

Jan. 10, 1961

H. REINSCH

2,967,987

SYNCHRONIZING APPARATUS

Filed April 23, 1956

2 Sheets-Sheet 1

FIG. 1

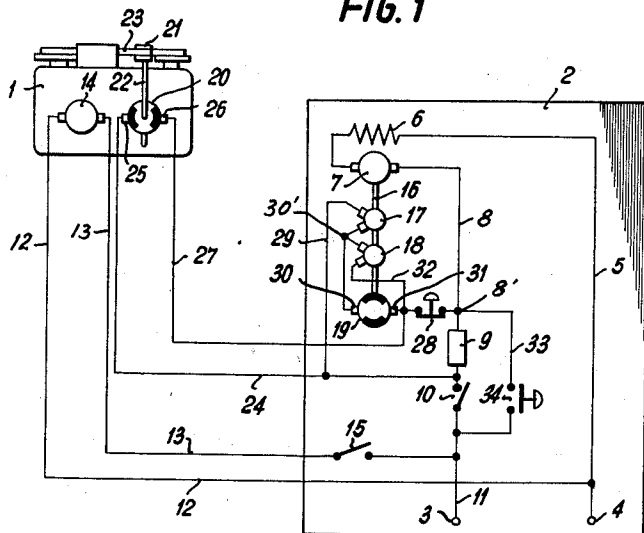
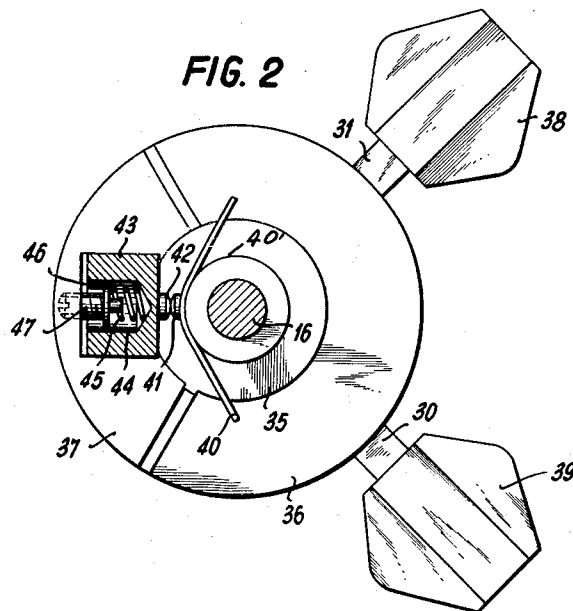


FIG. 2



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2 Sheets-Sheet 2

FIG. 3

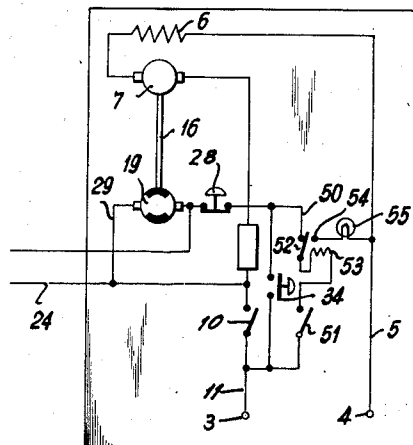
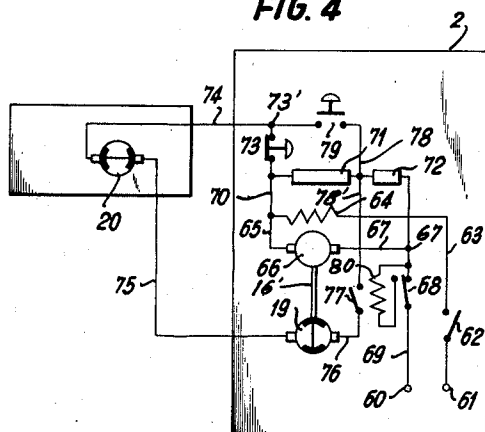


FIG. 4



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2,967,987

SYNCHRONIZING APPARATUS

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6 Claims. (Cl. 318—75)

The present invention relates to a synchronizing apparatus. More particularly, the present invention relates to an apparatus for synchronizing the speeds of a motion picture sound film and the sound track which may be recorded on a different tape from the film.

