United States Patent [19]

Deeran

[11] **3,832,044**

[45] **Aug. 27, 1974**

[54] **FILM LOOP CONTROL SYSTEM FOR SOUND MOTION PICTURES**

[75] Inventor: **Robert H. Deeran,** Derry, N.H.

[73] Assignee: **Poloroid Corporation,** Cambridge, Mass.

[22] Filed: **June 28, 1973**

[21] Appl. No.: **374,637**

[52] **U.S. Cl.** **352/14,** 352/180, 352/198, 226/42

[51] **Int. Cl.** **G03b 31/00**

[58] **Field of Search** 352/14, 72, 159, 29, 180, 352/198; 226/30, 42, 45; 242/183

[56] **References Cited**

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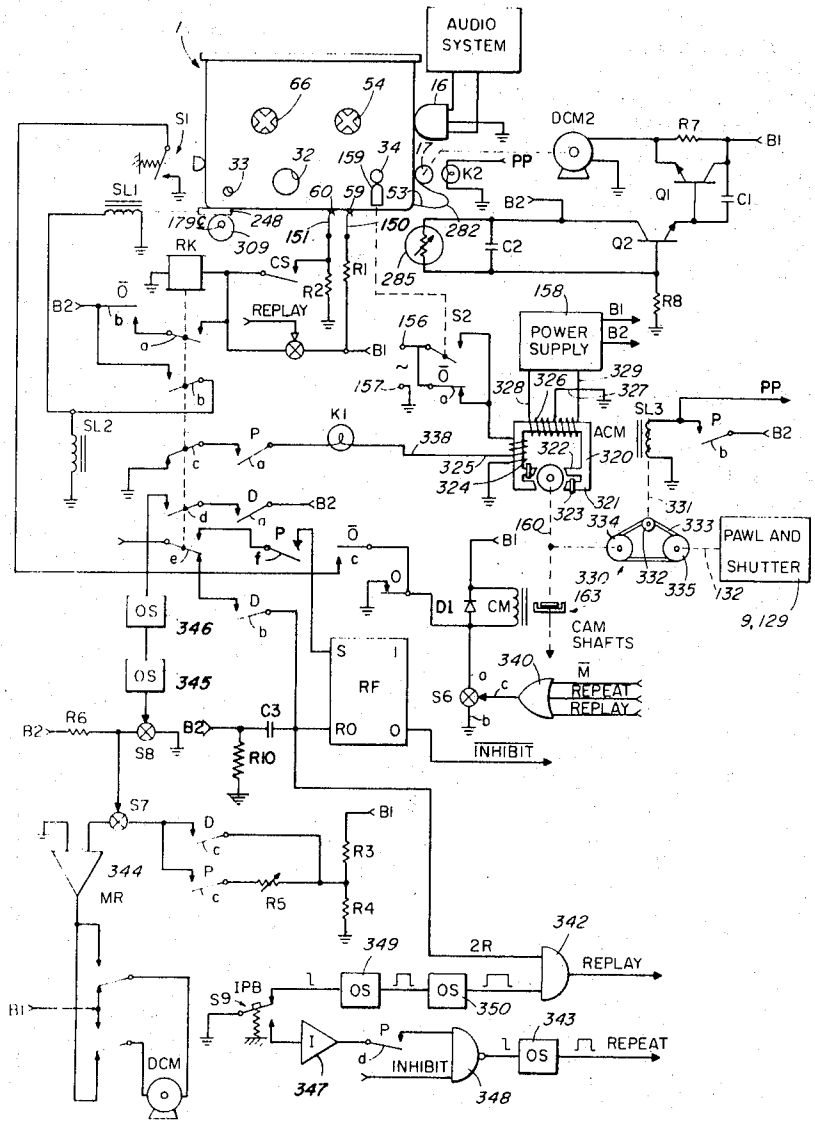
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Primary Examiner—Samuel S. Matthews
Assistant Examiner—Alan Mathews
Attorney, Agent, or Firm—John W. Ericson

[57] **ABSTRACT**

A film transport control system for a sound motion picture production and sound editing system, comprising a combined motor and transformer which serves to supply power to the apparatus, including power for the projection lamp, to drive a program control shaft that controls operation of the system for photographic processing, projection and rewinding operations, and to drive an incremental film advance pawl. A DC motor drives a capstan, to move the film at uniform speed past a transducer head, under the control of a photocell illuminated at times by a loop formed in the film between the sound head and the projection drive pawl driven by the combined motor and transformer. The photocell controls the motor through a two stage amplifier comprising two filtering capacitors to provide a long time constant control over the average speed of the capstan to reduce wow and flutter.

10 Claims, 19 Drawing Figures



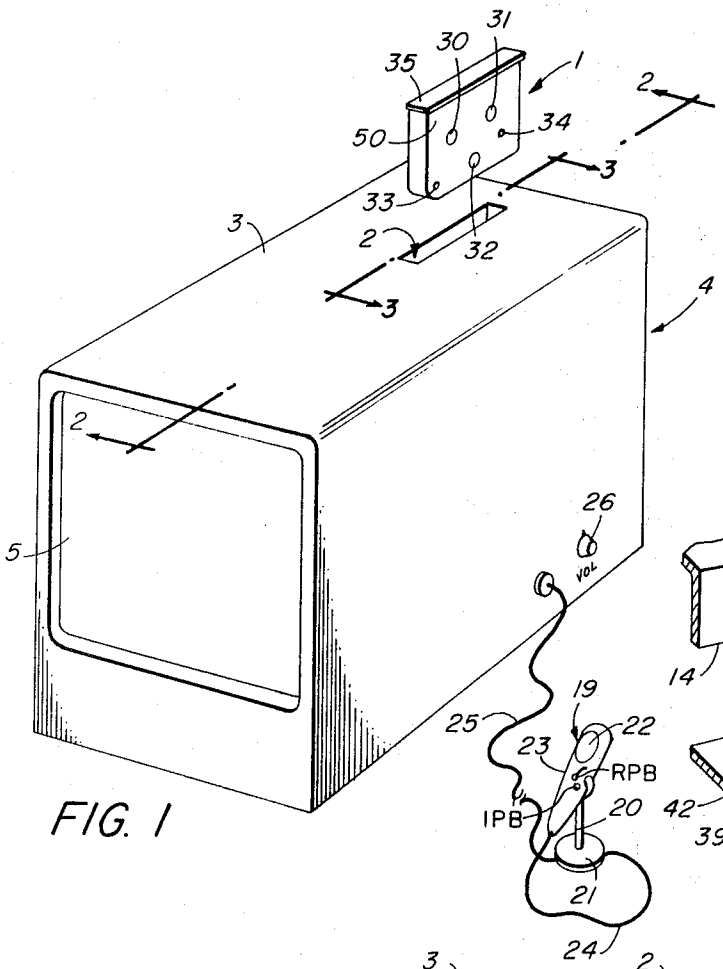


FIG. 1

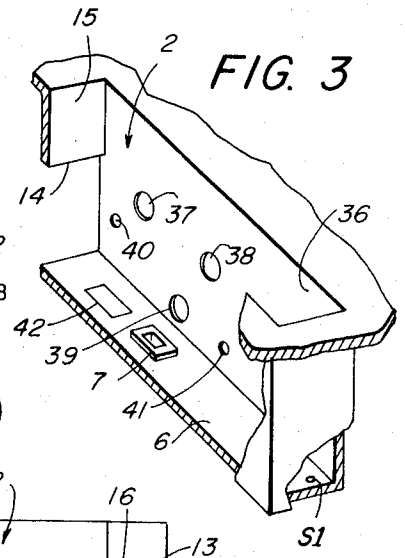


FIG. 3

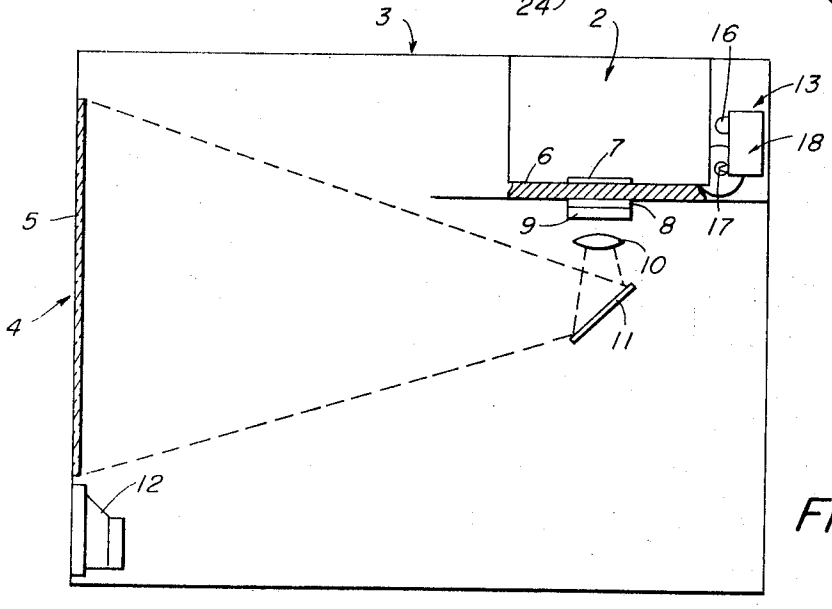


FIG. 2

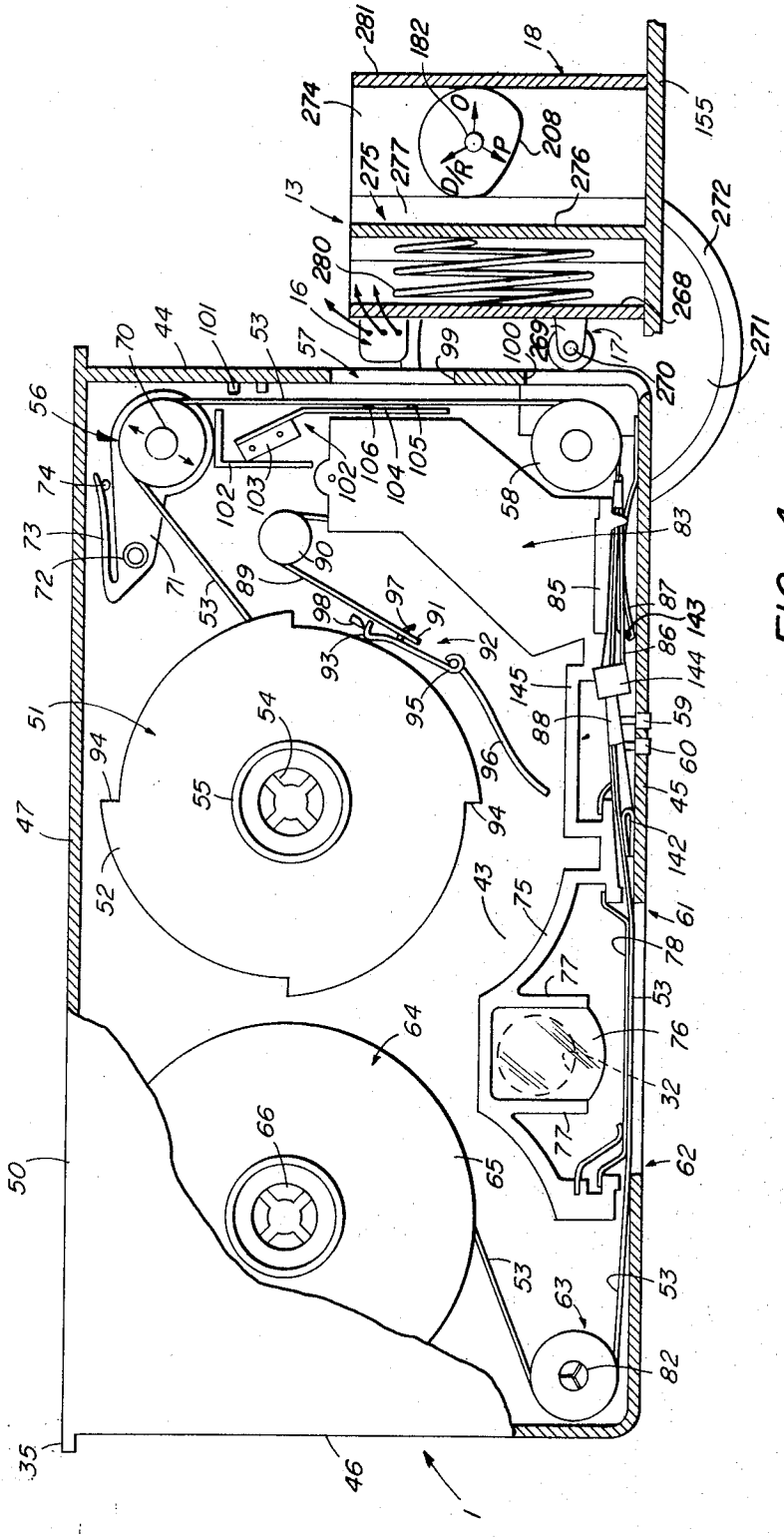

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FIG. 4

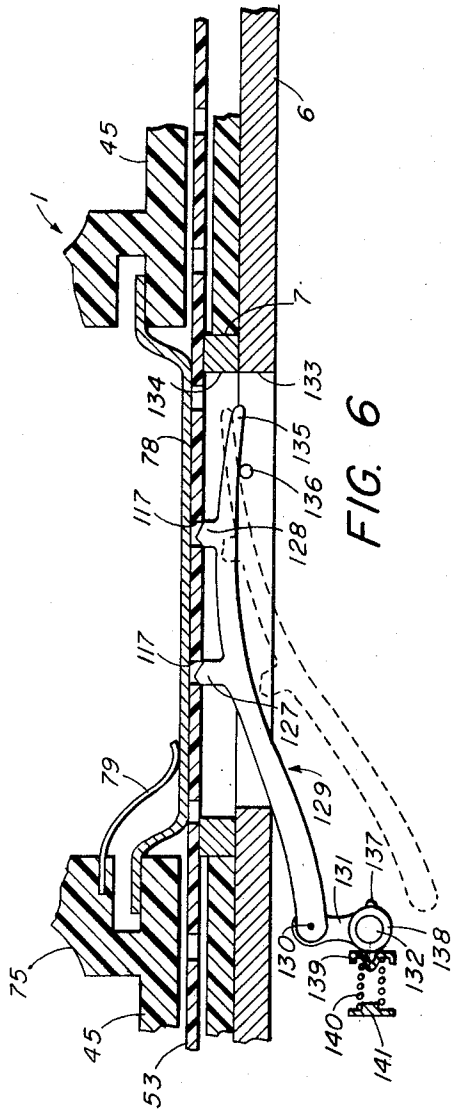

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6
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FIG. 6

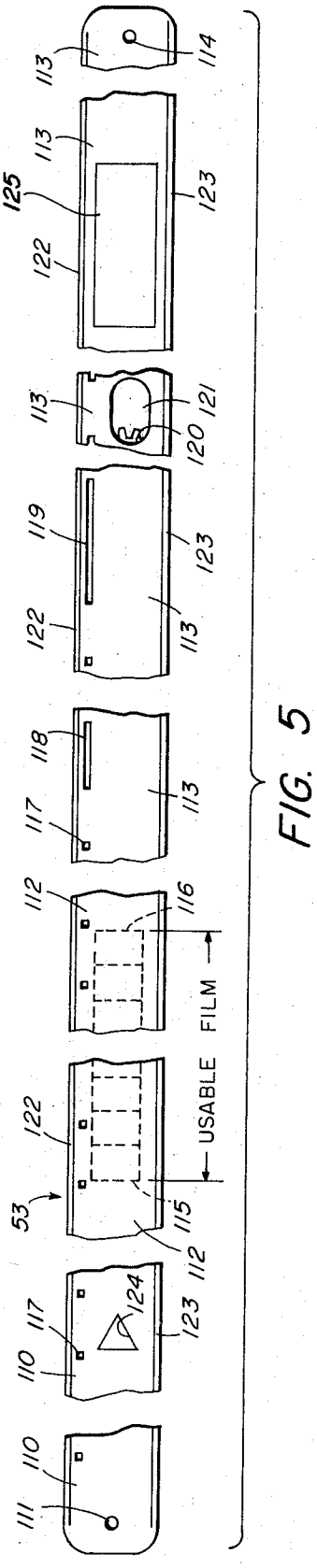

113
114
125
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123
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121
120
119
123
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118
117
113
112
116
FILM
USABLE
122
53
115
112
123
124
110
117
110
111

FIG. 5

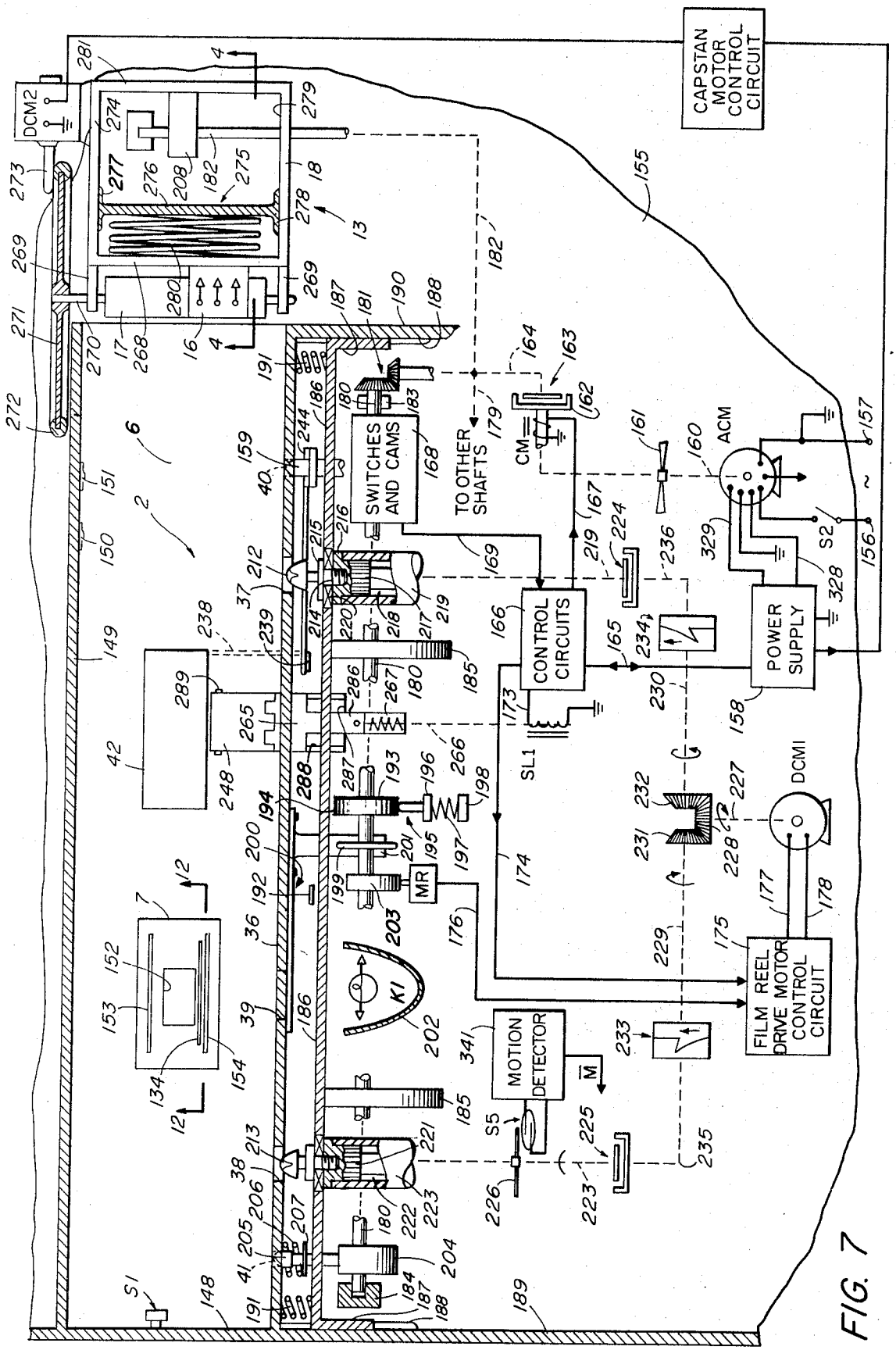

CAPSTAN MOTOR CONTROL CIRCUIT
DCM2
SWITCHES AND CAMS
TO OTHER SHAFTS
CM
ACM
CONTROL CIRCUITS
POWER SUPPLY
DCMI
MOTION DETECTOR
FILM REEL DRIVE MOTOR CONTROL CIRCUIT
MR
SL1
K1
S1
S2
S5
M

