United States Patent

Takata

[15] **3,680,803**

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[54] **TURBINE DRIVE FOR PHOTOGRAPHIC FILM PROCESSING MACHINES**

[72] Inventor: **Victor Takata,** Cambridge, Mass.

[73] Assignee: **Artisan Industries Inc.,** Waltham, Mass.

[22] Filed: **Aug. 4, 1970**

[21] Appl. No.: **60,837**

[52] **U.S. Cl.** .....**242/55.01,** 95/94 R

[51] **Int. Cl.** **B65h 51/20**

[58] **Field of Search**.....242/55.01, 47.5, 75.53; 95/94 R; 60/108

[56] **References Cited**

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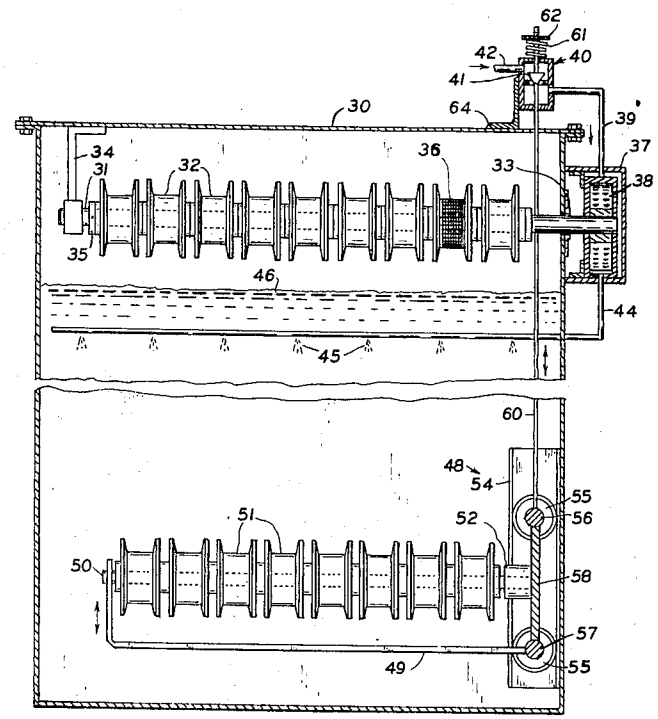
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Primary Examiner—Stanley N. Gilreath
Assistant Examiner—Milton Gerstein
Attorney—Richard L. Cannaday

[57] **ABSTRACT**

A drive for photographic film spools and film spool shafts includes a turbine wheel for rotating a shaft carrying a plurality of spools on that shaft with the speed of the shaft and spools modulated in response to changes in tension of the film carried on the spools. In another embodiment the shaft is driven by a turbine at an established speed with at least some of the film spools on the shaft being individually turbine driven to an overspeed of the shaft modulated in accordance with changes in film tension. In yet other embodiments there are turbine drives for individual spools rotatably mounted on stationary shafts, again with spool speeds being modulated according to changes in film tension. Drive modulation controls may be for a greater or smaller number of spools, and signals for modulation may originate in changes in tension either in film immediately passing over the spools whose speed is to be modulated or in film at a removed location. Fluid for energizing the turbine wheels associated with film spools or spool shafts may be either fluid used in the course of film processing or fluid from an independent source kept isolated from any processing fluid or fluids.

30 Claims, 31 Drawing Figures



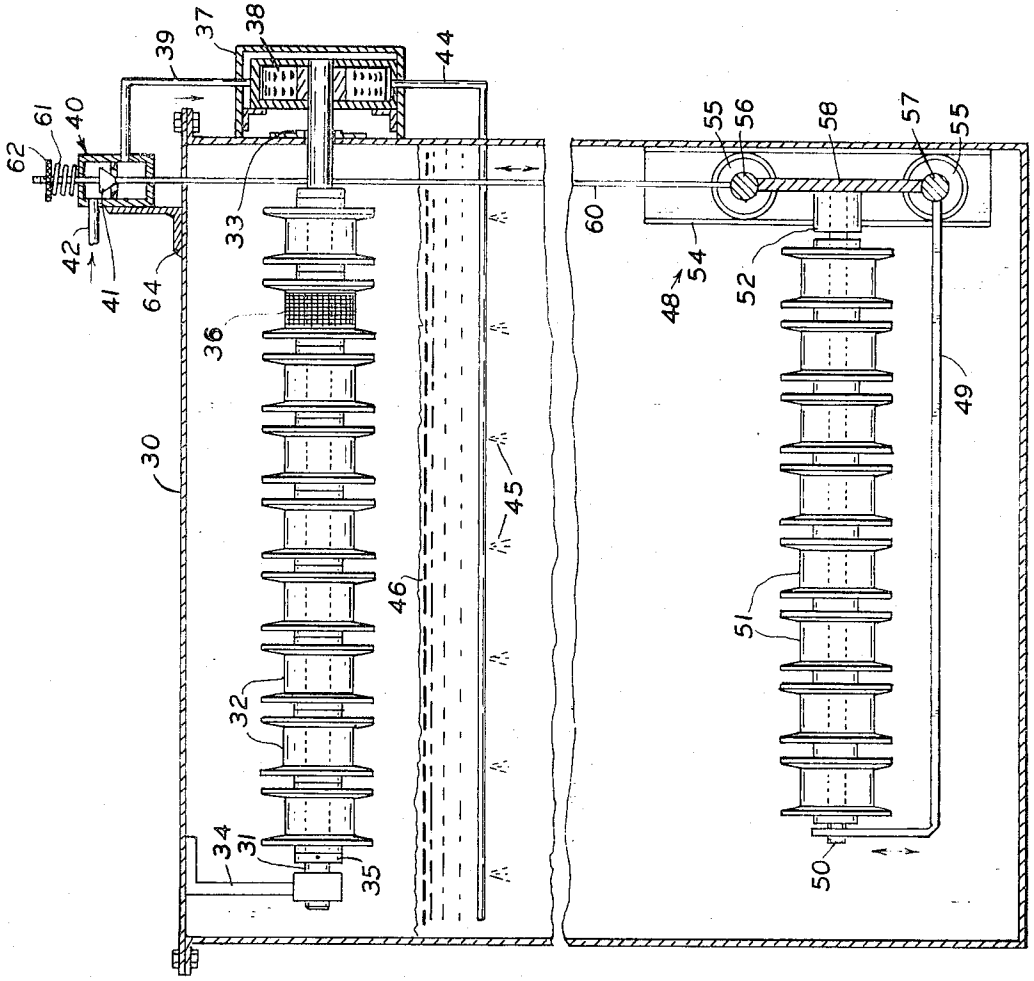


Fig. 1

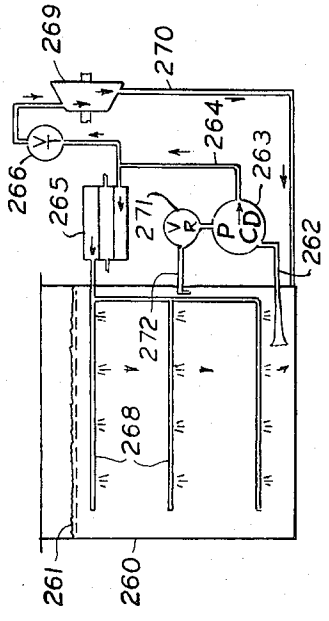


Fig. 27

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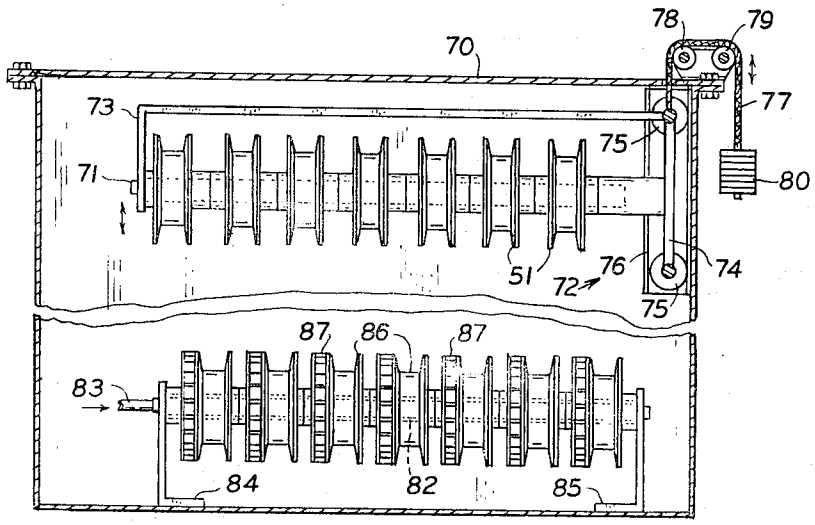