In conventional rotational speed synchronizing apparatus it is common practice to use relay arrangements which control the various motors which are being synchronized. For this purpose it is usually necessary to provide a separate energy source for the relays and of course, the relays themselves absorb a substantial amount of power which would be highly objectionable in the cheaper types of apparatus.

The present invention overcomes the disadvantages of the prior art by providing rotary circuit breakers synchronized with the rotary speeds of the respective motors and connected directly in the energizing circuit of one of the motors.

It is accordingly an object of the present invention to overcome the disadvantages of the prior art arrangements.

A second object of the present invention is to provide a new and improved apparatus for maintaining a predetermined relationship between the rotational speeds of independent rotary members.

Another object of the present invention is to provide a new and improved apparatus for synchronizing the rotational speeds of independent rotary members.

A further object of the present invention is to provide a new and improved apparatus for synchronizing the motion picture film transport mechanism with a sound track transport mechanism for the film.

Still another object of the present invention is to provide a new and improved apparatus which is relatively inexpensive to construct and which accurately synchronizes the rotational speeds of independent rotary members.

Still a further object of the present invention is to provide a synchronizing apparatus for independent rotary members which permits the rotary members thereof to be quickly brought up to the desired speed before the synchronizing action is commenced.

With the above objects in view the present invention relates to an apparatus for maintaining a predetermined relationship between the rotational speeds of independent rotary members and including energizing means for energizing the rotary members to cause the same to rotate, and switching means movable between circuit-opening and circuit-closing positions by the rotary members and connected in circuit between the energizing means and

2

one of the rotary members, for regulating the energization of the one rotary member so that the respective rotational speeds of the rotary members are maintained in a predetermined relationship whereby the switching means maintain a circuit in circuit-closed position when the predetermined speed relationship is not yet achieved and in circuit-open position when the predetermined speed relationship is surpassed, and vice versa.

In another embodiment of the present invention two different switching means are used. The switching means are connected in parallel with each other and in circuit between the energizing means and one of the rotary members.

In a preferred embodiment, the present apparatus is used for synchronizing the rotational speeds of two independent rotary members and includes a regulating means which is rendered ineffective by the switching means when the two rotary members are rotating at a speed ratio under a desired value and renders the regulating means effective when they rotate at a speed ratio over the desired value.

In still another embodiment of the present invention time delay means are used for preventing the operation of the switching means until the expiration of a predetermined time period. In addition, visual indication means may be provided for indicating when the predetermined time period has expired.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

Fig. 1 is an electrical schematic diagram showing the interconnection of the electrical synchronizing apparatus and showing the film projector and sound track mechanism in diagrammatic form;

Fig. 2 is a plan view of a rotary switch arrangement used with the apparatus shown in Fig. 1;

Fig. 3 is a partial electrical schematic view of another embodiment of the present invention; and

Fig. 4 is an electrical schematic diagram of still another embodiment of the present invention.

Referring to the drawings and more particularly to Fig. 1 it can be seen that the sound track transport mechanism is diagrammatically shown mounted on a housing 1 such as used for a magnetic tape recorder. Similarly, the motion picture projector is diagrammatically shown as a housing 2.

Near the bottom of the diagrammatic showing of the housing 2 is provided terminals 3 and 4 which are adapted to be connected to a source of energizing potential. The terminal 4 is connected on a conductor 5 to the field winding 6 of a driving motor 7 for the film transport. The other side of the motor 7 is connected on conductor 8 to a junction 8'. The junction 8' is connected to one terminal of a resistor 9, the other terminal of which is connected through a switch 10 and a conductor 11 to the second supply terminal 3.

Also connected to the junction 8', at the right hand side thereof, is a conductor 33 which is connected to one side of a normally open push button switch 34, the

other side of which is connected to the conductor 11.