FIG. 7

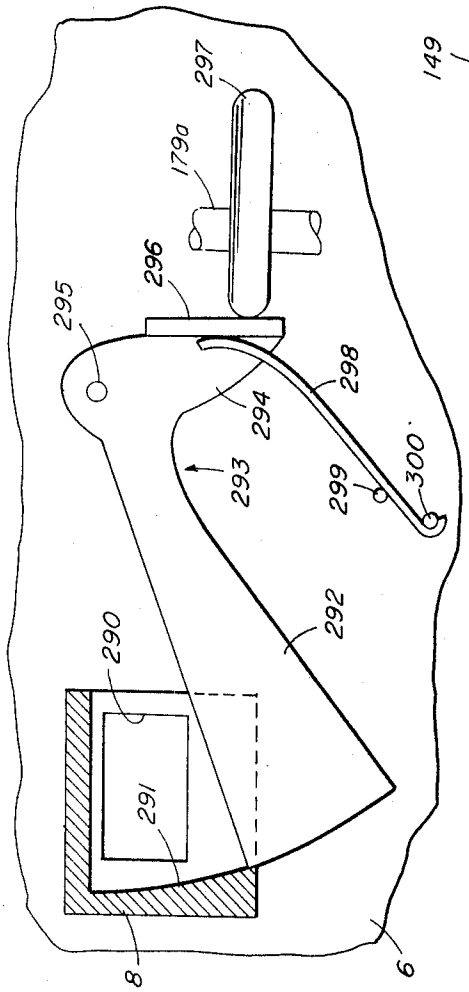


FIG. 9

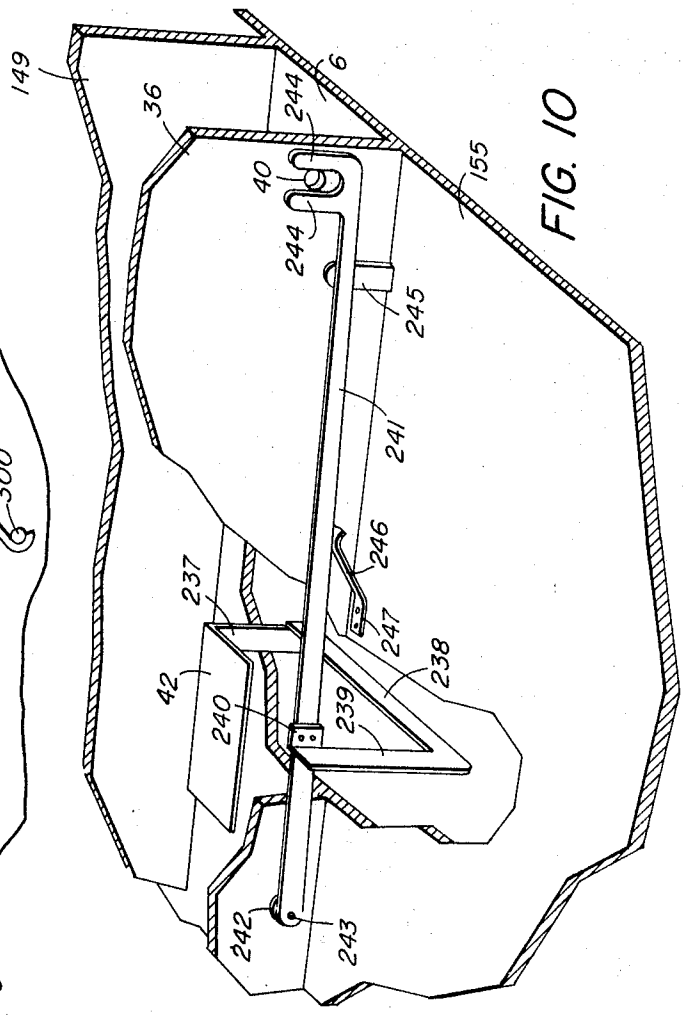


FIG. 10

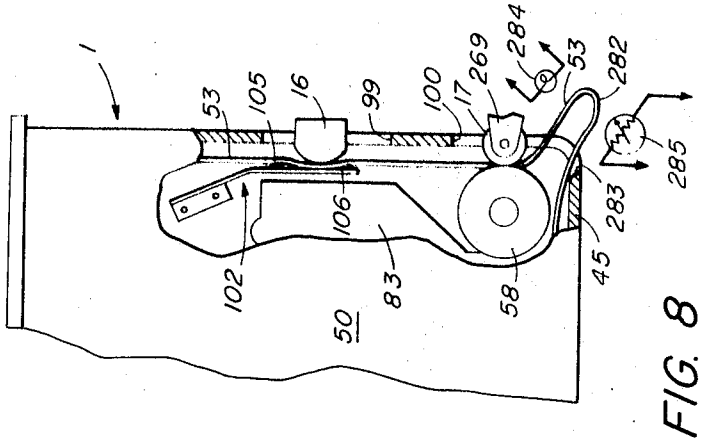


FIG. 8

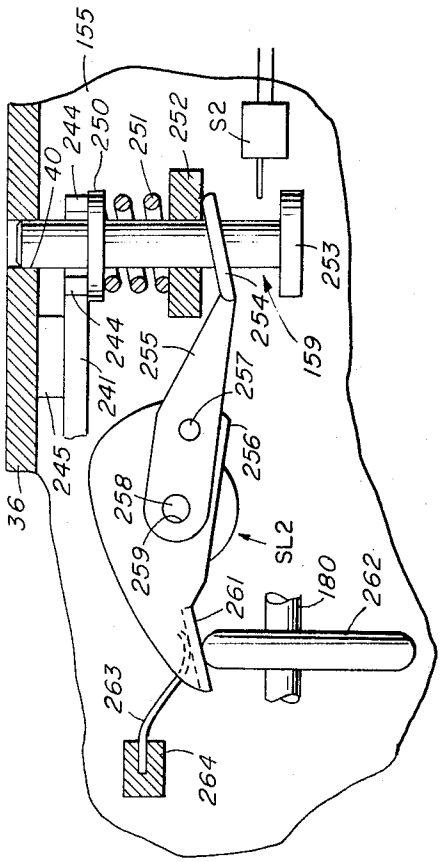

155
244
250
251
252
S2
40
253
254
159
244
241
255
257
245
256
258
259
SL2
261
180
262
263
264
36

FIG. 11

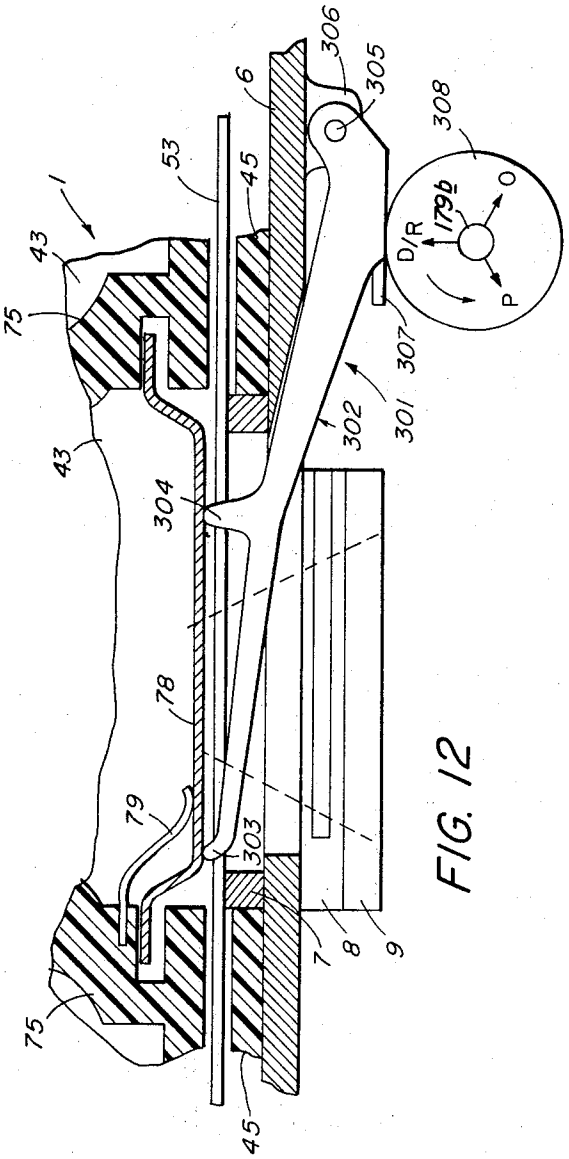

306
305
6
308
53
45
1
43
179b
D/R
O
P
75
307
302
301
43
304
78
79
303
7
8
9
75
45

FIG. 12

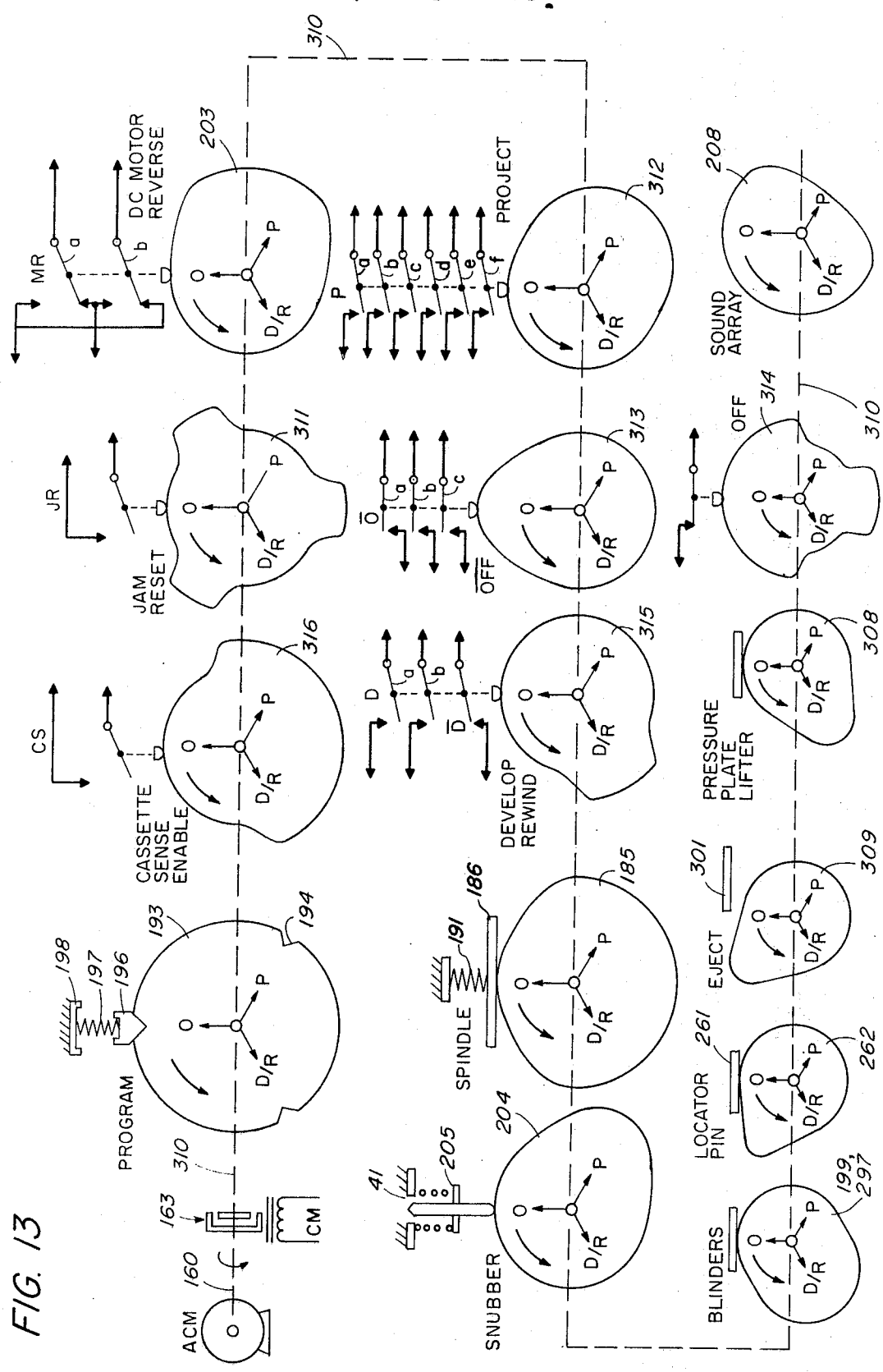

310
203
MR
DC MOTOR REVERSE
PROJECT
312
208
SOUND ARRAY
JR
JAM RESET
311
313
OFF
314
CS
CASSETTE SENSE ENABLE
316
DEVELOP REWIND
315
PRESSURE PLATE LIFTER
308
193
194
198
197
196
PROGRAM
186
191
SPINDLE
185
301
EJECT
309
261
LOCATOR PIN
262
163
CM
160
ACM
41
205
204
SNUBBER
199, 297
BLINDERS

FIG. 13

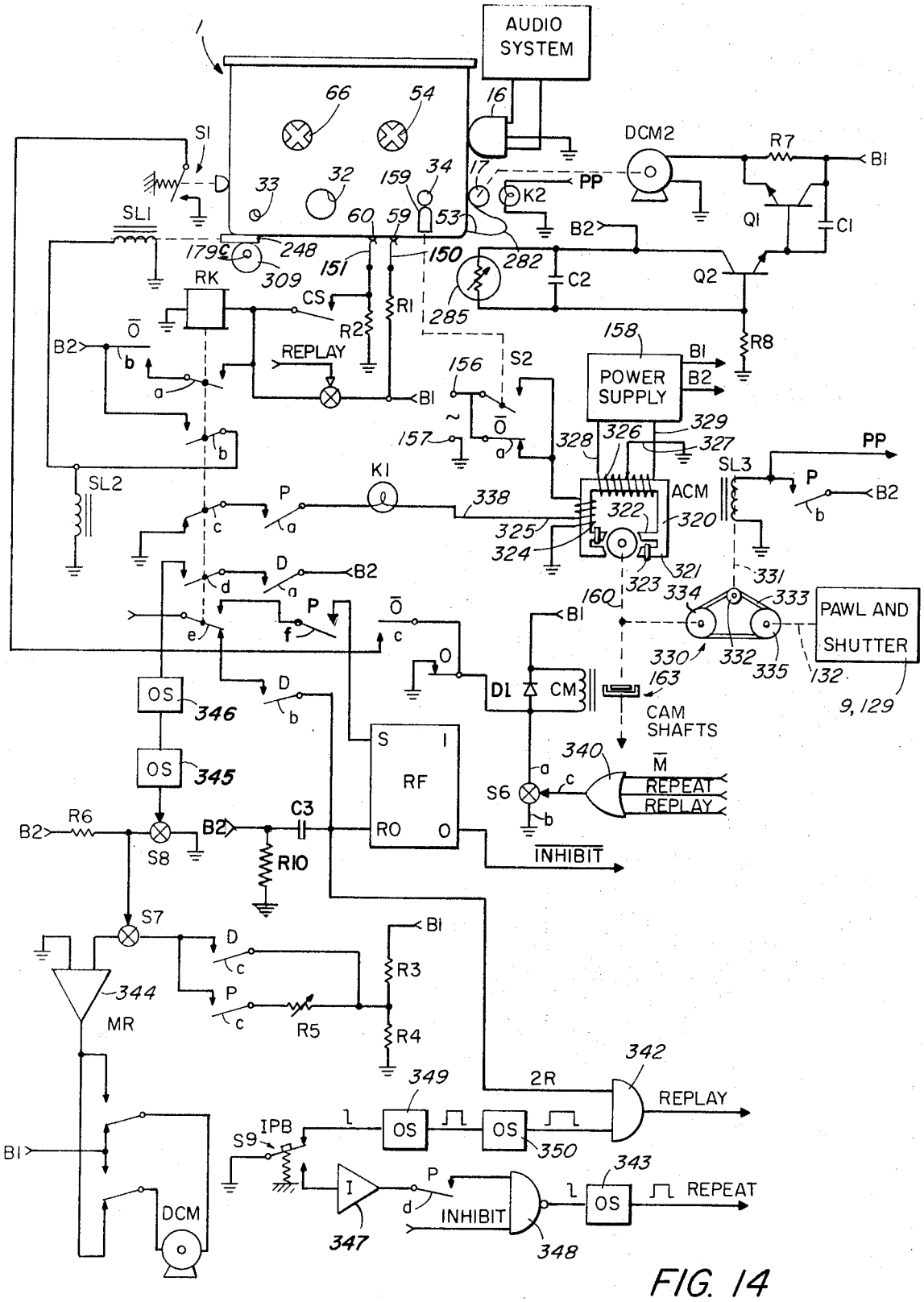

AUDIO SYSTEM
SI
SLI
RK
CS
R2
REPLAY
R1
S2
SL2
K1
P
D
B2
B1
POWER SUPPLY
ACM
SL3
PP
PAWL AND SHUTTER
9,129
CAM SHAFTS
DCM2
R7
Q1
C1
C2
Q2
R8
K2
OS
346
345
RF
S
I
RO
O
D1
CM
S6
M
REPEAT
REPLAY
INHIBIT
S8
R6
C3
R10
S7
MR
344
R5
R3
R4
2R
342
349
350
IPB
S9
343
REPEAT
347
348
DCM

FIG. 14

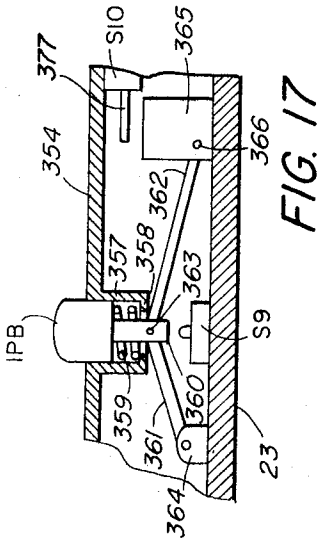


FIG. 17

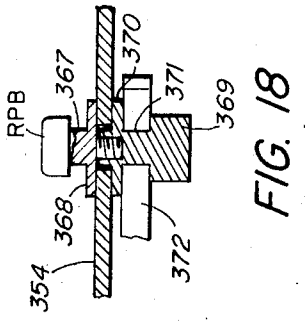


FIG. 18

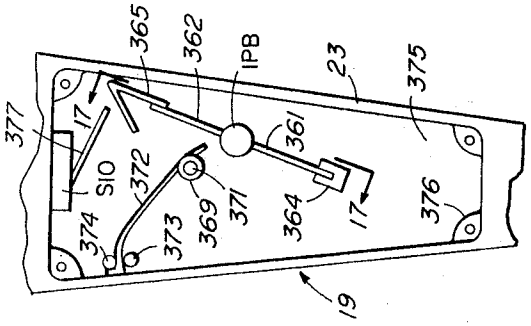


FIG. 16

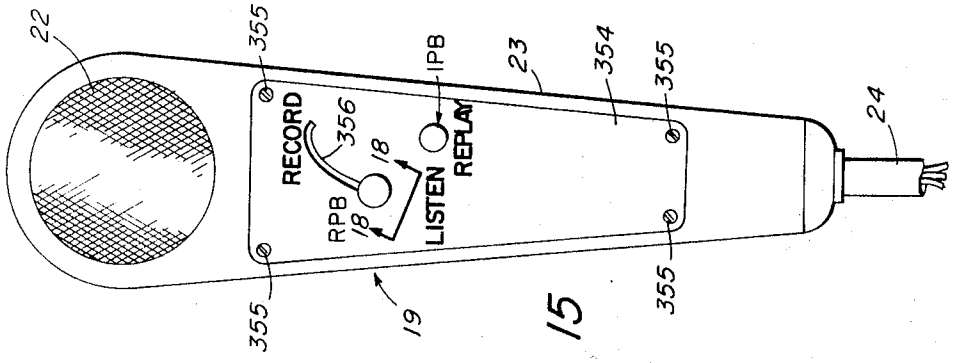


FIG. 15

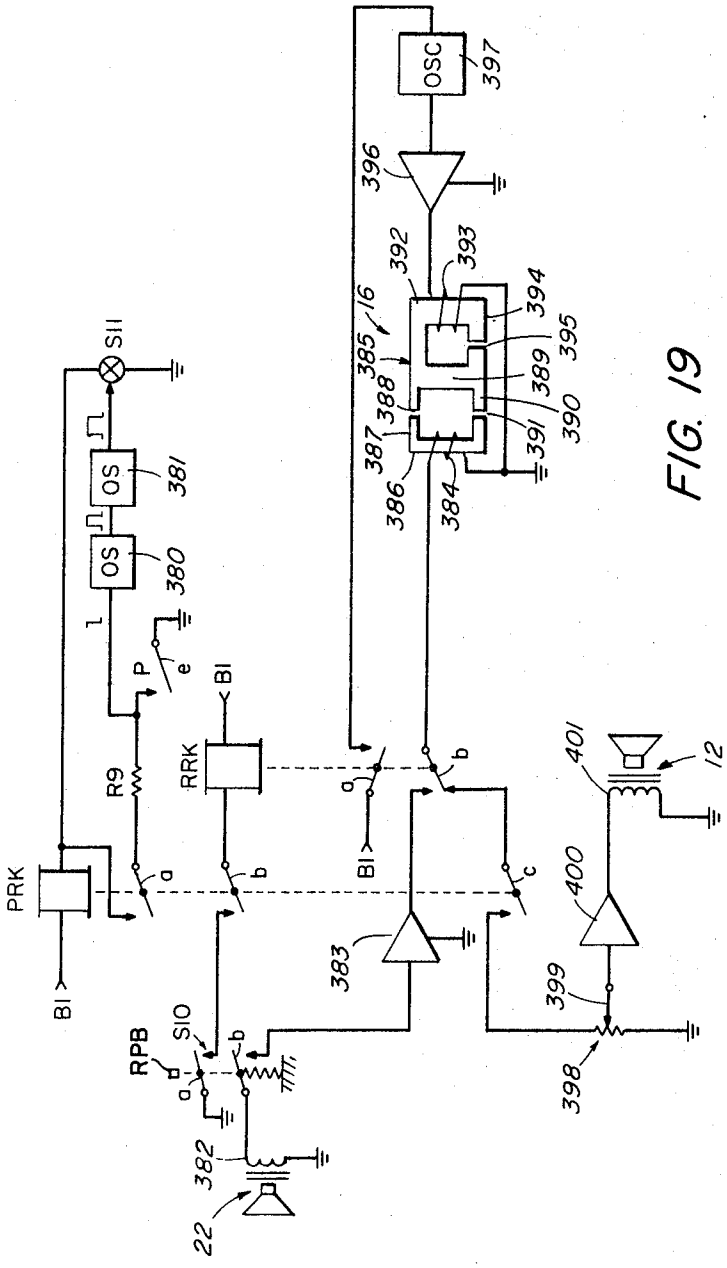

OSC
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SII
OS
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P
e
BI
R9
RRK
a
b
c
PRK
BI
RPB
SIO
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22
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400
401
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FIG. 19

FILM LOOP CONTROL SYSTEM FOR SOUND MOTION PICTURES

This invention relates to sound cinematography, and particularly to a novel sound motion picture producing and editing system.