Fig. 2

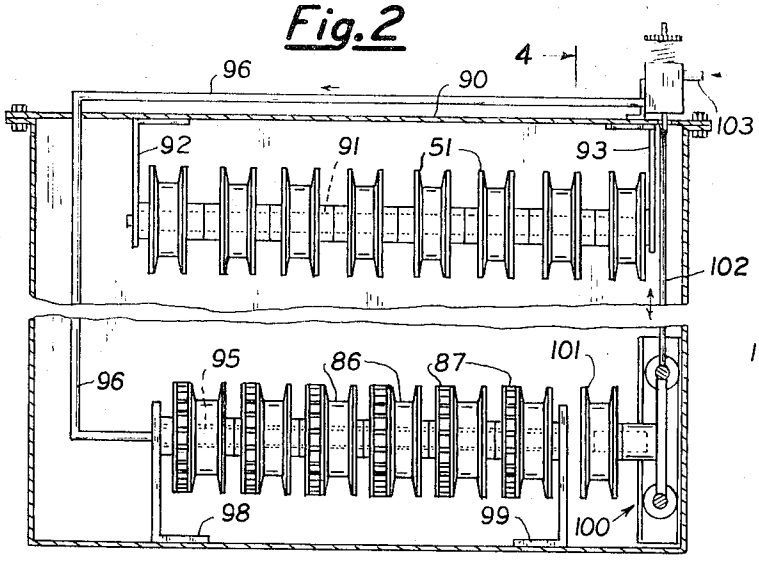


Fig. 3

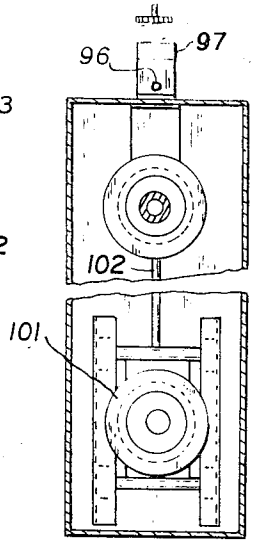


Fig. 4

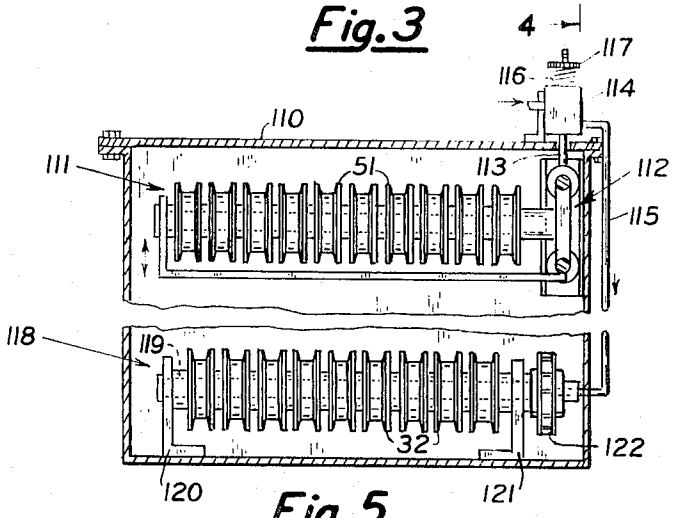


Fig. 5

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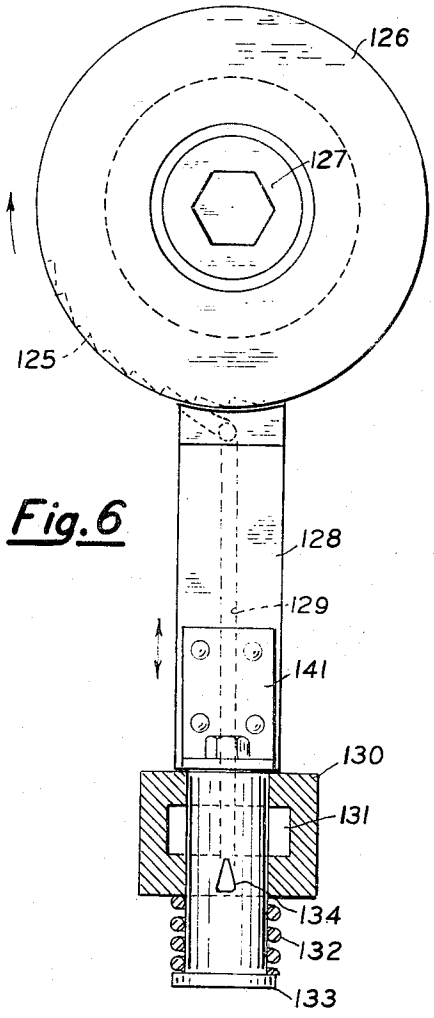


Fig. 6

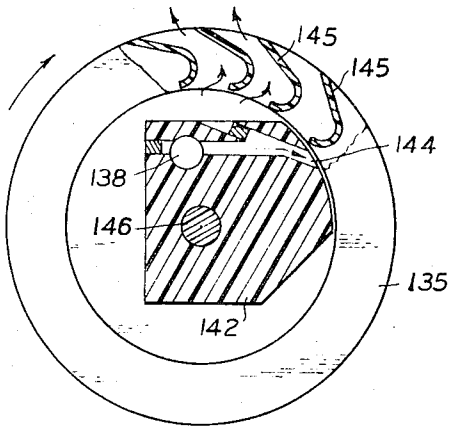


Fig. 8

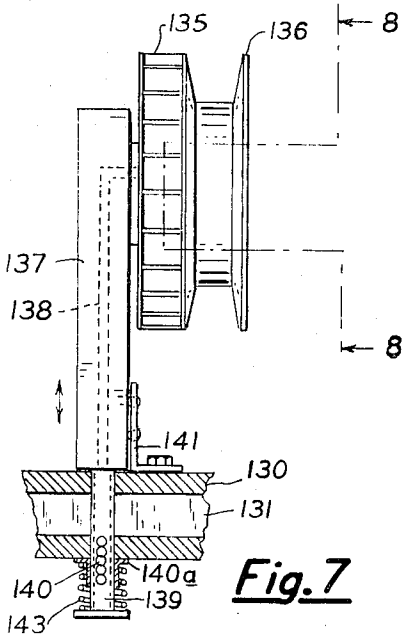


Fig. 7

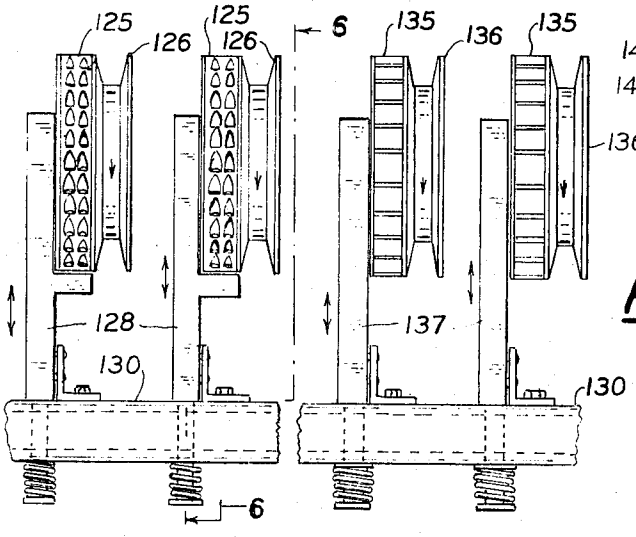


Fig. 9

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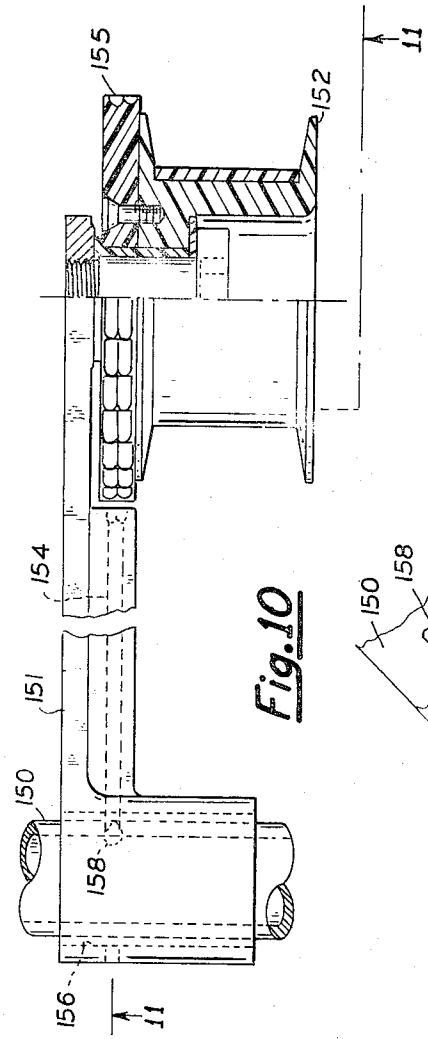


Fig.10

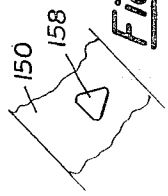


Fig.12

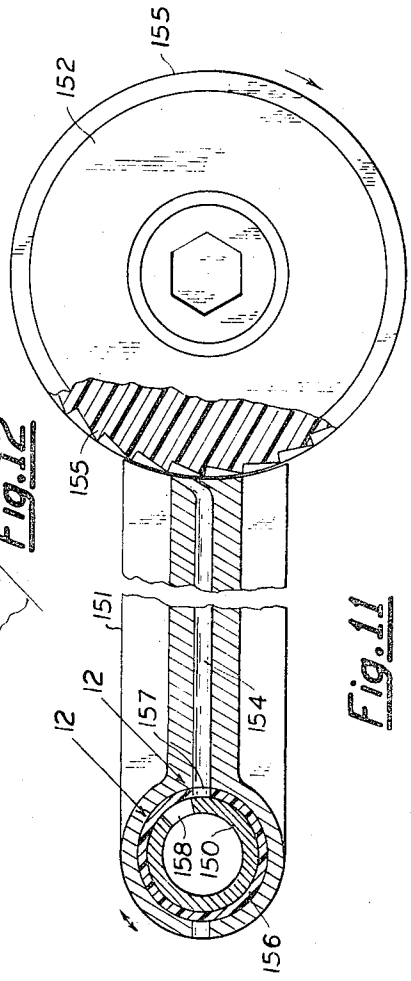


Fig.11

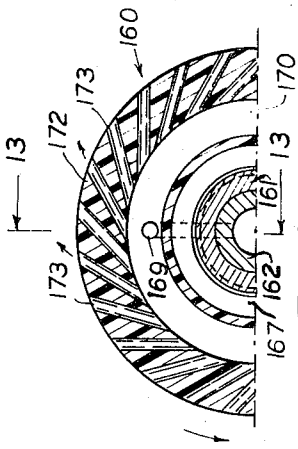


Fig.14

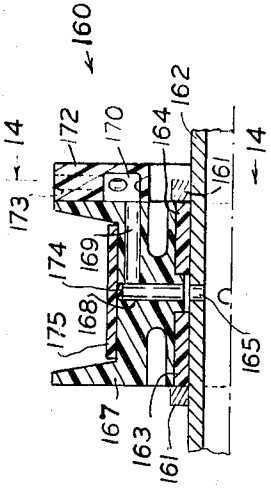


Fig.13

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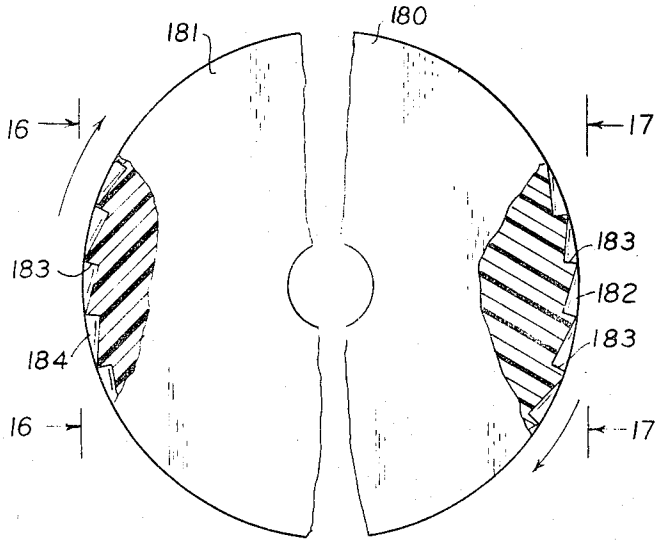


