May 2, 1933. J. T. BARKELEW 1,907,315

FILM DEVELOPING SYSTEM

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Fig. 1

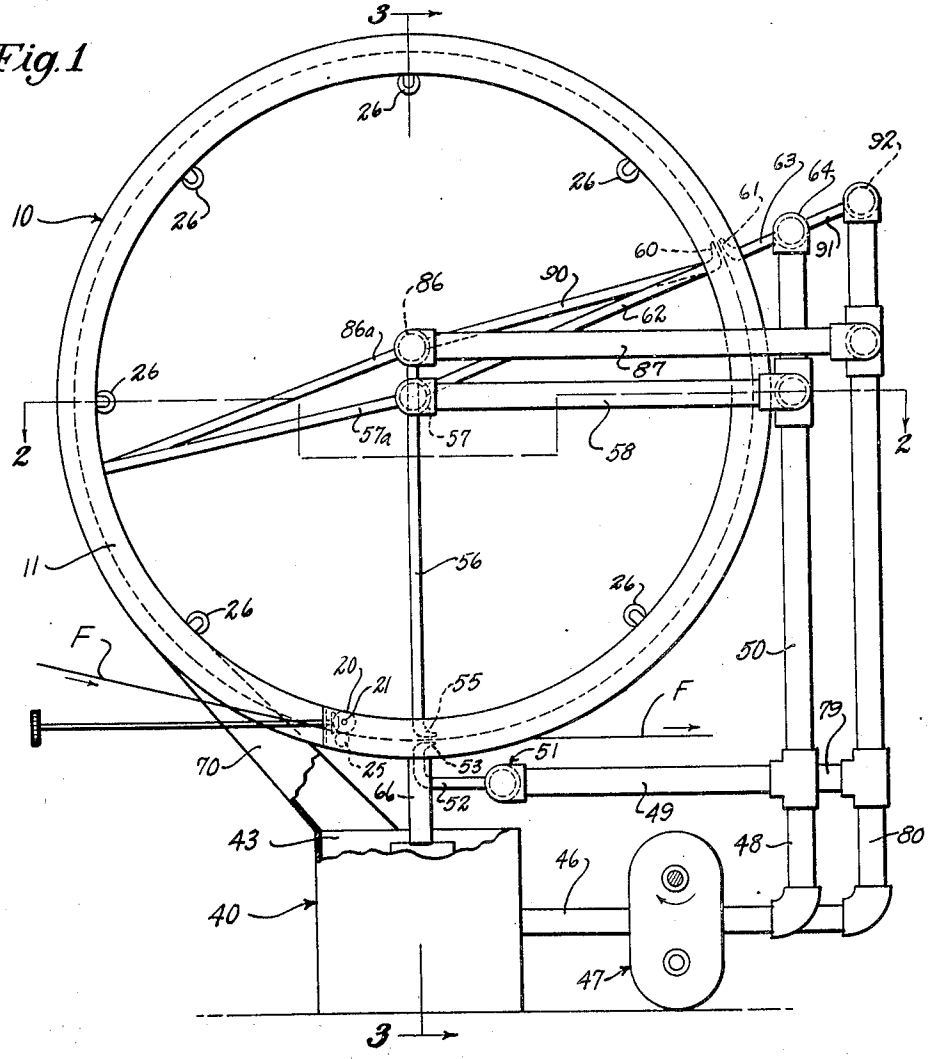
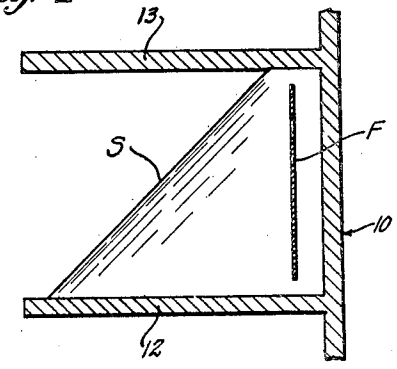


