Dec. 6, 1932. J. T. BARKELEW 1,890,026

FILM DEVELOPING SYSTEM

Filed March 21, 1931 2 Sheets-Sheet 1

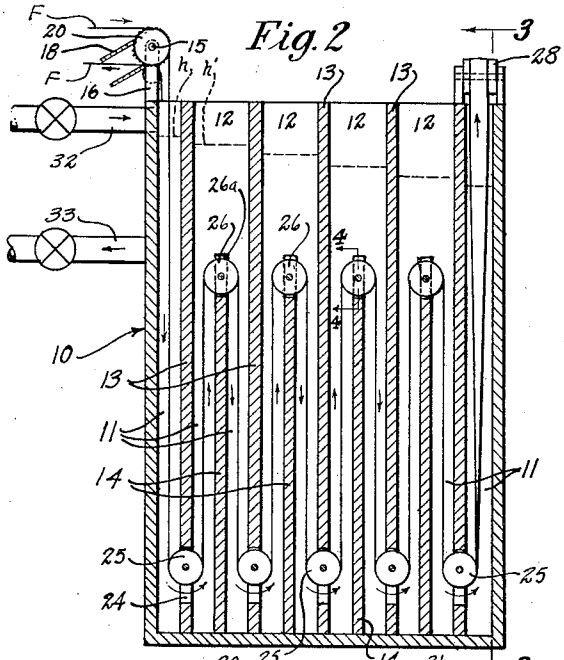


Fig. 2

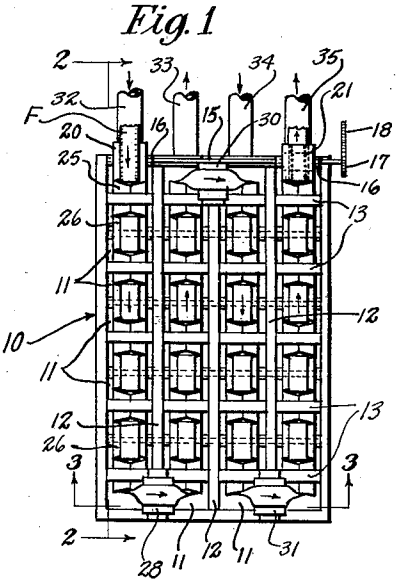


Fig. 1

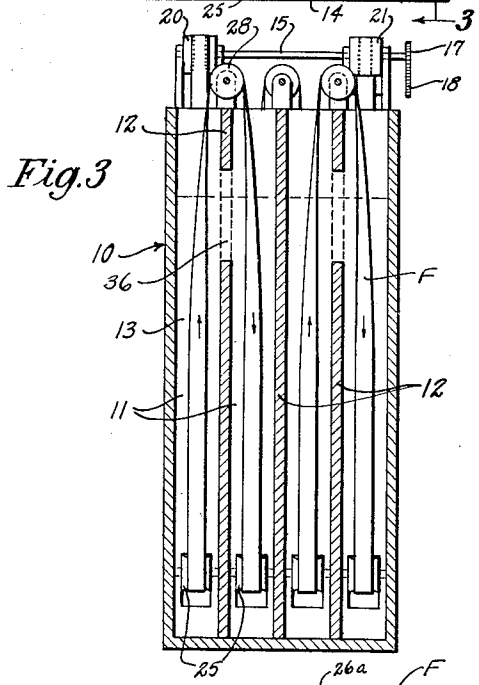


Fig. 3

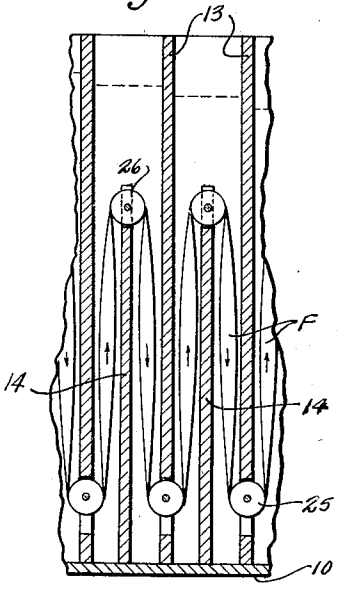


Fig. 5

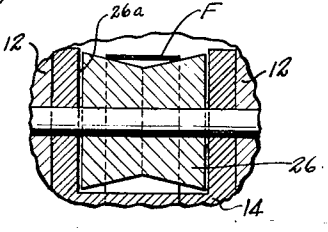


Fig. 4

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Fig. 7

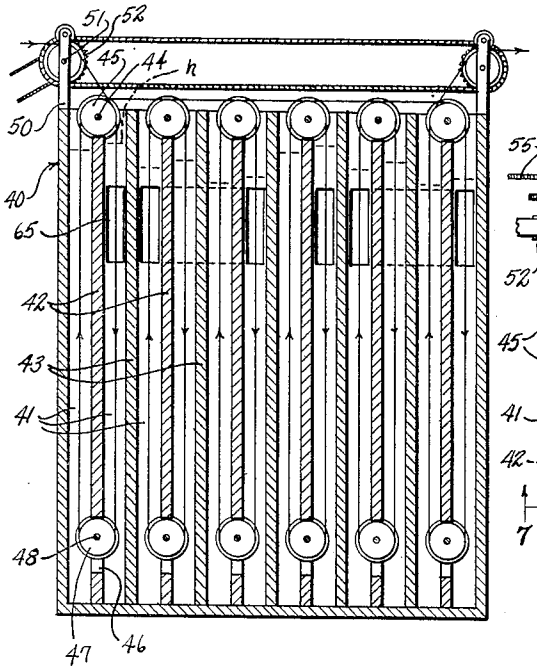


Fig. 6

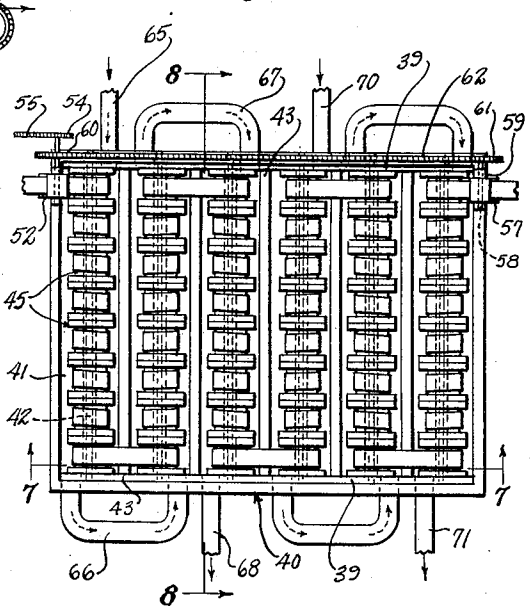
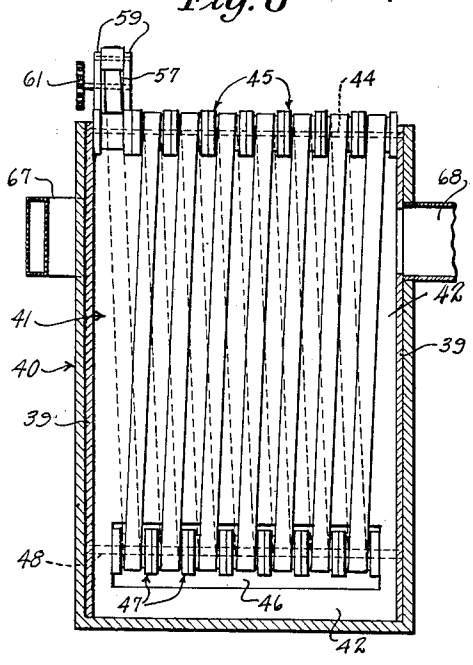
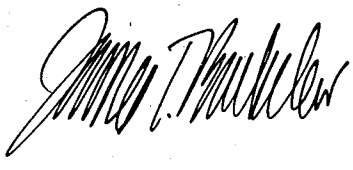


Fig. 8



Inventor



Patented Dec. 6, 1932 1,890,026

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 21, 1931. Serial No. 524,361.

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 solutions desired, 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 gradual expansion of the film as it becomes wet and 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.

Reference is here made to an application entitled "Film developing system," Ser. No. 489,600, filed October 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 disclosed, by flowing the several treating liquids continuously through successive conduits and causing the film to be dragged along by propulsive force arising from skin friction of the flowing treating liquids on the film.