Fig.15A Fig.15B

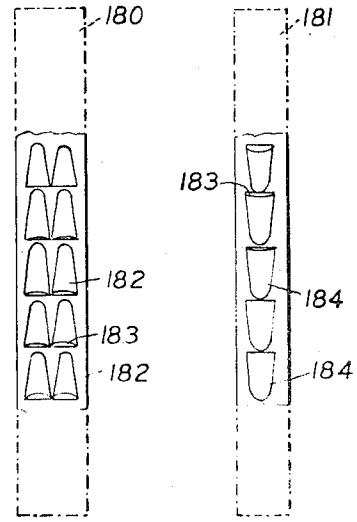


Fig.17 Fig.16

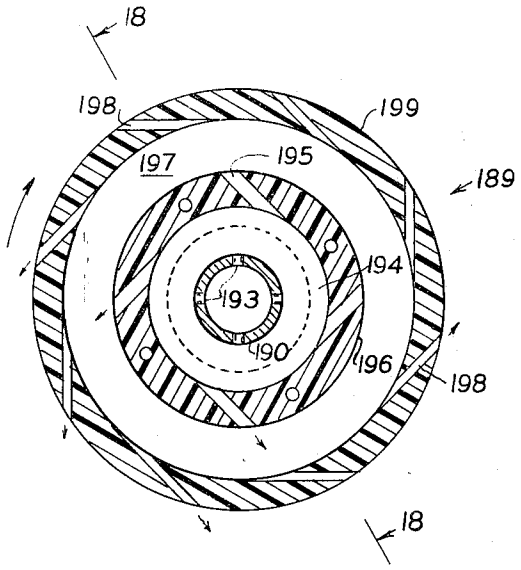


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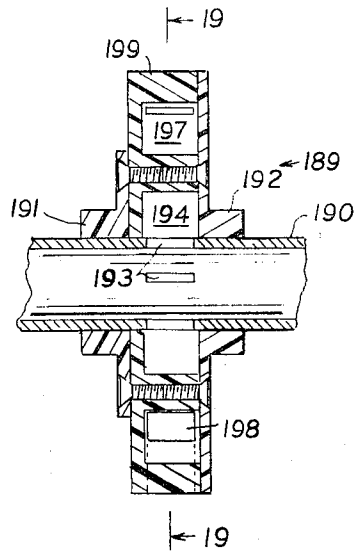


Fig.18

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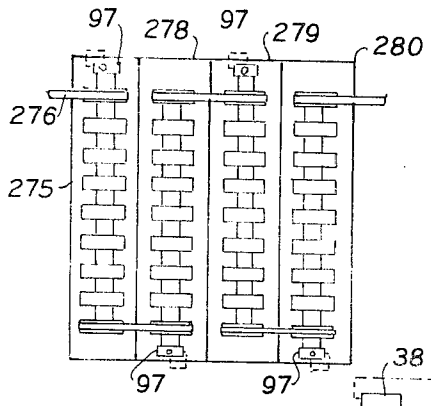


Fig.28

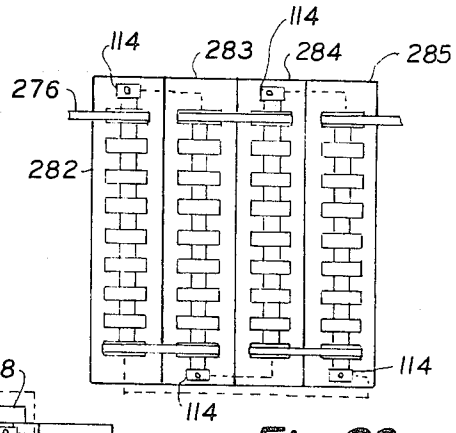


Fig.29

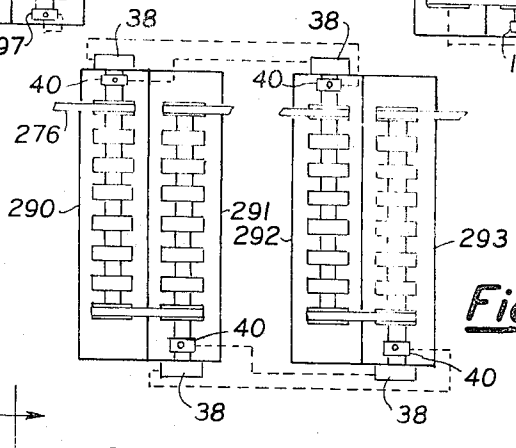


Fig.30

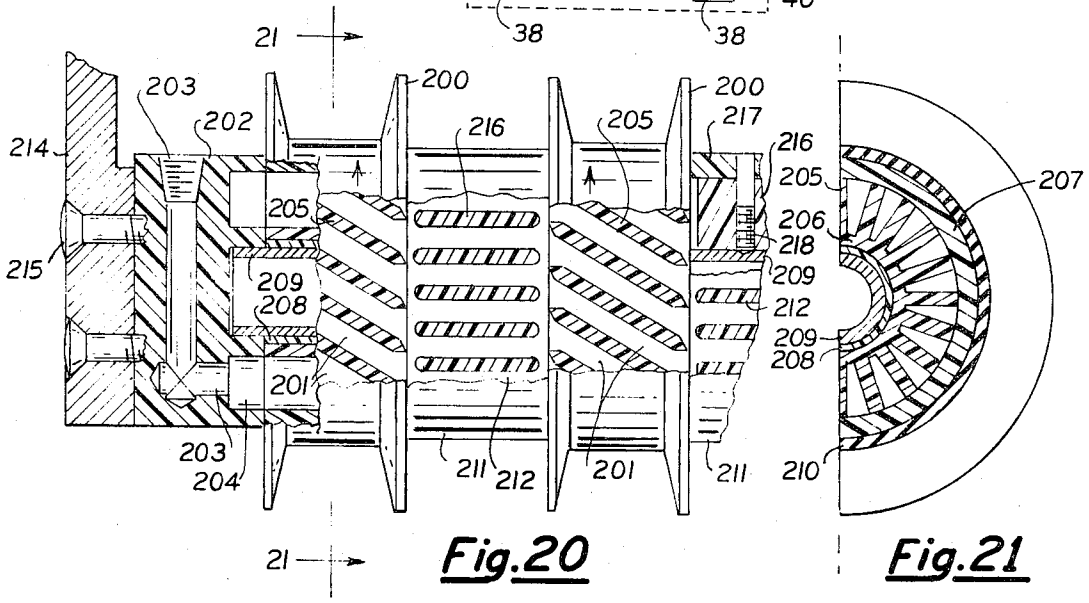


Fig.20

Fig.21

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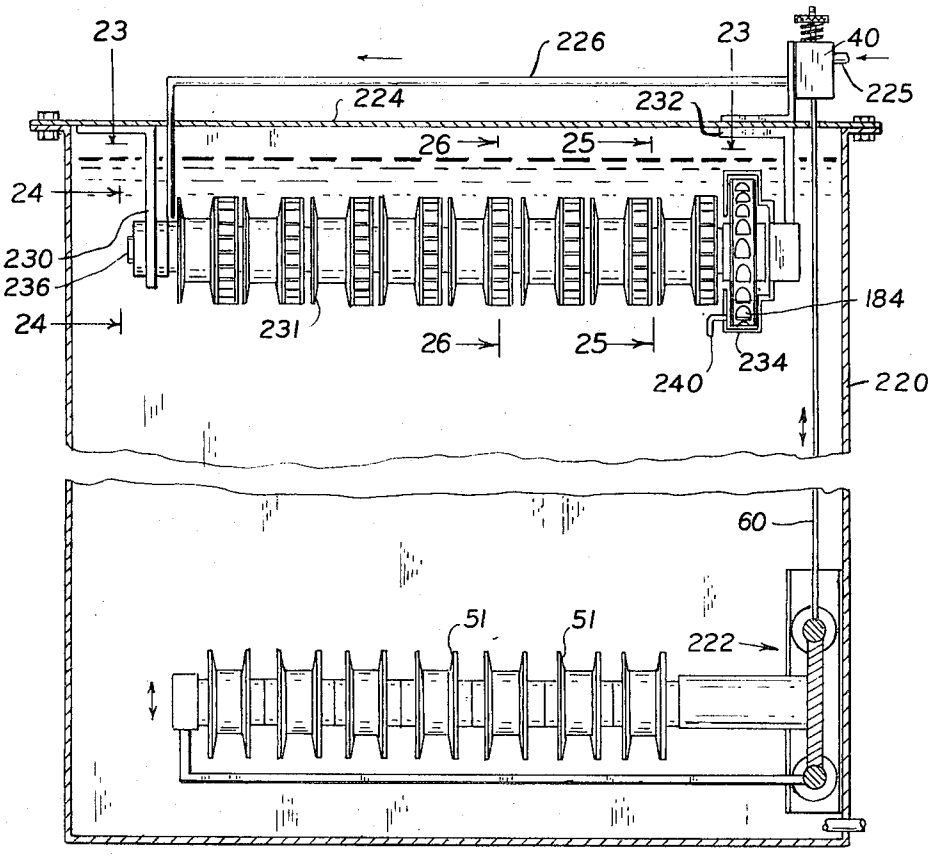


Fig. 22

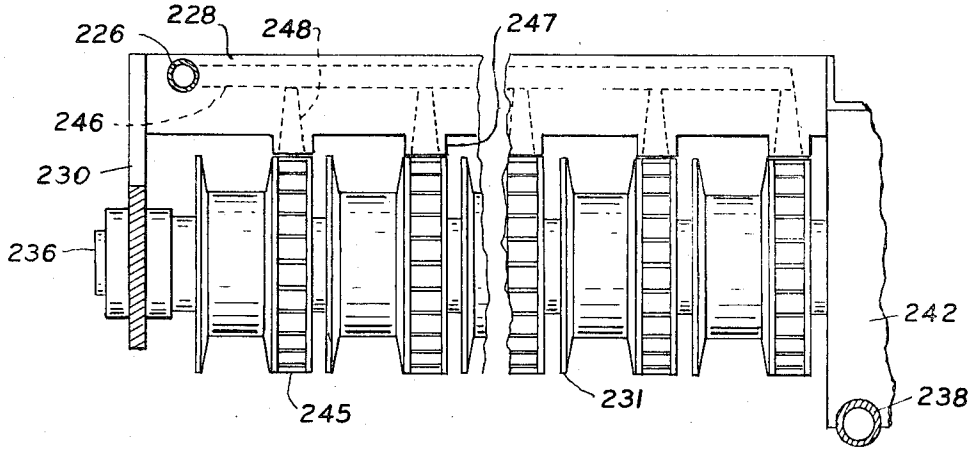


Fig. 23

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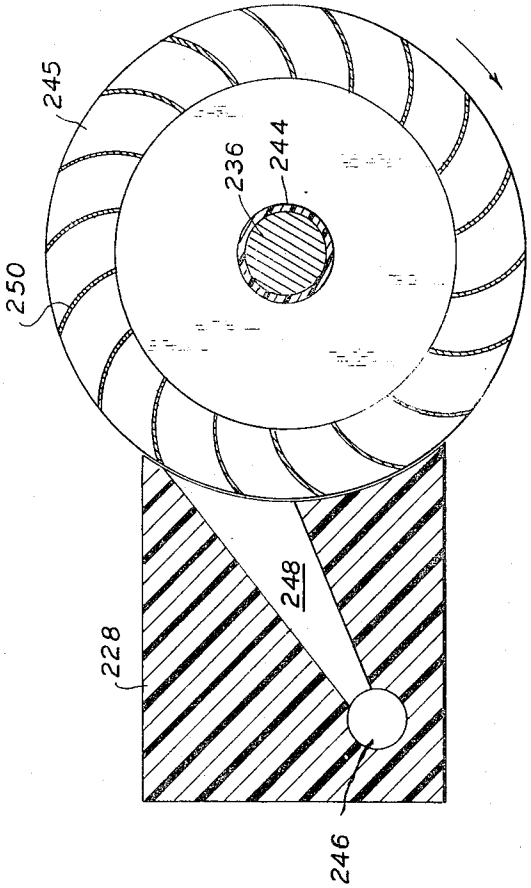