Fig. 4



Inventor

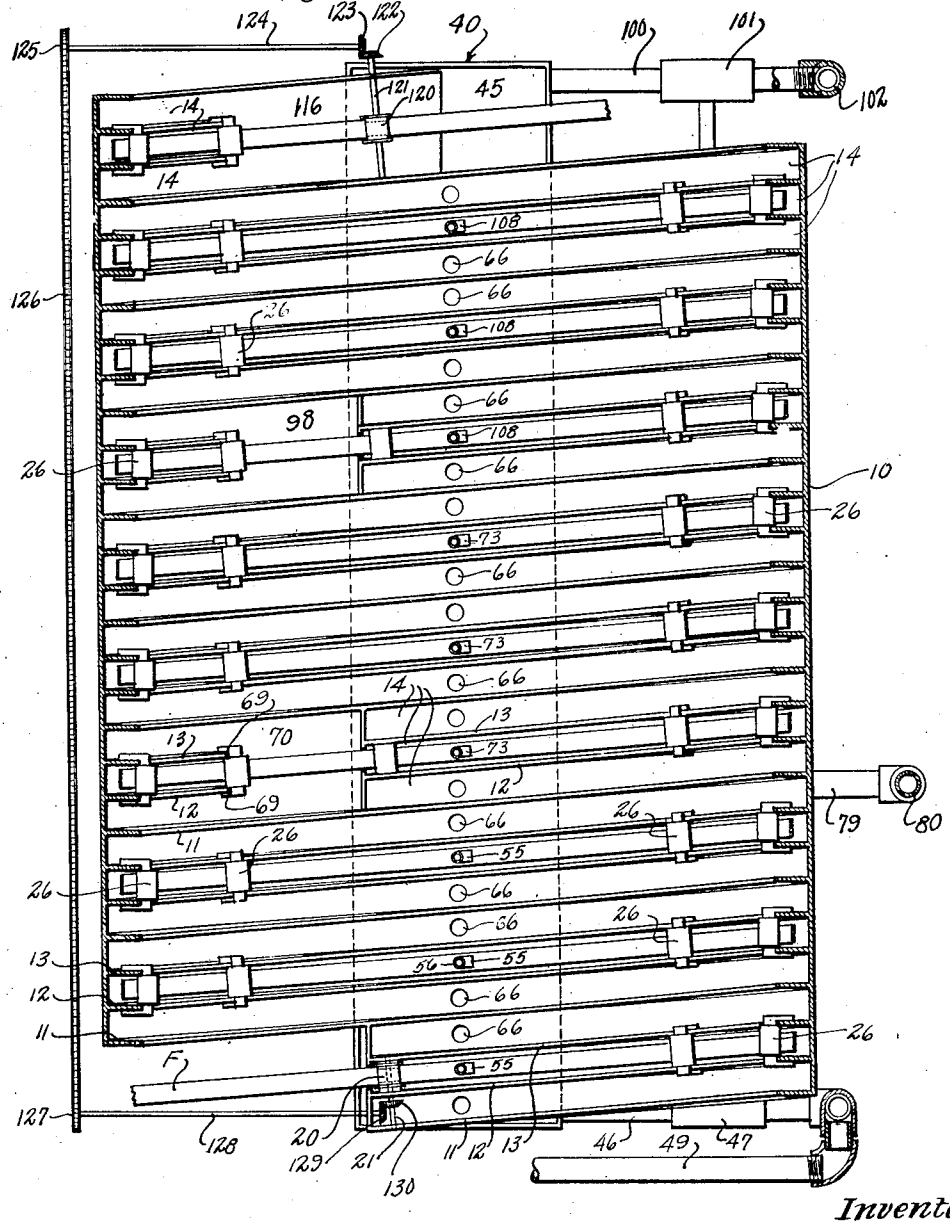
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Fig. 2



Inventor

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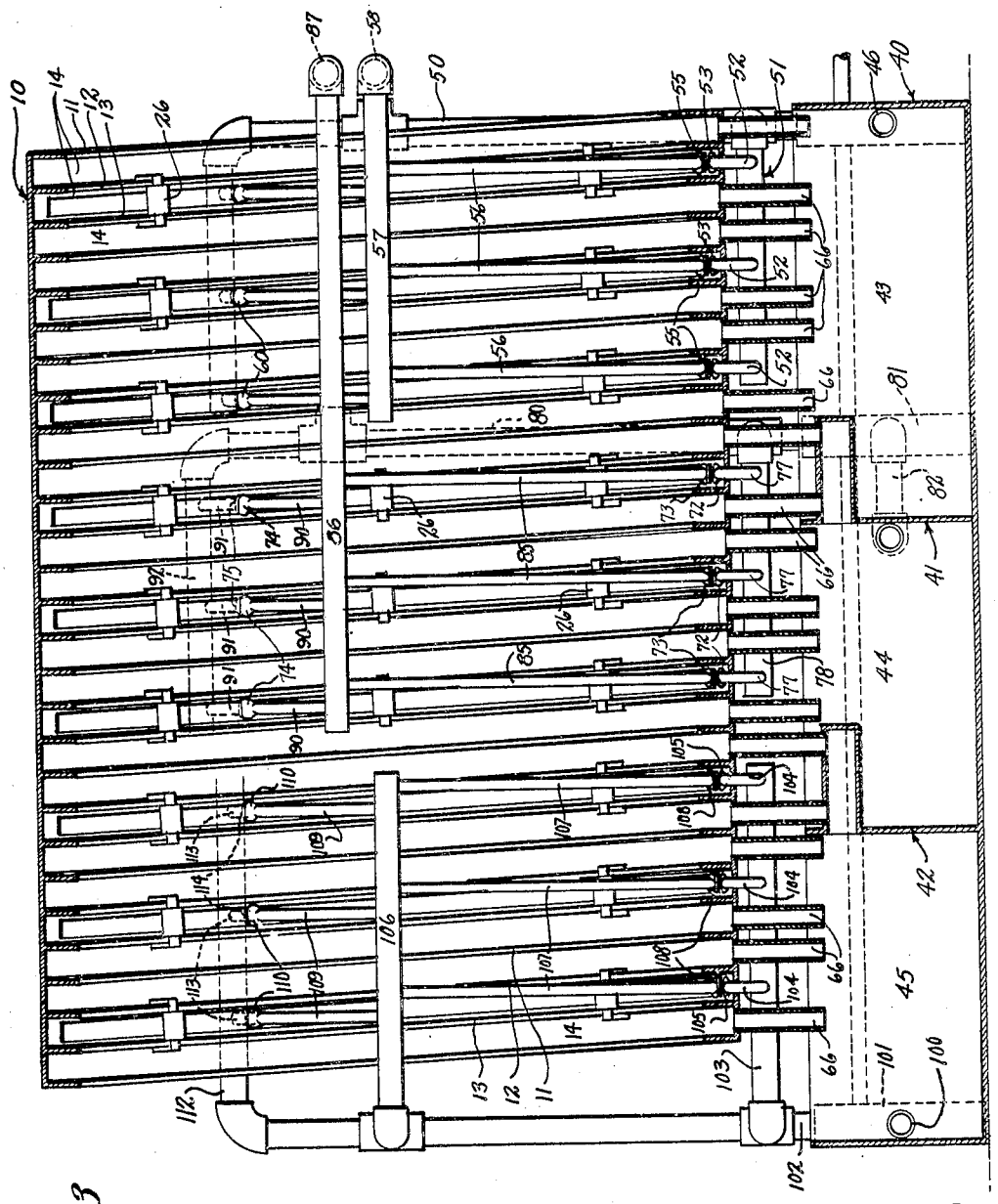