In U.S. application for Letters Patent Ser. No. 227,080, filed on Feb. 17, 1972 by Edwin H. Land for Photographic System for Processing and Projecting Transparencies, and assigned to the assignee of this application, a motion picture processing and projection system is disclosed with which motion pictures can be processed and projected substantially as soon as they have been exposed. This system makes use of a film cassette containing a strip of film, a supply of processing composition for the film, and an internally programmed processor responsive to manipulation of the film in the cassette for applying the processing composition to the film after its exposure.

The cassette is adapted to be inserted in a camera, for exposure of the film. After exposure, it is inserted into a film drive and projection system. This system comprises a receptacle shaped to receive the cassette, and cyclic drive apparatus for manipulating the film in the cassette. The film is manipulated in a sequence determined by a signal provided by the cassette that indicates whether or not the film has been processed.

In response to the insertion of a cassette containing unprocessed film, the film drive and projection apparatus manipulates the film in the cassette in a lighttight environment. That movement of the film activates the processor, developing the film to produce a series of fixed, visible, projectable images. Thereafter, the apparatus manipulates the film in an optical system causing it to be projected for viewing. The film is then rewound, for storage and subsequent reuse. Finally, the cassette is ejected. In response to the insertion of a cassette containing processed film, the system simply projects the film, rewinds it, and then ejects the cassette.

It would be highly desirable to supplement a system of the type described in the above-cited application by incorporating the facility for recording sound on the film strip, either as it is being exposed in the camera, or after the images have been processed. Recording a sound track simultaneously with the exposure of the film to produce a satisfactory motion picture requires skills that not everyone possesses. However, once the picture sequence has been produced, it is not a matter requiring unusual talents to select a musical accompaniment, or to provide a descriptive vocal commentary, to add the aural dimension to the visual sequence and thus provide a gratifying entertainment experience not requiring inordinate skill and talent to produce.

The art of producing sound motion pictures is highly developed. For the professional, it is merely a matter of selecting one of the numerous sophisticated systems available in order to produce almost any conceivable visual and aural experience. For the amateur, however, who does not have unlimited funds, time and professional skills at his command, the essential elements of a satisfying sound motion picture production system are economy, convenience and simplicity. The object of this invention is to extend the capabilities of a sound motion picture processing and projection system of the kind described in the above-cited application to facilitate the addition of a sound track without unduly complicating the system, making it inordinately costly, or significantly taxing the skill of the user.

More particularly, the object of my invention is to extend the capabilities of an existing motion picture processing and projection system to enable the user to add and reproduce a sound track without vitiating the basic design concept of the system which enabled it to be reduced to practice in a simple, reliable form. In particular, in constructing a film processing and projection system in accordance with the above-cited application Ser. No. **227,080,** a high degree of interrelation between the requirements of the several elements of the system was sought and attained in order to achieve essentially fully automatic operation without seriously compromising size, weight and reliability.

Perhaps the most fundamental consideration underlying the successful implementation of an automatic system is the choice of the power supply. In the system described in the above-cited application Ser. No. 227,080, the power supply is basically required to perform three functions. One is to manipulate the film in the cassette to cause it to be processed, to be rewound, or to be projected. A second is to provide energy for implementing the decision-making process that begins when a cassette is inserted in the apparatus.

A third, and surprisingly demanding requirement, is that adequate light be provided for projection of the film after it has been processed. In the latter regard, the state of the art dictates the use of a projection lamp having a relatively low voltage, high current filament for maximum brillance and service life. Since it is obviously desirable to operate any home entertainment system from the conventional **120** volt AC source, some form of transformer for producing the operating voltage for the projection lamp is clearly indicated.

In order to reduce the cost, size and weight of the apparatus required, a combination shaded pole induction motor and transformer was chosen as the key element of the power supply. Windings on this combination motor and transformer were employed to energize a DC power supply, to energize a motor shaft to control film advance for projection, to operate a cycle control for the system, and to energize the projection lamp. The result is a very economical system, considering the complexity of its functions, which serves to process, project and rewind film in a cassette inserted in the apparatus. The addition of sound to this system, without making any basic changes in the combination power supply concept, is the central problem to which the invention here described poses a solution.

Both magnetic and optical methods of recording of sound on film for the production of sound motion pictures are well known in the art. Because it is desired to make the system with which the invention is concerned susceptible to the addition of sound to the film at any time, or to sound editing, magnetic recording was chosen as the most practical expedient. The reason is that optical recording does not lend itself to selective recording or editing independently of the development of the visual images on the film.

In order to record and reproduce sound on the film, it is also well known that the film must move smoothly and uniformly past the sound transducer, whereas an intermittent motion at the projection gate is essential. In order to produce these different types of film motion in the same film without interference, it is common to provide a capstan for driving the film past the sound

head, and a film drive pawl for intermittently moving the film past the film gate, separated by a loop of film which is intermittently shortened and lengthened to take up the instantaneous differences in speed of the film at the film gate and at the sound recording station.

In order to maintain synchronism between the picture and sound, it is conventional to provide a constant speed mechanism for controlling the capstan, and to control the average speed of the film drive pawl in accordance with the speed of the capstan motor to make the average film speed the same past the sound station and the film gate. It has been proposed to establish a constant average speed at the film drive pawl, and to use this speed as the standard for controlling the capstan, but that is not ordinarily done because the imposition of a conventional speed control on the capstan motor would result in intolerable wow and flutter in the recorded and reproduced sound.

However, in the self-processing motion picture system with which the invention is concerned, it is quite undesirable to regulate the speed of the combination motor and transformer, which, among other things, drives the film advance claw. The reason is that any conventional regulation of the speed of this combined motor and transformer would also regulate both the RMS and the peak-to-peak values of the voltages provided to the DC power supply and to the projection lamp. Variations in the RMS voltage would affect the brillance of the lamp in a noticeable manner, whereas variations in the peak-to-peak value of the AC voltage supplied to the DC power supply would result in regulation of the DC control voltages developed, which would necessitate expensive voltage-regulating equipment that would be undesirable additions to the cost and complexity of the apparatus. Accordingly, a particular object of the invention is to facilitate the synchronization of sound and picture by regulating the capstan drive rather than the film pawl drive.

Briefly, the above and other objects of the invention are attained by the construction of a novel sound motion picture production and sound editing system in which the projection lamp, the DC power supply, and the film pawl drive and programming shaft are all supplied with energy by a combination motor and transformer which is not regulated in speed. The DC power supply serves to energize a capstan drive motor which is controlled in response to the length of a loop of film between the sound station and the projection station by a very long time constant servomechanism. The servomechanism adjusts the average speed of the capstan to the average speed of the film drive pawl sufficiently rapidly to take care of normal fluctuations in line voltage causing variation in the speed of operation of the combined motor and transformer, without requiring constant speed regulation of either drive. The result is an effectively constant speed drive for the capstan which is not characterized by unacceptable degrees of wow and flutter, coupled with a lamp which is essentially characterized by a sufficiently constant brillance.

The manner in which the apparatus of the invention is constructed, and its mode of operation, will best be understood in the light of the following detailed description, together with the accompanying drawings, of an examplary embodiment thereof.

IN THE DRAWINGS

FIG. **1** is a schematic perspective sketch of an audio-visual system comprising a replaceable film cassette and a sound motion picture producing and sound editing system in accordance with the invention;

FIG. **2** is a schematic elevational view, with parts shown in cross-section and parts broken away, of the producing and editing system of FIG. **1**, taken substantially along the lines **2—2** in FIG. **1**;

FIG. **3** is a schematic fragmentary perspective sketch of a portion of a cassette receiving receptacle in the producing and editing system of FIG. **1**, taken substantially along the lines **3—3** in FIG. **1**;

FIG. **4** is a schematic plan sketch, with parts omitted, parts shown in cross section, and parts broken away, of a film cassette in accordance with the invention, shown in conjunction with a sound array forming a part of the producing and editing system of FIGS. **1, 2** and **3**;

FIG. **5** is a fragmentary schematic plan sketch, with parts broken away, of a film strip forming a part of the cassette of FIG. **1**;

FIG. **6** is a schematic elevational cross-sectional sketch of a film drive mechanism forming a part of the apparatus of FIG. **1**, shown in conjunction with a portion of a cassette cooperating therewith;

FIG. **7** is a schematic fragmentary plan view, with parts shown in cross section, parts omitted, and parts broken away, illustrating a portion of the producing and editing system of FIG. **1**;

FIG. **8** is a fragmentary schematic view of portions of the cassette and sound array of FIG. **4**, showing elements of the sound array engaged with the film in the cassette;

FIG. **9** is a fragmentary schematic plan view, with parts omitted, parts shown in cross section, and parts broken away, of a blinder mechanism forming a part of the apparatus of FIGS. **2** and **7**, in one position assumed during its operation;

FIG. **10** is a fragmentary schematic perspective sketch of a locating pin latching mechanism forming a part of the apparatus of FIG. **7**;

FIG. **11** is a fragmentary schematic plan sketch, with parts omitted, parts shown in cross section, and parts broken away, of a locator pin and its actuating mechanism forming a part of the apparatus of FIG. **7**;

FIG. **12** is a schematic cross-sectional elevation of a portion of the apparatus of FIG. **7** taken substantially along the lines **12—12** in FIG. **7** and showing a pressure plate lifting mechanism in its cooperative relationship with a cassette;

FIG. **13** is a schematic block and wiring diagram of a cam shaft and associated parts forming part of the apparatus of FIG. **7**;

FIG. **14** is a schematic block and wiring diagram of control circuits forming a part of the apparatus of FIGS. **1** and **7**;

FIG. **15** is a schematic elevational view of a recording, replay and editing control forming a part of the system of FIG. **1**;

FIG. **16** is a fragmentary schematic view of a portion of the apparatus of FIG. **15**, with parts omitted and parts shown in cross-section;

FIG. **17** is a schematic fragmentary cross-sectional view of a portion of the apparatus of FIGS. **15** and **16**, taken essentially along the lines **17—17** in FIG. **16**;

FIG. 18 is a schematic fragmentary view of another portion of the apparatus of FIG. 15, taken essentially along the lines 18-18 in FIG. 15; and

FIG. 19 is a schematic wiring diagram of sound recording, erasing and reproducing apparatus forming a part of the producing and editing system of FIG. 1.

FIG. 1 shows the external cooperative aspects of an audiovisual system embodying the invention. The basic elements of this system are a cassette 1, adapted to be inserted in a pocket 2 formed in the outer housing 3 of a sound motion picture producing system generally designated 4. A translucent viewing screen 5, on which projected images at times appear, is mounted at the front of the housing 3.

As best shown in FIG. 2, the pocket 2 has a floor 6 on which an aperture plate 7 is mounted. The aperture plate 7 is adapted to extend into the cassette such as 1 and there register with the film in the cassette. Light, supplied in a manner to be described, passes through the film, and thence over a path traversing a suitable framing aperture in the aperture plate 7, a cooperating recess in the floor 6, a blinder housing 8, to be described, and a conventional shutter 9, to a lens 10. The lens focuses an image of the portion of the film selected by the framing aperture on a mirror 11, whence it is reflected to the screen 5.

A speaker 12 is mounted in the housing 3 of the system 4 at the front and below the screen 5 as indicated schematically in FIG. 2. The speaker 12 is at times energized to produce sound recorded on the film in the cassette 1 in a manner to be described. For that purpose, a sound array generally designated 13 is mounted in the housing 3 just behind the pocket 2, and communicates with a cassette in the pocket 2 through an aperture 14, FIG. 3, formed in an end wall 15 of the pocket 2. The sound array 13 generally comprises a combined recording, playback and erasing head 16, and a film drive capstan 17, mounted on a suitable support generally designated 18, and to be described in more detail below, so that it can be moved into and out of engagement with film in the cassette 1.

As shown in FIG. 1, an editing control unit generally designated 19 is removably mounted on a stand 20 having a base 21. The control unit 19 comprises a microphone 22 mounted in a suitable housing 23 adapted to be grasped in the hands of the user, and provided with a replay push button IPB and a two-position record-listen push button RPB, constructed and arranged in a manner to be described in detail below. The unit 19 is electrically connected to the base 21 of the apparatus by means of a flexible cable 24, which may be continuously connected to a cable 25 that electrically connects the remote assembly to the housing 3. A volume control 26 mounted on the exterior of the housing 3 enables the user to select the volume produced by the speaker 12 in a manner to be described.

As shown in FIG. 1, the cassette 1 is provided with a number of light-baffled openings 30, 31, 32, 33 and 34. These openings expose parts adapted to cooperate with corresponding parts of the film drive and projection system to perform various functions in the cassette. Thus, a drive sprocket formed on the takeup reel is accessible through the opening 30. A similar drive sprocket formed on the supply reel is accessible through the opening 31. Projection light is at times admitted to the cassette through the opening 32. A stop can enter, to brake a snubber roll forming a part of the cassette, through the opening 33. The opening 34 serves to admit a locating pin, forming a part of the motion picture producing and sound editing system to latch the cassette in position for manipulation, and to energize the producing and editing apparatus in a manner to be described.

A flange 35 is formed on the upper end of the cassette 1. This flange aids in grasping the cassette while inserting it in, or removing it from, the pocket 2. It also helps to fix the cassette in position in the producing and editing system, by engagement with the rim of the pocket 2.

Referring to FIG. 3, parts adapted to enter the openings in the cassette 1 just described at times enter the pocket 2 through corresponding openings in the side wall 36 of the pocket. Drive sprockets for the supply and takeup reels are adapted to enter through openings 37 and 38, respectively. A light beam for projection enters through an opening 39. The locating pin enters through an opening 40. The snubber roll stop enters through an opening 41.

In addition to the aperture plate 7 described above, the actuating arm of a normally open switch S1 is movably mounted on the floor plate 6. This switch is adapted to be closed when a cassette is inserted in the pocket 2, for purposes to appear.

A foot pedal 42 is movably mounted in the pocket 2 to be depressed by the insertion of a cassette. The foot pedal is connected to an actuating arm extending through the floor plate 6, as will be described below.

FIG. 4 shows, in part fragmentarily and in part schematically, the pertinent elements of an internally programmed cassette 1 adapted for use in the system of the invention. Except as modified in a manner to be described, the cassette may be constructed in the manner described in detail in the above-cited U.S. application Ser. No. 227,080.

The cassette comprises a housing formed of any suitable opaque material such as metal, plastic, or the like, and preferably manufactured in two cooperating parts.

The housing parts comprise a base plate 43 formed integral with side walls 44, 45, 46 and 47. The base plate 48 extends across the base of the side walls, and comprises one side of the housing, The walls 44, 45, 46 and 47 extend at least in part about the periphery of the base plate 43, and cooperate with interfitted walls, shown and described in the above-cited U.S. application Ser. No. 227,080, formed integrally with a cover generally designated 50. The cover plate 50 completes the upper side of the housing as seen in FIG. 4.

When the cover 50 is placed in position, it may be formed integral with the base plate and side walls by heat sealing, or by a suitable adhesive, or the like. If of metal, the inter-fitting parts may be interlocked with cooperating detents formed therein, in a manner conventional and well known to those skilled in the art.

The base and cover parts form, when assembled, the end flange 35 that serves to support and locate the cassette 1 in either a camera, or in the motion picture producing and editing system of FIG. 1.

Rotatably disposed within the cassette housing is a supply reel generally designated 51. The reel 51 is provided with an upper flange 52 and a corresponding lower flange, not shown, to guide a film strip 53 as it is wound about the spool portion of the reel 51, not

shown, to which one end of the film strip **53** is attached.

A sprocket schematically indicated at **54** may be formed integral with the reel **51** to adapt the reel to be driven about its axis of rotation. Access to the sprocket **54** may be provided through the aperture **31** in the cover plate **50** (FIG. **1**), light-baffled by suitable conventional annular flanges, such as **55**, formed on the upper surface of the flange **52** (FIG. **4**), and cooperating with corresponding coaxial flanges, not shown, on the inner side of the plate **50.** The lower flange of the reel **51** may be formed in a conventional manner with a cylindrical axial opening to receive a cooperating axle, not shown, formed integral with the base plate **43.**

Initially, the film **53** is in its unexposed state and coiled primarily about the supply reel **51.** It is shown in FIG. **4** in the position assumed as it nears the end of its movement away from the supply reel, as toward the end of exposure in a camera, in which it is nearly exhausted from the reel **51.**

In its path from the supply reel **51,** the film **53** first encounters a bobulator roll **56.** The film engages a portion of the periphery of the bobulator roll, as shown, and passes therefrom into a suitably light baffled sound recording and reproducing station generally designated **57.** The sound station terminates with the passage of the film **53** over a backup roller **58.** The film is at times engaged by the capstan **17** acting through the film against the roller **58,** whereupon the film is driven smoothly through the sound station, as will appear.

The roller **58** is journalled for rotation in the cassette housing. From the roller **58,** the film **53** passes through film processing means, to be described below. In addition to the apparatus for processing the film in a manner to be described, the film processing means comprises a signal generator for producing an external condition signal on terminals schematically indicated at **59** and **60,** to indicate whether or not the processing means has been actuated.

Beyond its path through the film processing means, the film **53** extends through a conventional light-baffled aperture schematically indicated at **61** and forming a portion of a film gate in the housing. The film **53** reenters the housing through a second light-baffled aperture generally deisgnated **62** and comprising a second portion of the film gate.

The film **26** next passes over a conventional snubber roll, generally designated **63,** and finally passes to a takeup reel generally designated **64,** comprising a spool portion to which the takeup reel end of the film is connected, and about which the film is wound as suggested in FIG. **4.**

In addition to parts corresponding to those parts described in connection with the supply reel **51,** the takeup reel **64** comprises an external upper flange **65** protruding beyond the maximum radius of the film **53** when substantially stored on the takeup reel. On the flange **65** is formed a suitable drive sprocket **66,** by means of which the film can be selectively advanced in a manner to be described.

The bobulator may be of any conventional construction suitable for the performance of the known function of isolating the film drive pawl associated with the camera from the inertia of the supply reel **51.** However, it is preferably of the form shown, in which the bobulator roll **56** is journalled on a pin **70** for rotation by the film.

The pin **70** is formed integral with a support **71** of plastic or the like. The support **71** is journalled to the base plate **43** by means of a pin **72** formed integral with the base plate, and biased by a spring **73** formed integral with the support **71.** The spring **73** acts against a post **74** formed integral with the base plate **43.** The bobulator roll **56** can thus both rotate about the pin **70,** and move backwards and forwards in the directions of the double arrow, shown in FIG. **4.**

The bobulator roll responds to increases or decreases in the tension of the film **53** by temporarily shortening or lengthening the film path, respectively. Such changes in film tension are produced by the actuation of the film drive pawl in the camera, and are determined by the inertial forces exerted by the supply reel **51,** together with the larger or smaller supply of film that may be on it at any given time. By that arrangement, as the film is advanced incrementally by the pawl associated with the camera, it can rapidly move the bpbulator roll against the spring **73** without immediately affecting the supply reel, which can then more or less gradually allow the bobulator roll to relax while supplying the segment of film taken by the pawl. As mentioned above, the film is driven smoothly through the sound station by the capstan **17,** so that the bobulator functions only as an idler in the motion picture producing and sound editing system of the invention.