Fig. 26

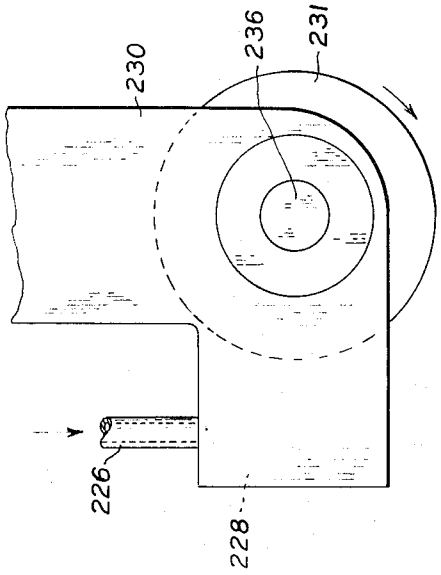


Fig. 24

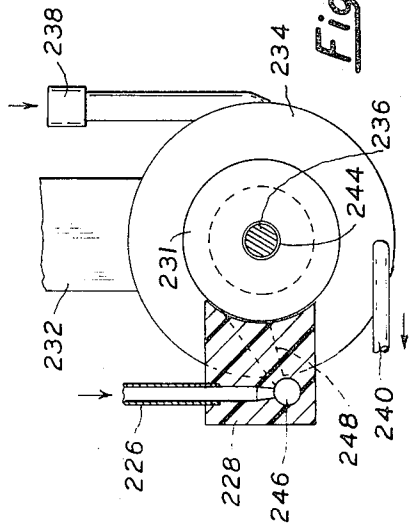


Fig. 25

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TURBINE DRIVE FOR PHOTOGRAPHIC FILM PROCESSING MACHINES

BACKGROUND OF THE INVENTION

1. Field of the Invention arrangements herein

With reference to classifications of art established in the United States Patent Office, the art to which the present invention pertains is found generally in the class titled "Photography" and particularly in the subclasses thereunder of "fluid treating apparatus" and further in those "with film guides" and "with tanks." Also of significance is the class titled "Winding and Reeling" and particularly the subclass of "storage on sheaves" under the subclass of "Reeling and Unreeling."

2. Description of the Prior Art

Photographic film processing tanks are conventionally known wherein the film is wound in a serpentine or helical manner around spools located on upper and lower shafts or other suitable mountings. Transport of film through such a tank or tank and shaft and spool assembly or arrangement requires that rotative power be applied to at least one spool. Usually this has been done by connecting a drive motor to the shaft on which the roll particularly selected to be the driving roll, so far as the film is concerned, is mounted or to which it is attached. The customary drive motors for film transport systems or apparatuses are known electric motors connected to the film spools or film spool shafts either directly or through suitable speed changing means as necessary and appropriate.

Limited attempts or attempted showings have been made of the use of fluid-powered motors for the driving of spools over or around which photographic film passes in the course of processing operations. In a few of these showings fluid-powered motors of the turbine type have been suggested, using that designation rather broadly to include paddle wheel types. In this connection attention may be given to U.S. Pats. No. 1,890,490 (Barkelew) "Film Developing System", No. 1,992,989 (Burns) "Film Roller and Driving Mechanism," No. 2,096,231 (Ensign et al.) "Horizontal Type Film Developing and Drying Machine" and No. 2,096,232 (Ensign et al.) "Film Drying Machine." In none of these patents nor in any other literature or actual apparatus embodiment known to the applicant, however, is there any showing or suggestion of a modulated turbine drive for one or more film spools wherein the modulation is provided by or in response to changes in tension in the film as it is conveyed through a processing apparatus and within any stage or operating unit of the apparatus is wound helically between upper and lower spools or rows of spools.

SUMMARY OF THE INVENTION

The present invention may be summarized at least in part with reference to its objects.

It is an object of the present invention to provide, and it does provide, a turbine drive to rotate one or more photographic film transporting spools disposed in a film processing tank, this drive being controlled by regulation of its energizing fluid at a flow control valve modulated as to setting or opening according to changes in tension of the film at some selected point or region in the system.

It is another object of the present invention to provide, and it does provide, a photographic film transporting system wherein a driving turbine rotates at least one film spool carried on a hollow arm or extension member which is moved in accordance with changes in film tension and as it moves modulates the flow of driving fluid to the turbine, the movement of the arm being translational or linear in one case and angular in another with respect to a conduit carrying pressurized fluid which flows from it into the movable arm through a variable flow control opening at their interface to discharge against the turbine wheel at the distant end of the arm.

It is another object of the present invention to provide, and it does provide, designs of turbine wheels suitable for use in the drive of photographic film processing systems which may rotate either an entire film spool shaft or individual spools on a shaft, and configured to receive their flow of energizing fluid either upon their outside peripheries as in the nature of conventional impulse wheels or from the inside as in the nature of outward radial flow reaction wheels in some cases or outward radial flow impulse wheels in others.

It is another object of the present invention to provide, and it does provide, designs of turbine wheels having outer peripheries which may serve as photographic film transporting or film spool surfaces, and receiving their flow of energizing fluid more or less axially to pass through them from side to side or end to end in slots or passages defined between skewed or angled internal guide vanes to thereby impart torque and rotation to the wheels. Within the scope of this object there is provided a shaft mounting arrangement for turbine wheels of the kind described allowing energizing fluid discharged from one wheel to flow into and drive another wheel of similar configuration giving, in effect, a staged turbine drive system.

It is another object of the present invention to provide, and it does provide, a number of particularized turbine drive systems or arrangements for photographic film spools and film spool shafts which are harmonious with each other to the extent that in some cases two given systems may be employed in one installation as a combination system susceptible to a high degree of control with each component drive system having, or enjoying the possibility of having, its own supply of energizing fluid subject to flow modulation according to changes in film tension or other appropriate considerations such as the setting of a master pressure regulating or flow control valve to give a basic operating speed or driving impulse.

A particular advantage of using a fluid motor drive rather than an electric motor drive for photographic film processing machines is that some equipment which will have to be present for other purposes may in a real sense be made to do dual duty by functioning additionally as part of the drive system. The outstanding examples of this are pumps which are used to circulate various film processing fluids through the several processing tanks for purposes of cooling and the breaking up of stratified liquid zones, and which may be used additionally to send processing fluids to fluid motors as the driving fluids for the same.

A fluid motor of almost any type is lighter and more compact than an electric motor for a given power out-

put. Among the various fluid motors the turbine kind is particularly advantageous with respect to mechanical simplicity and small size for a given throughput of driving fluid. All this lends great flexibility to a drive system because it becomes practical to install a fluid motor, especially a turbine, on essentially every film spool driving shaft throughout a processing apparatus or directly on one of the spools of each bank if the spool shaft is not rotatable. A turbine itself may actually be submerged in liquid processing fluid for convenience of construction and operation of the drive system, something not often contemplated for an electric motor.

Control or modulation of turbine speed and hence of shaft and/or spool speed may be selectively localized in response to, for particular instance, changes in film tension across a given bank of spools. In the customary use of electric motors, on the other hand, a single motor provides the shaft and spool drive for an entire film processing machine, and thus while the speeds of all spools may be varied together by controlling the speed of the motor or the degree of engagement of a master drive clutch it is not usually possible to vary spool or shaft speeds between banks, that is, from bank to bank, at least not conveniently so.

The nature and substance of the present invention as well as its objects and advantages will be more clearly perceived and fully understood by referring to the following description and claims taken in connection with the accompanying drawings which are described briefly below.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** represents a sectional side view of a film processing tank assembly equipped with a turbine drive mechanism modulated in response to the tension in the film, this mechanism being representative of the present invention;

FIG. **2** represents a sectional side view of another film processing tank assembly wherein each film spool on the lower shaft is equipped with an individual turbine drive;

FIG. **3** represents a sectional side view of yet another film processing tank assembly in which the film spools on the lower shaft are provided with turbine drives which are modulated in response to the reaction of a dancer roll assembly;

FIG. **4** represents a sectional end view showing the arrangement of the dancer roll assembly, this view being taken along line **4—4** in FIG. **3** looking in the direction of the arrows;

FIG. **5** represents a sectional side view of yet another film processing tank assembly in which the bottom shaft is driven by a turbine modulated in accordance with the translatory motion of the upper shaft;

FIG. **6** represents in an enlarged view a turbine-driven film spool carried by an arm having a modulating valve, this view being taken along line **6—6** in FIG. **9** looking in the direction of the arrows;

FIG. **7** represents in a partially reduced scale a turbine-driven film spool of yet another construction carried by an arm including a modulating valve;

FIG. **8** represents a sectional view of the turbine drive for the film spool of FIG. **7**, this view taken along line **8—8** in FIG. **7** looking in the direction of the arrows;

FIG. **9** represents in a slightly reduced scale a typical grouping on a fluid-conducting support of the turbine-driven film spools of both FIG. **6** and FIG. **7**;

FIG. **10** represents a side view partly in section of a turbine-driven film spool and its means of individual modulation as provided by its pivoted arm support mounting upon a fluid-conducting shaft;

FIG. **11** represents an end view also partly in section of the turbine-driven film spool of FIG. **10** taken along line **11—11** therein looking in the direction of the arrows;

FIG. **12** represents a fragmentary view looking downwardly upon a port in a fluid-conducting shaft, the view taken on and looking in the direction of the arrows **12—12** of FIG. **11**;

FIG. **13** represents a fragmentary sectional view of an alternate turbine-driven film spool construction, this view being taken along line **13—13** in FIG. **14** looking in the direction of the arrows;

FIG. **14** represents a fragmentary sectional side view of the film spool construction of FIG. **13**, this view being taken taken along line **14—14** looking in the direction of the arrows;

FIGS. **15A** and **15B** represent fragmentary side views partly in section showing a typical rim construction of yet two other turbine wheels or discs for driving film spools;