Fig. 3

Inventor

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Patented May 2, 1933 1,907,315

UNITED STATES PATENT OFFICE

JAMES T. BARKELEW, OF PASADENA, CALIFORNIA, ASSIGNOR TO PARAMOUNT PUBLIX CORPORATION, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

FILM DEVELOPING SYSTEM

Application filed March 25, 1931. Serial No. 525,130.

This invention relates generally to the art of propelling long strips, such as motion picture film, through liquid or fluid baths. The present invention is designed primarily for use in developing, fixing, washing and drying motion picture film, and is therefore spoken of primarily in that connection, but it will be understood the invention is also applicable to propulsion of film or other strips through other baths as well.

In developing motion picture film, the film strip is ordinarily run in succession through the developing solution, the fixing bath, the water wash, any other desired solutions, and finally the dryer, the film strip being continuously supplied to the developer bath and being delivered continuously from the dryer. Parts of the same film strip are thus in the wet bath while other parts are passing through the dryer. The principal difficulty heretofore encountered in propelling the film through such baths has arisen from the expansion of the film as it becomes wet and the shrinkage of the film as it dries. Since one part of the film strip may be undergoing wet treatment, and therefore be expanding, while another part of the film may be undergoing drying, and therefore be shrinking, both elongation and shrinkage must be contended with in the same film strip. And each and both such conditions lead to a set of difficulties so well recognized in the art as to require no detailed account here. The difficulties are mainly those attending the constant propulsion of a strip of changing length, without developing slack or too great tension.

Reference is here made to an application entitled "Film developing system," Ser. No. 489,600, filed Oct. 18, 1930, by Ingman, Garbutt and myself, in which is disclosed a film developing system designed to avoid all such difficulties as are above referred to. In accordance with the system therein disclosed the film is propelled through the various baths by force arising from the flow of the bath liquids through the bath containers. This is accomplished, in the preferred illustrative form therein described, by flowing the several treating liquids continuously through successive conduits and causing the film to be dragged along by propulsive force arising from the skin friction of the flowing treating liquids.

Such an arrangement, however, is apt to be inconveniently long or bulky, and it may be stated as a primary object of the present invention to provide a simple and compact apparatus of the class disclosed in said prior application through which the film can be propelled in a most simple manner, without putting sharp bends in the film or exerting undue strain thereon and in general without encountering the various difficulties inherent in other prior practice.

It may here be mentioned that the prior application referred to above includes claims generic to the invention disclosed in the present application, as well as to my copending companion applications entitled "Film developing system" Ser. No. 524,361, filed March 21, 1931, and Ser. No. 526,150, filed March 30, 1931.

In accordance with the present invention, the film is drawn through the treating conduit by the skin friction of the flowing treating fluid or liquid, as the case may be. The conduit, however, is arranged as a spiral raceway, preferably in the form of a spirally wound trough, the open side of which faces inwardly. The axis of the spiral may be either horizontal or vertical, and the treating liquid is flowed around the spiral trough with sufficient velocity that centrifugal force prevents it from dropping or spilling out. The film is dragged around the spiral trough by the flowing liquid with a minimum of strain since short bends are entirely eliminated, and for the further reason that no positive pull is exerted on the film at any point, the skin-friction pull being exerted on the film at all points.