The junction 3' is also connected to one side of a normally closed push button switch 28, the other side of which is connected to a sliding contact 31 of a rotary switch 19, having a second sliding contact 30 connected to a junction 30'. The contact 31 is also connected to the junction 30' by means of conductor 32 and a centrifugally operated switch 18. The switch 18 is mounted on the shaft 16 of the motor 7.

Also mounted on the shaft 16 is the rotary switch 19 and a second centrifugally operated switch 17. The switch 17 has one of its contacts connected to the junction 30' and the other contact thereof connected on conductor 29 to a conductor 24 which has one of its ends connected to one terminal of the resistor 9 and the other of its ends connected to a sliding contact 25 of a second rotary switch 20. It can be seen that the rotary switch 20 is mounted on the shaft 22 of a rotary member 21 which is rotated by the magnetic tape 23 of the magnetic tape recorder 1.

Mounted on the housing 1 is the driving motor 14 which transports the magnetic tape through conventional means which is not illustrated in order to avoid unnecessarily complicating the drawing. One brush of the motor 14 is connected on a conductor 12 directly to the terminal 4. The other brush of the motor 14 is connected by a conductor 13 through a switch 15 to the conductor 11 and the terminal 3.

It can also be seen that the rotary switch 20, mounted on the housing 1, has a second sliding contact 26 which is connected by conductor 27 to the sliding contact 31 of the rotary switch 19.

Referring now to Fig. 2, the operation of the rotary switches 19 and 20 will be described. The sliding contacts 30 and 31, in Fig. 2, are shown respectively mounted in housing members 39 and 38. These housing members contain resilient means which resiliently urge the respective contacts 30 and 31 into engagement with the outer periphery of a rotary disk member. The disk member is made out of a hub 35 of electrically insulated material and fixedly mounted on the shaft 16 so as to be rotatable therewith and a first electrically conductive lining 36 applied to a portion of the surface of the hub 35 including the outer periphery thereof. A second electrically conductive lining 37 is applied to substantially the remainder of the hub 35, including the respective peripheral portion thereof. The conductive linings 36 and 37 are electrically insulated from each other. Similarly, the contacts 30 and 31 are also normally electrically insulated from each other.

It can be seen that the contacts 30 and 31 will be electrically connected to each other when they both contact the same conductive lining on the member 35. For example, in the illustrated position, it is clear that the electrical contact 30 is electrically connected to the contact 31 through the lining 36 on the member 35. As the shaft 16 rotates, however, the member 35 rotates therewith so that the contacts 30 and 31 make sliding contact with linings 36 and 37 during different portions of the rotation cycle. In the embodiment illustrated in Fig. 2, the angular spacing between the contacts 30 and 31 and the relative dimensions of the linings 36 and 37 are so chosen that the contacts 30 and 31 are connected together electrically for exactly one-half of the rotational cycle of the shaft 16 and are insulated from each other during the remaining half of the rotation cycle.

An additional feature shown in Fig. 2 is the centrifugal switch arrangement. This includes a first contact 41 mounted on a member 40 which is mounted on the metallic center portion 40' of the insulating hub 35. The member 40 is in electrical contact with the electric coating 36. A second contact 42 is shown in contact position with the contact 41 and is mounted at one end of a weight 43. The weight 43 is slidably disposed in a rectangular opening in the lining 37 so that the edges

of the opening guide the weight 43 as it slides in a radial direction.

The weight 43 has a bore 44 in which is disposed a spring 45 which urges the weight 43 and the contact 42 radially inward into contact with the contact 41. The other end of the spring 45 bears against a disk 46 on the end of a screw 47 mounted in the lining 37 so that the screw 47 also is in electrical contact with the conductive lining 37 of the hub 35. Thus electrical contact is established between the lining 37 and the contact 42 by means of the electrically conductive weight 43 and disk 46.

In operation, the contacts 41 and 42 are normally in contact position so that the linings 36 and 37 are electrically connected together for all speeds below a predetermined speed. This predetermined speed may be chosen to be the synchronizing speed desired for the apparatus or some speed below the same. As this predetermined speed is reached, the centrifugal force will urge the weight 43 in an outward direction against the action of the spring 45 so that the contacts 42 and 41 will be separated. Up until this point, the linings 36 and 37 have been electrically connected to each other so that the contacts 30 and 31 have also been electrically connected to each other for the entire rotational cycle. However, when the contacts 41 and 42 are separated, the contacts 30 and 31 can only make electrical contact through the lining 36. Accordingly, contacts 30 and 31 are electrically connected only for one-half of the rotational cycle as soon as the contacts 41 and 42 are separated.

