circuit from the associated transformer by properly designing the transformer to that end. The design of such connecting circuits to secure the proper phase and amplitude relations between the interconnected elements is well understood in the art; and the circuits of Figs. 6 and 7, with appropriate changes in their electrical contents, may be employed for supplying the velocity variation currents of the reference system to a compensating oscillograph, instead of to the light valve as shown.

In the modification illustrated in Fig. 5 the conversion of velocity variations into corresponding electric current variations for the compensating control of the translating point is effected through the medium of light. As illustrated, the sound sprocket shaft 83 carries the sound sprocket 84 at one end and at the other end has rigidly attached to it a light disc 85 to the periphery of which an open-ended drum or cylinder 86 is secured. The sound sprocket shaft 83 is rotated by the driving shaft 87 through the medium of the beveled gears 88. Only one bearing 89 for the sprocket shaft is shown; but it will be understood that the shaft has such bearings as are necessary for its proper support. Fulcrumed either upon the shaft 83 as its bearing, or, if desired, upon a separate bearing carried by the frame of the machine, is a relatively heavy disc-shaped member or wheel 90. This member rotates idly upon its bearing and is driven by the rotating shaft 83 through the medium of a pin or post 91 set into the disc 85. The post 91 extends through a slit 92 in the member 90 and is connected at its free end, through the medium of the felt damped and adjustable springs 93, with the two posts 94 that are set into the face of the member 90. Obviously the damped resilient connection of the member 90 with the shaft 83 may be made in any one of a variety of ways, the idea being merely to connect it so that as a result of its moment of inertia coacting with the elasticity of the resilient connection 93, the combination shall have a natural resonant frequency below the lowest disturbing frequency that is to be compensated for, so that the rotating member 90 of the reference system shall have a uniform velocity of rotation, the damping of the resilient connection being such as to provide critical damping for the system.

In order to translate displacements between the members 85 and 90 due to velocity variations of the film or sound sprocket into corresponding light variations, the member 90 is provided with a cylinder or shell 95 which rotates coaxially with but just clears the outer surface of the cylinder or shell 86 attached to the periphery of the member 85. Each of the shells 86 and 95 is provided with a corresponding series of apertures that are preferably in the form of straight edged slits, the slits 96 in one of the shells preferably being slightly longer than the slits 97 in the other shell so as to avoid any possible variation of the light passing through registering slits by longitudinal or axial displacement of the two members with respect to each other. The series of slits in each shell extends completely around its periphery.

The rotary adjustment of the two members 85 and 90 with respect to each other is such that in normal rotation the slits are displaced with respect to each other by an amount equal to half their breadth, so that each slit in the series carried by one of the members is half obscured by a longitudinal wall of the corresponding slit in the other member. The breadth of each of the slits in the shells of the two members is equal to the maximum angular displacement of one member with respect to the other, so that the maximum displacement of the two members with respect to each other as a result of the greatest velocity variations will be such as to produce a movement the limits of which will be the complete registration and opening of the slits on the one hand, and their complete closure on the other. Any lesser amplitude of movement produces corresponding lesser variation in the area of the openings controlled by the slits.

The light system controlled by the series of slits in the peripheries of the shells 86 and 95 comprises, in the modification illustrated, an exciting lamp 98 within the shell 86 and a light sensitive element preferably in the form of two caesium photoelectric cells 99 in an enclosed space into which the light that passes through the registering series of slits is reflected. The exciting lamp 92 is preferably of a type having a straight filament extending longitudinally at the axis of the shell 86, so that the light is propagated radially with respect to each one of the circular series of slits 96 and 97. Surrounding the outer shell 95 and enclosing the photoelectric cells 99 is a stationary shell 100, the inner surface of which is light reflecting, and the shape of which is such as to reflect the light passing through the slits and concentrate it upon the photoelectric cells. The reflecting enclosure 100 is supported upon the frame of the machine in any convenient manner, and its open forward end is so arranged and proportioned as just to clear the outer surface of the rotating shell 95. The shell 95 may also carry a flange 101 which serves to prevent the admission of any external light to the enclosure within the shell 100.