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 simple, compact and efficient apparatus for carrying into effect one phase of the broad invention disclosed in said prior application.

It may here be mentioned that the prior application referred to 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. 525,130, filed March 25, 1931, and Ser. No. 526,150, filed March 30, 1931.

In accordance with the present invention, the film is drawn through bath containers or conduits by virtue of the skin friction of flowing treating liquids, but the conduits are compacted by novel convoluting arrangements. These arrangements have many features of advantage too numerous here to mention, which will appear and be more fully understood from the following detailed description of present preferred forms of the invention, reference for this purpose being had to the accompanying drawings, in which:

Figure 1 is a top plan view of film handling apparatus according to my invention;

Fig. 2 is a vertical longitudinal section taken as indicated by line 2—2 of Fig. 1;

Fig. 3 is a vertical transverse section taken as indicated by line 3—3 of Fig. 1;

Fig. 4 is a detail section taken on line 4—4 of Fig. 2;

Fig. 5 is a view similar to a portion of Fig. 2 but showing a variational arrangement;

Fig. 6 is a top plan view of another form of film handling apparatus according to my invention;

Fig. 7 is a vertical longitudinal section taken on line 7—7 of Fig. 6; and

Fig. 8 is a vertical transverse section taken on line 8—8 of Fig. 6.

No attempt is made to show structural details of the apparatus in more detail than is necessary for a fundamental understanding of the invention, the description taken with the drawings making apparent to those

skilled in the art how the several forms of the invention may effectively be embodied in practice.

Two general forms of the invention are shown in the drawings, first, a form in which the film moves through the apparatus in a series of zig-zag convolutions (Figs. 1 to 5), and second, a form in which the film moves through the apparatus in a series of spiral convolutions (Figs. 6 to 8).

Referring first to the zig-zag convolution form of Figs. 1 to 5, I show at 10 a suitable rectangular tank divided into vertical cells 11 by vertical longitudinal partitions 12, and alternate vertical transverse partitions 13 and 14. Longitudinal partitions 12 and transverse partitions 13 are shown as of the same height as the side walls of tank 10, whereas the transverse partitions 14 that alternate with partitions 13 terminate somewhat below the upper edge of the tank, as clearly shown in Fig. 2. In the apparatus shown, the tank is thus divided into four longitudinal rows of vertical cells 11, although this is of course not limitative of the invention, since the number of rows, as well as the number of cells in each, may be varied to suit individual requirements.

A transverse drive shaft 15 is here shown journaled in brackets 16 mounted on the left hand side wall of the tank, as viewed in Fig. 2, said shaft having a sprocket 17 and driving chain 18. Shaft 15 has a film sprocket 20 alined with the first of the four longitudinal rows of cells 11, and a film sprocket 21 alined with the last of said rows of cells. The film F is threaded over sprocket 20 and downwardly into the first cell of the first cell row. Near the lower end of said cell 11, wall 13 has an aperture 24 within which is mounted an idler roller 25. The film is threaded from the lower end of the first cell 11 under and around said roller 25 to pass upwardly through the next or second cell 11. It may here be noted that sufficient clearance is provided between the roller and the lower edge of aperture 24 to provide for the free passage of liquid from the first cell to the second, this being the course of liquid circulation. The roller is close to the upper and side edges of the aperture so as to substantially confine the liquid flow to the space below the roller. The film rises through the second cell to pass over an idler roller 26 suitably mounted over the upper edge of the first of the short partitions 14, thence downwardly through the next cell 11, and so on though however many cells may be provided in the first row. Rollers 26 are close to the upper edges of partitions 14, so that liquid flow mainly goes over the roller with the film. For this purpose rollers 26 may be mounted in notches 26a in the upper edges of the partitions as indicated in Figs. 2 and 4.

The arrangement is made such that the film strip rises in the last cell 11 of the first cell row, and the film is given a 90° twist in said last cell to pass over a roller 28 mounted on top of the partition 12 dividing the first and second rows of cells. From roller 28 the film is threaded downwardly through the adjacent cell 11 of the second cell row and given 90° twist to pass under the idler roller 25 in the lower end of the partition or wall 13 of the cell. The film is thus threaded in a zig zag path around the upper and lower rollers 26 and 25 through the successive cells to the outgoing end of the second cell row. From the last cell of the second row the film is taken upwardly through a 90° twist over a roller 30 mounted on the next partition 12, and from there downwardly through the first cell of the third row. At the end of the third cell row the film passes in a similar manner up and around a roller 31 to enter the fourth cell row, and from the outgoing end of the fourth cell row the film passes under the take-out sprocket 21 on shaft 15.