Referring now to Figs. 1 and 2, the operation of the apparatus will be explained. The resistor 9 of the motor 7 is normally chosen so that the voltage applied to the terminals 3 and 4 will drive the motor 7 at a speed below the desired synchronized speed. On the other hand, the motor 14 of the sound track mechanism is preferably chosen to run at the synchronized speed when the voltage is applied to the terminals 3 and 4.

In operation, the switches 10 and 15 are closed to start energization of the motors 7 and 14, respectively. The centrifugal switch 18, is arranged so that the contacts thereof will remain closed until some speed below the desired synchronization speed is reached. Accordingly, the conductor 32 will be connected to the junction 30' when the switch 10 is closed.

The centrifugal switch 17, also mounted on the shaft 16 of the motor 7, is arranged so that its contacts will remain closed until a speed somewhat higher than the desired synchronization speed is reached. Accordingly, the junction 30' will be directly connected to the conductor 29. It therefore can be seen that, at the start, when the switch 10 is closed, the resistor 9 is short-circuited by the circuit extending from the junction 8' through the normally closed switch 28, the conductor 32, the closed centrifugal switch 18, the closed centrifugal switch 17, the conductor 29 and the conductor 24.

With the resistor 9 short-circuited, the entire voltage is applied across the field winding 6 of the motor 7 so that the motor 7 is accelerated and quickly reaches a speed near the desired synchronization speed. At some point below this desired speed, the centrifugal switch 18 will open. This removes the short circuit across the resistor 9 due to the opening in the conductor 32. However, the rotary switch 19 which is rotating with the shaft 16 provides an electrical connection between the sliding contacts 30 and 31 thereof for one-half of the rotational cycle of the shaft 16. It can be seen that when the sliding contacts 30 and 31 are electrically connected together, the resistor 9 will again be short-circuited. However, since the contacts 30 and 31 are electrically connected for only one-half of the cycle, the rotary switch will short circuit the resistor 9 only for that one-half of the cycle.

On the other hand, the rotary switch 20 mounted on the rotating shaft 22 and driven by the motor 14 is also

5

rotating and connected in parallel with the rotary switch 19 across the resistor 9. The rotary switch 20 may be constructed in the same manner as the switch 19, as illustrated in Fig. 2, and accordingly at the predetermined substantially constant normal speed its sliding contacts 25 and 26 will be electrically connected to each other only for one-half of the rotational cycle of the shaft 22. If the shafts 16 and 22 are rotating at exactly the same rotational speed and the rotary switches 19 and 20 are out of phase 180° with each other, the resistor 9 will be short-circuited for the entire rotational cycle of the shafts 16 and 22.

However, since the motor 7 is normally arranged to run at slightly below the synchronized speed with the resistor 9 connected in series therewith, the short-circuiting of the resistor 9 will tend to increase the speed of the motor 7 above the synchronized speed. Therefore, the rotational speed of the shaft 16 will slowly increase. When this occurs the 180° angular arrangement between the rotary switches 19 and 20 will be changed. Therefore for short periods of the rotational cycle, the contacts 30 and 31 will be electrically insulated from each other during the same time interval as the contacts 25 and 26. Therefore the resistor 9 will no longer be short-circuited for short time intervals.

When the resistor 9 is inserted for short portions of the rotational cycle, the speed of the motor 7 will tend to decrease thereby making these portions smaller and smaller until the speed of the motor 7 is slightly below of synchronism with the speed of the motor 14 and the resistor 9 will be short-circuited for a great part of the rotational cycle. At this point, the speed of the motor 7 will again tend to slowly increase until the rotary switches are again more out of phase with each other and the cycle will be repeated with diminishing amplitude.