The various objects and features of advantage of the present invention will appear and be more fully understood from the following detailed description, reference for this being had to the accompanying drawings, in which:

Fig. 1 is an end elevation of film handling apparatus embodying my invention;

Fig. 2 is a horizontal transverse section taken on broken line 2—2 of Fig. 1;

Fig. 3 is a vertical longitudinal section taken on line 3—3 of Fig. 1; and

Fig. 4 is a cross section diagram of the spiral film trough when the axis of the spiral is vertical.

In the drawings numeral 10 designates a cylindric shell, here first described as a horizontal axis. Three inwardly projecting flanges 11, 12 and 13 are mounted on the inner surface of shell 10 and are arranged in helical spirals running from end to end therein, thus providing what may be considered as a set of triple pitch helical troughs 14, or the arrangement may be considered as comprising three adjacent troughs 14 formed into a helical spiral. The physical formation of this helical spiral is of no importance; I here describe it as formed by flanges in a shell—it can just as well be made by spirally bending the requisite number of channel irons. And the number of troughs may be varied; I here describe three for purposes hereafter stated.

At the beginning end of the spiral, flanges 12 and 13 defining middle trough 14 support a film feeding and hold-back sprocket 20, said sprocket being mounted on a shaft 21 which is driven at a constant speed. The film F is threaded under said sprocket 20 and retained thereon as by roller 25, the film thus being fed into the middle trough 14 defined by flanges 12 and 13, and passing through the spiral course of that trough to the out-going end of the treater, in a manner which will be more fully understood from what follows. Flanges 12 and 13 defining said middle trough 12, hereinafter referred to as the film trough or raceway, support suitably spaced film rollers 26 which prevent the film strip accidentally coming out of the film trough; although in the normal operation of the treater the flowing liquid causes the film to stay well within the trough and out of engagement with said rollers, as well as staying out of engagement with the inner wall of the trough, as clearly shown in Fig. 2. The film leaves its trough 14 at the outgoing end of the treater to be taken up by a suitable take-out, hereinafter to be more fully referred to, which preferably takes out the film at the same "sprocket hole" speed at which it is fed to the treater by feed roller 20.

Speaking generally, the film is advanced in its spiral trough 14 by the force due to skin friction of treating liquid which is flowed around said trough. The liquid is caused to flow in the trough always with sufficient velocity that its centrifugal force overcomes the force of gravity, so that the liquid will not drop out in passing around the upper side of the trough. To keep this velocity up to the value thus required, liquid is tangentially injected to the film trough with relatively high initial velocity at spaced points about the spiral. The liquid thus added, however, fills the film trough to overflowing, and this overflowing liquid is collected by the two troughs 14 at the sides of the film trough.

I proceed now to a more detailed description of how the above is accomplished. Below cylinder 10 is a tank structure 40 of substantially the length of said cylinder, the tank being divided by transverse partitions 41 and 42 into separate tanks or compartments 43, 44 and 45 arranged longitudinally of cylinder 10. These compartments serve as containers for the usual treating liquids used in the successive stages of the continuous treatment of the film. For instance, compartments 43, 44 and 45 may serve as supply containers for the developer, hypo and wash, respectively.

A pipe 46 leads from developer tank 43 to the suction end of a pump 47, the outlet of which is connected to a pipe line 48 having two main branches 49 and 50. Branch 49 leads to a horizontal header 51 arranged below and longitudinally of cylinder 10, said header extending from opposite the beginning end of spiral trough 14 to a point opposite a given convolution therein, here shown as opposite the third convolution, although this may be varied to suit individual circumstances. Header 51 is provided with feed pipes 52, one for each of the first three convolutions of the film trough, which extend through the wall of cylinder 10 into the bottom side of the film trough below the film strip and have tangential nozzle tips or jets 53 pointed in the direction of film movement. The liquid discharge by these jets flow upwardly in the film trough and exerts a propelling force on the film due to the drag of skin friction.

The inner surface of the film strip is acted upon directly opposite outside jets 53 by liquid discharge from tangentially directed inside jets 55, which are on the ends of feed pipes 56 leading from a header 57 mounted inside of the cylinder on the end of a pipe 58 extending from main branch 50. Thus in the form here shown both the inner and the outer surfaces of the film strip at the lower side of each turn of the spiral are acted upon by a tangentially jetted stream of developer, which has the effect of dragging the film forwardly by the force of skin friction. And the provision of jets on both sides of the film strip has the further effect of keeping the strip centered in the liquid stream.