FIG. **16** represents an end or edge view of the turbine wheel of FIG. **15A** showing a single-row pocket or bucket arrangement formed in the rim of the wheel, this view being taken along line **16—16** in FIG. **15A** looking in the direction of the arrows;

FIG. **17** represents an end or edge view of the turbine wheel of FIG. **15B** showing a double-row pocket or bucket arrangement this view being taken along line **17—17** in FIG. **15B** looking in the direction of the arrows;

FIG. **18** represents a sectional end or edge view of yet another turbine drive construction, this view being taken along line **18—18** in FIG. **19** looking in the direction of the arrows;

FIG. **19** represents a sectional side view of the turbine drive of FIG. **18**, this view being taken along line **19—19** in FIG. **18** looking in the direction of the arrows;

FIG. **20** represents a fragmentary view of yet another turbine drive for film spools with portions broken away and sectioned to shown the internal construction of the drive assembly;

FIG. **21** represents a sectional end view of the turbine drive of FIG. **20**, this view being taken along line **21—21** in FIG. **20** looking in the direction of the arrows;

FIG. **22** represents a sectional side view of a film processing tank assembly in which the upper film spool shaft is driven by one turbine and carries a plurality of film spools each having its own turbine drive independent of the drive of the shaft;

FIG. **23** represents a slightly enlarged and partly fragmentary plan view of the upper film spool shaft assembly and turbine drive of the processing tank of FIG. **22** taken along line **23—23** therein looking in the direction of the arrows;

FIG. **24** represents an enlarged fragmentary view looking at one end of the shaft and support of the upper film spool shaft drive of the processing tank of FIG. **22**

taken along line 24—24 therein looking in the direction of the arrows;

FIG. 25 represents an enlarged transverse sectional view of the upper film spool shaft, a film spool, and the driving fluid distributor header for the individual spool turbine wheels of the processing tank of FIG. 22 taken along line 25—25 therein looking in the direction of the arrows;

FIG. 26 represents a transverse sectional view in an enlarged scale of the aforementioned driving fluid distributor header and turbine drive of a film spool, this view being taken along line 26—26 in FIG. 22 looking in the direction of the arrows;

FIG. 27 represents a flow diagram of a film processing tank assembly wherein the fluid for driving a spool shaft turbine is supplied from, returned to and circulated within the tank, and

FIGS. 28, 29 and 30 represent somewhat diagrammatic plan views showing various flow control arrangements for modulating the turbine driving fluid supply to each of a series of tanks.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings in detail in which like numbers designated like members throughout the several figures, FIG. 1 shows a film processing tank 30 which, although illustrated as being closed, may be either open or closed at the top. This tank carries an upper shaft 31 upon which there are mounted a series of conventionally configured film spools 32 adapted to transport or convey film for processing into and out of the tank in a helical array and in a continuous manner. Shaft 31 is itself rotatably supported and retained near one end by a bearing 33 carried on a right-hand side wall or panel of the processing tank. This shaft is further supported at its left-hand end within the tank by a depending bracket 34 having a bearing therein. The attachment of spools 32 to shaft 31 may be rigid or fixed with the keying or pinning in the case of one or a few spools with the remainder of the spools having a frictional rotative engagement with the shaft either directly or by compression against each other and finally against a banking collar 35. This allows some variations in spool speed as tension in strands of films varies. A spool 36 with a specially treaded tractive surface would be fixed to the shaft near the in-leading point for film.

Exterior to the tank 30 and carried by the right-hand side wall thereof is a housing 37 within which is disposed a turbine wheel 38 fastened on shaft 31 and adapted to rotate that shaft and the spools thereon. Positioned to direct a supply of driving fluid in a tangential direction against the rim of the turbine wheel, which may be of the general kind shown in FIG. 16 or FIG. 17, there is an inlet conductor 39 which receives fluid from a flow modulating valve 40. This valve has a tapered disc element 41 for throttling or flow control purposes, and receives a supply of pressurized fluid through feed conduit 42. From the turbine housing 37 the fluid after impinging upon turbine wheel 38 is exhausted by means of a drain 44 whereby it is conducted into the interior of tank 30 for final discharge through a plurality of outlet openings 45. Discharge of the fluid in this manner causes it to be turbulated into the tank to readily mingle with the main body of the tank fluid 46. Although the drain 44 is shown as a single pipe entering the tank, a plurality of pipes of course may be provided. The level of fluid 46 in tank 30 is variable depending upon the particular process being carried out in the tank. In certain circumstances it may be desired to have the fluid surface near the top of the tank or at least above the film-carrying periphery of spools 32. For maintenance of any selected level, fluid must be withdrawn from the tank at the same rate at which it is returned or discharged into the tank. Withdrawal means is not shown in FIG. 1, but a representative means or system for such withdrawal is illustrated in FIG. 27.

In the lower portion of tank 30 there is disposed an elevator generally designated 48. This elevator includes a horizontal support member 49 having an upturned left end which supports one end of a lower shaft 50. A series of spools 51 are carried on this lower shaft which may be a "dead" or non-rotating shaft. When shaft 50 is non-rotating the lower spools are disposed to be freely rotatable with respect to it. However, when factors such as film tension, turbulation of the processing fluid and other process variables make it desirable to have lower shaft 50 itself freely rotatable this shaft may be mounted in bearings suitably provided in support member 49 and an elevator boss 52. One of the spools 51 may then be fixedly attached to the shaft 50, but generally these spools are freely rotatable thereon. All of the described shaft and spool arrangements are known in the prior art and no novelty is ascribed herein to any of them considered by themselves.

Referring in particular to the assembly of elevator 48, it is to be comprehended that that assembly includes a pair of channel members 54 mounted on the inner surface of tank 30. These channels are shaped and sized so as to engage and retain within their U-formed inwardly extending leg portions a set of four rollers 55 arranged in upper and lower pairs. These rollers are freely rotatable upon transverse shaft projections 56 and 57 carried on each end of a vertical support member 58, and are within channel members 54. The elevator assembly is weighted appropriately either integrally or by external attachment for any given processing circumstance of the film, whether as full liquid immersion or as an exposure to a liquid spray or to a drying atmosphere, etc., so as to provide a proper basic tension in the film wound helically between and around the spools on the upper and lower shafts 31 and 50 as the film extends and is transported through the whole processing apparatus.

Still referring to FIG. 1, it may be seen that a control rod 60 extends upwardly from elevator assembly 48. This rod passes freely through the top panel of tank 30, and near its upper end carries on it tapered disc 41 of modulating drive flow control valve 40 through which the rod further passes in sealed but slidable fashion. Valve assembly 40 includes a spring 61 surrounding one extremity of the valve stem which is an extension of control rod 60, and a nut 62 above the spring which is adjustable to control finely the vertical position of the valve disc and the elevator. In practice, valve mount 64 is preferably an adjustable bracket permitting gross vertical adjustment of the position of valve 40 with respect to tank 30, and hence to a considerable extent

adjustment of the position of elevator assembly **48**. This assumes at least a slight amount of flexibility or adjustability in fluid conductor **39**. Cycling of flow control valve **40** as its disc element moves vertically together with the elevator responsively to changes in film tension increases or decreases the flow of fluid through inlet conduit **39**, as appropriate.

Referring next to FIG. **2**, there is represented a film processing tank **70** having an upper shaft **71** carried by an elevator assembly **72**. In the manner of tank **30** and its lower shaft, this upper shaft **71** is supported at one end by a bracket **73** carried by the elevator assembly. This elevator assembly includes a vertical member **74**, transverse shafts, and upper and lower pairs of rollers **75** sized to be movably retained in facing channels **76**. Shaft **71** may be a "dead" shaft and it carries film spools **51** which may be free turning for independent rotation on the shaft. In the illustrated embodiment, the upper shaft assembly is supported by a cable **77** diagrammatically shown as being carried by pulleys **78** and **79** so that a weight **80** on the downwardly hanging free end of the cable may be increased or decreased to compensate for the weight of the elevator and film spools assembly and film tension. Of particular note in FIG. **2** is the lower shaft arrangement in which this shaft **82** is hollow and is supplied with pressurized fluid through a conduit **83**. Shaft **82** is non-rotatably supported by brackets **84** and **85**, and each of the film transporting spools **86** on this shaft is rotatable with respect to it. Further, each spool is provided with a radial-flow turbine wheel or flange **87** more fully described hereinafter, but which may here be said generally to be of a kind shown in FIGS. **13** and **14**. These turbine flanges drive lower film spools **86** when themselves supplied with pressurized fluid from conduit **83**. The fluid supply is or may be regulated by means of a valve not shown to control the speeds of the turbine-driven spools.

Referring next to FIGS. **3** and **4**, there is shown yet another film processing tank **90** in which an upper shaft **91** is carried by means of bearing brackets **92** and **93** extending downwardly from the cover portion of the tank. Mounted on this shaft, which may be a "dead" shaft, are a plurality of free turning film spools **51**. Carried upon a lower shaft **95**, which is contemplated as being a hollow, non-rotating, fluid-conducting shaft, are a plurality of film spools **86** driven by turbine flanges **87**, similar to the arrangement of FIG. **2**. This lower shaft **95** is fed by pressurized fluid from an inlet line or conduit **96**, with the flow rate of the fluid being regulated by a modulating valve **97** mounted on the cover portion or top panel of tank **90**. To the right of lower shaft **95** which is fixedly mounted on brackets **98** and **99** there is a dancer roll assembly which includes an elevator assembly **100** having a boss portion upon which a freely turning film spool **101** is mounted. The dancer roll assembly moves vertically in response to changes in the tension of the film helically transported in tank **90**. As the assembly is moved it cycles a control rod **102** which in turn actuates valve **97** to modulate the flow of pressurized fluid from supply line **103** to and through line **96**.

Referring next to FIG. **5**, there is depicted yet another assembly of a film processing tank **110** in which an upper shaft assembly **111** carrying a plurality of freely turning film spools **51** is supported by an elevator assembly **112**. The latter assembly is movable vertically in response to changes in the tension in the films so as to cycle a rather short or stubby control rod **113**. This rod, as it is actuated, causes a valve **114** to modulate a fluid flow to feed conduit **115**. Rod **113** is adjustably supported by means of spring **116** and nut **117**. In particular, the lower portion of tank **110** has within it a lower shaft assembly **118**. This assembly includes spools **32** which may all be freely rotatable upon a shaft **119** itself rotatably supported by bearing brackets **120** and **121**, although preferably at least one of these spools is fixed to the shaft to be rotated thereby at shaft speed. A turbine drive generally designated **122** is disposed to be actuated by means of a supply of pressurized fluid carried by conduit **115** from valve **114**. The wheel or rotor of the turbine drive is fixed to shaft **119** so that the wheel and the shaft turn together. The construction of the turbine drive **122** is more particularly described hereinafter in conjunction with FIGS. **18** and **19**.