The exciting lamp 98 is mounted upon a fixture 102 carried by the enclosing shell 100 and extending axially thereof. The forward end of the fixture and the lamp clear the edges of a circular opening 103 in the wall of the shell 86, and a flange 104 is secured to the fixture 102 so as to overlap the opening 103 and prevent any direct passage of light from the enclosure within the shell 86 into the space enclosed by the reflecting shell 100. Supports for the photoelectric cells 99 are carried at the base of the fixture 102, and the necessary wiring for the exciting lamp 98 and the photoelectric cells 99 may be carried out through the fixture and connected with the external circuits. The reflecting shell 100 with its attached fixture 102 carrying the exciting lamp 98 and the photoelectric cells 99 are so mounted upon the frame of the machine that it and the parts that it carries may be withdrawn axially to permit access to the various elements. The photoelectric cells 99 are so mounted that their light sensitive surfaces are directed radially outward.

The maximum light available for the variable excitation of the photoelectric cells 99 may be increased by increasing the number of slits in the corresponding series in each of the shells 86 and 95, the number being limited only by the requirement that the breadth of the wall between adjoining slits shall not be less than the slit breadth. With slits and intervening walls thus related, the maximum amount of variable light which is capable of passing through into the interior of the reflecting enclosure 100 when the slits are in registration is equal to half of the light that falls upon an annulus on the interior surface of the shell 86 having a breadth equal to the length of the registering portions of the slits. If desired, in order to increase the current output produced by the light that passes through the slits, the caesium photoelectric cells 99 may be replaced by photronic cells or selenium photo E. M. F. cells of the type described by Bergmann in the Physikalische Zeitschrift, Vol. 32, No. 7, April 1, 1931, pages 286–288.

To eliminate the effect of slight spacing irregularities in cutting the slits in the shells 86 and 95, each pair of registering slits in the two shells may be cut in a single operation; and then, in assembling them with the associated members 85 and 90 of the reference system, the shells may be maintained in the same relation with respect to each other as that which they occupied when they were cut. In order that the limiting displacements of one member of the reference system with respect to the other shall not be exceeded, the members are provided with properly spaced and preferably adjustable limit stops.

The controlling elements of a modified form of reference system operating on the principle of translating velocity variations into light variations is illustrated in Figs. 8 and 9. The exciting lamp 105 is placed at the principal focus of the lens 106 so as to project a parallel beam of light through the apertures controlled by the shutters 107 and 108. The light which passes through the apertures in the shutters may fall directly upon the photoelectric cell 109, or, as shown, may pass through another lens 110 which changes the direction of the light rays so as to cause them to be projected at any desired angle onto the photoelectric cell.

The shutters 107 and 108 are exactly similar, and may be of the form shown in Fig. 9. In the form here shown, the openings for the passage of light are approximately 15° sector-shaped apertures 111 separated from each other by 15° opaque walls 112. Under normal operating conditions each sector-shaped aperture of one shutter is approximately one-half obscured by the corresponding sector-shaped wall of the other shutter. Therefore, a 7½° angular shift of the shutters with respect to each other in one direction causes a complete opening of all the apertures and a 7½° angular shift in the other direction causes a complete closure of the apertures.

The elements 113 and 114 at the juxtaposed ends of which the shutters 107 and 108 are mounted, may be tubes or hollow shafts, one of which is an operative part of the variable velocity part of the reference system and the other of which is an operative part of the uniform velocity part of the system. Therefore, any velocity variation in one of the elements with relation to the other causes a corresponding variation of the light which the shutters control, and a corresponding variation in the voltage output of the photoelectric cell. This variable output may be utilized to control the light valve, as already described, or to control an electro-responsive device for regulating the operation of the associated mechanical system. It will be understood, of course, that the system schematically illustrated in Figs. 8 and 9 is so organized that the only light which falls upon the photoelectric cell 109 is that which passes through and is controlled by the shutters 107 and 108 of the reference system.

In the modification illustrated in Fig. 10, the light which is projected from the exciting lamp 115 to the photoelectric cell 116 is that which passes through only a part of the registering apertures of the rotating cylinders 117 and 118 of the reference system. The number of apertures operative in the control of the light is determined by the length of the opening 119 in the shield 120. The length of the aperture 119 is adjusted to subtend exactly the same arc as that subtended by one opening and one closure in the reference system cylinders, or an even multiple thereof. In the present instance, the arc subtended by the shield opening 119 is equal to that subtended by two sets of openings and closures in the reference system.