It will be seen that the film advancing force of these jets is applied just as the film strip passes the lower side of the spiral and is starting to rise. It will be apparent that any number of such pairs of inner and

outer jets may be spaced around each convolution of the spiral film trough; and in the present instance I employ for each convolution a pair of jets preferably arranged approximately 120° beyond said lower jets. Thus at a point here shown spaced approximately 120° from the lower jets in each convolution, there is provided a pair of inside and outside tangential jets 60 and 61, respectively, inside jets 60 being on the ends of feeder pipes 62 leading from header 57, while outside jets 61 are on the ends of feeder pipes 63 leading from a header 64 which is connected to pipe 50. The liquid discharged by these upper jets 60 and 61 gives additional forward force and velocity to the general circulation to compensate the decrease in velocity in that part of the spiral due to the uphill direction of flow.

The liquid tangentially discharged by these upper jets 60 and 61 thus keep up the required velocity of flow around the last part of the uphill section of the trough, and after passing around the top side of the spiral trough the liquid is accelerated by the force of gravity so that as it passes the jets at the bottom side of the trough it is moving with considerable velocity. The lower jets 52 and 53 then supply whatever additional force is required to cause the liquid to rise and pass the upper jets 60 and 61 with good velocity, after which said upper jets keep the liquid moving upwardly and over the top as above described.

As has previously been stated, to keep the liquid in the trough when flowing around the top side of the spiral the velocity of flow must be sufficiently great that centrifugal force acting on the liquid will be at least as great as the force of gravity. This condition is easily calculated for any given diameter of tank, as will be more fully described later. The ideal condition for perfectly uniform pull on the film strip at all points is obtained when the velocity of liquid flow is uniform all around the spiral. The jets arranged as above described achieve this end in sufficient measure for all practical purposes, the jets supplying propulsive force to the liquid on the uphill side of the spiral while gravity supplies force to the liquid on the downhill side. However, if the liquid on the downhill side so increases in velocity as to tend too greatly to "thin out" the stream, additional liquid can be added to the trough on the downhill side as by means of pipes 57*a* and 86*a* (shown only in Fig. 1) leading from headers 57 and 86, respectively, and discharging into the film troughs.

When the axis of the spiral is vertical, the flow around each convolution is substantially uniform, but the liquid must be flowed with sufficient velocity to "bank up" so as to cover the film. Fig. 4 shows a cross-section diagram of a spiral trough whose axis is vertical, and it will be apparent that sufficient liquid must be used that the film will be covered when the liquid is flowing with its proper velocity. In Fig. 4 the liquid surface S is shown at an angle of approximately 45°, and to achieve this condition the design must be made with proper regard to diameter of spiral and flow velocity. The angle will be 45° when V, the velocity of flow, is equal to $\sqrt{gr}$, where g is gravity and r is the radius of the spiral.

I prefer to keep the film troughs full of liquid at all points, the excess liquid caused by the jet feeds passing over the edges of the trough and going out tangentially into the adjacent collector troughs. The collector troughs are each provided at the lower side of each convolution with a discharge conduit 66 leading downwardly to the supply tank 43, as clearly shown in Fig. 3, so that this overflow is taken immediately back to the original supply.

Developer is thus injected to the film trough throughout a given number of convolutions or sections of the spiral, but at the end of the unit comprised by said convolutions the developer is separated from the film and returned to the supply tank. The film however, continues on and is taken by a second section of the spiral trough wherein it is acted upon for instance by injected hypo, as now to be described.

Thus at the end of the first or "developer" section of the trough, and preferably at a suitable point in the spiral where the liquid is moving downwardly, the flanges 12 and 13 defining the film trough are interrupted for a distance, as indicated at 69, and at said point the three adjacent troughs 14 are merged into a tangential outlet trough 70 secured in a suitable opening in the wall of cylinder 10 and leading downwardly at an oblique angle to be returned to tank 43. The liquid from the full film trough spreads laterally upon entering said trough 70, and because of the greater flow area in trough 70 decreases somewhat in velocity. This is of advantage in getting the liquid from over the film down into the discharge trough. Beyond outlet 70 the flanges 11 and 12 that form troughs 14 are continued, the film taking the middle trough as before.

The film is advanced through the succeeding or second section of the spiral conduit by injected hypo, which here constitutes the second treating liquid. To this end the film trough convolutions of the next section of the treater are provided with inside and outside lower jets 72 and 73, respectively, and inside and outside upper jet 74 and 75, respectively, all similar to those described for the developer section of the apparatus. The lower outside jets 73 are on feed pipes 77 leading from a header 78

that extends from a branch pipe 79 of pipe line 80, said pipe line 80 leading from the outlet of a pump 81, the suction end of which is connected by pipe 82 with the hypo tank 44. The lower inside jets 73 are on the ends of feed pipes 85 leading from a header 86 extending horizontally into the spiral over header 57, header 86 being on the end of a pipe line 87 connected to pipe 80. The upper inside jets 74 are on the ends of feeders 90 leading from header 86, while the upper outside jets 75 are on the ends of feeders 91 leading from a header 92 connected to pipe line 80.

The lower sides of the collection troughs 14 are again provided with outlet pipes 66, which here, however, lead back to the hypo supply tank 44.