In the above manner a very accurate synchronization is attained between the motors 7 and 14 since the control provided by the rotary switches 19 and 20 is a very fine control. That is, the resistor 9 will be rendered effective when the relative phase relationship between the rotary switches 19 and 20 are only a few degrees away from the desired position.

Since the rotary switches 19 and 20 provide such a fine synchronization control, some coarser control means are provided. These coarser control means include the centrifugal switches 17 and 18. In addition coarse accelerating and decelerating controls are respectively provided by the push button switches 34 and 28. That is, at the start of the motors 7 and 14, when the switches 10 and 15 are initially closed, the push button switch 34 may be operated. When this occurs, it can be seen that the resistor 9 is short-circuited by the closed switch 34 so that the rotary switching means 19 and 20 are rendered ineffective and inoperable. When the desired synchronized rotational speed of the motors 7 and 14 is reached, the push button 34 may be released and its restoring spring will restore it to its normally open position. At this point the fine control means afforded by the rotary switches 19 and 20 is then rendered effective to short-circuit the resistor 9 at the exact synchronized speed.

In the event that the push button switch 34 has been closed so long and the motor 7 has been permitted to reach a speed substantially higher than the desired synchronized speed, the centrifugal switch 17 will be opened. This will take switch 19 out of circuit with the motor 7 and leave only switch 20 effective, after switch 34 is released, so that, with the resistor 9 in series with the motor 7, the speed of the motor 7 will be decreased until the desired synchronized speed is reached. At this point, the centrifugal switch 17 again closes and the rotary switches 19 and 20 regain effective control of the resistor or regulating means 9 for the motor 7.

Similarly, the opening of the normally closed switch 75

6

23 will also render ineffective the centrifugal switches 17, 18 and the rotary switches 19, 22. With the push button switch 28 opened, the resistor 9 will be in series with the motor 7 and thereby cause the motor to run slower if it is above the synchronization speed.

It is of course apparent that the motors 7 and 14 need not be exactly synchronized with each other in order to use fine control arrangement of the rotary switches 19 and 20. That is, the angular arrangement of the contacts and coatings on the switches 19 and 20 may provide an arrangement whereby one of the motors will run slower or faster than the other motor and this predetermined speed relationship between the two motors may be maintained by the rotary switches 19 and 20.

Instead of introducing the resistor 9 in order to slow down the motor 7, it might also be possible to open the energization circuit of the motor 7 by means of the switches 19 and 22. However, this might provide too sharp a change for the desired smooth running projector motor 7. Therefore, the resistor 9 arrangement, used as regulating means for the motor 7, is to be preferred.

Referring now to Fig. 3, another embodiment of the speed regulation arrangement of the present invention is shown. In this embodiment, the parts which are numbered with numbers corresponding to Fig. 1, have the same function as they do in Fig. 1.

It can be seen that in Fig. 3, there are no centrifugal switches mounted on the rotating shaft 16 of the motor 7. Also, the sound track transport means such as the magnetic tape recorder 1, is not shown since it corresponds to that shown in Fig. 1 for this embodiment.

In Fig. 3, a second switch 51 is provided substantially in parallel with the switch 10, and has one terminal connected to the conductor 11 and the other terminal connected to one side of a heater winding 53. The other side of the heater winding 53 is connected to a thermal sensitive switch element 52, such as a bi-metallic element. The element 52 in its normal position is connected to the conductor 50 and when the heater winding 53 has reached a certain temperature, the thermal sensitive element 52 is deflected into contact with the contact 54. Connected to the contact 54 is one terminal of a lamp 55, the other terminal of which is connected to the conductor 5 and the terminal 4.

In operation, the switch 51 is closed at the same time as the switch 10. Therefore, the resistor 9 is short-circuited by the switch 51, the heater winding 53, the thermal sensitive element 52 and the conductor 50. As current flows through the heater winding, the temperature surrounding the thermal sensitive element 52 increases until the element 52 is deflected out of contact with the conductor 50 and into contact with the contact 54. At this point, the short circuit across the resistor 9 is removed and the lamp 55 is energized. The operator, seeing the lamp in energized condition, opens the switch 51 thereby removing the flow of current through the heater winding 53 and the lamp 55. At this point, the resistor 9 can no longer be short-circuited by the thermal sensitive element 52. Therefore, the rotary switches 19 and 20 are again able to provide their fine synchronization control explained hereinabove with respect to Fig. 1.