If the length of the slit 119 were slightly shorter than it should be the forward one of the two beams of light indicated in Fig. 10 would be completely cut off at one end of the slit before the following beam had started to pass through at the other end of the slit; and if the slit 119 were slightly longer than it should be, the following light beam would start to enter at one end of the slit before the forward light beam had been completely cut off at the other end of the slit. In either case there would be a slight variation in the output of the photoelectric cell that would not represent rotational velocity variations between the two members 117 and 118 of the reference system. This is prevented by an accurate adjustment with respect to each other of the slit 119 of shield 120 and the angular spacing and dimensions of the slits and separating walls of the two rotating members 117 and 118. The exciting lamp 115 has a straight filament that is arranged at the axis of rotation of the rotating system. As shown in Fig. 10, the beams of light, after passing through the slits and the aperture in the shield 120, are directed to the photoelectric cell 116 by the lens 121 in the lens tube 122.

An obvious modification of the arrangement illustrated in Fig. 10 is to permit the perforations in one side of the sound record film, as the sound track on the other side passes the translating point, to serve as the element 117 of the reference system, the region around and between the film perforations being photographically blackened. Any shift in the position of the perforations with respect to the corresponding perforations in the uniformly rotating member 118 of the reference system, as a result of velocity variations in the movement of the film, causes corresponding variations in the transmitted light and corresponding variations in the photoelectric cell output.

Where the translation of the velocity variations into electric current variations is effected through the medium of light and as photoelectric cell, as in Figs. 5, 8, 9 and 10, the photoelectric cell is connected in the usual manner with an amplifier, and the output of the amplifier passes to the light valve or like device through a correcting circuit the constants of which are so chosen as to deliver the compensating current to the light valve in proper phase and amplitude.

What is claimed is:

1. The method of compensating for velocity variations created by momentary deviations from uniformity of a sustained velocity of a sound record film past its translating point, which consists in generating electric currents corresponding in relative strength to the amplitudes of velocity variations between a part associated and moving at the same velocities as the film and a part moving at a sustained uniform velocity equal to the average velocity of the film, and utilizing said currents to produce a compensating adjustment to obtain a uniform velocity relation between the film and its translating point.

2. The method of compensating for velocity variations created by momentary deviations from uniformity of a sustained velocity of a sound record past its translating point, which consists in moving a part associated with the record in the proximity of a part moving uniformly at a velocity equal to the average velocity of the first part, converting the velocity variations between the two parts into electric currents, and utilizing said currents to produce a compensating adjustment of the translating point.

3. The method of controlling velocity variations created by momentary deviations from uniformity of a sustained velocity which consists in moving a part associated with a controlled member in the proximity of a uniformly moving part associated with a controlling member, converting variations in the relative velocity of movement of said parts into corresponding electric currents, and utilizing said currents to govern the relative velocity of movement of the controlled member.

4. The method of controlling velocity variations created by momentary deviations from uniformity of a sustained velocity which consists in moving a part associated with a controlled member in the proximity of a uniformly moving part associated with a controlling member, converting variations in the relative velocities of movement of said parts into corresponding light variations, translating said light variations into correspondingly varying electric currents, and utilizing said currents to govern the relative velocity of movement of the controlled member.

5. A compensating system for velocity variations created by momentary deviations from uniformity of a sustained velocity of a sound record, including a reference system having one element associated and moving with the sound record and another element moving at a uniform velocity equal to the average velocity of said first element, and means for converting velocity variations between said elements into correspondingly varying forces and applying said forces to compensate for velocity variations in the movement of said sound record.

6. A compensating system for velocity variations created by momentary deviations from uniformity of a sustained velocity of a photographic sound record film, including a reference system having one element associated and moving with the film and another element moving at a uniform velocity equal to the average velocity of said first element, means for converting velocity variations between said elements due to irregularities in the movement of the film into correspondingly varying forces, and means for utilizing said forces to compensate for said film movement irregularities.

7. In a sound picture apparatus employing a photographic sound record film, sound translating mechanism including a device adapted to effect a compensating movement between the translating line of light and the record film to compensate for velocity variations created by momentary deviations from uniformity of a sustained velocity, an element moving with the film, an element having a sustained uniform velocity of movement equal to the average velocity of movement of said first element, and means responsive to velocity variations between said elements for actuating said device.