The developer enters the first cell of the first cell row through a pipe 32 located near the upper end of said cell, and in the present instance leaves the outgoing end of the second cell row through a pipe 33 located a proper distance below pipe 32. Pipe 32 delivers developer to the first cell to maintain it say at the level h. This developer continuously flows downwardly in the first cell and through aperture 24 at its lower end into and upwardly in the second cell, the liquid rising therein above roller 26 to a level h', which, of course, will be lower than level h. The flow of the liquid continues with the film downwardly in the third cell, through aperture 24 at the lower end thereof, upwardly in the fourth cell to a level h'' below level h', and so on with the film to the end of the cell row.

From the last cell 11 of the first cell row the liquid passes through an aperture 36 located in partition 12 at the liquid level in the cell, into and downwardly through the adjacent, first cell of the second row. The liquid thence follows the film path in the manner described above to the final cell of row number two, which it leaves by way of pipe 33. Outlet pipe 33 is below inlet pipe 32, and the liquid level falls from cell to cell, as shown, the level in the final cell being at or above the outlet 33. The velocity of liquid flow through the cells will depend upon the difference in elevation of pipes 32 and 33, and upon the velocity of liquid feed and take-off through those pipes, and the cross sectional sizes of the cells. In designing the apparatus the cell sizes are made such as to pass a suitable volume of liquid (suitable volume for treating the film) at such a velocity as to cause film movement at the velocity desired. Variations in liquid velocity, in any given apparatus, may be attained by controlling inflow and outflow by valves or

by relative differences in elevation of inflow and outflow pipes.

In the form here shown a pipe 34 delivers liquid to the ingoing end of the third cell row in a manner similar to the delivery of developer to the first cell row, and a pipe 35 takes said liquid from the fourth cell row in a manner similar to the take-off of developer from row two. The treating unit comprising cell rows three and four may be made use of as a second developer unit, or may be used, for instance, for the subsequent hypo-treatment, in which case hypo is introduced through pipe 34. In case both treating units, or even more if desired, are used for the developing treatment of the film, the advantage is gained that the film passes successively through fresh batches of the developer, and the further advantage is gained that the time of treatment can be varied by selection of the number of units employed. It will be understood, of course, how additional cell row units may be provided for the hypo in case both of these illustrated are used for developer, and further how an additional unit or units may be provided for further treatments and for the final wash, such additional units not being illustrated since they are duplicates of those shown. The film, as will well be understood, can be finally taken off from the apparatus at the end of any one of the units, and the units can be made to have each any desired number of cells. And, at the transverse passages over rollers 28, etc., from one row or unit to another, it will be readily understood that the film need not be dropped down into the next succeeding row, but can be carried transversely over one or more rows or units. For instance, in Fig. 1, the film can be carried directly from roller 28 to roller 31, in which case the second and third cell rows would be skipped and the film only subjected to half the time of developing and fixing. In such manners, by properly threading the film, and further by varying the speed of film travel, the times, both absolute and relative, of film treatments may be controllably varied.

In operation, the film is fed by sprocket 20 downwardly into the first cell 11 to be taken through the film path hereinabove described. The developer is pumped through inlet pipe 32 into the first cell, and maintains a circulation in the zig-zag path described on to the outlet pipe 33 because of the drop in elevation between pipes 32 and pipe 33. The circulating developer, flowing downwardly and upwardly through successive cells, advances the film by the force of skin friction, drawing it from feed sprocket 20 in the convoluted path around the described idler rollers of the first and second cell rows. In a similar manner the film is advanced through the third and fourth cell rows by the liquid entering through pipe 34 and leaving through pipe 35. The film is constantly taken from the last cell of row four by take-out sprocket 21.