Referring next to FIG. **6**, and also to FIG. **9** as necessary, in certain circumstances it is desirable that film spools be driven at varying rates or speeds which may be independent of those of adjacent spools. The spool speed and the film speed are modulated in response to tension actuation by the strands of film being helically fed over the spools. In FIG. **6** there is shown a turbine flange or wheel **125** characterized by two rows of cups or buckets formed in its circumferential periphery. A film spool **126** is mounted on the turbine flange which is freely rotatable upon an Allen-head stud **127** carried on the outer end of an arm **128** having within itself a fluid passageway **129**. The outer or discharge portion of this passageway, which may have either a straight or a tapered local configuration, is disposed at an angle to bring it tangent through a lateral projection on arm **128** to the periphery of the turbine flange. Arm **128** itself is reciprocatably carried transversely in and through a fluid conductor **130** which in the present instance is represented as being a rectangular tube having an interior passageway **131**. Fluid conductor **130**, as specifically shown, would occupy essentially the position of a lower spool shaft such as shaft **119** in the overall tank and film shaft and spool arrangement shown in FIG. **5**.

A shouldered or reduced lower end portion of arm **128** is slidable in a precise opening formed in this conductor **130**. A compression spring **132** is disposed between conductor **130** and a lower boss **133** on arm **128** and acts to urge the arm downwardly. A tapered inlet port **134** in the arm is located to be substantially covered by the wall of the conductor **130** except when the arm is moved upwardly to bring this port in way of passageway **131** in the conductor **130**. As the inlet port **134** is moved upwardly into passageway **131** the pressurized fluid in this passageway enters port **134** and passageway **129** providing a metered rate of flow of fluid into and through the passageway to drive turbine wheel **125** by impingement upon its peripherial buckets, thus also driving spool **126**. Although illustrated primarily as a lower spool shaft arrangement, the fluid conductor, sliding arm and film spool system of FIG. **6** may, as appropriate, be inverted and used as an equivalent arrangement for an upper spool shaft.

Referring next to FIGS. 7 and 8, there is shown an alternate turbine flange 135 carried by and adapted to rotate a film spool 136. This spool is carried by an arm 137 having within itself a passageway 138 adapted to receive and convey pressurized fluid from conductor 130 which, similarly to conductor 130 of FIG. 6, may have the approximate position and orientation of either a lower or an upper film spool shaft according to desired arrangement. A reduced end portion 139 of arm 137 has a plurality of transverse holes 140 disposed to be moved into the interior passageway 131 of the conductor to receive a determined flow of fluid therefrom and admit this flow to passageway 138. A flanged sleeve or collar 140*a* is carried slidably on the reduced end portion 139, and is disposed to cover the lower portion of holes 140 when the arm 137 is in its lowermost condition. Fluid conductor 130 has mounted on its upper external surface a roller or ball bearing bracket 141 adapted to rollably engage and retain arm 137 in a properly oriented attitude to the conductor. Fluid passage 138 extends from arm 137 into the interior of a center support portion 142 (FIG. 8) for turbine flange 135. Arm 137 and elements carried by it are urged downwardly by means of a spring 143 acting between collar 140*a* and a boss at the bottom of the arm so that the plurality of holes 140 normally tend to be below the interior passageway 131 of conductor 130. As the spool 136 and arm 137 are drawn upwardly by tension in film passing around the spool the pressurized fluid in passageway 131 enters passageway 138 through the exposed holes 140 in way of the interior passageway 131.

Referring particularly to FIG. 8, it may be seen that center support portion 142 receives a supply of fluid from passageway 138 in the support arm 137. A transverse outlet passageway 144 connects with passageway 138, and discharges pressurized fluid as a turbine nozzle into an annular array of buckets or cups 145 on turbine wheel 135. The fluid flowing from passageway 144 impinges upon successive cups or buckets 145 to cause the turbine wheel and film spool 136 attached to it to rotate clockwise, as indicated, around shaft 146 which is fixed in center support portion 142.

Referring next to FIG. 9, a fluid conductor 130 carries a plurality of individual turbine-driven spools 126 and 136. As shown these spools are driven by turbine flanges 125 and 135. The spools are arranged in spaced array and the turbines or turbine flanges on which they are mounted are driven by pressurized fluid from conductor 130. Each of the left two arms 128 as it is moved up or down brings more or less of its tapered inlet port 134 (FIG. 6) in way of interior passageway 131 so as to modulate the amount of fluid entering and flowing through its passageway 129 and impinging upon and driving the turbine flange 125 and attached spool 126 mounted on it. In the right-hand portion of FIG. 9 there are shown a pair of film spools 136 and supporting turbine flanges 135 on arms 137 with the fluid passing through flanges 135 from the same or a like conductor 130. The speeds of these spools are also individually modulated by means of the transported film being wrapped around and tensioned upon the spools so that as the spools are rotated and the film is tightened or slacked the varying tension in the film will cause the spools and their turbine flanges and arms to cycle up and down to expose more or fewer holes (FIG. 7) to the pressurized fluid in passageway 131 and thereby cause these spools to be driven faster or slower in response to changes in tension in the film. Thus so far as control of flow of turbine driving or actuating fluid and through it the speeds of turbine wheels or flanges 125 and 135 and their respectively attached film spools 126 and 136 are concerned there are, in effect, throttling interfaces of individually variable size or opening between the interior region of fluid conductor 130 on the one hand and those of hollow arms 128 and 137 on the other hand.

Referring next to FIGS. 10, 11 and 12, there is shown another individually driven film spool installation wherein a circular conduit 150 rotatably supports upon its outer surface an arm member 151 which carries on its outer or free end a turbine-driven film transport spool 152. Conduit 150, similarly to fluid conductor 130, may have the approximate position and orientation of either a lower or an upper film spool shaft according to desired arrangements. Within the support arm 151 there is provided a fluid passageway 154 which, as seen in FIG. 11, has its free or outer end disposed at an angle as a turbine nozzle to bring it substantially tangent to the periphery of the turbine flange 155 of film transport spool 152. The journaled or inner end of arm member 151 is provided with a bearing 156 which also acts as a fluid seal. This bearing has formed in it an inlet port 157 which coincides with passageway 154 so that as inlet port 157 is rotated as bearing 156 turns with the swinging of the arm on conduit 150 this port can be brought in way of a triangular or otherwise shaped outlet port 158 formed in the conduit. As seen in FIG. 11, counterclockwise rotation of arm 151 around conduit 150 brings inlet port 157 more and more in way of outlet port 158. Depending upon changes in angular orientation of arm 151 to conduit 150, i.e., variations in the size or opening of the throttling interface between those members, there is thus provided an effective control valve for regulating the flow of fluid to and through fluid passageway 154 for final discharge against turbine flange portion 155 of the rotatable assembly including film transport spool 152. Spool speed is thus controlled according to angulation of hollow arm 151 which in turn is determined by film tension.

Referring next to FIGS. 13 and 14, there is shown a turbine-driven film spool assembly generally indicated as 160 which is freely rotatable between locating rings 161 on a hollow shaft 162 which may be either a lower or an upper shaft within a processing tank, and may, for example, correspond to shaft 82 in FIG. 2 and shaft 95 in FIG. 3. Film spool 160 is provided with sleeve bearings 163 and 164. These bearings act as a fluid sealing means along shaft 162 as well as rotating upon it. They are mounted with a small space between them to define a circular passageway for the distribution of pressurized fluid from within hollow shaft 162. This fluid flows outwardly through an opening or discharge port 165 in the wall of shaft 162. Within the spool body 167, corresponding to any spool 86 in either FIG. 2 or FIG. 3, there is provided at least one radially disposed fluid passageway 168 connecting with a longitudinally extending passageway 169. Pressurized fluid is discharged through these passageways into a distribut-

ing ring or annular passage **170** formed in the turbine flange portion **172** of the spool assembly. This portion corresponds to any turbine flange **87** in either FIG. **2** or FIG. **3** although shown on the right hand rather than the left hand side of its associated film spool.

As is to be particularly noted in FIG. **14**, annular passage **170** communicates with the inner ends of a plurality of preferably equally spaced tangentially disposed passageways **173** so that actuating fluid under pressure entering distributing ring **170** flows as indicated by the arrows outwardly through the outer or discharge ends of passageways **173** to cause the film spool to rotate counterclockwise as shown. Radial passageway **168** has its outer end closed by plug **174**, and spool body **167** may have a rubber sleeve **175** providing a film transport surface. Also, while passageways **173** may be of uniform cross section as shown for ease of manufacture of turbine flange or wheel portion **172**, through which actuating fluid flows generally radially outwardly, they may likewise be of varying cross section to give optimum conversion of pressure energy to velocity or kinetic energy.

Referring next to FIGS. **15A**, **15B**, **16** and **17**, there are shown two turbine flange embodiments **180** and **181** each adapted to be attached to or molded integrally with the side of a film spool in the manner of the turbine-driven spools of FIGS. **6**, **10** and **11**, or to serve as turbine wheel **38** in the apparatus of FIG. **1**. Formed in the outer periphery of the flange **180** are two series of pockets **182** in parallel, side-by-side arrangement as seen in FIGS. **15B** and **17**. These pockets may be made by molding or by machining with an end mill and moving the end mill into the periphery of the flange. Each pocket, whether molded or machined, is formed so that its end wall **183** is about parallel to or coincident with a line tangent to a small circle concentric with the turbine flange. Flow of actuating fluid under pressure against the outer peripheral pocket wall **183** causes the turbine flange or wheel to rotate in the direction of the arrow shown in FIG. **15B**. As seen in FIGS. **15A** and **16**, turbine flange **181** is formed with a single row of pockets **184**, each defined in the manner of the pockets of the double row or series of pockets **182** of wheel or flange **180**. The determination of the size of the pockets **184** and number of pockets in the periphery is a matter of design in individual cases. Whether a single row of pockets or multiple rows of pockets are to be provided, the amount of fluid flow and size of the discharging stream are determining factors in the design of the pockets in the flange rim.

Referring next to FIGS. **18** and **19**, there is shown yet another turbine embodiment in which a turbine generally designated **189** is adapted to drive a hollow shaft **190** to which it is fixedly attached by means of hub or collar portions **191** and **192**. The shaft **190** conveys pressurized fluid within itself, and this fluid is fed from the interior of the shaft to the turbine by means of holes or ports **193** in the shaft wall through which the fluid enters an inner circular chamber **194** in the turbine. From chamber **194** the fluid flows outwardly through tangentially disposed passageways **195** in intermediate wall **196** into an outer circular chamber **197** from which it is discharged through a plurality of outlet passageways **198**. These passageways **198** are tangentially disposed to the inner surface of outer wall **199** in which they are defined, and, like passageways **173**, they may have varying as well as uniform cross section. As the fluid is expelled outwardly through and from outer wall **199** it causes the turbine member to rotate in a clockwise direction as shown by the arrow of FIG. **19** rotating shaft **190** with it. Film spools, not shown, may be mounted on the shaft to be driven by it as it is turned by the turbine. In operation turbine **189**, through which actuating fluid flows generally radially outwardly, and shaft **190** correspond respectively to turbine **122** and shaft **119** shown in FIG. **5**.