8. In a sound picture apparatus employing a linear sound record carrier, sound translating mechanism including a device adapted to effect a compensating movement of the translating point with relation to the sound record carrier, a reference system having an electrical element associated and moving with the record carrier and another electrical element having a uniform

movement equal to the average velocity of the record carrier movement, and means adapted to convert velocity variations in the relative movement of said elements into corresponding electric currents and apply the same to said device to cause said compensating movement.

9. A control system for sound picture apparatus, including a member associated and moving with a sound record, a member moving at a uniform velocity equal to the average velocity of said first member, an electromagnetic system having an element set in motion by the relative movements between said members to generate electric currents corresponding to said movements, a translating element, and means for utilizing said currents for obtaining a uniform velocity relation between said sound record and said translating element.

10. A velocity control reference system, including a member adapted to rotate at a variable velocity, a member rotated at a sustained uniform velocity equal to the average velocity of said first member, an electromagnetic system having one element carried by one of said members and another element carried by the other of said members arranged to generate electric currents commensurate with the amplitudes of velocity variations, and means for utilizing for velocity control the currents generated by the relative movements of said members.

11. A velocity control reference system, including a member adapted to rotate at a variable velocity, a member rotated at a sustained uniform velocity equal to the average velocity of said first member, means for producing a magnetic field carried upon one of said members for producing electric currents commensurate with the amplitude of velocity variations, a conductor carried by the other member lying in said magnetic field and adapted to cut the same as a result of relative movement between said members, and velocity control means adapted to be actuated by the electric currents thus produced.

12. A velocity control reference system including a member adapted to rotate at a variable velocity, a member rotated at a sustained uniform velocity equal to the average velocity of said first member, a permanent magnet having an annular field carried upon said uniform velocity member, a coil carried upon said variable velocity member and adapted to move in said annular magnetic field, and velocity control means adapted to be actuated by the electric currents produced by the movement of said coil in said annular magnetic field.

13. A velocity control reference system, including a member adapted to rotate at a variable velocity, a member rotated at a sustained uniform velocity equal to the average velocity of said first member, an electromagnetic system carried upon and rotating with said rotating members and adapted to generate electric currents corresponding to relative movements between said members, and means operating by electromagnetic induction for converting the currents generated by said electromagnetic system into correspondingly varying electric currents in an external electric circuit.

14. A transfer system for feeble alternating electric currents including a rotating element in which said feeble currents are generated, a transformer having two coaxial windings one of which is rotatable with respect to the other on the common axis of the two windings, said rotatable winding rotating with said rotating element and being traversed by said feeble currents, and the other winding being connected with an external circuit.

15. A velocity control reference system, including a member adapted to rotate at a variable velocity, a member adapted to rotate at a uniform velocity equal to the average velocity of said first member, a source of light and a light responsive element, said members being provided with series of corresponding apertures adapted to be interposed in normally overlapping relation between said source of light and said light sensitive element in the rotation of said members to control the light in accordance with velocity variations between said members, and a controlling circuit connected with said light sensitive element.

16. In a sound picture apparatus employing a photographic sound record film, sound translating mechanism including a device adapted to effect a compensating movement between a translating line of light and the record film, an element moving with the film, an element having a uniform velocity of movement equal to the average velocity of movement of said first element, each of said elements being provided with a corresponding series of light transmitting and light obscuring portions normally in partially obscuring relation with each other, a source of light and a light sensitive element so arranged that the passage of light from one to the other is controlled by the relation between the light transmitting and light obscuring portions of said members, and an operating connection between said light sensitive element and said compensating device.

17. A velocity control reference system, including a member adapted to rotate at a variable velocity, a member adapted to rotate at a uniform velocity equal to the average velocity of said first member, two peripherally slotted telescoping cylinders having their peripheral slots normally in overlapping relation with respect to each other, each of said cylinders being carried upon and rotating with a different one of said members, a source of light and a light sensitive element so arranged that the passage of light from one to the other is controlled by the varying overlap between the peripheral slots in said cylinders, and a controlling circuit connected with said light sensitive element.

18. The method of compensating for velocity variations in the movement of a sound record film past a translating line of light, consisting in moving one electrical element at a uniform velocity and another electrical element at the velocity of the film, in associating the two elements in a manner to create rapid changes in electrical current values responsive to relative motion as a result of variations in the second electrical element and in using said electrical currents to adjust the line of light in a manner to obtain a uniform velocity relation between the film sound record and the translating line of light.