The pull on the film through the apparatus is due to the frictional drag of the flowing liquid, and is dependent in amount upon the velocity of flow of the liquid. This velocity of flow is of course dependent upon the drop in elevation of the liquid from cell to cell, and therefore upon the elevational drop between the liquid level in the first cell and the level of the outgoing conduit. The arrangement is made such that the resultant velocity of liquid flow will drag the film through at the speed desired, or preferably will tend to drag the film through just a little faster than the speed permitted by the feed sprocket at the beginning end of the conduit, thus giving the conditions of frictional overdrive. The feed sprocket 20 thus acts as a hold-back, the liquid being flowed through the conduit with sufficient velocity to provide a small amount of frictional overdrive so that the film will be kept moving in taut condition but will not be pulled tightly against the rollers at the turns in the conduit and will not be too strongly pulled against the hold back sprocket. The flow of liquid with the film around the rollers tends to lift and keep the film off the rollers and does do so if the film tension is not too great.

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. In this case slack due to elongation will be moved forwardly through the machine and will tend to accumulate in the final cell of the last cell row. This is for the reason that the frictional overdrive of the flowing liquid on the film tends to move any slack forwardly, while the take-out sprocket removes the film only at a constant "sprocket hole" rate. It will be understood, however, that this accumulation of slack is, within certain limits, constant in amount and does not continue to grow once running conditions are established. 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 fulfils 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.

A frictional hold-back and a frictional take-out can be substituted for the sprocket hold-back and sprocket take-out, if desired. A frictional take-out exerting just enough frictional pull to take the film out from the

last roller but not enough to pull the film through the machine may be desirable over a sprocket take-out operating on wet and soft film. A simple form of frictional take-out can be made, for instance, at 21 by taking the sprocket teeth off that roller and making the frictional driving diameter of the roller just slightly larger than the pitch diameter of feed roller or sprocket 20. However, any other frictional drive may be used.

For convenience in threading film, the whole cellular partition structure, on which the rollers 25 and 26 are mounted, may be so fitted in the tank as to be lifted out of it. This is also true of the form of Figs. 6 to 8, to be described.

In Figs. 5 I have shown a variational threading arrangement, in which the film is given a 180° twist in each cell so that the back face of the film can always be presented to the film rollers, the advantage of which will be self-evident.

In Figs. 6, 7 and 8 I have shown another form of my invention. In this case a tank 40 is divided by alternate transverse partitions 42 and 43 into long transverse compartments 41. A shaft 44 is shown journaled in removable false side walls 39 over each partition 42, and rotatably mounted thereon is a series of individual free film rollers 45. Near the lower end of each partition 42 is an aperture 46 wherein individual lower film rollers 47 are freely mounted on a shaft 48, lower rollers 47 being placed in staggered relation to the upper rollers 45.

On the left hand end wall of tank 40, as viewed in Fig. 7 is mounted a pair of brackets 50 journaling a shaft 51 on which is mounted a film sprocket 52, said sprocket being located opposite a film roller 45 at one end of the first compartment 41. Shaft 51 is driven by means of a sprocket 54 and chain 55.

The film is threaded from sprocket 52 over the end roller 45 to pass downwardly at one end of the second transverse compartment 41 from the left hand end of the tank, as shown in Fig. 7. At the lower end of said compartment the film passes under the end lower roller 47 rearwardly to first compartment 41, through which it then rises to thread around the second upper roller 45. From there the film passes downwardly to the second lower roller 47, and so on in a long spiral arrangement over upper and lower rollers to the opposite side of the tank. From the last upper roller 45 of the series associated with first and second compartments 41, the film passes to the first upper roller 45 of the second row or series of rollers, as clearly shown in Fig. 6. The film then passes over upper and lower rollers 45 and 47 in another long spiral back to the first side of the tank, where it is taken forwardly to the next row of rollers, and so on to the outgoing end of tank where the film finally leaves over a take-out sprocket 57, said sprocket 57 being mounted on a shaft 58 journaled in brackets 59 mounted on the tank. The feed and take-out sprockets are interconnected by means of sprockets 60 and 61 mounted respectively on shafts 51 and 58 and a connecting chain 62.

For convenience in threading, the compartment walls may be lifted out as a unit by raising false side walls 39. The length of film in the machine may be varied as the film is initially threaded by skipping any desired equal number of spiral loops at the corresponding ends of successive roller rows.