A lighttight shield around the film gate formed by the apertures **61** and **62** is formed by a wall portion **75** formed integral with the base plate **43** and made integral with the cover plate **50** after assembly of the parts in the manner described above. An exposed chamber behind the film **53** is thus formed for the purpose of admitting projection light.

The apparatus for this purpose is conventional, and will only briefly be described. In short, it comprises a prism generally designated **76** and comprising a mirror, not shown, but disposed at 45° to the plane of FIG. **4.** As schematically indicated, the prism **76** is mounted between extensions **77** formed on the wall **75.**

Light enters the cassette through the port **32** formed in the cover plate **50** in directions normal to the plane of FIG. **4.** The mirror in the prism **76** directs this light downwardly through the film **53** in the film gate for the projection of images on the film through the lens **10** (FIG. **2**).

Also disposed in the chamber bounded by the wall member **75** and the film passing through the film gate is a conventional pressure plate **78,** located between the prism and the film, and biased by a spring **79** into engagement with the film. The spring **79** is supported and retained by suitably shaped extensions of the support wall **75,** as shown.

The pressure plate serves in the conventional manner to cooperate with a camera, by locating the focal plane of the film during exposure. An aperture, not shown, is provided in the pressure plate **78,** to pass light entering through the prism assembly **76** through a selected frame of the film **53,** after the film is processed in a manner to be described. It is preferred that the aperture in the pressure plate be somewhat larger than the frame to be projected so that the aperture in the aperture plate **7** (FIGS. **2** and **3**) serves as the limiting aperture bounding the projected frame.

The snubber roll **63** may also be of entirely conventional construction. As illustrated, it is provided with a hub portion schematically indicated at **82** that is adapted to protrude through the (suitably light-baffled) aperture **33** in the cover panel **50** for engagement by a stop member, comprising a part of either the camera or of the motion picture producing and editing system. The stop member engages the snubber roll when the film is to be incrementally advanced by a pawl for exposure or projection purposes. The cooperation between the snubber roll **63** and the takeup reel **64** is conventional, but will be briefly described.

The drive sprockets **54** and **66** of the supply and takeup reels **51** and **64,** respectively, are adapted to be engaged by corresponding drive sprockets comprising a part of a camera, or of the producing and editing apparatus to be described. In the producing and editing apparatus, both supply and takeup reels are adapted to be driven through slip clutches. In the camera, only a drive for the takeup reel need be provided. This drive comprises a slip clutch connected to a sprocket driving the takeup reel drive sprocket **65,** in cooperation with a drive pawl for sequentially engaging a series of the sprocket holes **38** formed in the film **26,** along a portion of the edge of the film in the film gate between the apertures **60** and **61.**

When the snubber roll **62** is stopped by engagement of the hub **82** as described above, operation of either the camera or of the production and editing system to incrementally advance the film towards the takeup reel, by engagement of a pawl with the sprocket holes in the film **26,** will momentarily loosen the film from engagement with the stationary snubber roll **62** and allow the slip clutch driving the takeup reel **63** to takeup that increment of the film advanced by the pawl. Between engagements of the pawl, the slip clutch prevents the takeup reel from advancing the film.

In the production and editing system to be described, the snubber roll **63** is engaged only while the film is to be incrementally advanced onto the takeup reel. When the film is rewound onto the supply reel, the snubber roll **63** is disengaged and acts as an idler. As will appear, that may occur either during the processing of the film while rewinding, or during subsequent rewinding of the processed film after projection.

The film processing means may be as described in the above-cited U.S. application Ser. No. 227,080, except as modified in a manner to be described. As shown in FIG. **4,** the apparatus generally comprises wall means comprising portions of, or formed integral with, the base plate **43** and the cover plate **50,** which serve to guide, support and house the various elements of the processing apparatus to be described. These walls form an outer film composition containing housing generally designated **83,** defining a chamber in which there is mounted an initially sealed container of processing composition as fully described in the above-cited U.S. application Ser. No. 227,080. The container **83** communicates with a coating nozzle generally designated **85.** These elements are mounted above the plane of the film **53.**

Principally located below, but in part surrounding, the film **53** is a pressure pad generally designated **86.** The pressure pad is acted on by a spring, generally designated **87,** as fully described in the above-cited U.S. application Ser. No. 227,080.

The basic elements of the processing station further comprises a combined metallic pressure pad deflection can and nozzle closure valve assembly generally designated **88,** and the pair of electrical terminals **59** and **60** mentioned above. The terminals **59** and **60** are bridged by the valve assembly **88** before the film is processed to provide a low impedance electrical signal. The valve assembly **88** is moved after the film is processed to open the circuit path between the terminals **59** and **60** to produce a high impedance between the terminals **12** thereafter, as fully described in application Ser. No. 227,080.

A pod of processing composition within the container **83** is initially sealed by one end of a tear-tab generally designated **89.** The tear-tab **89** extends from sealing engagement with the plastic pod of processing composition in the container **83,** out through a suitable slot in the container **83,** and over a roller **90** in the cassette housing to an end **91** connected to a release arm generally designated **92.**

The release arm **92** may be formed of thin sheet spring metal, bent over at one end **93** to form a hook adapted to engage one of a set of teeth **94** formed on the flange **52,** and corresponding teeth formed on the lower flange of the supply reel **51.** The arm **92** is secured at one end to a pin **95** that is adapted to slide in curved guide slots such as **96,** one formed in the base plate **43,** and the other, not shown, in the cover plate **50.** A hook **97** on the release arm **92** extends through a suitable aperture in the tear-tab **91.** When the supply reel is rotated counterclockwise as seen in FIG. **4,** as during exposure of the film in the camera, the hook **93** formed on the arm **92** is not engaged by the teeth **94,** but is simply brushed up into engagement with a fixed support **98** secured to the base plate **43.** On the other hand, when the supply reel **51** is first rotated clockwise as seen in FIG. **4,** as to rewind the film on the supply reel, one of the teeth **94** catches the hook **93** and drives the arm **92** downward under the guidance of the slots **96,** pulling the tear-tab **89** partly out of the container **83** and releasing the processing composition in the manner fully described in the above-cited copending application Ser. No. 227,080. The arm **92** will carry the tear-tab down until it is moved out of engagement with the supply reel **51** as the slot **96** diverges from the path of the teeth **94.** This arrangement replaces the more complex mechanism described in the cited application Ser. No. 227,080, and relies on the fact that once the film is exposed, it will not be rewound on the supply reel until it is desired to process it.

As indicated, the end wall **44** of the cassette **1** is modified by the provision of a first aperture **99,** adapted to receive the sound head **16,** and a second aperture **100,** adapted to admit the capstan **17** and to permit the escape of a small loop of film in a manner to be described. A container **83** and walls such as **75** in the lower side of the cassette housing serve as light shields for the openings **99** and **100** over that region of the cassette. Additional light baffles suggested as ribs **101** and a wall **102** defining the upper end of the sound station **57** serve to provide light baffles for film beyond that station in the upper directions.

A backup spring generally designated **102** is mounted behind the film in the sound station **57.** The spring is formed with one end bent over as indicated at **103** and there secured to the base plate **43.** An extending arm **104** of the spring carries a pair of raised film engaging

portions **105** and **106** that serve to receive and support the film **53** as the head **16** is moved into engagement with it in a manner to be described. Spacing of the raised portions **105** and **106** causes a desirable partial wrapping of the film **53** around the sound head **16.**

As in the photographic system described in U.S. application Ser. No. 227,080, the system of the invention makes use of a photofinishing process in which the strip of film **53,** following exposure in the camera, is contacted with a single processing composition to form a finished transparency from the latent image or images formed on the film during its exposure. In order to provide sound recording and reproducing capabilities, a magnetic sound track is provided along one or both edges of the film, as will next be described with reference to FIG. **5.**

As shown in FIG. **5,** the film strip **53** comprises a leader **110** terminating at an end formed with an aperture such as **111.** The aperture **14** serves to connect that end of the film to the takeup reel **64.**

Behind the leader, which may be in the neighborhood of 18 inches in length, there is a strip **112** of photographically useful film, upon which projectable images may be formed. The strip **112** may be, for example, approximately 50 feet in length for 8 mm film.

Following the photographically useful portion of the film is a trailer region generally designated **113.** The trailer **113** terminates at another end formed with an aperture **114** by means of which that end of the film is adapted to be connected to the supply reel **51.**

The film **53** may comprise a base of any suitable transparent material of the kind conventionally used for film bases. On this base is applied, at least over the central portion of the photographically usable length of the film **112,** an emulsion comprising a photosensitive coating, whereon a series of latent images illustrated by a series extending from a first frame **115** to a last frame **116** may be formed with a camera. The photosensitive coating is preferably of one of the forms, next to be described, which can subsequently be processed to form a projectable image on the film base.

Photosensitive coatings usable in the practice of the invention may be of any conventional variety adapted to be developed by a monobath processing composition to form a positive transparency suitable for projection. In particular, a currently preferred embodiment of the invention makes use of a film structure, which, upon the base, comprises a photosensitive layer including both a photosensitive negative emulsion and an image-receiving layer to which a positive image may be transferred by diffusion during development without necessitating the subsequent removal of the emulsion containing its developed negative image. This highly desirable feature is made possible by a developed negative image having low covering power.

In typical silver transfer reversal processes for the projection of black and white images, a silver halide developer and a silver halide solvent are applied in an aqueous alkaline solution to a photoexposed silver halide emulsion stratum, where they develop exposed silver halide to silver, and react with unreduced silver halide to form a soluble silver complex. This complex, in order to form a positive print, is transferred and reduced to silver on a silver-receptive stratum upon which the silver halide stratum has been superposed.

In one practice, in the completion of this process, the silver-receptive and silver halide strata have been separated in order to render the positive print visible. However, as indicated above, the positive print may be rendered visible without separation of the silver halide and the silver-receptive strata. For example, the silver-receptive stratum may be so constructed as to provide an unusually vigorous silver precipitating environment which causes the silver deposited upon it, in comparison with silver developed in the silver halide stratum, to possess very high covering power, i.e., opacity for a given mass of reduced silver. If the silver halide is in such a concentration as to give rise only when fully developed to a predetermined low maximum density, and if the silver complex is reduced to silver in a vigorous silver precipitating environment, the resulting negative and positive prints in superposition provide a composite print that presents a good image for projection purposes so long as they are contained on a transparent support. Since the silver halide stratum and the silver-receptive stratum need not be separated, an overall simplification of the silver transfer reversal process is achieved.

A composite film assembly of this type, as well as processing compositions for producing a fully developed black and white image without the necessity of removing the developed negative image after processing, are shown in U.S. Pat. No. 2,861,885 to Edwin H. Land, which issued on Nov. 25, 1958, for Photographic Processes and Products. Other composite film assemblies capable of producing developed full color images without the necessity of removing the developed emulsion are shown in U.S. Pat. Nos. of Edwin H. Land, 2,726,154, issued Dec. 6, 1955, for Photographic Product, and 2,944,894, issued July 12, 1960, for Photographic Processes Utilizing Screen Members.

It should be noted that the invention is not directed to the chemistry by which images are developed in a photosensitive emulsion and transferred to an image receiving stratum. However, in the practice of the invention, whether the film employed is black and white or color film, at the present time the preferred embodiment of the invention employs film of a type not requiring the removal of a negative emulsion after it is developed.

Referring again to FIG. **4,** the film **53** is formed along one edge with sprocket holes such as **117** at regular intervals adapted to cooperate with a drive pawl, in a manner to be described, in either camera or projector, for incremental advancement of the film. The series of sprocket holes **117** adjacent the trailing end of the film may be interrupted by a first elongated sprocket hole **118.** This elongated hole **118** may span, for example, two of the sprocket holes **117.**

Further along the film in the direction of the supply reel end, the series of sprocket holes **117** is again interrupted by a second elongated sprocket hole **119,** longer than the sprocket hole **118** and, for example, spanning three of the sprocket holes **117.** As will appear, the first elongated sprocket hole **118** establishes an exposure end point in the camera, whereas the second sprocket hole **119** determines a film takeup termination point in the producing and editing apparatus to be described.

Basically, termination of film advance at the first elongated sprocket hole **118** is attained by the use of a single drive pawl in the camera, which sequentially engages the sprocket holes **117** to advance the film by one frame length in a conventional manner. Toward the end of each such advance stroke, as is conventional,

the pawl is cammed down out of engagement with the film. When the single pawl engages the elongated aperture **118**, the camming down movement occurs before the film engages the leading edge of the elongated hole. The pawl may cycle repeatedly thereafter without further advance of the film. This serves to effect a termination of film advance for the purposes of exposure adjacent the end of the region of photographically useful emulsion, to alert the photographer, by the somewhat different sound produced when the pawl skips the film, that his cassette should be replaced.

The film drive system for projection purposes is provided with a double pawl, comprising two integral pawls spaced apart by one frame length, each pawl being of the same shape as the single pawl in the camera. When the first elongated aperture **118** is encountered, the leading pawl of the pair serves to engage the leading edge of the aperture **118** to cause the film to be advanced without interruption. For normally spaced sprocket holes **117**, both of the pawls engage the film in sequential sprocket holes. However, when the second elongated sprocket hole **119** is encountered, the pawls will pass through it without film engagement, and thereby terminate film advance in the same manner as did the single pawl upon engagement of the double length sprocket hole **118**.

Formed on the trailing end **113** of the film **53**, beyond the exposure advance termination portion just described in the direction of the supply reel end of the film **53**, in a detent engaging element here shown as an aperture **120** formed in the film, adjacent which a projecting bump **121** is formed, as by pressure, heat and pressure, or the like. The edge of the bump **121** forms a hook adapted to engage a detent in the form of a process control actuating element, to be described, as the film is moved with respect to the detent in the direction of the takeup reel.

Formed on the leader end **110** of the film **53** is another detent engaging means, here shown as an aperture **124** in the central region of the film. This aperture serves to actuate the valve member **88** forming a part of the processing apparatus described above, for purposes to appear.

Formed on the sides of the film **53**, on the base side opposite the side on which the emulsion is coated, are a pair of side rails **122** and **123**. At least the rail **123** is coated with a conventional ferromagnetic recording medium so that the rail **123** serves as a soundtrack for recording and reproduction. The rails **122** and **123** protrude slightly above the surface of the film **53**, and serve two basic purposes in the system of the invention. First, when the fluid is processed as to be described, it is initially wet over the useful emulsion region as it is transferred from the processing station to the supply reel. The rails serve to keep the wet surfaces of the emulsion from contacting the dry base surface of the film as it is wound on the reel. The use of the rail **123** as a recording surface also makes it possible to maintain contact between the sound track and the transducer head without exerting pressure on the emulsion side of the film.

A capstan wear pad **125**, of plastic or the like, is preferably cemented to the trailing end **113** of the film behind the bump, on the side where the rails **122** and **123** are located. This wear pad **125** prevents the capstan **17** from wearing a hole through the film **53** under conditions to be described.

The manipulation of the film in the cassette **1** to process it after it has been exposed is fully described in the above-cited copending application Ser. No. 227,080. However, in order to visualize this process in conjunction with the sound recording and reproducing features of the system of the invention, it will next be briefly described with reference to FIGS. **1 – 5**.

Referring to FIG. **4**, it will be assumed that an initially unexposed strip of film **53** stored primarily on the supply reel **51** has been exposed in a camera, so that it has been advanced onto the takeup reel **64** to the exposure termination point determined by the first elongated sprocket hole **118** in the film (FIG. **5**). The tear-tab **89** and its release mechanism will be in the positions shown in FIG. **4**, with the hook **93** against the stop **98**.

Next, assume that operation is continued by further rotation of the takeup reel **64** counterclockwise, as seen in FIG. **4**, to bring the film **53** farther onto the takeup reel. During this rotation, the supply reel **51** will move counterclockwise in FIG. **5**, causing the teeth **94** to pass the hook **93** without effective engagement therewith.

FIG. **4** shows the parts of the coating station in their initial position, which is maintained during exposure of the film and during a portion of the first increment of motion just described, from the exposure termination point toward the second termination point in which the film is substantially exhausted from the supply reel, and in which the second elongated sprocket hole **119** in FIG. **5** will be encountered. During the interval of travel between those positions, and prior thereto, the cam and nozzle closure plate assembly **88** is detachably held in place in the manner described in copending U.S. application Ser. No. 227,080, and a film engaging hook **142** formed on the assembly **88** is lightly engaging the base of the film **53**.

The pressure pad **86** is initially held in place by engagement of an integrally formed hook **143** with a detent formed on the end of the spring **87**. In that position, the end of the pressure pad **86** lightly engages the base of the film **53** and ears **144** formed on the pressure pad are in engagement with a ledge formed on a wall segment **145** formed integrally with the wall **75**.

The parts of the coating station will remain in the position shown in FIG. **4** until, during the further advance of the film **53** towards the takeup reel, the film engaging bump **121** approaches and engages the end of the pressure pad **86**. When that occurs, near the second termination point established by the second elongated hole **119** in the film (FIG. **5**), the bump **121** will move the pressure pad to the left in FIG. **4**, to a position in which the ears **144** have moved out of engagement with the ledge on the wall **145**, and upwardly under the influence of the spring **87**. The pressure pad **86** will swing up into engagement with the film **26** and carry the emulsion side of the film into coating engagement with the nozzle **85**, as described in the above-cited copending application Ser. No. 227,080.

Next, assume that the first rewind operation is begun, by rotating the supply reel **51** clockwise in FIG. **4**, to advance the teeth such as **94** towards the book **93** on the release arm **92**. Further clockwise movement of the reel **51** will cause the teeth **94** to drive the release arm **92** downwardly and to the left in FIG. **4**, pulling the tear-tab **89** to release processing composition to the

coating nozzle **85.** The composition will then be uniformly coated on the emulsion side of the film **53.**

The coating operation will continue as the film is rewound onto the supply reel until the processing composition is substantially exhausted, and the film is stored substantially all on the supply reel **51.** Toward the end of that operation, the aperture **124** (FIG. 5) will approach and engage the hook finger **142** formed on the valve and cam assembly **88.**

As the film **53** continues to move onto the supply reel, engagement of the aperture **124** in the film with the spring arm **142** will carry the cam and valve member **88** to the right of the position shown in FIG. **4,** bringing cams formed on the member **88** into contact with the pressure pad **86** in the region of the ears **144,** with the cam assembly **88** being guided by the ears **144,** as the assembly **88** moves to the nozzle closing position.

Movement in this direction will continue to move the assembly **88** to the right, as it goes to a position in which the end of the valve assembly **88** closes the nozzle **85.** The cam assembly **88** and pressure pad **86** are then latched in a final position as described in application Ser. No. 227,080.

During its movement from the position shown in FIG. **4** to the final position just described, the cam and valve assembly **88** disengages the contacts **59** and **60,** and thus provides a signal indicating that the film has been processed.

FIG. **6** schematically illustrates the film advance pawl mechanism in operative relation to the film **53** in a cassette **1** inserted in the pocket **2** of the producing and editing system (FIG. **3**), with the film gate in registry with the aperture plate **7.** The apparatus comprises a pair of film drive pawls **127** and **128** formed on a lever generally designated **129.** The pawls **127** and **128** are adapted to engage sequential sprocket holes **117,** to advance the film incrementally. For that purpose, the lever **129** is pivoted as indicated at **130** to a crank arm **131.** The crank arm **131** is fixed to a shaft **132** that is at times driven synchronously by an AC motor, to be described.

As shown, the lever **129** passes through a suitable aperture **133** formed in the floor plate **6,** and thence through a slot **134** in the aperture plate **7** into engagement with the film. An end **135** formed on the lever **129** rides on a pin **136** secured to the floor plate **6.** Thus, as the crank **129** rotates, the pawls **127** and **128** drive the film **53** to the left in FIG. **6** until they are brought down out of engagement with the film in response to rotation of the crank arm **129.** Thereafter, the pawls are brought up beneath the plane of the film, as suggested by the dotted lines in FIG. **6,** back to a position in which they can engage the next pair of sprocket holes **117,** and then undergo another advance stroke.

A projection **137** formed on an extension **138** of the hub of the crank arm **131** is adapted to releasably engage a detent **139** urged against the hub **138** by a spring **140** compressed between the detent **139** and a fixed support **141.** That causes the pawl to stop in the dotted line position, out of engagement with the film, when the drive for the shaft **132** is disengaged in a manner to be described.