At the end of the hypo section of the spiral the troughs 14 merge into a discharge trough 98, similar to trough 70, through which the hypo is returned to its supply tank 44.

The film thence goes on through a final spiral trough section, which may be the usual wash unit. As shown in the drawings, the wash water is taken from tank 45 through pipe 100 to pump 101, and from there pumped through pipe line 102 to a header 103 provided with feed pipes 104 carrying the lower outside jets 105. Pipe line 102 also connects to a header 106 extending horizontally into tank 10 from the end opposite headers 67 and 86. To header 106 are connected feeders 107 carrying the lower inside jets 108, and feeders 109 carrying the upper inside jets 110. Pipe 102 also connects to a header 112 and having feeders 113 carrying the upper outside jets 114.

At the end of the wash section of the spiral, the troughs 14 discharge the wash water into outlet trough 116, which returns it to tank 145. At this point the film may be finally taken out of the film trough, for instance, by a film sprocket 120 (Fig. 2) mounted on a shaft 121 journaled in the trough walls, as shown. This sprocket may be interconnected in any suitable manner with feed sprocket 20 so that the film will be removed from the apparatus at the same "sprocket-hole" rate at which it is fed thereto. For this purpose there is conventionally here shown on shaft 121 a bevel gear 122 meshing with a bevel gear 123 on a shaft 124 that has a chain sprocket 125, said sprocket being connected by a chain 126 with a sprocket 127 on a shaft 128, which in turn has a bevel gear 129 meshing with a bevel gear 130 on the drive shaft 21 of the feed sprocket 20.

The pull on the film through the apparatus is due to the frictional drag of the flowing liquid, and is therefore dependent in amount upon the velocity of flow of the liquid. The velocity of flow is determined, therefore, with regard to the provision for a suitable propulsive force on the film, but also with regard to several other factors. Among these is the requirement, when the axis of the spiral is horizontal, that the velocity be sufficient to keep the liquid in the trough in passing over the top of the spiral. As has been said, to achieve this end the velocity of liquid flow must be at least sufficient that centrifugal force on the liquid will overcome the force of gravity thereon. The critical velocity v at which centrifugal force equals gravity g is obtained when

$$v = \sqrt{gr}$$
$$= 5.67\sqrt{r}$$

where r is the radius of the spiral. And as previously mentioned, the same velocity of flow will maintain the liquid surface in the trough at 45° when the axis of the spiral is vertical. Choosing a spiral four feet in diameter, a critical velocity of about eight feet per second is obtained, and the liquid feed must be injected with sufficient initial velocity to maintain this critical flow velocity in the trough. With such constants the film can be moved at two feet per second or more. The number of convolutions in the developer, hypo and wash units will then of course be chosen with regard to the above factors so that the desired time of treatment is obtained in each unit, all as will readily be understood.

The exact velocity of the film is controlled by the speed at which the feed sprocket 20 is driven. Since the liquid flows at a greater velocity, the conditions of slight frictional overdrive are provided, the liquid tending to move the film just slightly faster than the speed permitted by the feed sprocket, which therefore functions as a hold back. With these conditions the film is kept taut but is not pulled against the rollers 26 inside the raceway, and is not too strongly pulled against the hold back sprocket.

By the arrangement shown there will be no slippage either at the ingoing or outgoing ends and there will therefore always be a constant length of film (a constant number of sprocket holes) in the machine. Of course, the wet film always tends to elongate, and elongation will vary with various samples of film, but within such limits the length of film between the hold back and take-out sprockets is constant. It will thus be understood that the take-out merely removes the film from the machine, and does not function to pull the film through. The take-out fullfils another function, however, in acting as a hold back on the film so that any apparatus beyond the developing apparatus cannot exert tension on the constant length of film between the feed sprocket and take-out.

It will be understood the drawings and description are to be considered merely as illustrative of and not restrictive on the broader claims appended hereto, for various changes in design, structure and arrangement may be made without departing from the spirit and scope of said claims.

I claim:

1. In film treating apparatus, a film raceway embodying a liquid conduit in the form of a spiral, means for feeding a film strip into one end of said spiral conduit, and means for flowing liquid around the conduit to propel the film therethrough.

2. In film treating apparatus, a film raceway embodying a liquid conduit in the form of a helical spiral, means for feeding a film strip into one end of said spiral conduit, and means for flowing liquid around the conduit to propel the film therethrough.

3. In film treating apparatus, a film raceway embodying a liquid conduit in the form of a helical spiral whose axis is horizontal, means for feeding a film strip into one end of said spiral conduit, and means for flowing liquid around said spiral conduit to propel the film therethrough.

4. In film treating apparatus, a film raceway embodying a liquid conduit in the form of a helical spiral whose axis is horizontal, means for feeding a film strip into one end of said spiral conduit, and means for introducing liquid to the conduit with sufficient velocity to flow around the tops of the turns of the spiral so that the film strip is acted upon throughout the conduit by propulsive force due to skin friction of the flowing liquid.