Referring next to FIGS. **20** and **21**, there is shown another embodiment of a turbine drive for film spools in which a plurality of film spools **200** are constructed with internal passageways **201** which are disposed at angles to cause the film spools to rotate in the direction of the arrows upon fluid under pressure flowing into these passages and experiencing a change in direction of flow. As seen in a sectional portion of FIG. **20**, a shaft end member **202** is constructed with an inlet fluid-feeding passageway **203**, the fluid arriving at which being subject to flow modulation, terminating in an outlet annulus **204**. This annulus is disposed to discharge pressurized fluid into the ends of the angled passageways **201** in the end one of a plurality of spools **200**. These passageways are in the nature of helical slots defined by wall sections **205** extending from an interior hub portion **206** to an outer retaining ring portion **207**. A bearing member **208** within hub portion **206** supports each spool **200** rotatably on shaft **209**. A rubber sleeve **210** on the outer surface of each spool provides a film transport surface of a conventional nature.

Between adjacent spools **200** there is a transfer member **211** fixed on shaft **209** and having radially oriented transfer slots **212** disposed to coincide with the discharge ends of successive slots **201** of an upstream spool **200** and the inlet ends of successive slots **201** of the spool **200** next downstream. By this arrangement fluid under pressure is allowed to flow generally axially through the whole array of spools **200** and transfer members **211** imparting rotation to each of the spools or axial flow turbine wheels enclosed circumferentially by spools. This assembly, in which shaft **209** may be either an upper or a lower film spool shaft, is generally contemplated to include only a very few spools **200**, for example, three or four, because the leakage of fluid between spool and transfer members and the drop of pressure may cause the rotational speed of additional spools to be too low.

In the apparatus of FIG. **20** the non-rotating shaft **209** extends into and is retained by shaft end member **202**. As shown, the inlet end of passageway **203** is threaded to receive a pipe or fluid conduit, not illustrated. A supporting bracket **214** is attached by screws **215** to shaft end member **202**, and by this bracket one end of the shaft assembly is mounted in space in a film processing tank. The ends of the wall sections **205** are tapered to points to assist in insuring a smooth flow of fluid through the system. Wall members **216** defining the slots **212** in transfer member **211** have their ends mounted and spaced a short distance from the faces of the transfer member. An outer sleeve **217** has a sliding engagement with a like face on ring **207** of spool **200**. A set screw **218** is disposed in each transfer member **211**,

and engages the hollow shaft 209 to retain its member 211 fixedly on that shaft. It is also to be comprehended that instead of straight helical and radial slots 201 and 212 in the spools and transfer members respectively fluid passage slots in these members may be made, for example, with a chevron-type or herringbone configuration. The slots in the transfer members would be disposed in the reverse direction from those in the spools.

Referring next to the film processing tank assembly of FIGS. 22 through 26, there is shown a film tank 220 which includes an elevator assembly 222 carrying a lower shaft having a plurality of free-turning spools 51 in the manner of the elevator assembly of FIG. 1. A control rod 60 extends upwardly to and through tank cover 224 and into a flow control valve 40 operable in the manner of the corresponding valve of FIG. 1. A fluid conductor 225 conveys pressurized fluid to valve 40 where further fluid flow is modulated in response to the actuation of the tapered disc of the valve by elevator 222. From valve 40 a modulated flow of pressurized fluid is fed through supply pipe or conductor 226 to a distributing header 228. This header 228 is most clearly seen in FIGS. 23 through 26. A left-hand shaft bracket 230 is attached to and supported from and by the cover panel 224. Bracket 230 rotatably supports and retains the left-hand end of an upper film spool shaft carrying a series of spools 231. The right-hand end of the upper film spool shaft assembly is retained and rotatably supported by a right-hand bracket 232 which also is attached to and supported from and by tank cover 224.

A driving turbine 234 which may have a single or dual array of pockets 184 formed in its rotor in the manner of the turbine drive wheels of FIGS. 16 and 17 is attached fixedly to the upper spool shaft at the right-hand end thereof, it being understood that a turbine or turbine wheel of any other suitable design could be used as well. As particularly shown in FIG. 22, the spool shaft 236 extends from left-hand bracket 230 to right-hand bracket 232. The turbine drive or driving turbine 234, which is also shown in FIG. 25, receives its high pressure fluid or drive power through a fluid conductor 238 which is in turn supplied from a source or means such as the pump 263 shown in FIG. 27. Low pressure fluid exhaust from the turbine drive is expelled or discharged into the fluid within tank 220 through an outlet fitting or conduit 240.

A turbine shroud or housing 242 is sized and positioned around the turbine wheel so that fluid fed through conduit 238 connected into the housing is directed to impinge upon the buckets or cups 184 of the wheel or rotor after which it is discharged through the outlet 240, having imparted a substantial amount of its energy to the turbine wheel for rotating the upper spool shaft. The film spools 231 on this shaft are contemplated to be free to turn upon the shaft 236 to the extent that they are carried on bearings 244 which are best seen in FIG. 26. As thus mounted, the spools only tend to rotate with and at the rotating speed of shaft 236 on account of whatever drag effects there may be between the shaft and bearings 244. Under certain conditions this drag may drive the spools 231 at a low limit of operating speed. However, some or all of the spools 231 on the upper shaft may be driven additionally by individually connected turbine wheels or flanges 245 to provide or achieve, in effect, a combination drive.

The several turbine flanges 245 are driven by fluid from distributing header 228 which is formed with a fluid conducting passageway 246 extending for essentially the whole length of the header. This passageway is connected to and is fed by pressurized fluid from supply pipe 226. At selected positions along header 228 there are laterally extending portions 247 within which are formed fluid distributing nozzles 248 connecting off of passageway 246 and disposed to present their outlets at the peripheries of successive turbine wheels 245 attached to film spools 231. The modulated supply of pressurized actuating fluid flowing from nozzles 248 is used to drive the spools 231 by its action upon the radial blades 250 which the turbines comprise. The fluid from the nozzles 248 is contemplated as being the fluid from the tank 220 so that after acting upon the turbine wheels 245 of the spools 231 it reenters the tank and mixes freely with the main body of fluid there as it is discharged from the turbine blades, having flowed generally radially inwardly through them. Shroudings or housings may be provided around turbine wheels 245 where these wheels are operated submerged and it is desired that they should not have any churning or local turbulating effect on the surrounding processing fluid.

Referring next to FIG. 27, there is shown a typical film processing tank fluid circulating system. Within a tank 260 there is a body of fluid 261. A suction line or pump supply line 262 extends from near the bottom of the tank to a pump 263 which discharges pressurized fluid through a line 264 feeding to both a heat exchanger 265 and a valve 266 which may be in the nature of a throttle valve or modulating drive flow control valve similar to valve 40. The fluid discharged through the heat exchanger flows back into main fluid body 261 through a plurality of discharge pipes 268 within tank 260. The returning fluid is distributed within the tank in this way usually to control the temperature and state of turbulation or mixing of the main fluid body. The fluid passing through valve 266 is fed to a turbine 269 for driving a film transporting spool or shaft of spools, and from the turbine the spent fluid is returned through conduit 270 to the bottom of the tank.

When the turbine is within the tank and is immersed in the fluid, the discharge line 270 may be absent with the returning or exhausting fluid being expelled directly into the surrounding fluid body 261. The fluid shown as going to turbine 269 may alternatively be directed to turbine wheels or flanges associated with individual film spools according to the general arrangement of the apparatus shown in FIG. 9. Excess pressure in the circulating system is prevented by a discharge relief valve 271 on pump 263 from which relieved fluid may return to tank 260 through line 272.

Referring finally to FIGS. 28, 29 and 30, there are shown schematics of various film tank groupings and techniques of regulation of the film tension by certain modulating controls for the drive of the film as it passes through individual tank groupings. There may be one or more than one bank of film spools in each tank of a grouping. In FIG. 28 a film tank 275 has an incoming film strip 276 entering at the upper left-hand corner thereof as the system is shown in plan with the film feeding helically through the tank until it reaches the distant end of the bank of spools therein. Thereupon this film is transferred to the next adjacent tank 278. In

tank **275**, the tension in the advancing film modulates the adjustment of a valve **97** (FIG. **3**) to power the turbine wheels of a bottom row of film spools and the same arrangement is made in the adjacent and successive tanks **278**, **279** and **280**. In particular, according to the arrangements of FIG. **28**, variations in film tension within a particular tank modulate the turbine drive in that same tank.

In FIG. **29**, film strip **276** enters a tank **282** at the upper left hand corner thereof as the tank is shown in plan view, and then at the lower right hand corner of the tank the film is transferred to an adjacent tank **283**. From tank **283** the film is transferred to tank **284** at its upper left hand corner and from the lower right-hand corner of that tank the film is transferred to tank **285**. Tanks **282**, **283**, **284** and **285** are considered to be constructed and equipped in the manner of tank **110** and its internal arrangements of FIG. **5**, and the valve **114** of each tank modulates the drive of the lower shaft of film spools in another tank. As indicated by a dashed line, the modulated fluid flow from valve **114** of tank **282** drives the lower spool shaft of tank **283**. The modulated flow of fluid from valve **114** of tank **284** drives the lower spool shaft of tank **285**, and the modulated flow of fluid from valve **114** of tank **285** drives the lower spool shaft of tank **282**. Thus, except for the last tank, variation of film tension in any tank modulates the turbine drive of the tank next downstream from it.

In FIG. **30** the grouping of tanks **290**, **291**, **292** and **293** contemplates tanks and tank equipment similar to that of FIG. **1**. Variation in tension of film strip **276** entering and being transported through tank **290** cycles valve **40** of that tank to modulate the drive of turbine **38** of tank **292**. Film tension variation in tank **291** cycles valve **40** thereof to modulate the turbine drive of tank **293**. Similarly, film tension variation in tank **292** effects modulation of the turbine drive of tank **290** and variation in film tension in tank **293** modulates the turbine drive in tank **291**, thus in effect giving feedback modulation of turbine drive between tanks of various pairs of tanks according to film tension variations. Other control arrangements embodying various aspects of the arrangements of FIGS. **28**, **29** and **30**, but not limited to just those aspects, may be used as the operating situation suggests or requires.