As described above, when the pawls **127** and **128** engage an elongated sprocket hole such as **118** in FIG. **4,** the film will continue to be advanced. However, when a more elongated sprocket hole, such as **119** in FIG. **5,** is encountered, having a spacing equal to three of the sprocket holes **117,** both pawls **127** and **128** will fail to engage the film, and film advance will cease, even though the shaft **132** continues to rotate.

Further details of the motion picture producing and sound editing system will next be described with reference first to FIG. **7.** As there shown, the pocket **2** that is adapted to receive the cassette described above is, in part, formed in the housing **3** by two walls described above; i.e., the floor plate **6** and the wall **36** normal thereto, through which certain cooperating parts of the system extend. The pocket **2** is further defined by an end wall **148** and a side wall **149** opposite the wall **36.** As described above in connection with FIG. **3,** there is an end wall segment **15,** not shown in FIG. **7,** opposite the end wall **148.** Along the wall **149** are mounted a pair of suitably insulated contacts **150** and **151** that are adapted to engage the contact terminals **59** and **60** formed on the cassette.

The aperture plate **7** referred to above that is mounted on the floor plate **6** is shown in FIG. **7** to comprise a framing aperture **152** that defines the margins of the portion of the film in the cassette to be projected. Beside this aperture **152** is the slot **134** through which the film drive pawl, described above, is adapted to protrude for engagement with the film in a cassette in the pocket **2.** Another symmetrical pair of slots **153** and **154** are formed in the aperture plate **7.** There slots are adapted to receive a pair of pressure plate raising arms, to be described, which serve at times to disengage the pressure plate **78** of FIG. **4** from the film **53,** for purposes to appear.

A floor plate **155** is formed integral with the housing **3,** coplanar with the floor plate **6** and normal to the wall **36.** On this plate **155** are mounted most of the operative parts of the system to be described.

Energy for the system is arranged to be supplied from a suitable source of alternating current, such as a 60Hz, 120 volt source, connected to a pair of terminals **156** and **157.** The terminal **157** is shown connected to a reference ground, for convenience, and the terminal **156** is connected over contacts of an on-off switch S2 to mechanical and electrical power supply elements here shown schematically in FIG. **7** as a conventional DC power supply **158,** and a conventional combined AC motor and transformer ACM. As will appear, the switch S2 is normally open, and is closed by a locator pin **159** when a cassette is inserted in the pocket **2** and the locator pin extends into the cassette to latch the cassette in the pocket.

The motor ACM may be of the conventional shaded pole induction type, having an energizing primary winding with a tap for energizing a projection lamp, to be described, and secondary windings connected to the DC power supply. These windings of the motor will be more particularly described below.

The output shaft **160** of the motor ACM drives a fan schematically indicated at **161,** and also drives the input side **162** of a conventional electromagnetic clutch **163** having an output shaft **164.** The shaft **164** is adapted to be driven from the shaft **160** through the clutch **163** when a clutch magnet CM is energized in a manner to appear. Another electromagnetic clutch, to be described below and not shown in FIG. **7,** is driven by the shaft **160,** for purposes to appear.

The fan **161** supplies air for cooling a projection lamp, to be described, and may also be used to supply air to the cassette to aid in drying the film after it is coated with processing composition.

The power supply **158** provides DC voltages for energizing various other elements of the apparatus, as will appear. In particular, the power supply **158** is connected over leads schematically indicated at **165** to control circuits schematically shown at **166.**

The control circuits **166** at times supply energizing current for the clutch magnet CM over a lead **167.** Control inputs are provided to the circuits **166** by switches and cams schematically indicated at **168,** over leads generally designated **169.** The control circuits **166** at times provide energizing current over a lead **173** to energize a cassette ejector disabling solenoid SL1. Other circuits, schematically indicated at **174,** affect the operation of a film reel drive motor control circuit generally designated **175.**

The motor control circuit **175** is also influenced by a motor reversing switch MR that performs its control function over leads schematically indicated as a single lead **176.** The output of the motor control circuits **175,** illustrated at **177** and **178,** is supplied to energize a conventional DC motor DCM1 to cause it to rotate in either of two opposite directions, in a manner to appear.

The shaft **164,** driven by the motor ACM when the clutch magnet CM is energized, serves as the main programming shaft for directing the operation of the film drive, projection and audio recording and reproduction system under the influence of mechanical and electrical signals supplied by the cassette. Auxiliary shafts schematically indicated at **179** are driven by the shaft **164** as will be described in further detail below. A main cam shaft **180** is driven from the shaft **164** by means schematically shown in FIG. 7 as a pair of bevel gears **181.** An additional shaft **182** is driven by the shaft **164** synchronously with the shaft **180,** to control the sound array in a manner to be described below.

The shaft **180** is supported in bearings schematically indicated at **183** and **184,** fixed with respect to the plate **155.** Carried on the shaft **180** are a number of cams, several of which control switches, to be described. In particular, the switches and cams **168** are driven by the shaft **180,** and comprise a number of elements to be described below in conjunction with FIG. **13.** Only those parts are shown in FIG. 7 which are conveniently displayed in fragmentary and schematic form, to illustrate the functional relationship between the elements of the system and indicate their relative location.

Two drive control cams **185** are symmetrically disposed on the shaft **180** and affixed thereto. These cams serve at times to drive a spingle plate **186** towards the wall **36.**

The spindle plate **186** comprises a bar of metal or the like, provided with integral guide flanges **187** at its ends. The flanges **187** are slidable in ways, suggested at **188,** formed integral with walls **189** and **190.**

The spindle plate **186** is normally urged to the position shown in FIG. 7 by a pair of compression springs **191** located between the wall **36** and the spindle plate **186.** When so moved by the cams **185,** the spindle plate moves toward the wall **36,** where it may be latched at times by a stop **192,** as described in detail in the above-cited copending application Ser. No. 227,080.

Also carried on the shaft **180** is a program disc **193** formed with three slots **194** disposed 120° apart on the disc. These slots serve to locate program stops, as shaft angles on the cam shaft **180,** by engagement with a detent schematically shown at **195.** The detent **195** comprises an element **196** adapted to engage the slots **194,** and urged into engagement therewith by a spring **197.** The spring **197** extends between the element **196** and a support **198** fixed to the plate **155.**

A blinder control cam **199** is disposed on the shaft **180** and affixed thereto. It is arranged to operate a blinder generally designated **200** through a cam follower **201** formed integral with the blinder **200** and adapted to engage the cam **199.** This blinder and its operating mechanism are more fully described in the above-cited U.S. application Ser. No. 227,080.

The blinder **200** at times interrupts the supply of light from a projection lamp Kl. The lamp Kl is disposed in a reflector generally designated **202** that is mounted on the plate **155** to direct light from the lamp through the port **39,** for admission to a cassette in the pocket **2.**

A motor control cam **203** is mounted on the shaft **180** and serves to control the position of the motor reversing switch MR. That relationship will be described below in more detail in connection with FIG. **14.**

A snubber engaging cam **204** is fixed to the shaft **180.** This cam at times drives a snubber stop **205** through the port **41** in the wall **36** for engagement with the snubber hub **82** in a cassette inserted in the pocket **2.** The snubber stop **205** is normally urged back into the port **41** by means of a spring **206** acting between the wall **36** and a collar **207** formed on the snubber stop.

A cam **208** for controlling the position of the sound array **13** is mounted on the shaft **182** to be driven synchronously with the snubber control cam **204.** The cams **204** and **208** may be shaped and orientated, in a manner to be described, so that the sound array and the snubber stop are engaged and disengaged simultaneously.

A drive sprocket **212** for the supply reel of a cassette in the pocket **2,** and a drive sprocket **213** for the takeup reel, are mounted on the spindle plate **186.** These drive sprockets are adapted to protrude through the ports **37** and **38** in the wall **36** when the spindle plate **186** is driven toward the wall **36** by the cams **185.**

The sprocket **212** is formed integral with a shaft **214.** A collar **215** is formed integral with the shaft **214.** Another collar **216** is detachably secured to the shaft **214** by means schematically shown as cooperating threads formed on the parts. This collar **216** may be integral with a splined extension **217** that engages corresponding splines **218** formed in a cylindrical bore in the end of a drive shaft **219.**

The shaft **214** and the collars **215** and **216** cooperate with bearings schematically indicated at **220,** mounted in the spindle plate **186** to allow the shaft **214** to rotate in the spindle plate, while preventing it from being translated along the axis of the shaft **214** with respect to the plate **186.** The splines **218** and the splined extension **217** cooperate to allow the shaft **214** to be driven by the shaft **219,** while allowing relative translational motion between the shafts **214** and **219.** Thus, the shaft **214** may be fixed relative to the base plate **155** against translational motion, while rotatable with respect thereto.

The sprocket 213 may be rotatably mounted against translational motion in the spindle plate 186 by means identical to those just described with respect to the sprocket 212. A translational coupling is provided comprising splines 221 affixed to the sprocket 213 and cooperating with splines 222 formed in a shaft 223, in the manner described above, to allow the sprocket 213 to be drivably connected to the shaft 223 while free to slide axially with respect thereto. The shaft 223 is also translationally fixed relative to the plate 155, but mounted for rotation thereon.

The shaft 219 is connected to one side of a conventional slip clutch 224, and the shaft 223 is similarly connected to one side of a conventional slip clutch 225. Each of the shafts 219 and 223 is at times driven through its associated slip clutch, and at other times is driven from the associated sprockets 212 and 213, as will appear.

A vaned ferromagnetic element 226 is mounted on the shaft 223 for rotation therewith, carrying its vanes past a conventional magnetic read switch S5 such that the switch S5 is opened and closed a number of times during each revolution of the shaft 223. The switch S5 provides an input signal to a motion detector, in a manner fully described in the above-cited U.S. application Ser. No. 227,080.

The slip clutches 224 and 225 are arranged to be driven at times by the DC motor DCM1 through means next to be described. As schematically indicated, the motor DCM1 is provided with an output shaft 227. The shaft 227 drives a bevel gear 228. The gear 228 drives a pair of shafts 229 and 230 in opposite directions through bevel gears 231 and 232, respectively. The shaft 229 is connected to one side of a conventional one-way clutch schematically indicated at 233, and the shaft 230 is connected to one side of a conventional one-way clutch 234.

When the shaft 229 is rotated in the direction of the arrow in FIG. 7, the clutch 233 will be engaged and drive the slip clutch 225 through a shaft 235. When the shaft 229 is rotated in the opposite direction, the clutch 233 will be disengaged. Similarly, when the shaft 230 is rotated in the direction of the arrow in FIG. 7, the clutch 234 will be disengaged. When the shaft 230 is rotated in opposite direction, the clutch 234 will be engaged to drive the shaft 219 through the slip clutch 224 by means of an intermediate shaft 236.

The foot pedal 42 mounted adjacent the floor plate 6 in the pocket 2 will next be described in its relation to the locator pin 159, with reference to FIGS. 7 and 10. As best shown in FIG. 10, the foot plate 42 is provided with a downwardly depending arm 237 which extends through a suitable aperture in the floor plate 6 to a transverse arm 238, formed integrally with the foot plate 42 and the arm 237, and extending over beneath the wall 36 to an upwardly extending arm 239.

The arm 239 extends up through a suitable aperture in the base plate 155 to an end 240 formed integrally therewith. The end 240 is connected to a lever 241. The lever 241 is spaced at one end from the base is pivoted 36 by means of a conventional spacer 242, and isicoted to the wall 36 by a pin 243. At the opposite end, the lever 241 is formed with upstanding yoke arms 244 that surround the port 40, through which the locator pin is adapted to protrude.

The lever 241 is spaced from the wall 36 at the end adjacent the yoke arms 244 by a spacer 245 secured to the wall 36. When the foot pedal is depressed, the lever 241 is rotated to carry the yoke arms 244 out of the way of the recess 40, for purposes to appear. The lever 241 and interconnected parts, including the foot pedal 42, are urged into the position shown in FIG. 10 by a spring 246 secured to the base plate 155 by means schematically indicated at 247.

Referring next to FIG. 11, the locator pin 159 is formed integral with a collar 250 that engages the yoke arms 244 in the position of the floor plate 42 shown in FIG. 10 and described above. The pin 159 is urged toward the port 40 by a spring 251 compressed between the collar 250 and a support 252 affixed to the floor plate 155 and slidable with respect to the pin 159.

A second collar 253 is formed on the end of the locator pin 159, and is adapted to operate the switch S2, to close a pair of normally open contacts thereon, when the pin 152 moves through the port 40. As noted above, the contacts of the switch S2 control the supply of power to the system.

The collar 253 is also adapted to engage a yoke 254. The yoke 254 is out of engagement with the collar 253 in the position of the parts shown in FIG. 11, assumed when the system is in its standby condition and no cassette is located in the pocket 2.

The yoke 254 is formed integral with a lever 255. The lever 255 is pivoted to a cam following lever 256 by means of a pivot pin 257 formed integral with the lever 256, and is detachably connected to the lever 256 by a second pin 258 that is at times removable by withdrawing it through an aperture 259 in the lever 255 in which it is shown in FIG. 11, to allow the lever 255 limited freedom of movement, independently of the lever 256.

The lever 256 is pivoted on the housing of a solenoid SL2. As more fully described in the above-cited copending U.S. application Ser. No. 227,080, when the solenoid Sl2 is energized, the pin 258 is retracted to allow the lever 256 to be rotated by the cam 262 without moving the yoke 254 to retract the locator pin 159.

A cam follower 261 is formed at the end of the lever 256, and is adapted to engage a cam 262 fixed to the cam shaft 180. The follower 261 is resiliently urged into engagement with the cam 262 by a spring 263 having one end fixed in a suitable support 264 formed integral with the base plate 155.

As best shown in FIG. 13, the cam 262 has three principal positions, 120° apart in terms of the angle of the shaft 180, and labelled O, P and D/R. Mnemonically, these positions may be considered the OFF position, the PROJECT position, and the DEVELOP/REWIND position. They are sequentially assumed during operation of the apparatus, beginning with the location O in engagement with the cam follower 261, and then going sequentially to the positions P and D/R, and finally back to O, in the direction of the arrow shown in FIG. 13.

The relationship of these detented shaft angles to other functions performed in the apparatus will be described below. However, so far as the locating pin goes, the positions of the parts assumed when the point on the cam labelled O engages the cam follower 261 are shown in FIG. 11. That is the position assumed when no cassette is in the pocket 2, as described above. In that position, the cam 262 has moved the levers 255

and **256** to an idle position in which the yoke **254** is out of engagement with the collar **253** on the pin **159.**

When a cassette is placed in the pocket **2,** the floor pedal **42** is depressed and the yoke arms **244** move down out of engagement with the collar **250** on the pin **159,** allowing the pin **159** to enter and protrude through the recess **40** in the plate **36.** The contacts of the switch S2 are now closed by the collar **253,** and the collar **253** moves into adjacent relationship to the yoke **254.**

Referring to FIGS. **11** and **13,** the cam **262** can rotate from the OFF position, and through the PROJECT and DEVELOP/REWIND positions, without effecting a displacement of the cam follower **261.** However, as the cam **262** moves from the D/R position to the O position, the cam follower **251** will be actuated to rotate the lever **256** clockwise as seen in FIG. **11.** Whether or not the locating pin **159** will be actuated by this movement, assuming that it has previously been released to protrude through the recess **40,** will depend on whether or not the solenoid SL2 is energized. If it is energized, to retract the pin **258,** the cam **256** will move independently of the cma **255,** allowing the pin **159** to remain in the position engaging the cassette.

Assuming that the cam **256** has been rotated with the pin **258** retracted, the aperture **259** in the lever **256** that is adapted to receive the pin **258** is now moved out of position to engage the pin. As the cam **290** moves to the OFF position, the cam follower **261** will return to the position shown in FIG. **11.** It will remain in that position as the cam **262** rotates through the O, P, and D/R positions. As the parts return to the position shown in FIG. **11,** if the solenoid SL2 is deenergized, the pin **258** will reenter the aperture **259,** again fixing the lever **255** to the lever **256.**

If the solenoid SL2 is not energized as the cam **262** moves from the D/R position to the O position, the levers **255** and **256** will move together to retract the pin **159** by engagement of the yoke **254** with the collar **253,** causing the pin **159** to be withdrawn and the switch S2 to open its contacts.

The construction of the sound array **13** will next be described with reference to FIGS. **4, 7** and **8.** As shown in FIGS. **4** and **7,** the array **13** comprises a rectangular frame **18.** The sound recording, playback and erase head **16** is mounted on a front panel **268** formed integral with the frame **18.** A pair of ears **269** are formed integral with the front panel **268** and extend outwardly to form bearings for an axle **270** on which the capstan **17** is fixed. The capstan **17** may be of polyurethane, rubber or other resilient friction material.

The axle **270** is fixed to the hub of a wheel **271** about the periphery of which a rubber tire **272,** of rubber, polyurethane or the like is mounted. The tire **272** engages the output shaft **273** of a DC motor DCM2. The motor DCM2 is thus adapted to rotate its shaft **273** at high speed, whereby the disc **271** is driven through the tire **272,** driving the shaft **270** and the capstan **17** at a lower speed appropriate for moving the film at approximately three inches per second. The motor DCM2 is mounted on a side plate **274** formed integral with the frame **18.**

An I-beam generally designated **275** is welded to or otherwise formed integral with the base plate **155** as best shown in FIG. **4.** The I-beam **275** has a central web **276** and end flanges **277** and **278.** The flange **277** slidably engages the side plate **274,** and the flange **278** slidably engages a side plate **279** formed integral with the frame **18.** A spring **280** extends between the web **276** of the I-beam **275** and the front panel **268.**

The cam **208** mounted on the shaft **182** engages a back wall **281** formed integrally with the frame **18.** The cam **208** is shown in FIG. **4** in the off position, or O position, in which the head **16** and capstan **17** are held out of engagement with the cassette **1.** When the cam **208** is rotated to its P position, the head **16** and capstan **17** are allowed to move into the cassette to engage the film in the manner shown in FIG. **8.** As shown, the head **16** urges the film **53** against the bumps **105** and **106** formed on the spring **102** to cause a partial wrapping of the film **53** around the head **16.** The capstand **17** urges the film against the ideler **58,** driving the film in the direction shown by the arrow.

As will appear, operation of the apparatus will result in the formation of a loop **282** in the film as the film **53** leaves the capstan **17** and passes out of the cassette, and then back in over a guide ledge **283** formed on the bottom wall **45** of the cassette **1.** A lamp, light-emitting diode, or the like, **284,** is disposed in the production and editing apparatus adjacent the region in which the loop **282** is formed, and a photocell **285** is disposed in the housing mounted on the plate **155** adjacent the light source **284** so that the photocell will be illuminated by the light source except when the loop **282** protrudes from a cassette **1** in the pocket **2** and shields the photocell from the lamp. Resistance of the photocell **285** is sensed by circuit means to be described, to govern the length of the loop **282** so it maintains a constant average length. The purpose of the loop **282** is to isolate the intermittent motion of the film **53** at the film gate from the smooth and uniform motion desired past the sound head **16** and produced by the capstan **17.**

Referring next to FIGS. **7, 13** and **14,** the cassette ejecting mechanism comprises an eject enabling plate **248** slidably mounted in the floor **6** of the pocket **2.** The plate **248** is hinged, as schematically indicated in FIG. **7,** to a connecting plate **265** having an extension **286** that is connected to the armature **266** of the solenoid SL1. The assembly is urged into the position shown in FIG. **7** by a spring **267** extending between the end of a slot formed in the base plate **155** and the extending end **286** of the hinged eject enabling plate assembly.

The plates **248** and **265** are slidably mounted in a slot **287** formed in the base plate **155,** and in the portion thereof comprising the floor plate **6** of the pocket **2,** on ways schematically indicated at **288.** The hinged end plate **248** is thus enabled to move from the position shown in **7,** in which a cam admitting slot **289** in the floor plate **6** is covered, to the position shown, in which the end plate **248** exposes the slot **289.**

An eject cam **309** is mounted on a shaft **179***c* (FIGS. **13** and **14**), comprising one of these auxiliary shafts **179** rotatable with the shaft **180** and achematically indicated in FIG. **7.** As more fully described in the above-cited U.S. application Ser. No. 227,080, the eject cam is adapted to move to a position protruding through the slot **289** in FIG. **7** between the D/R and O positions of the cam shaft. With the solenoid SL1 energized and the end plate **248** retracted from the position shown in FIG. **7,** the cam **209** can enter the slot **289** and rotate through a full revolution without contacting the bottom of a cassette **1** inserted in the pocket. However, should the cam be rotated to its ejecting position when the so-

lenoid SL1 is deenergized, the hinged end plate **248** will overlie the slot **289**, such that when the cam **309** rises to the position in which it protrudes through the slot **289**, the end plate **248** will be hinged up and eject the cassette **1**.