It is apparent that since the heater winding 53 takes a predetermined period of time in order to heat up sufficiently for actuating the thermal sensitive element 52, that the motor 7 will be able to reach its synchronizing speed by the time the element 52 is actuated. Accordingly, the arrangement of Fig. 3 provides a time delay means which renders the rotary switches 19 and 20 ineffective and the resistor 9 ineffective for a substantially predetermined time. It is also clear that instead of a lamp 55 some other visual indicating means may be provided or that a relay may be used which automatically opens the switch 51.

Referring now to Fig. 4, still another embodiment of the present invention is provided. In this embodiment,

the energizing voltage is applied to supply terminals 60 and 61. The terminal 61 is connected to one side of a switch 62, the other side of which is connected by conductor 63 to one side of a field winding 64, the other side of which is connected by conductor 65 to one brush of the motor 66. The other side of the motor 66 is connected by conductor 67 to junction point 67'. It is clear that the motor 66 corresponds to the motor 7 of Fig. 1 and is used for driving the transport mechanism in the motion picture projector 2.

The junction 67' is connected to one side of a switch 68, the other side of which is connected by conductor 69 to the supply terminal 60. The switch 68 has a normally open contact connected to one side of a heater winding 80, the other side of which is connected to the normally closed contact thereof.

The junction 67' is also connected to one side of a resistor 72, the other side of which is connected to one side of a resistor 71. Resistor 72 is also connected by conductor 78 to one side of a normally open push button switch 79, the other side of which is connected to a junction 73'. The junction 73' is connected to one side of a normally closed push button switch 73, the other side of which is connected to the resistor 71 and by conductor 70 to the field winding 64. The junction between the resistor 72 and the resistor 71 is also connected by a conductor 78' to a fixed contact of a normally open switch having a thermal sensitive element 77, the other side of which is connected by conductor 76 to one sliding contact of the rotary switch 19. The other sliding contact of this switch is connected by a conductor 75 to one contact of the rotary switch 20. The other contact of the rotary switch 20 is connected by conductor 74 to junction 73.

The resistor 71 is chosen to be larger than the resistor 72. Therefore, in operation, when the switches 62 and 68 are closed so that the winding 80 is connected between the conductor 69 and the junction 67', the entire voltage applied to the supply terminals 60 and 61 is connected across the motor 66. The resistance of the heater winding 80 is kept proportionally small. Therefore, the motor 66 quickly accelerates towards its synchronizing speed. It should be apparent that the unillustrated motor of the magnetic tape recorder also accelerates towards its synchronizing speed in the same manner as described hereinabove with respect to Fig. 1 by operation of the unillustrated switch 15.

When the heater winding 80 has raised the temperature of the temperature sensitive element 77, sufficiently, the element 77 closes the switch in which it is connected so that the rotary switches 19 and 20 are connected into the circuit. If the motors of the film projector and the sound track transport mechanism are rotating at nearly the same speed, the resistor 71 will be short-circuited for every half rotational cycle of the shaft 16' of the motor 66 when the rotary switches 19 and 20 are in phase. The constance of the motor 66, the resistor 72 and the field winding 64 are chosen so that, with resistor 71 short-circuited in this way, the motor 66 will run at a speed slightly below the desired synchronous speed.

Therefore, with the resistor 71, short-circuited by the rotary switches 19 and 20, the speed of the motor 66 will decrease until the rotary switches 19 and 20 are no longer in phase. At this point, the resistor 71 will be placed in series with the resistor 72 for a greater portion of the rotational cycle. For this portion, a greater amount of current will flow through the resistor 66, since the larger resistor 71 will have been placed in circuit parallel to the motor 66. This will increase the rotational speed of the motor 66 until the desired synchronism between the rotary switches 19 and 20 is again achieved.