5. In film treating apparatus, a film raceway embodying a liquid conduit in the form of a helical spiral whose axis is horizontal, means for feeding a film strip into one end of said spiral conduit, and means for flowing liquid around said spiral conduit with a velocity at least as great as 5.67 $\sqrt{r}$ feet per second, where r is the radius of the helical spiral.

6. In film treating apparatus, a film raceway embodying a liquid conduit in the form of a helical spiral whose axis is horizontal, means for feeding a film strip into one end of said spiral conduit, and means for flowing liquid around said spiral conduit with a velocity substantially equal to 5.67 $\sqrt{r}$ feet per second, where r is the radius of the helical spiral.

7. In film treating apparatus, a film raceway embodying a liquid conduit in the form of a helical spiral, means for feeding a film strip into one end of said spiral conduit, and means for flowing liquid around said spiral conduit with a velocity substantially equal to 5.67 $\sqrt{r}$ feet per second, where r is the radius of the helical spiral.

8. In film treating apparatus, a film raceway embodying a liquid conduit in the form of a helical spiral, means for feeding a film strip into one end of said spiral conduit, and means for tangentially injecting liquid into said spiral conduit to flow in the direction of movement of the film strip.

9. In film treating apparatus, a film raceway embodying a liquid conduit in the form of a helical spiral, means for feeding a film strip into one end of said spiral conduit, and means arranged at spaced points in the spiral conduit for tangentially injecting liquid to flow in the direction of movement of the film strip.

10. In film treating apparatus, a film raceway embodying a liquid conduit in the form of a helical spiral whose axis is horizontal, means for feeding a film strip into one end of said spiral, said film being threaded through the spiral conduit to be taken from its outgoing end, jets for tangentially injecting liquid into the spiral conduit to flow in the direction of film movement, said jets located at the lower sides of the turns in the spiral, and similar jets located in the direction of film movement from the first mentioned jets and between said jets and the upper sides of the turns in the spiral.

11. In film treating apparatus, a film raceway embodying a liquid conduit in the form of a helical spiral, means for feeding a film strip into one end of said spiral, said film being threaded through the spiral conduit to be taken from its outgoing end, and jets arranged to inject liquid tangentially into the conduit at points located outside the outer surface of the film spiralled in the conduit.

12. In film treating apparatus, a film raceway embodying a liquid conduit in the form of a helical spiral, means for feeding a film strip into one end of said spiral, said film being threaded through the spiral conduit to be taken from its outgoing end, jets arranged to inject liquid tangentially into the conduit at points located outside the outer surface of the film spiralled in the conduit, and jets arranged to inject liquid tangentially into the conduit at points located inside the inner surface of the spiralled film.

13. In film treating apparatus, a film raceway embodying an open liquid trough wound in a helical spiral with its open side facing inwardly, means for feeding a film strip into one end of said spiral trough, said film strip being guided to travel through the spiral trough, and means for flowing liquid around the spiral trough in the direction of film travel.

14. In film treating apparatus, a film raceway embodying an open liquid trough wound in a helical spiral with its open side facing inwardly, means for feeding a film strip into one end of said spiral trough, said film strip being guided to travel through the spiral trough, and means for flowing liquid around the spiral trough in the direction of

film travel with sufficient velocity with reference to the radius of the spiral that the liquid will stay in the trough by virtue of centrifugal force.

15. In film treating apparatus, a film raceway embodying an open liquid trough wound in a helical spiral, the open side of said trough facing inwardly in the spiral, means for feeding a film strip into one end of said spiral trough, said film strip being guided to travel through the spiral trough, and means for flowing liquid around the spiral trough in the direction of film travel.

16. In film treating apparatus, a film raceway embodying an open liquid trough wound in a helical spiral whose axis is horizontal, the open side of said trough facing inwardly in the spiral, means for feeding a film strip into one end of said spiral trough, said film strip being guided to travel through the spiral trough, and means for flowing liquid around the spiral trough in the direction of film travel with sufficient velocity with reference to the radius of the spiral that the liquid will stay in the trough by virtue of centrifugal force.

17. In film treating apparatus, a film raceway embodying an open liquid trough wound in a helical spiral, the open side of said trough facing inwardly in the spiral, means for feeding a film strip into one end of said spiral trough, said film strip being guided to travel through the spiral trough, and means for flowing liquid around the spiral trough in the direction of film travel with sufficient velocity with reference to the radius of the spiral that the liquid will stay in the trough by virtue of centrifugal force.

18. In film treating apparatus, a film raceway embodying an open liquid trough wound in a helical spiral whose axis is horizontal, the open side of said trough facing inwardly in the spiral, means for feeding a film strip into one end of said spiral trough, said film strip being guided to travel through the spiral trough, and means for flowing liquid around the spiral trough in the direction of film travel with a velocity at least as great as $5.67 \sqrt{r}$ feet per second, where r is the radius of the helical spiral.