The stop **192** mentioned briefly above in connection with FIG. 7 is adapted to be erected when the solenoid SL1 is energized, by means shown and described in the above-cited copending U.S. application Ser. No. 227,080. In the energized condition of the solenoid SL1, the stop **192** rises into position to interfere with the spindle plate **186**. In the deenergized condition of the solenoid SL1, the spindle shaft **186** can move back and forth between the position shown in FIG. 7, and a position which the sprockets **212** and **213** extend into the pocket **2**, without interference by the stop **223**.

The cams **185** in FIG. 7 are arranged to move the spindle plate **186** past the stop **192** before the solenoid SL1 is energized, allowing the plate **186** to pass over the stop **192** before it is erected, in the event that it is erected by energization of the solenoid SL1 in a manner to appear.

As indicated in FIG. **2**, a blinder housing **8** is mounted underneath the floor plate **6** of the pocket **2** beneath the aperture plate **7**. As shown in FIG. **9**, the housing **8** is provided with an aperture **290** sufficiently larger than the aperture **152** in the aperture plate **7** so that it will not limit the light transmitted through the film. A transverse slot **291** is formed in the block **8**, to admit a blinder **292**.

The blinder **292** is formed on one end of a bell crank generally designated **293**. The bell crank **293** has another arm **294**, and at the juncture of these arms a pivot pin **295**, secured to a suitable mounting post formed integral with the floor plate **6**, mounts the bell crank **293** for rotation in the housing for movement between the position shown in FIG. **9**, in which the aperture **290** is exposed, and a position in which the aperture is closed.

The arm **294** carries a cam follower **296** that engages a cam **297**. The cam **297** is mounted an a cam shaft **179***a*, comprising one of the auxiliary shafts **179** driven by the motor ACM through the clutch **163** synchronously with the shafts **180** and **182**, as described above in connection with FIG. **7**.

The cam follower **296** is urged into engagement with the cam **297** by a spring **298**. The spring is mounted between a pair of pins **299** and **300**, secured in turn to the floor plate **6** as suggested in FIG. **9**.

The cam **297** is arranged to close the blinder **292** simultaneously with the closure of the blinder **200** for the lamp port **29**, described above in connection with FIG. 7 and more fully described in the above-cited U.S. application Ser. No. 227,080. When both of these blinders are closed, and a cassette is inserted in the pocket **2**, the portion of the film exposed in the film gate of the cassette is thus surrounded by a lighttight housing, in which the film may be processed by appropriate actuation of the supply and takeup reel described above. The ports **99** and **100** in the cassette **1** may be shielded by appropriate fixed opaque walls in the housing **3**, not shown, surrounding the compartment in which the sound array **13** is movably mounted. As will appear, the light source **284** (FIG. **8**) is not energized until after the film has been processed.

FIG. **12** shows the pressure plate lifting mechanism. As more fully described in U.S. application Ser. No. 227,080, the pressure plate **78** in a cassette **1** in the pocket **2** is at times raised to the position shown in FIG. **12** by a yoke generally designated **301**, that comprises a pair of levers **302**, only one of which is shown in FIG. **12**. Each of the levers **302** has an outer pressure plate lifting arms **303** formed at one end and an inner pressure plate lifting arm **304** formed intermediate its ends.

Pivot pins **305** extending through the arms **302** and through a suitable support **306** formed integral with the floor plate **6** journal the lifter yoke **301** for rotation relative to the floor plate **6**. The levers **302** are thus adapted to pivot between the position shown in FIG. **12**, in which the arms **303** and **304** raise the pressure plate **78** out of engagement with the film **53** in a cassette **1** inserted in the housing and registering with the aperture plate **7**, to a lowered position in which the pressure plate **78** engages the film **53**. It should be noted that raising of the pressure plate **78** to the position shown in FIG. **12** interrupts the light seal previously provided at the film gate. However, the film in the cassette **1** remains protected against light at this time by the aperture plate **7**, the walls of the pocket **2**, and the end flange **35** on the cassette.

The arms **302** are joined by an integral plate **307** that serves as a cam follower, cooperating with a cam **308** that is fixed to a cam shaft **179***b*, comprising another of the auxiliary shafts **179** indicated schematically in FIG. **7**, and rotating in unison with the main cam shaft **180** and its drive shaft **164**. As indicated in FIG. **12**, the cam **208** is arranged to raise the arm **302**, lifting the pressure plate **78**, in the D/R position of the cam shaft. The purpose is to eliminate unnecessary drag on the film **53** during processing, when the film is being drawn through the coating station, and during rewinding for storage, when a relatively high rewind speed and minimum friction are desirable.

Referring next to FIG. **13**, there is shown the set of cams and cam actuated switches comprising the programming apparatus for the motion picture producing and sound editing system. For simplicity, the shaft driven by the electromagnetic clutch comprising the winding CM, shown in FIG. **7** as the shaft **164**, the main cam shaft **180**, and the auxiliary shafts schematically indicated at **179** and **182**, are represented as a single shaft **310** arranged to be driven by the motor ACM from the shaft **160** when the clutch magnet CM is energized.

The various cams are shown schematically in FIG. **13** as disposed on the shafts **310** in their cooperative relationship, each cam being shown in the position corresponding to the OFF position and labelled O. As noted above, the cam shaft has three dwell positions 120° apart, including the OFF position O, the PROJECT position P, and the DEVELOP/REWIND position D/R. Other functions are performed between these dwell positions, as will appear.

All of the cams are adapted to rotate in the direction of the arrows, when the shafts **310** are driven by the clutch **163**. The registry, of the cam shafts **310** at the dwell positions is insured by the detent **196** engaging one of the notches **194** in the program disc **193**. In practice, the clutch magnet CM is energized until the cam shafts near this position, and system inertia carries the shafts and their associated cam followers into the detented dwell position under the influence of the detent **196**.

The apparatus includes seven cam controlled switches. One of these is a cassette sensing switch CS controlled by a cam **316** that is open in the O position of the apparatus and closed from a position approaching the P position to a position after the D/R position. When this switch is closed, the terminals **59** and **60** on the cassette **1** (FIG. **4**) are interrogated to determine whether or not the film in the cassette has been processed.

A jam reset switch JR, having a function to be described, is controlled by a cam **311.** The switch JR is closed between each of the dwell positions O, P, and D/R, and opened at the dwell positions.

The DC motor reversing switch MR comprises two transfer contacts *a* and *b* that engage back contacts, as shown, in the OFF and D/R positions, and front contacts in the P position. Circuits controlled by these contacts cause the DC motor DCM1 to run, when energized, in a first direction in the P position, and in an opposite direction in the D/R position. Either position of the contacts could be assumed in the O position.

A PROJECT switch P comprises six contacts *a*, *b*, *c*, *d*, *e* and *f* each closed in the P position of the apparatus by a cam **312,** and open in other positions of the apparatus. Contacts of this switch close various circuits effective in the PROJECT mode of operation, as will appear.

An $\overline{\text{OFF}}$ switch labelled $\overline{\text{O}}$ is opened by a cam **313** in the OFF position, and closed in other positions of the apparatus. This switch has three contacts *a*, *b* and *c*, which control circuits to be described in positions other than the OFF position.

Another cam **314** closes a switch labelled O in all positions of the apparatus except the P and D/R dwell states. Closure of this switch is effective to maintain energization of the clutch magnet CM, as will appear, and signifies by its closed state that the apparatus is not in either of the PRODUCT or D/R dwell positions.

A cam **315** controls two contacts labelled D*a* and D*b*, each closed in the D/R position of the apparatus. A contact labelled $\overline{\text{D}}$ is closed in all positions except the D/R position, and is open in that position, for purposes to appear.

The spindle cams **185,** snubber cam **204,** blinder cams **199** and **297,** locator pin withdrawal cam **262,** eject cam **309,** sound array cam **208** and pressure plate lifter cam **308,** all described above, are shown in FIG. **13** in their cooperative relation to the cam control switches and the program disc just described. The various states assumed as the cam shafts schematically indicated at **310** are rotated will be discussed below in more detail in connection with the operation of the system.

Referring next to FIG. **14,** there is shown a schematic block and wiring diagram illustrating the cooperative relationship between a cassette **1** inserted in the pocket **2** (FIG. **1**) and selected elements of the electromechanical control system therefor.

As briefly described above, the power supply **158** and the AC motor ACM are arranged to be energized over the AC line terminals **156** and **157** when the switch S2 is closed. The contacts of this switch are closed when the locator pin **159** is inserted into the port **34** of a cassette **1** inserted in the pocket **2** of the production and editing system. As indicated in FIG. **14,** the switch S2 is paralleled by a contact O*a* that is closed except when the apparatus is in the OFF position by the cam **313** in FIG. **13.** This switch contact, and other shown in FIGS. **13, 14** and **19,** to be described, are shown in the OFF position.

The combined motor and transformer ACM comprises a conventional stator **320** having pairs of poles such as **321** and **322,** one pole of each pair, such as **321,** being provided with a conventional shortcircuited shading coil **323.** A primary winding **324** on the stator **320** supplies energizing current for the motor, and is tapped as indicated at **325** to provide a suitable source of voltage for energizing the lamp K1. The primary winding **324** also supplies energizing current for a secondary winding **326,** having a center tap connected to ground as indicated at **327,** and leads **328** and **329,** balanced with respect to ground, connected to the input terminals of the DC power supply **158.**

The power supply **158** may be any conventional means for converting alternating current to direct current. It serves to provide two regulated DC potentials B1 and B2 that are positive with respect to ground. For example, the voltages B1 and B2 may be 12 volts and 10 volts, respectively.

The drive shaft **160** of the AC motor ACM drives the clutch **163,** engaged at times by the clutch magnet CM, referred to above. When the clutch magnet is energized, the input cam shaft **164** rotates to cause rotation of the other cam shafts described. The output shaft **160** of the motor ACM also drives the auxiliary shaft **132** connected through the crank **131** to the film advance pawl **129,** when a clutch schematically indicated at **330** is energized. The shaft **132** also drives a conventional shutter **9,** by conventional means not shown.

The clutch **330** is energized at times when a solenoid SL3 is energized. The armature **331** of the solenoid SL3 is connected to a pulley **332,** such that when the solenoid SL3 is energized, a belt **333** it tightened to complete a drive connection between a pulley **334,** driven by the shaft **160,** and a pulley **335,** connected to the shaft **132.**

When a cassette **1** is inserted in the system, so that the locator pin **159** enters the port **34** in the cassette and closes the switch S2, the external terminals **59** and **60** on the cassette are conditioned for interrogation by a circuit which extends from the supply terminal at B1, through a first resistor R1, over terminals **150** and **151** which engage the terminals **59** and **60,** and thence through a resistor R2 to ground.

The resistor R1 is selcted to limit the current flowing through the contacts **150** and **151** and the terminals **59** and **60,** when the latter are internally bridged as described above, while allowing the full supply voltage B1 to be used to interrogate the contacts. That is because the resistance presented by the terminals **59** and **60** may be initially relatively high, owing to dry contact resistances that exist as thin films across the contacts, and which are greatly reduced when current is established.

The resistor R2 is selected in value to establish a suitable control potential across it, when the terminals **59** and **60** are bridged within the cassette **1,** to energize a relay RK. The relay RK is energized when the cassette terminals **59** and **60** are bridged, and the interrogation switch CS is closed. That establishes a pickup circuit for the relay RK.

Once energized, the relay RK completes a stick circuit including its own front contact *a*, and the contact $\overline{O}b$, closed except when the apparatus is in the OFF po-

sition. The stick circuit extends from the supply terminal at B2, a lower voltage than the voltage B1, over contact $\overline{Ob}$, the front contact *a* of the relay RK, and thence through the winding of the relay RK to ground.

The projection lamp K1 is at times energized over a lead **338** connected to the tap **325** on the primary winding **324.** The circuit for the lamp extends from the lead **338** through the filament of the lamp K1, and thence over the contact *Pa*, closed when the apparatus is in its PROJECT state, and back contact *c* of the relay RK, closed when the relay is deenergized, to ground.

The solenoid SL1, which actuates the cassette eject enabling plate **248** in FIG. **7** and also effects the positioning of the stop **223** for the spindle plate described above, and the solenoid SL2 which, when energized, disables the cassette locating pin withdrawal mechanism, are energized in parallel over a front contact *b* of the relay RK, closed when it is energized. A circuit for the energization of the pawl and shutter drive control solenoid SL3 is completed when the contact *Pb* is closed in the PROJECT state of the apparatus. When the relay RK is deenergized, closing its back contact *f*, and the contact *Pb* is closed, an energizing current signal labelled PP is produced to energize the lamp K2.

A diode D1 is connected in parallel with the clutch winding CM for the conventional purpose of protecting the winding against transients. An energizing circuit for the clutch magnet extends from the power supply terminal at +B1, through the winding of the clutch magnet, and thence over three selectively effective parallel paths. The first extends over contact $\overline{Oc}$, closed except when the apparatus is in its OFF state, and thence over the contacts of the switch S1, closed except when a cassette **1** is inserted in the housing. This circuit serves to return the film drive and projection system to its OFF state when no cassette is present and the system is not in its OFF state. The power supply voltage is maintained under these conditions by contact $\overline{Oa}$.

A second circuit for the clutch magnet CM is completed over the contact O, closed when the apparatus is in its OFF state. That circuit is effective to drive the apparatus through its OFF state only if the locator pin **159** has not been withdrawn as the apparatus nears its OFF state to open the power supply contacts S2. If that has occurred, both the power supply input switch S2 and the parallel contact $\overline{Oa}$ will be opened, as the apparatus enters its OFF position.

The third circuit which at times energizes the clutch magnet CM extends from the lower terminal of the winding CM through the load terminals *a* and *b* of a convention electronic switch S6 to ground. The switch S6 may be any conventional device, such as a transistor or the like, which exhibits a low impedance between its load terminals when a control terminal *c* is biased positive with respect to its load terminal *b*, and which exhibits a high impedance between its load terminals at other times.

The switch S6 is biased into conduction when the output terminal of a conventional OR gate **340** is at logic **1**, or positive with respect to ground. That occurs when any of three input leads receives a logic **1** signal of the set $\overline{M}$, REPEAT and REPLAY.

Referring to FIG. **7**, the signal $\overline{M}$ is produced at times by a motion detector **341.** The motion detector **341** is fully described in the above-cited U.S. application Ser. No. 227,080. Briefly, it responds to produce a positive signal $\overline{M}$ when the shaft **223** ceases to move, and thus stops the motion of the ferromagnetic vanes **226** past the switch S5. When the shaft **223** is rotating in either direction, the switch S5 is repeatedly opened and closed, removing the signal $\overline{M}$.

Essentially, the switch S5 serves to discharge a capacitor when it is repeatedly opened and closed. When the switch S5 remains either open or closed for a predetermined time, the capacitor is charged to a voltage that causes the signal $\overline{M}$ to be produced. The contacts JR discharge the capacitor between the positions D/R, O and P of the cam shafts, thus resetting the motion detector.

By way of detailed comparison with the apparatus as described in application Ser. No. 227,080, the signal $\overline{M}$ would appear at the base of the transistor Q2 in FIG. **46** of that application.

At a dwell position such as P or D/R calling for the operation of the DC motor DCM1, once the motor is in operation to drive either the takeup or the supply reel, the switch contacts S5 will be repeatedly closed and opened, preventing signal $\overline{M}$ from appearing until motion of the film drive shaft has stopped. That will allow the apparatus to remain in its current dwell position until the film has been transported to the extreme position towards which it is being driven. Thereafter, the signal $\overline{M}$ will be produced again to allow the apparatus to be driven to its next dwell position.

Referring again to FIG. **14,** the signal REPLAY is at times produced as a logic **1** signal at the output terminal of a conventional AND gate **342,** in a manner to be described below. The signal REPEAT is at times produced as a positive pulse at the output terminal of a conventional one shot multivibrator **343,** under conditions to be described below.

The signals REPEAT and REPLAY are used to cause the apparatus to interrupt the production of a sound motion picture when the apparatus is in the PROJECT state, to set the apparatus to the D/R state to rewind all or part of the film, and then to resume production for review of a portion of the recorded sound and picture sequence, or for sound editing, as will appear. The instant replay circuits do not, per se, comprise this invention, but are described and claimed in copending U.S. application for U.S. Pat. Ser. No. 261,301, filed on June 9, 1972 by Edwin H. Land for Manually Controlled Replay System for Automatic Transparency Processing and Projection Apparatus, and assigned to the assignee of this application.

The motor control circuit for the film reel drive motor DCM1 comprises a drive current supply circuit for the winding of the motor that extends from the supply terminal at B1 over one of the motor reversing contacts MR selected by the position of the motor reverse control cam **203** in FIG. **13,** through the winding of the motor, and thence over the other contact MR to the active output terminal of a conventional amplifier **344.** When supplied with appropriate input signal, in a manner to be described, the amplifier **344** acts as an adjustable current sink that will cause the motor DCM1 to run in a direction selected by the position of the contacts MR.

In accordance with the illustrated embodiment of the invention, the motor DCM1 is required to run at a first speed for projection, and at a second and higher speed for rewinding and processing. A fast rewind signal is provided by a potentiometer comprising a resistor R3

connected in series with a resistor R4 between the supply terminal at B1 and ground. The junction of the resistors R3 and R4 is connected to the input terminal of the amplifier over a switch contact Dc, closed in the D/R state of the apparatus, and a conventional electronic switch S7, which is normally closed and is controlled in a manner to be described.

The circuit just described provides a relatively high current signal to the amplifier **344.** A lower current signal, to cause the motor DCM1 to rotate more slowly for projection purposes, extends from the junction of the resistors R3 and R4 through a variable resistor R5, and thence over a contact Pc, closed when the apparatus is in its PROJECT state, and through the load terminals of the switch S7 to the active input terminal of the amplifier **344.**

The control terminal of the switch S7 is normally biased into conduction by a circuit extending from supply terminal at B2 through a resistor R6 to the control terminal of the switch S7. The load terminals of a conventional electronic switch S8 are connected between the control terminal of the switch S7 and ground, so that when the switch S8 is closed, forward bias for the switch S7 is removed and the switch S7 is opened.

The control terminal of the switch S8 is connected to the output terminal of a conventional one shot multivibrator **345.** The multivibrator **345** is arranged to be triggered by the rising trailing edge of a negative pulse produced by a conventional multivibrator **346.** When triggered, the multivibrator **345** produces a positive output pulse for a predetermined time to cause the switch S8 to close and thus temporarily interrupt the signal to the amplifier **344.**

The multivibrator **346** is triggered by a rising transition produced when the relay RK is energized and the apparatus goes to its D/R state. For that purpose, a trigger circuit for the multivibrator **346** extends from the supply terminal at B2 over contact Da, closed in the D/R state of the apparatus by the cam **315,** and front contact *d* of the relay RK.

As more fully described in the above-cited U.S. application Ser. No. 227,080, when the apparatus goes to its D/R state and the film in the cassette **1** is unprocessed, so that the relay RK is energized, it is desired to start the motor DCM1, which causes the release of processing composition in the cassette **1,** and then to wait for a brief interval to allow the composition to flow down into the coating nozzle **85** in FIG. **4** before resuming operation of the motor DCM1 to coat the film with processing composition. The pulse produced by the multivibrator **345** accomplishes this purpose after a delay introduced by the duration of the pulse from the multivibrator **346.**

During the interval of the pulse produced by the multivibrator **346,** the motor DCM1 will run to allow processing composition to be released in the cassette **1.** Then, for the duration of the pulse from the multivibrator **345,** the motor will stop to allow processing composition to come down into the nozzle. As will appear, the capstan drive motor DCM2 will be operated at this time, but the capstan **17** will not be in engagement with the film, so that this processing cycle will not be interferred with.

The control circuit for the capstan drive motor DCM2 will next be described. The motor DCM2 may be any conventional DC motor. It has an energizing circuit extending from the supply terminal at B1 over a first path through a resistor R7 and thence through the winding of the motor DCM2 to ground.

A second energizing circuit extends from the terminal at B1 from the collector to the emitter of a conventional npn transistor Q1, and thence through the windings of the motor DCM2 to ground. The base of the transistor Q1 is returned to the supply terminal at B1 through a capacitor C1. The base of the transistor Q1 is also connected to the emitter of a conventional npn transistor Q2.

The base of the transistor Q2 is returned to ground through a resistor R8. The base of the transistor Q2 is also connected, through the photocell **285,** to the supply terminal at B2. A capacitor C2 is connected in parallel with the photocell **285.** The collector of the transistor Q2 is connected to the supply terminal at B2, as shown.

In the operation of the motor control circuit, before the loop **282** is formed on the film, the photocell **285** will be fully illuminated by the lamp K2 and thus exhibit a minimum resistance. Accordingly, most of the supply voltage B2 will appear across the resistor R8, causing the transistor Q2 to be forward biased into saturation conduction. That will cause the transistor Q1 to be forward biased, and maximum current will flow to the motor DCM2.