19. The method of compensating for momentary velocity variations of differing amplitudes in a sound record film as it moves past a translating line of light, consisting in moving one electrical element at uniform velocity and another electrical element at the variable velocity of the film, in associating the two elements in a manner to create rapid changes in electrical

current values responsive to the relative motion therebetween commensurate with the amplitude of film velocity variations and in using said electrical currents to move said line of light longitudinally of the film substantially the same distance as the film sound record is moved by velocity variations of different amplitudes.

20. In a sound picture apparatus employing a linear sound record carrier, means to control the uniform translation of sound comprising two elements operatively connected to a member which drives said sound record carrier, said elements being so connected to said member that momentary variations in uniformity of the velocity of the member create relative motion in one element with relation to the other substantially equivalent to the variation in velocity transmitted to the record carrier, means for producing varying forces corresponding to the extent of movement of one element with relation to the other uniformly proportional to the amplitude of the variations, and means for applying said forces to compensate for said momentary deviations in velocity of the sound record carrier.

21. In a sound picture apparatus employing a linear sound record carrier, sound translating mechanism including a device adapted to effect a compensating positional change of the translating line of light with reference to the record carrier, control apparatus for said device comprising one element driven by a member directly in contact with said sound record carrier, and one element flexibly connected to said latter member, said elements being so associated with each other that momentary variations in the uniformity of the sustained velocity of the record carrier create relative motion in one element with relation to the other, means for producing varying forces corresponding to the extent of movement of one element with relation to the other uniformly proportional to the amplitude of the variations, and means for applying said forces to operate said device for altering the position of said line of light to obtain a uniform velocity relation between the translating line of light and the sound carrier.

22. In a sound picture apparatus employing a photographic sound record film, sound translating mechanism including a device adapted to effect a compensating positional change of the translating light with reference to the film sound record, a velocity variation control system including two electrical elements operatively connected to a member which drives the film, said elements being so connected to said member that momentary variations in the uniformity of the sustained film velocity create relative motion in one element with relation to the other corresponding in extent to the amplitude of the velocity variations, to produce varying electrical currents corresponding in relative strength to the amplitude of said variations, and means for applying said currents for operating said device to effect a compensating positional change of the translating light corresponding to the momentary variations in the sustained velocity of the film.

23. A compensating system including a mechanical transmission system terminating in a driving member rotated at a uniform sustained velocity with momentary deviations created by irregularities in applied torque in said mechanical transmission system, a velocity control device driven by said mechanical transmission system in multiple with said member, said device comprising one element adapted to rotate at said uniform sustained velocity and another element adapted to rotate at said uniform sustained velocity with velocity variations created by said driving member, a coupling excited by the relative motion of said elements for creating forces capable of work, a strip driven by said member with variations in velocity to the same extent as the member, a separate device cooperatively associated with said strip, and means for utilizing said forces for moving said separate device to the same extent as said strip.

24. A compensating system including a mechanical transmission system terminating in a driving member rotated at a uniform sustained velocity with momentary deviations created by irregularities in applied torque in said mechanical transmission system, a velocity control device driven by said mechanical transmission system in multiple with said member, said device comprising one element adapted to rotate at said uniform sustained velocity and another element adapted to rotate at said uniform sustained velocity with velocity variations equivalent to those in said driving member, creating an electromagnetic coupling excited by the relative motion of said elements for generating electric currents varying in strength with the amplitude of velocity variations, an induction coil rotated by said driving member, and means for transmitting the electrical currents created by said coupling to said induction member for converting the currents generated by said electromagnetic coupling into corresponding varying electric currents of increased strength for operating electrical apparatus in an external circuit.

25. A compensating system including a transfer system for feeble electric currents including an electromagnetic coupling excited by relative motion of its members responsive to momentary variations in the sustained velocity of a prime mover for generating feeble electrical currents, a strip driven by said prime mover, a device operable for compensating for variations in the movement of said strip, and an induction coil having a rotatable member operated by said prime mover and electrically connected to said coupling for converting the feeble currents generated by said coupling into correspondingly varying electrical currents of a strength to operate said compensating device.

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