The push button switches 73 and 79 again provide manually operated controls independent of the synchronized rotary switches 19 and 20. That is, if the normally open switch 79 is closed, the resistor 71 will be short-

circuited regardless of the operation of the switches 19 and 20 and the motor 66 will tend to run slower. On the other hand, if the normally closed switch 73 is opened, the resistor 71 will remain in circuit parallel to the motor 66 and the motor 66 will run faster regardless of the relative positions of the rotary switches 19 and 20.

It is of course apparent that the rotary switches need not be mounted directly on the rotary shafts of the driving motors but may be coupled thereto so as to have some predetermined speed relationship therewith. Of course, it is desirable that any coupling between the rotary switch and the shafts of the driving motors should be a non-slip type of coupling. Also, those switches which are not push button switches can be arranged to be operated by the same shaft so that a single movement of the switch will start the energization of the motors or stop the same.

As indicated hereinabove, the embodiments illustrated in Figs. 1 and 3, the resistor 9 need not be used. However such an arrangement should only be provided for very light loads.

It will be possible to synchronize the speed of more than two rotary members if the proper rotary switches are provided having the proper angular spacing between their contacts and the coatings on their respective insulating members are also properly defined.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of movement synchronizing arrangements differing from the types described above.

While the invention has been illustrated and described as embodied in a synchronizing arrangement for a motion picture projector and related sound track, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. Apparatus for maintaining a predetermined relationship between the rotational speeds of independent rotary members comprising, in combination, energizing means for energizing the rotary members to cause the same to rotate; switching means movable between circuit-opening and circuit-closing positions by said rotary members and connected in circuit between said energizing means and one of the rotary members for regulating the energization of said one rotary member so that the respective rotational speeds of the rotary members are maintained in a predetermined relationship whereby said switching means maintain the circuit between said energization means and said one rotary member in circuit-closing position when the speed relationship differs from the predetermined in a first sense and in circuit-opening position when the speed relationship differs from the predetermined in the other sense; a first centrifugally operated switch fixedly mounted on said one rotary member for rotation therewith and connected in circuit between said energizing means and said switching means for rendering said switching means ineffective until a first predetermined rotational speed of said one rotary member is reached; and a second centrifugally operated switch fixedly mounted on said one rotary member for rotation therewith and connected in circuit between said energizing means and said switching means for rendering said switching means ineffective for all rotational speeds of said one rotary member higher than a second predetermined rotational speed.

2. Apparatus for synchronizing the rotational speeds

of two independent rotary members comprising, in combination, energizing means for energizing the rotary members to cause the same to rotate; regulating means connected in circuit between said energizing means and one of the rotary members for maintaining the rotational speed of said one rotary member at a predetermined value different from the normal rotational speed of the other rotary member; first switching means fixedly mounted on said one of said rotary members and rotatable therewith, said first switching means being connected in circuit between said energizing means and said one rotary member and being rotated thereby through circuit opening and circuit closing positions, at a rate determined by the rotational speed of said one rotary member; second switching means fixedly mounted on the other of said rotary members and rotatable therewith, said second switching means being connected in circuit between said energizing means and said one rotary member and being rotated by the other rotary member through circuit opening and circuit closing positions at a rate depending upon the rotational speed of the other rotary member; each of said switching means including an electrically insulating member mounted on one of the rotary members and rotatable therewith; a first electrically conductive lining partially covering the surface of said insulating member, a second electrically conductive lining covering substantially the remainder of said surface and electrically insulated from said first conductive lining, and a pair of spaced contacts, electrically insulated from each other, and resiliently urged against said linings on said insulating member to make sliding electrical contact with said linings thereon, said contacts being spaced from each other a predetermined amount and said linings covering a predetermined peripheral surface portion of said insulating member so that said contacts are electrically connected to each other for only one half of the rotation of the respective rotary member whereby when the rotary members are in synchronism, one of said switching means is in circuit opening position when the other switching means is in circuit closing position to render said regulating means ineffective and when the rotary members are not in synchronism, said switching members are at least partially simultaneously in circuit opening and circuit closing positions to render said regulating means effective.