The motor DCM2 will run rapidly, driving the capstan faster than the average speed at which film is advanced by the pawl **129** at the film gate. The result will be that the loop **282** will quickly form, extending from the cassette to interrupt the light path between the lamp K2 and the photocell **285.**

The resistance of the photocell **285** will go up, thereby reducing the forward bias on the transistor Q2 and therefore tending to cut off the transistor Q1. When the transistor Q1 is cut off in this fashion, the only current flowing to the motor DCM2 will be that supplied through the resistor R7.

The resistor R7 is selected to make this minimum current inadequate to drive the capstan **17** as fast as the film is advanced by the pawl **129.** The loop **282** will accordingly be adjusted in average size to a fixed average length with the capstan **17** running at the average speed at which the film is advanced by the pawl **129.**

Since the pawl operates at typically eighteen cycles per second, the resistance of the photocell **285** will fluctuate at essentially that frequency. The capacitor C2 provides filtering to average out the control signal supplied to the transistor Q2, with a first fluctuating time constant determined by the instantaneous resistance of the photocell **285,** the capacitance of the capacitor C2 and the resistance of the resistor R8. The capacitor C1 provides additional filtering, with a second time constant determined primarily by the capacitance of the capacitor C1, the base resistance of the transistor Q1, and the output impedance of the first stage comprising the transistor Q2. This time constant is preferably substantially greater than the maximum value of the first time constant.

It is desired to make this filtering sufficient that the motor DCM2 will have a relatively slow response, below the range of wow and flutter that would be troublesome. For example, the control circuit may be arranged to cause a maximum regulation of 0.5 percent of the speed of the motor DCM2 over a two-second interval once the loop has been formed and the system is in operation. For that purpose, typical values of the

critical components are 6 ohms for the resistor R7, 220 microfarads for the capacitor C1, 520,000 ohms for the resistor R8, and 1.33 microfarads for the capacitor C2. These values assume a voltage B1 of 12 volts and a voltage B2 of 10 volts.

The value of the resistor R8 essentially selects the sensitivity of the photocell. The photocell will typically fluctuate in resistance from a value on the order of megohms, when it is dark, to a value on the order of 100 ohms, when it is fully illuminated. The mass of the disc 271 with its tire 272, in FIG. 7, for example, serves as a flywheel to further integrate the capstan speed.

It has been found that the flutter at 18 cycles per second can be reduced to 0.1 percent, with a switching voltage amplitude at the winding of the motor DCM2 of 0.12 volts. It will be noted that neither the motor ACM or the motor DCM2 is regulated to constant speed, but that the resulting speeds are essentially constant for all practical purposes. It is highly undesirable to regulate the speed of the motor ACM, because that would regulate the voltage applied to the lamp K1.

As shown in FIG. 14, the replay button IPB controls a switch S9. The switch S9 comprises a manually operated, spring-returned pushbutton having an armature connected to ground. When the pushbutton IPB is momentarily depressed, it provides a ground-going transition that is inverted by a conventional inverting amplifier 347.

In the PROJECT state of the apparatus, when a contact P*d* is closed, the signal at the output of the inverter 347 is applied to one input terminal of a conventional NAND gate 348. A second input terminal of the gate 348 receives a level $\overline{\text{INHIBIT}}$ that is at logic 1 when a flip flop RF is reset. When the contact P*d* is closed, the level $\overline{\text{INHIBIT}}$ is present, and the pushbutton IPB is momentarily depressed, the gate 348 produces a ground-going transition that triggers the one-shot multivibrator 343, described above, to produce the positive pulse labeled REPEAT.

When the pushbutton IPB is depressed and then released, a ground-going transition is supplied to trigger a conventional one-shot multivibrator 349 to produce a positive pulse having a predetermined duration adequate to insure at least a minimum interval of rewinding before projection is resumed. The trailing edge of the pulse produced by the multivibrator 349 triggers a conventional multivibrator 350 to produce a positive output pulse that is applied to one input terminal of the two-input terminal AND gate 342 described above.

The gate 342 also receives a signal labeled 2R that is present at logic 1 when contact D*b* is closed in the D/R state of the apparatus, and when the relay RK is released to close its back contact *e*. Under these conditions, a circuit extends from the supply terminal at B2 over back contact *e* of the relay RK, over the front contact D*b* controlled by the cam 315 in FIG. 13, to the reset input terminal of the flip flop RF, and to the second input terminal of the gate 342. When this signal 2R is present and the one-shot multivibrator 350 is triggered, the gate 342 produces the pulse labeled REPLAY, as described above.

The flip flop RF may be of any conventional design, arranged to be reset by a positive pulse applied to its reset terminal R, and to be set by a positive level applied to its input terminal S. The flip flop RF is also reset by a pulse supplied through a capacitor C3 from the supply terminal at B2 when a cassette is first inserted in the pocket 2 and the power supply is energized. The capacitor C3 is discharged through a resistor R10 when the power supply is deenergized.

The flip flop RF is set when the relay RK is energized and the apparatus is in its PROJECT state by a circuit extending from the supply terminal at B2 over front contact *e* of the relay RK, contact P*f*, and thence to the set terminal of the flip flop. When reset, a positive signal labeled $\overline{\text{INHIBIT}}$ is present at the logic 0 output terminal of the flip flop RF.

The purpose of the flip flop RF is to inhibit the use of the replay pushbutton IPB during the first projection cycle after film has been processed. This first projection cycle is desirably carried through without interruption so that the film is uniformly dried after it is processed.

Referring next to FIGS. 15, 16, 17 and 18, the mechanical details of the operator's control unit 19 will next be described. As shown, the unit 19 comprises a housing 23 in which the microphone 22 is mounted. A front panel 354 is removably secured to the housing 23 by means shown as four machine screws 355.

The replay pushbutton IPB extends through a suitable aperture in the plate 354. Similarly, the recording control pushbutton RPB is mounted over the panel 354 and is adapted to be moved in an arcuate slot 356 formed in the panel 354. As best shown in FIG. 17, the pushbutton IPB extends into a well 357 formed integral with the cover panel 354 and terminating in a ledge 358 that supports a spring 359 that urges the pushbutton IPB upwardly as seen in FIG. 17.

A shaft 360 is formed integral with the pushbutton IPB. The shaft 360 is pivotally secured to two links 361 and 362 by means shown as a pivot pin 363. The link 361 is pivoted at its other end to a fixed support 364 formed integrally with the housing 23. The link 362 is pivoted at its other end to a wedge 365, by means shown as a pivot pin 366. When fully depressed, the pushbutton IPB actuates the spring return micro-switch S9 described above in connection with FIG. 14.

As best shown in FIGS. 16 and 18, the record control button RPB is formed integral with a shaft 367 on which a collar 368 is formed. The shaft 367 is threaded ito engagement with cooperating threads formed in a post 368 having a collar 370 adapted to confront the collar 368 to form a sliding attachment to the cover panel 354 for movement of the pushbutton RPB in the slot 356. A reduced portion 371 formed on the post 369 is adapted to slidingly receive a spring 372. As shown in FIG. 16, the spring 372 is fixed in a well in the housing 23 below the cover panel 354 by means shown as a pair of posts 373 and 374. These posts, and the support 364, are located in a recess 375 formed in the housing 23, and provided with posts such as 376 at the corners that are drilled and tapped to receive the screws 355.

A microswitch S10 is adapted to be actuated by the pushbutton RPB when it is moved all the way to the top right-hand corner of the slot 356 as seen in FIG. 15. For this purpose, the switch S10 is provided with an actuating lever 377 that is adapted to be engaged by the post 369 on the pushbutton RPB in the upper right-hand position of the pushbutton RPB in FIG. 15. In that position, a slight downward curve of the slot 356 allows the pushbutton RPB to be retained by pressure of the spring 372 when the pushbutton is released by the operator. In that position, the microswitch S10 is actu-

ated, for purposes to be described below in connection with FIG. **19.**

The pushbutton RPB can be returned to the LISTEN position, either by movement by the operator against the force of the spring **372** to bring the pushbutton back to the region of the arc in which it will be driven down to the position shown in FIG. **15** by the spring, or by actuation of the pushbutton IPB. When the pushbutton IPB is depressed, if the pushbutton RPB is in the upper right-hand corner of the slot **356,** the wedge **365** will move it out to the region in which it will be driven down to the LISTEN position by the spring **372.** This interlocking feature prevents actuation of the microswitch **S9** to initiate a rewind and reprojection operation while the pushbutton RPB is in the RECORD position. The purpose of this feature is to prevent the user from inadvertently erasing previously recorded material on the film **53** when the apparatus returns to the PROJECT state after the pushbutton IPB has been released.

Referring next to FIG. **19,** the audio system for the motion picture production and sound editing system of the invention will next be described.

It is desired to inhibit recording and erasing except during the PROJECT state of the apparatus. It is also desirable to inhibit recording or erasing during the formation of a loop **282** in the manner described above in connection with FIG. **14.** A relay PRK is provided to insure that these conditions are met.

An energizing circuit for the relay PRK extends from the supply terminal at B1 through the winding of the relay, and thence through the load terminals of a conventional electronic switch **S11** to ground. The switch **S11** is closed for an interval sufficient to pick up the relay PRK when the apparatus goes to the PROJECT cycle after a delay sufficient to permit formation of the film loop and establish synchronization of the sound and picture.

A contact *Pe* is closed when the apparatus goes to the PROJECT cycle. That applies a ground-going transition to a conventional one-shot multivibrator **380.** The multivibrator **380** is designed to produce a pulse having a duration sufficient to insure that the film loop is formed and stabilized. At the trailing edge of the pulse produced by the multivibrator **380,** a second multivibrator **381** is triggered to produce an output pulse having a duration sufficient to close the switch **S11** long enough to pick up the relay PRK.

Once picked up, the relay PRK completes a stick circuit over its own front contact *a,* through a current limiting resistor **R9,** and thence over the project contact *Pe* to ground. The relay PRK will thus remain energized as long as the apparatus is in the PROJECT cycle, and will drop out as soon as the apparatus goes toward the D/R state from the PROJECT state.

A recording relay RRK is adapted to be picked up any time after the relay PRK is picked up. For this purpose, an energizing circuit for the relay RRK extends from the supply terminal at B1 through the winding of the relay RRK, over front contact *b* of the relay PRK, and thence to a normally open contact *a* of the switch **S10** controlled by the record pushbutton RPB. As the pushbutton RPB is moved to the RECORD position when the relay PRK is energized, the relay RRK will be energized and remain energized until either the apparatus goes out of the PROJECT cycle or the pushbutton RPB is moved out of the RECORD position, either by the user's direct action, or because the pushbutton IPB has been depressed.

The microphone **22** has a winding **382** connected between ground and the armature of a normally open contact *b* of the switch **S10.** When this contact *b* is closed, by movement of the pushbutton RPB to the RECORD position, the microphone output coil **382** is connected to the active input terminal of a conventional audio amplifier **383.** At times when the amplifier **383** is effective to record, the relay RRK will be energized, closing a circuit over its front contact *b* between the active output terminal of the amplifier **383** and a record and playback winding **384** forming part of the head **16.**

As schematically illustrated, the head **16** is preferably of the type which combines the functions of recording, playback and erasing. For that purpose, the head **16** comprises a ferromagnetic core generally designated **385** formed with a first magnetic path including a leg **386** on which the winding **384** is wound, a leg **387** interrupted by a back gap **388,** a central leg **389,** and a return leg **390** interrupted by a record and playback gap **391.** A second magnetic path includes the center post **389,** a path through a leg **392** on which an erase winding **393** is disposed, and a return leg **394** interrupted by an erase gap **395.**

The erase winding **393** is adapted to be energized by an amplifier **396** in response to the output signal from a high frequency oscillator **397,** oscillating at a frequency such as 60KHz when supplied with an energizing signal over front contact *a* of the relay RRK. The core **385** and windings **384** and **393** are preferably designed so that when erase current is supplied to the gap **395** by the winding **393,** sufficient flux at the high frequency of the erase current is coupled into the record gap **391** so that a conventional high frequency bias signal is added to the audio signal from the amplifier **383.**

When the relay PRK is energized, and the relay RRK is deenergized, the winding **384** serves as a playback winding and supplies an audio signal over back contact *b* of the relay RRK, front contact *c* of the relay PRK, and through a volume control potentiometer **398** to ground. The potentiometer **398** is provided with a wiper **399** actuated by the volume control knob **26** in FIG. **1.** The wiper **399** is connected to the active input terminal of a conventional audio output amplifier **400,** which supplies energizing current to the winding **401** of the speaker **12** in FIG. **2.**

It will be apparent that by the arrangement just described it is possible to listen to sound recorded on a film **53** at any time during the PROJECT cycle after the film loop has been formed. When the listener decides to edit or add to the sound recorded on the film, when the switch RPB is moved to the RECORD position, the apparatus immediately goes to the RECORD state with the energization of the relay RRK, interrupting the playback circuits and establishing the recording circuits so that recording can be begun immediately after the point when the listener decides to interrupt. The use of this facility together with the instant replay button IPB enables the user to repeatedly review a scene and edit the accompanying sound track until it is as desired.

Having thus described the system of the invention, its operation will next be described. Referring to FIG. **4,** it will be assumed that a cassette of film has been ex-

posed in a camera, such that it is disposed primarily on the takeup reel **64** and located at the exposure termination point established by the first elongated sprocket hole **118** in FIG. **5.**

The parts of the apparatus will be in the position illustrated in FIG. **4,** with the terminals **59** and **60** presenting a closed circuit because they are bridged by the cam and valve member **88.** The production and editing system will be in the condition shown in FIG. **7,** with the reel drive sprockets **212** and **213** retracted, and the apparatus deenergized because the contacts of the locator pin actuator switch S2 are open. The locator pin **159** will be in its retracted position. The cam shafts **179, 180** and **182** will be in the O position.

Referring to FIG. **14,** the contact **0** will be closed, preparing a circuit for the clutch magnet CM. However, the clutch magnet will not be energized, because the power supply contacts S2 and $\overline{O}a$ are both open. The switch S1 will be closed.

Next, assume that a cassette **1** in the state described is inserted into the pocket **2.** The first effects will be to depress the foot pedal **42,** open the switch S1, and register the terminals **59** and **60** on the cassette **1** with the contacts **150** and **151** located on the wall **149** of the pocket **2** (FIG. **7**).

Referring to FIGS. **10** and **11,** when the foot pedal **42** is depressed, the yoke arms **244** will be removed from the collar **250** on the locating pin **159,** allowing the locating pin to be driven by the spring **251** into the position in which it protrudes through the port **40** in the wall **36.** The pin **159** will enter the port **34** in the cassette, latching the cassette in the pocket. That locates the cassette and prevents premature removal of the cassette with the film partially processed, or in a random position. At the same time, the switch S2 closes its contacts.

Referring to FIG. **14,** with the switch S2 closed, its contacts supply power to the combined motor and transformer ACM, causing the shaft **160** to rotate and drive the blower fan **161** (FIG. **7**). At the same time, the power supply **158** will be energized.

The power supply voltages B1 and B2 will now appear, causing the clutch magnet CM in FIG. **14** to be energized over the closed contact O. The flip flop RF will be reset by a pulse through the capacitor C3. The capstan drive motor ACM2 will operate at its highest speed, in the absence of a loop **282,** but the capstan **17** and head **111** will not yet engage the film **53.**

The cam shaft **164** will now be driven, causing the cam shafts **179,180** and **182** to be driven. Referring to FIGS. **7** and **13,** rotation of the shaft **180** will cause the cams **185** to begin to rotate from their O position toward their P position. The spindle plate **186** will pass over the stop **192** in its lower position. When the plate **186** has passed over the stop **192,** the cam **316** will close the cassette sense enable switch CS, as shown in FIG. **13,** preparing the cassette sense enabling circuit for the energizing of the relay RK as seen in FIG. **14.** Since the terminals **59** and **60** on the cassette **1** are bridged at this time by the valve **88,** within the cassette, the relay RK will be energized, and close its stick circuit over its own front contact *a* and the contact $\overline{O}b$, which is now closed because the cam **313** in FIG. **13** has moved away from the O position toward the P position.

The solenoids SL1 and SL2 will now be energized. Referring to FIG. **7,** energizing the solenoid SL1 will cause the hinged end plate **248** of the cassette eject enabling assembly to be moved back away from the slot **289,** to prevent premature ejection of the cassette **1** by the cam **309.** At the same time, the stop **192** is moved into position to prevent movement of the spindle plate **186** back out of engagement, in the manner described in detail in the above-cited U.S. application Ser. No. 227,080.

Referring to FIG. **11,** energization of the solenoid SL2 will retract the latching pin **258** from the lever **255** to disable the locator pin withdrawal assembly. As shown in FIG. **13,** the cam **262** will not effect any movement of the cam follower **261** during this rotation from the position O to the position P.

As the spindle plate **186** completes its movement toward the wall **36** in FIG. **7,** the drive sprockets **212** and **213** will engage the corresponding takeup reel drive sprocket and supply reel drive sprocket **66** and **54** of the cassette (FIG. **4**). This connection is established just before the raising of the stop **192** as described above, so that engagement of the drive sprockets will be maintained by the stop **192** during the sequence of operations to follow regardless of the positions of the cams **185.**

Referring to FIGS. **7** and **13,** as the cam shaft reaches the P position, the snubber stop cam **204** will drive the snubber stop **205** into engagement with the snubber hub **82** of the snubber roll **63,** as seen in FIG. **4.** At the same time, the sound array control cam **208** will allow the sound array **13** to move into engagement with the cassette, so that the capstan **17** and head **16** go into the operative positions shown in FIG. **8.** With the motor DCM2 operating at high speed, the loop **282** will form rapidly.

Referring to FIG. **14,** with the apparatus in its P position, the contact P*b* will be closed, causing the solenoid SL3 to be energized and engaging the pulleys **332** and **334** with the belt **333** to drive the film advance pawl **129** and to operate the shutter **9.** The contact P*f* will be closed, and with the relay RK energized and its front contact *e* closed, the flip flop RF will be set to remove the level $\overline{\text{INHIBIT}}$. Thus, the pushbutton IPB will be disabled. The projection lamp K1 will not be energized at this time, because its energizing circuit is open at the open back contact *c* of the relay RK.

Referring to FIGS. **13** and **14,** the motor reverse contacts MR will be moved by the cam **203** into their upper position, causing the motor DCM1 to drive the film takeup reel through the shaft **227,** the gears **228** and **231,** the shaft **229,** the clutch **233,** the clutch **225,** the shaft **223,** and the drive sprocket **213** in FIG. **7.**

The control circuit for the motor DCM1 will extend from the supply terminal at B1 in FIG. **14** through the resistor R3, variable resistor R5, contact P*c*, and the load terminals of the closed switch S7 to the active input terminal of the amplifier **344.** That will cause the motor DCM3 to run at a speed slightly greater than the average rate of film advance by the pawl **129.**

The film will now be advanced from the termination point established by the sprocket hole **118** in FIG. **5** to the point established by the second elongated sprocket hole **119** in FIG. **5.** Referring to FIG. **6,** when that point is reached, the pawl teeth **127** and **128** will skip through the elongated sprocket hole **119** without engagement with the film, and the takeup reel will stop.

At some point just after the elongated sprocket hole **119** is reached by the pawl **129,** the end of the film on the takeup reel will be reached with the capstan **17** located over the capstan wear pad **125** on the film **53.** The capstan will continue to rotate on the wear pad for a short time, without further extending the loop **282.**

During the advance movement of the film onto the takeup reel just described, the bump **121** on the film **53** will engage the end of the pressure pad **86,** moving the pressure pad into coating relation with the nozzle **85** as described above. During the same interval, referring to FIG. **7,** the contacts of the switch S5 repeatedly close and open to prevent the motion detector **341** from producing the signal $\overline{M}$.

During this first advance movement of the film, although the sound system is operative, no sound will normally be heard, even though sound may have been recorded on the film in the camera. The reason is that sound would not normally be recorded beyond the recording point corresponding to the exposure endpoint on the film established by the elongated sprocket hole **118.**

When the elongated sprocket hole **119** on the film is encountered, the shaft **223** in Figure will stop, because frictional engagement of the film with the snubber roll is no longer relieved by the drive pawl, and the shaft **223** will be unable to drive the takeup reel against this load. Accordingly, the switch S5 will cease to be opened and closed. Referring to FIG. **7,** that will cause the motion detector to produce the signal $\overline{M}$, after a time delay incorporated to prevent false operation in the manner described in detail in the above-cited U.S. application Ser. No. 227,080.

When the signal $\overline{M}$ is produced, the clutch magnet CM will be energized. The signal $\overline{M}$ applied to the gate **340** will cause the switch S6 to be closed for this purpose, as seen in FIG. **14.** The shaft **164** and its associated cam shafts will be driven to the next dwell position. Referring to FIG. **13,** the cams will now begin to move from the P position towards the D/R position.