It is to be noted, to be sure, that in the case of a grouping of tanks constructed and equipped similarly to the tank of FIG. **2** there is no modulation of the flow of pressurized fluid being received by the turbine mechanism of any lower shaft which is directly or automatically responsive to variation in film tension. In this case regulation of flow of turbine driving fluid depends upon the adjustment of a pump or valve within the control and at the discretion of the operator of the apparatus. A "pull out" or "pacer" roll used at the end of a grouping of tanks may be driven by a turbine receiving a flow of pressurized fluid modulated in accordance with the tension of the film strip in a tank. The "pacer" roll may also be driven by a turbine whose speed is regulated through its fluid supply by a valve controlled by other means. The individual film spool turbine drives described in connection with FIG. **9** may additionally have their supply of pressurized fluid in conduit **130** modulated in accordance with the tension of the film strip going over and around the spools as the strip is transported through a tank. The film spool drive of FIGS. **20** and **21** may also be modulated by the tension of film in banks in a tank or the speed may be modulated by other valve means for fluid flow control.

In all instances it should be understood that the pressurized fluid used with and for the various turbine drives or drive systems hereinbefore described and of which the flow is appropriately modulated need not be a fluid used for processing the transported film, at least not so far as any given turbine wheel is concerned, although it may be and often is such a fluid. There is no prohibition against the pressurized energizing or driving fluid being supplied from a source altogether outside of the film processing system or being a gaseous fluid such as compressed air in some cases rather than a liquid under pressure although in certain processing operations or steps such as film drying the processing fluid may indeed be air. Of course where the energizing fluid for a turbine drive is not a film or strip material processing fluid appropriate means must be provided at the turbine exhaust or discharge to isolate this fluid and carry it away without allowing it to mix with and dilute and possibly contaminate any processing fluid.

Considering particularly the matter of combination drives, of which an example is shown in FIGS. **22** through **26**, a wide range of combinations or combination components may be employed. It is, furthermore, not a requirement that both elements in the combination be turbines or turbine drives, although at least one would need to be to bring the apparatus within the contemplation of the present invention. Referring to FIG. **22**, upper spool shaft **236** could be extended to the right bringing its right-hand end outside of tank **220** as the shaft passed through a suitable seal or gland in the right-hand wall of the tank. Shaft **236** could then be driven easily by an electric motor or any other suitable prime mover in place of a fluid actuated turbine. By means of such prime mover, including a fluid actuated turbine, it will be convenient in at least some instances to maintain a steady, i.e., unmodulated, speed on upper spool shaft **236** or whatever shaft is driven by the prime mover. It may be expected that because of friction drag effects, possibly intentionally provided, the rotation of the shaft will induce a bit of angular motion in the film spools, carrying turbine wheels, mounted in a nominally free turning condition upon it. The film spools may then be brought up to a higher speed, and modulated in speed, by supplying actuating fluid to their turbines in a controlled or at least controllable manner described hereinbefore.

CONCLUSION

As this invention may be embodied in several forms, singly or combined, without departing from the spirit or essential characteristics thereof, the present embodiments are therefore illustrative and not restrictive. Protection by Letters Patent of the present invention in all its aspects as the same are set forth in the appended claims is sought to the broadest extent that the prior art allows.

I claim as my invention:

1. In an apparatus for transporting photographic film wherein said film is wound helically from shaft to shaft over spools carried on a plurality of shafts in spaced relation one to another, a drive system comprising (1) a

fluid-actuated turbine connected in driving relation to at least one of said spools, (2) means for sensing changes in tension in said film and adapted to generate signals responsive to such changes, and (3) means for receiving signals from said tension change sensing means and adapted to modulate the flow of actuating fluid to said turbine according to such signals and thereby regulate the driven speed of said one spool.

2. An apparatus for transporting photographic film according to claim 1 in which said turbine comprises a turbine wheel configured to have actuating fluid therefor impinge upon the outer periphery thereof.

3. An apparatus for transporting photographic film according to claim 2 in which said turbine wheel is freely rotatably mounted on one of said shafts, and in which at least one of said spools is attached to said turbine wheel to turn with the same on said one shaft.

4. An apparatus for transporting photographic film according to claim 2 in which said turbine wheel is fixedly mounted on a rotatable one of said shafts, and in which at least one of said spools is fixedly mounted on said one shaft to turn with the same and said turbine wheel.

5. An apparatus for transporting photographic film according to claim 1 in which said turbine comprises a turbine wheel configured to have actuating fluid therefor flow radially outwardly therethrough.

6. An apparatus for transporting photographic film according to claim 5 in which said turbine wheel is freely rotatably mounted on one of said shafts and receives actuating fluid through said one shaft, and in which at least one of said spools is attached to said turbine wheel to turn with the same on said one shaft.

7. An apparatus for transporting photographic film according to claim 5 in which said turbine wheel is fixedly mounted on a rotatable one of said shafts and receives actuating fluid through said one shaft, and in which at least one of said spools is fixedly mounted on said one shaft to turn with the same and said turbine wheel.

8. An apparatus for transporting photographic film according to claim 1 in which said turbine comprises a turbine wheel configured to have actuating fluid therefor flow axially therethrough.

9. An apparatus for transporting photographic film according to claim 8 in which said turbine wheel is freely rotatably mounted on one of said shafts, and in which at least one of said spools is attached to said turbine wheel to turn with the same on said one shaft.

10. An apparatus for transporting photographic film according to claim 9 in which said one spool encloses said turbine wheel circumferentially.

11. An apparatus for transporting photographic film according to claim 1 in which said turbine comprises a turbine wheel configured to have actuating fluid therefor flow radially inwardly therethrough.

12. An apparatus for transporting photographic film according to claim 11 in which at least one of said spools is freely rotatably mounted on one of said shafts, and in which said turbine wheel is attached to said one spool to turn with the same on said one shaft.

13. In an apparatus for transporting photographic film wherein said film is wound helically from shaft to shaft over spools carried on a plurality of shafts in spaced relation one to another with at least one of said shafts being movable in space in response to changes in tension in said film, a drive system comprising (1) a fluid-actuated turbine connected in driving relation to at least one of said spools, and (2) means connected in motion-sensing relation to said movable shaft and adapted to modulate the flow of actuating fluid to said turbine according to shaft movement and thereby regulate the driven speed of said one spool.

14. An apparatus for transporting photographic film according to claim 13 in which said turbine comprises a turbine wheel configured to have actuating fluid therefor impinge upon the outer periphery thereof.

15. An apparatus for transporting photographic film according to claim 13 in which said turbine comprises a turbine wheel configured to have actuating fluid therefor flow radially outwardly therethrough.

16. An apparatus for transporting photographic film according to claim 13 in which said turbine comprises a turbine wheel configured to have actuating fluid therefor flow axially therethrough.

17. An apparatus for transporting photographic film according to claim 13 in which said turbine comprises a turbine wheel configured to have actuating fluid therefor flow radially inwardly therethrough.

18. An apparatus for transporting photographic film according to claim 13 in which said means connected in motion-sensing relation to said movable shaft and adapted to modulate the flow of actuating fluid to said turbine according to shaft movement comprises (i) a conduit connected to said turbine wherethrough actuating fluid may flow to said turbine from a source of fluid under relatively elevated pressure, (ii) a fluid flow control valve in said conduit between said turbine and said source of fluid under relatively elevated pressure, and (iii) means connecting said movable shaft with said fluid flow control valve whereby the opening of said valve is determined according to the position of said shaft.

19. An apparatus for transporting photographic film according to claim 18 in which said means connecting said movable shaft with said fluid flow control valve is so disposed that the opening of said valve and the flow of actuating fluid therethrough are increased when said shaft moves in accordance with increasing tension in said film and decreased when said shaft moves in accordance with decreasing tension in said film.

20. An apparatus for transporting photographic film according to claim 18 in which said movable shaft is a dancer roll shaft.

21. In an apparatus for transporting photographic film wherein said film is wound helically from shaft to shaft over spools carried on a plurality of shafts in spaced relation one to another with at least one of said shafts being movable in space in response to changes in tension in said film, a drive system comprising (1) a fluid-actuated turbine comprising a turbine wheel connected in driving relation to at least one of said spools, (2) a hollow arm whereon said turbine wheel and said one spool are together mounted for rotation on a common shaft and wherethrough actuating fluid may be supplied to said turbine wheel, and (3) a fluid conductor extending generally parallel to the shaft axis of rotation of said turbine wheel and said one spool and with which said arm is movably connected, there being a throttling interface between the interior regions of said

fluid conductor and said hollow arm whereby the flow of actuating fluid to said turbine through said conductor and said arm is modulated according to the movement of said arm with respect to said conductor, and thus according to the movement of the shaft of said turbine wheel and said one spool with respect to said fluid conductor, to thereby regulate the driven speed of said one spool.

22. An apparatus for transporting photographic film according to claim **21** in which said turbine wheel is configured to have actuating fluid therefor impinge upon the outer periphery thereof.

23. An apparatus for transporting photographic film according to claim **21** in which said turbine wheel is configured to have actuating fluid therefor flow radially outwardly therethrough.

24. An apparatus for transporting photographic film according to claim **21** in which said hollow arm is disposed to perform reciprocating linear motion substantially transversely to the axis of said fluid conductor.

25. An apparatus for transporting photographic film according to claim **21** in which said hollow arm is disposed to perform oscillatory angular motion around the axis of said fluid conductor.

26. An apparatus for transporting photographic film according to claim **21** in which said hollow arm is disposed to move with respect to said fluid conductor in a manner enlarging said throttling interface and thereby increasing flow of actuating fluid to said turbine in response to increasing tension in said film and diminishing said throttling interface and thereby decreasing flow of actuating fluid to said turbine in response to decreasing tension in said film.

27. In an apparatus **3)** transporting photographic film wherein said film is wound helically from shaft to shaft over spools carried on a plurality of shafts in spaced relation one to another with at least one of said shafts being movable in space in response to changes in tension in said film, a drive system comprising (1) a prime mover connected in driving relation to a given shaft, (2) at least one spool rotatably mounted on said given shaft (3) a fluid-actuated turbine connected in driving relation to said one spool, and (4) means connected in motion-sensing relation to said movable shaft and adapted to modulate the flow of actuating fluid to said turbine according to shaft movement and thereby regulate the driven speed of said one spool with respect to the driven speed of said given shaft.

28. An apparatus for transporting photographic film according to claim **27** in which said prime mover is a fluid-actuated turbine.

29. An apparatus for transporting photographic film according to claim **27** in which said turbine comprises a turbine wheel configured to have actuating fluid therefor flow radially inwardly therethrough.

30. An apparatus for transporting photographic film according to claim **29** in which said turbine wheel is attached to said one spool to turn with the same on said given shaft.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,680,803 Dated August 1, 1972

Inventor(s) Victor Takata

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the list of references, second item: for "Barkelen" read --Barkelew--. Column 4, line 22: cancel "taken" (second occurrence in line). Column 8, line 4: for "films" read --film--. Column 20, line 4 (Claim 27, line 1): for "3)" read --for--.

Signed and sealed this 2nd day of January 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

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