The developer is initially introduced to the apparatus by means of a conduit 65 which is fitted into the side wall of the tank to communicate with the second compartment 41 from the left hand end, by means of a conduit 65, as clearly shown in Fig. 6. The developer flows downwardly in this compartment to pass through the opening 46 below roller 47 into the first or left hand end compartment, within which the liquid rises. From the upper end of said first compartment the developer is taken out through the side wall of the tank by a conduit 66 (Fig. 6) and introduced to the upper end of the fourth conduit 41 from the end. In a similar manner to the flow through the first and second compartments, the developer then flows downwardly in the fourth compartment, rearwardly through aperture 46 and upwardly in the third compartment. The developer leaves the upper end of said third compartment by way of a conduit 67 to enter the sixth (next even numbered) compartment from the beginning side of the tank, thence flows through the aperture 46 to the compartment immediately to the rear, and is here shown as finally removed from the system through a conduit 68 leading from the upper end of the last mentioned compartment 41, although the number of compartments can of course be continued further before the developer take-off if desired. It is to be noted that the developer is introduced to the even numbered compartments, counting from the left end of the tank in Figs. 6 and 7, and is delivered from the upper ends of the odd numbered compartments.

A second liquid delivery pipe 70 is shown discharging into the next even numbered compartment 41. The circulation arrangement from here on is a duplication of that previously described, the liquid being finally discharged through a conduit 71 leading from the upper end of the last odd numbered compartment 41. Here again, the second circulation unit may be considered either as a second developing unit, or as a hypo unit; and it will be apparent that any number of such circulation units to care for the successive treatments of the film nay be provided as required.

It will be noted that the direction of move-

ment both of the liquid and of the film sections within the even numbered compartments is always downward, and within the odd numbered compartments is always upward. The developer may be introduced through conduit 65 with sufficient head that the liquid will rise in the initial compartment 41 to an elevation above said conduit 65, say to a level indicated at *h*. The inlet conduit 65, intermediate conduits 66 and 67, and discharge conduit 68 are in the present instance all on the same level, and level *h* will therefore be at an elevation above all of said conduits so that the liquid will tend to flow through the apparatus with a velocity depending, among other factors, upon the difference in elevation of level *h* and discharge conduit 68, the liquid level in successive conduits decreasing in the direction of flow, as clearly indicated in Fig. 7. The various considerations involved in determining the liquid flow velocity are basically the same as discussed in connection with the previously described embodiment of the invention.

As has been pointed out above, the direction of liquid flow is always downward in the even numbered compartment 41 and upward in the odd numbered compartment 41, while the film is spiraled around its rollers in such a manner that its forward direction is always downward in the even numbered compartments and upward in the odd numbered compartments. The liquid and film thus are arranged to move in the same direction and the skin friction of the flowing liquid is availed of to cause advance of the film through its spiral path. The velocity of film advance is again of course dependent upon the velocity of liquid flow, as in the case described above, and it will be obvious that the fundamental considerations presented above in connection with the operation of the previous embodiment apply here in a similar manner.

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 convoluted conduit through which a film may be propelled by skin friction of a liquid flowing therethrough, said conduit comprising a succession of vertical compartments communicating each to the next alternately at their lower and upper ends, means for flowing liquid through said conduit, and means for feeding a film into said conduit in the direction of liquid flow therethrough.

2. In film treating apparatus, a convoluted conduit through which a film may be propelled by skin friction of a liquid flowing therethrough, said conduit comprising a succession of vertical compartments communicating each to the next alternately at their lower and upper ends, means for introducing liquid to the first compartment of the series to take a given level therein and to flow from compartment to compartment throughout the series, means for withdrawing said liquid from the last compartment of the series at a level below the level in said first compartment, and means for feeding a film into said first compartment.

3. In film treating apparatus, a convoluted conduit through which a film may be propelled by skin friction of a liquid flowing therethrough, said conduit comprising a succession of vertical compartments communicating each to the next alternately at their lower and upper ends, means for introducing liquid to the first compartment of the series to take a given level therein and to flow from compartment to compartment throughout the series, means for withdrawing said liquid from the last compartment of the series at a level below the level in said first compartment, means for feeding a film into said first compartment, and idler film rollers at the points of communication between successive compartments.