Referring to FIGS. **13** and **14,** as the cams move away from their P position, the P contacts will open and the solenoid SL3 will be deenergized. That will disengage the shaft **160** from the shaft **132,** and the pawl and shutter will cease to operate.

The cam **314** will close the OFF contact O between the P and D/R positions. The contact O will maintain a circuit for the clutch magnet CM until the apparatus nears its D/R position.

As shown in FIG. **13,** the reset contact JR will be closed between the P and D/R positions. The contact JR will reset the motion detector **341** for the next cycle of operation, removing the signal $\overline{M}$.

Referring again to FIG. **13,** the motor reversing contact MR will now be changed to the other position, preparing the film reel drive motor DCM1 to be driven towards the supply reel. As the cams move away from the P position, the snubber stop **205** will be retracted. The cam **208** will move the sound array **13** out of engagement with the film, with the motor DCM2 continuing to operate.

The blinder cams **199** and **297** will move the associated lamp and aperture plate blinders towards their positions closing the light apertures in the pocket **2,** so that the film in the cassette will now be in a lighttight environment. The pressure plate cam **308** will be operated to raise the pressure plate, by the mechanism shown in FIG. **12.**

Referring to FIG. **14,** when the apparatus reaches its D position, contact Dc will be closed, and the motor DCM1 will begin to operate in response to the high speed signal supplied from the junction of the resistors R3 and R4. The multivibrator **346** will be triggered by the closing of the contact *Da* with the front contact *d* of the relay RK closed.

Referring to FIG. **7,** the motor DCM1 will now drive the supply reel shaft through the shafts **227** and **230,** the clutches **234** and **224,** and the shaft **219** and sprocket **212.** The film will begin to advance onto the supply reel. The first result will be to pull out the loop **282** formed during the previous PROJECT cycle. Next, the takeup reel will begin to rotate, thereby driving the shaft **223** through the sprocket **213.** That will cause the switch S5 to open and close, as before.

For the interval during which the multivibrator **346** (FIG. **14**) produces its output pulse, the motor DCM1 will continue to drive, advancing film onto the supply reel and causing the tear-tab release mechanism described above in connection with FIG. **4** to be actuated to strip the tear-tab in part from the initially sealed receptacle of processing fluid.

At the end of the pulse produced by the multivibrator **346,** the multivibrator **345** will be triggered to close the switch S8, thus opening the switch S7, to stop the motor DCM1 for an interval sufficient to allow processing composition to flow into the nozzles **85.** During that interval, the switch S5 will not function. However, as described in the above-cited U.S. application Ser. No. 227,080, a minimum delay greater than the duration of the pulse from the multivibrator **345** is preferably provided before the motion detector **341** will respond to produce the signal $\overline{M}$.

At the end of the pulse produced by the multivibrator **345,** the motor DCM1 will begin to turn again at the speed established by the signal supplied from the junction of the resistors R3 and R4. Processing of the film will occur as described above. The switch S5 in FIG. **7** will now function normally, preventing the production of the signal $\overline{M}$.

When the end of the film is reached, the takeup reel will stop rotating, and the shaft **223** in FIG. **7** will accordingly stop. That will stop the rotation of the vanes **257,** and the switch S5 will no longer be opened and closed. The signal $\overline{M}$ will again be produced, preferably in the manner described in the above-cited U.S. application Ser. No. 227,080, after a time delay sufficient to allow uniform development of the film.

When the signal $\overline{M}$ is produced, the clutch magnet CM in FIG. **14** will be energized to drive the cam shafts from their D/R positions toward their O positions. Referring to FIGS. **13** and **14,** the contact O will be reengaged, to keep the clutch magnet energized during the shaft movement to the O position.

The pressure plate lifter cam **308** will move into a position in which the pressure plate in the cassette is again lowered into engagement with the film. The blinder cams **199** and **207** will be actuated to open the light ports into the pocket **2.**

The spindle cams **185** will begin to move back from the spindle plate **186** in FIG. **7.** When that occurs, with the stop **192** in its raised position as described above, the stop **192** will be held frictionally in position, pre-

venting the spindle plate **186** from being retracted as the cams **185** are retracted.

During most of the motion of the cam shaft from its D/R position to its O position, the contacts $\overline{O}$ remain closed by the cam **313** in FIG. **13.** That maintains the relay RK in FIG. **14** energized, and keeps the solenoids S11 and S12 energized.

When the cam shaft reaches its O position, the contacts $\overline{O}$ will be opened, and the relay RK will be released. That will cause the solenoids SL1 and SL2 to be deenergized. The hinged plate **248** will move back over the slot **289,** as it can do with the cam **309** in the neighborhood of its O position, so that the cam **309** will be enabled to eject the cassette as it next approaches its O position.

Referring to FIG. **11,** when the solenoid SL2 is deenergized, the pin **258** will extend into the link **255,** enabling the locating pin withdrawing mechanism. Between the positions D/R and O, the jam reset contact JR will be closed, causing the motion detector **341** to be reset as described above.

When the apparatus reaches its O position, the clutch magnet CM will remain energized over contact O (FIG. **14**). Accordingly, the cam shaft will continue to rotate to carry the apparatus to its P position. As it does so, the spindle cams **185** will again engage the spindle plate **186** in FIG. **7,** and that action will relax the frictional engagement between the stop **192** and the spindle plate **186** and allow the stop **192** to fall below the plate **186.**

At this point, the apparatus is in the condition that it would be in had a cassette of previously processed film been inserted in to the pocket **2.** Accordingly, the following description applies both to the sequence of operations that occur when a cassette of unprocessed film is inserted, after it has been processed, and to the insertion of a cassette of processed film.

As the apparatus reaches its P position, with the relay RK in FIG. **14** deenergized, contact P*a* will be closed to energize the projection lamp K1. Contact P*b* will be closed to energize the solenoid SL3, causing the film drive pawl **129** to be actuated and the shutter **9** to be opened and closed synchronously therewith. Contact P*a* will be closed, triggering the multivibrator **380** in FIG. **19** to begin the time delay for enabling the loop **282** to form before the record button RPB is enabled.

The cams **204** and **208** will move the snubber stop **205** and the sound array **13** into operating position as described above. The loop **282** will form raipdly, and then stabilize, under the control of the photocell **285.**

Referring to FIG. **14,** the film reel drive motor control circuit will now supply a signal through the resistor R5 to cause the motor DCM1 to drive the takeup reel slowly in the direction to advance film onto the takeup reel. The signal will be supplied over closed contact P*c* and the closed switch S7.

The processed images on the film **26** will now be projected on the screen **5** as seen in FIG. **1,** synchronously with the reproduction of any signal that may have been recorded on the sound track **123** (FIG. **5**). For 8 mm film having approximately **50** feet of processed images, that operation may occupy, for example, approximately three minutes and **20** seconds.

After the initial delay to enable film loop formation, the relay PRK in FIG. **19** will pick up. That will enable the recording of sound by means of the microphone **22** under the control of the pushbutton RPB. However, the pushbutton IPB will be disabled during this first projection cycle by the absence of the signal $\overline{\text{INHIBIT}}$.

The projection and sound reproducing cycle will continue until the sound elongated sprocket hole **119** on the film **53** is reached, whereupon the takeup spool drive shaft **223** in FIG. **7** will stop. The motion detector **341** will now function to produce the signal $\overline{M}$, so that the clutch magnet CM will again be energized, driving the apparatus towards its D/R position. The snubber stop **205** and the sound array **13** will be retracted as described above. The blinders for the light apertures in the pocket **2** will again be closed, but that operation will not be significant because the film has already been processed.

When the apparatus reaches its D/R position, the closure of contact D*b* in FIG. **14,** with the relay RK deenergized and its back contact *e* closed, will reset the flip-flop RF to produce the signal $\overline{\text{INHIBIT}}$. Closure of the contact D*c* will cause the motor DCM1 to rewind the film rapidly onto the supply reel. That operation may occupy, for example, about ten seconds. At the end of rewind, the motion detector **341** will again respond, to reenergize the clutch magnet CM and drive the apparatus back towards its O position.

Referring to FIG. **11,** the pivot pin **258** has been reengaged with the lever **255.** Accordingly, as the apparatus nears its O position, the locator pin **159** will be withdrawn to the position shown in FIG. **11.**

Prior to the withdrawal of the locator pin, the cams **185** in FIG. **7** allow the spindle plate **186** to be moved back away from the wall **36,** withdrawing the drive sprockets **212** and **213** from the cassette. Following the withdrawal of the locator pin, the ejector cam **309** will rise into the slot **289** in FIG. **7,** ejecting the cassette **1** through the intermediate plate **248** to a position raised slightly out of the pocket **2** in the housing **3,** where it can conveniently be grasped for withdrawal by the operator.

When the locator pin is withdrawn, the contacts of the switch S2 are opened. Referring to FIG. **14,** that action does not immediately disable the power supply, because the contact $\overline{O}a$ remains closed until the apparatus reaches its OFF position. When it does reach that position, the contact $\overline{O}a$ opens, restoring the apparatus to its initial condition in which it is in readiness for the insertion of another cassette.

It will be apparent that had a cassette containing previously processed film been inserted in the pocket **2,** the terminal **59** and **60** would not initially be bridged. Accordingly, the relay RK would not be picked up. The flip-flop RF will be set through the capacitor C3 when the supply voltage B2 first appears, and will remain reset. The apparatus would then move from its O position to its P position in the manner described above, following the processing of unprocessed film.

After the relay PRK in FIG. **19** has been picked up following the delay to allow loop formation in the manner described above, the apparatus is operative to permit sound recording and editing by the use of the replay button IPB. Suppose that no sound has previously been recorded on the film strip, and it is desired to record sound at the beginning of the picture sequence after the film has been processed.

Substantially as soon as the cassette has been inserted and the apparatus has reached its PROJECT state, the

instant replay button IPB can be depressed, causing the REPEAT signal to be produced by means of the apparatus shown in FIG. **14.** That will close the switch **S6** through the BR gate **340,** causing the clutch magnet CM to be energized and operating the apparatus from its PROJECT state to its D/R state.

If the pushbutton IPB is immediately released after it is depressed, with the film near the beginning of its projection cycle, after the time delay produced by the multivibrator **349,** the multivibrator **350** will be triggered to supply a pulse to the AND gate **342.** With the apparatus in its rewind state, the contact D*b* will be closed, and the gate **342** will be enabled over the circuit completed over the back contact *e* of the relay RK and the contact D*b*.

The REPLAY pulse will thus be produced, causing the switch **S6** to be closed again through the gate **340,** and driving the apparatus towards its O state. With the REPLAY signal present, the relay RK will be energized, and will remain energized over its own front contact *a* and the contact $\overline{O}b$, closed until the apparatus reaches the OFF position. The solenoids SL1 and SL2 will be energized, preventing the cassette from being ejected as it moves into the OFF position, and preventing the locator pin from being withdrawn as described above.

The apparatus will then continue to move from its O position to its P position again. As the apparatus moves through the O position, the relay RK will be released as before.

Because the control system for the capstan drive motor DCM2 will operate to form the loop **282** within a second of the entry of the sound array into the cassette, the relay PRK will pick up soon enough so that the operator can begin to record substantially as soon as he sees pictures on the screen **5.** For this purpose, it is convenient to move the record button RPB to the RECORD position as soon as the pushbutton IPB is released. Thus, a sound track can be recorded substantially at the beginning of the picture sequence and continued to the end of the sequence.

When the button RPB is returned to its LISTEN position, the operator can produce the sound picture recorded. By use of the pushbutton IPB, this recorded sound sequence can be reviewed and edited if desired, by returning the film to a desired starting point ahead of the point at which editing is desired. The recorded program can be interrupted at any time after the relay PRK has been picked up in the PROJECT cycle, so that if it is desired to change the recorded signal from a given point on, that can readily be done.

While the invention has been described with respect to the specific details of a particular embodiment thereof, many changes and variations will occur to those skilled in the art upon reading the foregoing description. Such can obviously be made without departing from the scope of the invention.

Having thus described the invention, what is claimed is:

1. Film transport and illumination apparatus for a sound motion picture system utilizing strip film on which visual images and a sound track can be recorded, comprising incremental drive means operable to move the film strip past an optical station in increments corresponding to image frames, a capstan operable to move the film past a sound station at a substantially uniform speed dependent on the rate of rotation of said capstan, an induction motor having a stator and an output shaft, means connecting the output shaft of said induction motor to said incremental drive means to operate said drive means at a rate determined by the speed of said shaft, a primary winding on said stator, a secondary winding on said stator, a projection lamp connected in series with at least a portion of one of said windings, means for connecting a source of alternating current to said primary winding, a direct current motor having a winding and an output shaft, speed reduction means drivingly connecting the output shaft of said direct current motor to said capstan, direct current power supply means having first, second and third output terminals and input terminals energized by said secondary winding for producing first and second direct voltages, said first direct voltage being produced between said first and said third output terminals and said second direct voltage being produced between said second and said third input terminals, a first resistor connected in series with the winding of said direct current motor between said first and said third output terminals, a transistor having an emitter and a collector connected in parallel with said resistor, said transistor having a base, a first filter capacitor connected between the base and the collector of said first transistor, a second transistor having a collector, an emitter and a base, the collector and the emitter of said second transistor being connected between said second terminal and the base of said first transistor, a second resistor connected between the base of said second transistor and said third output terminal, a second filter capacitor connected between the base of said second transistor and said second output terminal, a photocell connected in parallel with said second filter capacitor, light source means for illuminating said photocell along a path adapted to be interrupted by a loop of film formed between said drive means when said uniform speed differs from the average speed of the film produced by said incremental drive means, whereby the resistance of said photocell is modulated at the rate of operation of said incremental drive means to modulate the amount of current flowing between the emitter and the collector of said second transistor at a rate determined by the capacitance of said second filter capacitor and thereby modulate the bias on said first transistor at a rate determined by the capacitance of said first filter capacitor, said capacitors and said speed reduction means being selected to make the response time of said capstan long relative to the rate of operation of said incremental drive means.

2. In combination with a sound motion picture system having a film drive pawl driven by an induction motor at a relatively fixed rate to move a strip of film incrementally past a projection station and a projection lamp at said projection station energized by a winding on said induction motor, a sound drive system for driving the strip of film through a sound station at uniform speed, comprising capstan means adapted to engage the film, a DC motor for driving said capstan means at a speed determined by the amount of current supplied to said DC motor and a motor speed control circuit for said DC motor comprising a source of voltage, a fixed resistor connected between said DC motor and said source to supply a first component of current to said DC motor to operate said capstan means at a speed causing film motion below the average film speed produced by said film drive pawl, first amplifying means

responsive to a first applied signal to supply additional current to said DC motor in amounts determined by said first applied signal, first filter means for damping changes in the amplitude of a signal applied to said first amplifying means, second amplifying means responsive to a second applied signal to apply a first signal to said first amplifying means, second filter means for damping changes in the amplitude of a signal applied to said second amplifying means, and sensing means responsive to the length of a strip of film between said stations for applying a second signal to said second amplifying means fluctuating at said rate of operation of said film drive pawl.

3. A film transport system for moving a strip of motion picture film uniformly past a sound station and incrementally past a projection station, comprising capstan means located at said sound station and adapted to engage the film and move it through said sound station when said capstan means is driven by a shaft at a speed determined by the speed of the shaft, a DC motor having a shaft connected to said capstan means, an induction motor having an output shaft and an energizing winding, incremental film transport means located at said projection station, connected to the output shaft of said induction motor and adapted to engage the film and move it incrementally through said projection station at an average speed determined by the speed of said induction motor output shaft, circuit means for supplying alternating current to the energizing winding of said induction motor, sensing means located between said stations and responsive to the length of the film between said stations for producing a control signal in accordance with said length that fluctuates at the frequency of operation of said incremental drive means, and two stage amplifying means controlled by said signal for supplying direct current to said DC motor at a rate tending to keep the average length of the film between said stations constant, a first stage of said amplifying means comprising filter means for damping fluctuations in said signal with a first variable time constant, and a second stage of said amplifying means comprising means for damping the damped signal from said first stage with a time constant substantially greater than the maximum time constant of said first stage.

4. The apparatus of claim **3,** in which said sensing means comprises a radiation responsive impedance and means for irradiating said radiation responsive impedance over a path interrupted by a length of film between said stations greater than a predetermined length.

5. The apparatus of claim **4,** in which said first stage comprises a source of DC voltage, a resistor, a capacitor, and an amplifying device having a pair of load terminals and a control terminal, said source having terminals connected in series with said radiation responsive impedance and said resistor, said capacitor being connected in parallel with said radiation responsive device, and means connecting one load terminal and the control terminal of said amplifying device in parallel with said capacitor, whereby said first time constant is determined primarily by said capacitor, said resistor and said radiation responsive impedance, and the other of said load terminals and one terminal of said source comprise output terminals for applying said damped signal to said second stage.

6. The apparatus of claim **4,** in which said second stage comprises a source of DC voltage, a resistor, a capacitor, and an amplifying device having a pair of load terminals and a control terminal, said source having terminals connected in series with said DC motor and said resistor, the load terminals of said amplifying device being connected in parallel with said resistor, and said cpacitor being connected between a first of said load terminals and said control terminal, said second time constant being determined in part by said capacitor, and said control terminal and one of said load terminals comprising input terminals to which the damped signal from said first stage is applied.

7. The apparatus of claim **4,** in which said first stage comprises a first source of DC voltage, a first resistor, a first capacitor, and a first amplifying device having a pair of load terminals and a control terminal, said first source having terminals connected in series with radiation responsive impedance and said first resistor, said first capacitor being connected in parallel with said radiation responsive device, and means connecting one load terminal and the control terminal of said first amplifying device in parallel with said first capacitor, whereby said first time constant is determined by said first capacitor and said radiation responsive impedance, the other of the load terminals of said first amplifying means and one terminal of said first source comprising output terminals for applying said damped signal to said second stage, and in which said second stage comprises a second source of DC voltage, a second resistor, a second capacitor, and a second amplifying device having a pair of load terminals and a control terminal, said second source having terminals connected in series with said DC motor and said second resistor, the load terminals of said second amplifying device being connected in parallel with said second resistor, and said second capacitor being connected between a first of the load terminals and the control terminal of said second amplifying device, said second time constant being determined in part by said second capacitor, and the control terminal and one of the load terminals of said second source comprising input terminals of said second stage to which said output terminals of said first stage are connected.

8. A sound motion picture system, comprising means forming a projection station at a first location, a projection lamp located at said projection station, a film drive claw located at said projection station, means forming a sound station at a second location, a film drive capstan located at said sound station, means for guiding a strip of film over a path from said capstan to said claw, said path including a region in which the film is free to form a loop of variable length, an induction motor, means operated by said motor for driving said claw, capstan drive means comprising a DC motor for driving said capstan at a speed determined by an applied current, said induction motor comprising a set of windings linked by a common core, means connecting at least a part of one of said windings in series with said lamp, first and second input terminals connected to one of said windings and adapted to be excited by an alternating voltage to cause the excitation of all of said windings, means responsive to the length of a loop of film in said region for producing an output signal in accordance with said length and fluctuating at the rate of operation of said film drive claw, means connected to one of said windings for producing a DC voltage, means

controlled by said DC voltage for producing a component of current adequate to drive said DC motor at a speed below the speed required to move film at the average rate at which film is moved by said drive claw, first amplifying and filtering means controlled by said output signal for producing a damped control signal in accordance with said output signal but fluctuating at a first lower rate than said output signal, second amplifying and filtering means controlled by said DC voltage and said damped control signal for producing a control current component in accordance with said damped control signal but fluctuating at a second rate lower than said first lower rate, and circuit means for applying the sum of said current components to said DC motor.

9. A sound motion picture system, comprising means forming a projection station at a first location, a projection lamp located at said projection station, a film drive claw located at said projection station, means forming a sound station at a second location, a film drive capstan located at said sound station, means for guiding a strip of film over a path from said capstan to said claw, said path including a region in which the film is free to form a loop of variable length, an induction motor, means operated by said motor for driving said claw, capstan drive means comprising a DC motor for driving said capstan at a speed determined by an applied current, said induction motor comprising a set of windings linked by a common core, means connecting at least a part of one of said windings in series with said lamp, first and second input terminals connected to one of said windings and adapted to be excited by an alternating voltage to cause the excitation of all of said windings, means connected to one of said windings for delivering an applied current to said DC motor, said applied current delivering means including means responsive to the length of a loop of film in said region for delivering an applied current to said DC motor selected to cause said capstan to drive the film at a speed below the average speed of the film being produced by said film drive claw when the length of a loop of film in said region is greater than a predetermined length and for delivering an applied current to said DC motor selected to cause said capstan to drive the film at a speed above the average speed of the film being produced by said film drive claw when the length of a loop of film in said region is greater than the predetermined length.

10. The system of claim **9** wherein said applied current delivering means additionally includes means for making the time of response of said capstan to changes in the length of the film loop in said region long relative to the rate of operation of said film drive claw.

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