19. In film treating apparatus, a film raceway embodying an open liquid trough wound in a helical spiral whose axis is horizontal, the open side of said trough facing inwardly in the spiral, means for feeding a film strip into one end of said spiral trough, said film strip being guided to travel through the spiral trough, and means for flowing liquid around the spiral trough in the direction of film travel with a velocity substantially equal to $5.67 \sqrt{r}$ feet per second, where r is the radius of the helical spiral.

20. In film treating apparatus, a film raceway embodying an open liquid trough wound in a helical spiral, the open side of said trough facing inwardly in the spiral, means for feeding a film strip into one end of said spiral trough, said film strip being guided to travel through the spiral trough, and means for flowing liquid around the spiral trough in the direction of film travel with a velocity substantially equal to $5.67 \sqrt{r}$ feet per second, where r is the radius of the helical spiral.

21. In film treating apparatus, a film raceway embodying an open liquid trough wound in a helical spiral with its open side facing inwardly, means for feeding a film strip into one end of said spiral trough, said film strip being guided to travel through the spiral trough, means for introducing liquid to flow around the spiral trough in the direction of film travel so as to advance the film, and a spiral collection trough adjacent the film raceway trough and adapted to catch liquid overflow from said raceway trough.

22. In film treating apparatus, a film raceway embodying an open liquid trough wound in a helical spiral, the open side of said trough facing inwardly in the spiral, means for feeding a film strip into one end of said spiral trough, said film strip being guided to travel through the spiral trough, means for introducing liquid at spaced points in the spiral trough to flow around the trough in the direction of film travel so as to advance the film, and a spiral collection trough adjacent the film raceway trough and adapted to catch liquid overflow from said raceway trough.

23. In film treating apparatus, a film raceway embodying an open liquid trough wound in a helical spiral, the open side of said trough facing inwardly in the spiral, means for feeding a film strip into one end of said spiral trough, said film strip being guided to travel through the spiral trough, means for introducing liquid at spaced points in the spiral trough to flow around the trough in the direction of film travel so as to advance the film, and a spiral collection trough adjacent each side of the film raceway trough and adapted to catch liquid overflow from said raceway trough.

24. In film treating apparatus, the combination of three adjacent liquid troughs wound in a helical spiral with their open sides facing inwardly, means for feeding a film strip into one end of the intermediate one of said three troughs, said film strip being guided to travel through said trough, and means for flowing liquid around said trough in the direction of film travel so as to advance the film, the troughs at the sides of the intermediate trough collecting liquid overflow from the intermediate trough.

25. In film treating apparatus, a film raceway embodying a liquid conduit in the

form of a spiral, means for feeding a film strip into one end of the spiral, around through the spiral, and out of the other end of the spiral, and means for flowing liquid around the spiral conduit in contact with the film therein at sufficient velocity that the liquid will stay in the spiral raceway by virtue of centrifugal force.

26. In film treating apparatus, a film raceway embodying a liquid conduit in the form of a spiral whose axis is horizontal, means for feeding a film strip into one end of the spiral, around the spiral, and out of the other end, and means for flowing liquid around the spiral conduit in contact with the film therein with sufficient velocity to flow around the tops of the turns of the spiral.

27. In film treating apparatus, a film raceway embodying a liquid conduit in the form of a spiral, means for feeding a film strip into one end of the spiral, around the spiral, and out at the other end, and means arranged at spaced points in the spiral conduit for tangentially injecting liquid to flow around the spiral in contact with the film therein.

28. In film treating apparatus, a film raceway embodying a liquid conduit in the form of a helical spiral whose axis is horizontal, means for feeding a film strip into one end of said spiral, said film being threaded through the spiral conduit to be taken from its outgoing end, jets for tangentially injecting liquid into the spiral conduit to flow around the spiral in contact with the film therein, said jets located at the lower sides of the turns in the spiral, and similar jets located in the direction of film movement from the first mentioned jets and between said jets and the upper sides of the turns in the spiral.

29. In film treating apparatus, a film raceway embodying an open liquid trough wound in a helical spiral with its open side facing inwardly, means for feeding a film strip into one end of said spiral trough, said film strip being guided to travel through the spiral trough, and means for flowing liquid around the spiral trough with sufficient velocity with reference to the radius of the spiral that the liquid will stay in the trough by virtue of centrifugal force.

30. In film treating apparatus, a film raceway embodying an open liquid trough wound in a spiral with its open side facing inwardly, means for feeding a film strip into one end of said spiral trough, said film strip being guided to travel through the spiral trough, means for introducing liquid to flow around the spiral trough in contact with the film therein, and a spiral collection trough adjacent the film raceway trough and adapted to catch liquid overflow from said raceway trough.

In witness that I claim the foregoing I have hereunto subscribed my name this 10th day of March, 1931.

JAMES T. BARKELEW.