4. In film treating apparatus, a conduit through which a film may be propelled by skin friction of a liquid flowing therethrough, said conduit comprising a series of vertical liquid cells communicating each to the next alternately at their lower and upper ends, free film rollers at the points of communication of successive cells, means for introducing liquid to the first cell of the series to flow through the cells in succession, and means for feeding a film strip into the first cell.

5. In film treating apparatus, a conduit through which a film may be propelled by skin friction of a liquid flowing therethrough, said conduit comprising a series of vertical liquid cells communicating each to the next alternately at their lower and upper ends, means for introducing liquid to the first cell of the series to flow through the cells in succession, and means for feeding a film strip into the first cell.

6. Film treating apparatus comprising a unit of vertical liquid cells arranged in a plurality of adjacent cell rows, the cells in each row communicating each to the next alternately at their lower and upper ends, means for introducing liquid to a cell at one end of the first of said rows to flow through the cells of that row in succession, a liquid passage to the first cell of each succeeding row from the last cell of the immediately preceding row, in such a manner that the liquid flows through the rows in succession, a liquid outlet from the last cell of the last row, and means for feeding a film into the first cell of the first row to be carried by skin friction

of the flowing liquid successively through the cells of the unit.

7. Film treating apparatus comprising a unit of vertical liquid cells arranged in a plurality of adjacent cell rows, the cells in each row communicating each to the next alternately at their lower and upper ends, means for introducing liquid to a cell at one end of the first of said rows to flow through the cells of that row in succession, a liquid passage from the last cell of said row to the adjacent cell of the next row, a liquid passage to that cell of each succeeding row that is adjacent the last cell of the immediately preceding row, in such a manner that the liquid flows through the several rows in succession, a liquid outlet from the last cell of the last row, and means for feeding a film into the first cell of the first row to be carried by skin friction of the flowing liquid successively through the cells of the unit.

8. Film handling apparatus comprising a unit of vertical liquid cells arranged in a plurality of adjacent cell rows, the cells in each row communicating each to the next alternately at their lower and upper ends, means for introducing liquid to a cell at one end of the first of said rows to flow through the cells of that row in succession, a liquid passage to the first cell of each succeeding row from the last cell of the immediately preceding row, in such a manner that the liquid flows through the rows in succession, a liquid outlet from the last cell of the last row, means for feeding a film into the first cell of the first row to be carried by skin friction of the flowing liquid successively through the cells of the unit, and means for guiding the film from cell to cell.

9. In film treating apparatus, a container, a vertical wall dividing said container into two compartments, a liquid inlet at the upper end of one compartment, a communication between compartments at the lower end of said vertical wall, a liquid outlet in the upper portion of the other compartment, an upper film roller at the upper end of the partition, and a lower film roller in the communication between compartments at the lower end of the partition.

10. In film treating apparatus, a container, a vertical wall dividing said container into two compartments, a liquid inlet at the upper end of one compartment, a communication between compartments at the lower end of said vertical wall, a liquid outlet in the upper portion of the other compartment, a series of upper film rollers at the upper end of the partition, and a corresponding series of film rollers in the communication between compartments at the lower end of the partition, the film strip being wound in a spiral around said upper and lower rollers.

11. In film treating apparatus, a container; a series of vertical parallel partitions dividing said container into a row of alined compartments; a liquid inlet at the upper end of the second compartment from one end of the row, a liquid passage from the upper end of the first compartment of the row to the upper end of the fourth compartment, and a liquid outlet from the upper end of the third compartment of the row; a liquid communication through the lower end of the partition between the first and second compartments and a liquid communication through the lower end of the partition between the third and fourth compartments; a lower film roller mounted in each of said communications; and an upper film roller mounted at the upper end of each of said last mentioned partitions.

12. In film treating apparatus, a container; a series of vertical parallel partitions dividing said container into a row of alined compartments; a liquid inlet at the upper end of the second compartment from one end of the row, a liquid passage from the upper end of the first compartment of the row to the upper end of the fourth compartment, and a liquid outlet from the upper end of the third compartment of the row; a liquid communication through the lower end of the partition between the first and second compartments and a liquid communication through the lower end of the partition between the third and fourth compartments; a series of lower film rollers mounted in each of said communications; and a corresponding series of upper film rollers mounted at the upper end of each of said last mentioned partitions.

In witness that I claim the foregoing I have hereunto subscribed my name this 25th day of February, 1931.

JAMES T. BARKELEW.