3. Apparatus for synchronizing the rotational speeds of two independent rotary members comprising, in combination, energizing means for energizing the rotary members to cause the same to rotate; regulating means connected in circuit between said energizing means and one of the rotary members for maintaining the rotational speed of said one rotary member at a predetermined value different from the normal rotational speed of the other rotary member; switching means operated by the rotary members and connected in circuit between said energizing means and said one rotary member for rendering said regulating means ineffective when one of the two rotary members is in advance and rendering said regulating means effective when the other rotary member is in advance, each of said switching means including an electrically insulating member mounted on one of the rotary members and rotatable therewith, a first electrically conductive lining partially covering the surface of said insulating member, a second electrically conductive lining covering substantially the remainder of said surface and electrically insulated from said first conductive lining; and a pair of spaced contacts, electrically insulated from each other, and resiliently urged against said linings of said insulating member to make sliding electrical contact with said linings thereon, said contacts being spaced from each other a predetermined amount and said linings covering a predetermined peripheral surface portion of said insulating member so that said contacts are electrically connected to each other for only one half of the rotation of the respective rotary member.

4. Apparatus as claimed in claim 1, including first manually operable normally open switch means connected in parallel with said switching means movable by said rotary members and capable of rendering, upon being moved to closed position, said last mentioned switching means ineffective so as to cause increase of speed of said one of said rotary members; and second manually operable normally closed switch means connected in series with said switching means movable by said rotary members and capable, upon being moved to open position, to render said last mentioned switching means ineffective so as to cause decrease of speed of said one rotary member.

5. Apparatus for maintaining a predetermined relationship between the rotational speeds of independent rotary members, comprising, in combination, first and second motor means for driving the rotary members, respectively, to cause the latter to rotate, one of said motor means having a predetermined substantially constant speed; speed reducing means in circuit with the other one of said motor means; first and second switching means operable by said first and second motor means, respectively, and each being movable between circuit-opening and circuit-closing positions, in cycle with the rotation of said motor means, respectively, said first and second switching means being connected in parallel with each other and with said speed reducing means so as to constitute a by-pass for the latter when said first and second switching means are simultaneously in circuit-closing position, for regulating the energization of said other one of said motor means in such a manner that the respective rotational speeds of the rotary members are maintained in a predetermined relationship by said switching means maintaining said by-pass effective and said speed reducing means ineffective when the speed relationship differs from the predetermined one in a first sense, and by maintaining said by-pass ineffective and said speed reducing means effective when the speed relationship differs from the predetermined one in the other sense; and a by-pass circuit including speed responsive switch means operable by said other one of said motor means and connected in parallel with said first and second switching means for automatically by-passing said switching means when the rotational speed of said other rotational member is below a minimum speed being a predetermined speed difference below a speed having the predetermined speed relationship with said predetermined substantially constant speed of said one motor means.

6. Apparatus for maintaining a predetermined relationship between the rotational speeds of independent rotary members, comprising, in combination, first and second motor means for driving the rotary members, respectively, to cause the latter to rotate, one of said motor means having a predetermined substantially constant speed; speed reducing means in circuit with the other one of said motor means; first and second switching means operable by said first and second motor means, respectively, and each being movable between circuit-opening and circuit-closing positions, in cycle with the rotation of said motor means, respectively, said first and second switching means being connected in parallel with each other and with said speed reducing means so as to constitute a by-pass for the latter when said first and second switching means are simultaneously in circuit-closing position, for regulating the energization of said other one of said motor means in such a manner that the respective rotational speeds of the rotary members are maintained in a predetermined relationship by said switching means maintaining said by-pass effective and said speed reducing means ineffective when the speed relationship differs from the predetermined one in a first sense, and by maintaining said by-pass ineffective and said speed reducing means effective when the speed relationship differs from the predetermined one in the other sense; and a by-pass circuit including speed responsive switch means operable by said

11

other one of said motor means and connected in series with said one of said switching means for automatically rendering ineffective said one of said switching means when the rotational speed of said other rotational member is above a maximum speed being a predetermined speed difference above a speed having the predetermined speed relationship with said predetermined substantially constant speed of said one motor means.

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