July 29, 1941. H. W. HOUSTON 2,251,232

METHOD AND APPARATUS FOR DEVELOPING FILM

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Fig. 2.

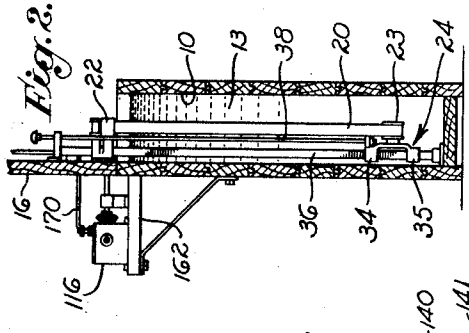


Fig. 1.

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Fig. 3.

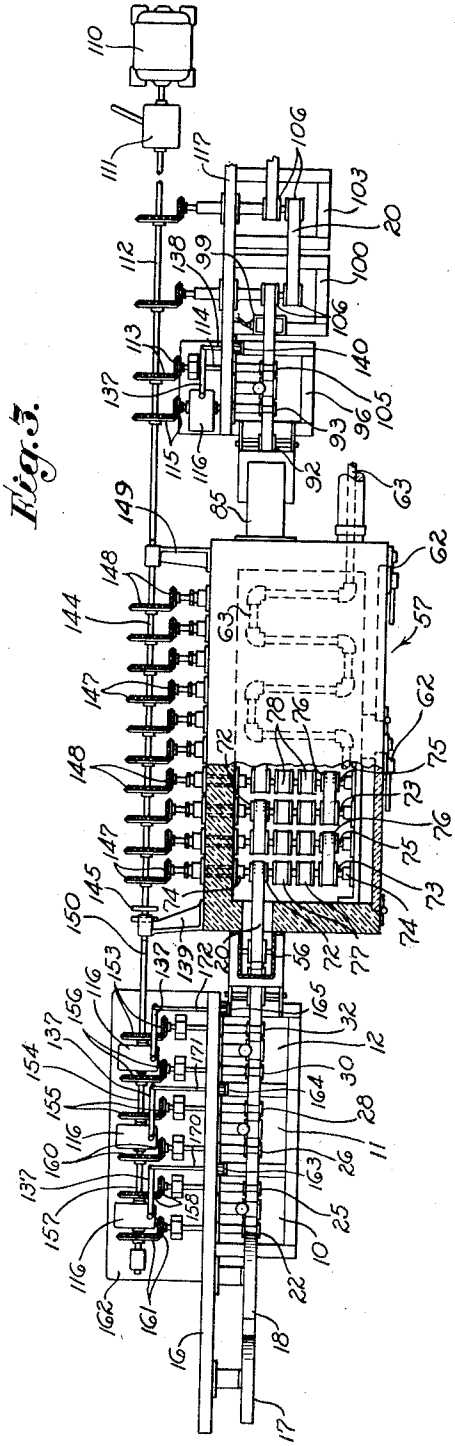


Fig. 5.

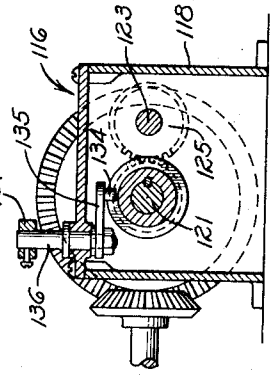
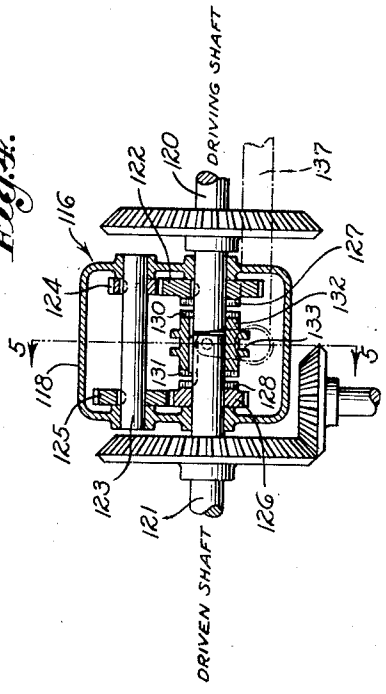


Fig. 4.



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UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS FOR DEVELOPING FILM

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Application November 7, 1938, Serial No. 239,202

9 Claims. (Cl. 95—94)

My invention relates a method and apparatus for developing photographic film.

My invention has as one of its principal objects the provision of apparatus for the development of film according to a method wherein the emulsion is developed while in contact with only a limited quantity of a developing solution insufficient to completely develop the emulsion. Under such circumstances, as development proceeds, the developing solution adjacent the high-light or heavily exposed portions of the image rather quickly becomes exhausted and development ceases in these portions, but inasmuch as a lesser quantity of developing solution is required by the shadow or lightly exposed portions of the image, development in these portions proceeds long after ceasing in the high-light portions. Thus the lightly exposed portions are developed to an abnormally great degree compared to that to which the heavily exposed portions are developed. Preferably the concentration of the developing solution and the quantity thereof which is in contact with the emulsion during development are adjusted to result in the desired density or contrast of the high-light portions of the image when development ceases in those portions and the ensuing time of development is adjusted to result in development of the lightly exposed portions of the image to the desired degree.

When this method of development is followed, it is found that the approximately straight line portion of the H & D curve representing the relation between density of image and logarithm of exposure is longer than when the commonly used method of development is employed. The H & D curve extends straight to a much lower exposure and, when the emulsion is developed to the same gamma (slope of H & D curve), lies above the H & D curve for ordinary development. The effect of this improved development is, therefore, similar to a greatly increased speed of the emulsion plus an extended exposure range. These effects have proven of great advantage in scenic photography, and photography in various scientific fields, and in sound recording.

One of the objects of my invention is to provide apparatus for continuously developing film, and particularly for continuously developing film acoording to the method above described.

Another object is to provide means for supplying a predetermined limited quantity of developing solution to any portion of the film while it is moving through the apparatus.

Another object is to provide apparatus for developing film according to the method above described in which the developing solution in contact with the film is prevented from oxidation during development by reason of an inert atmosphere surrounding the film during the development period.

Another object is to provide means for controlling the physical environment of the film during the development period.

Another object is to provide a method of developing film comprising wetting the film with developing solution, removing excess unabsorbed solution from the surface of the film, subsequently conducting the film into a chamber filled with a gas inert to the developing solution, and carrying out development of the film while surrounded by the gas by action of the developing solution contained in the film.

Another object of the invention is to provide a method and means for sealing the chamber in which development takes place against gas leakage while permitting passage of the film into and out of the chamber.

Another object is to provide an efficient squeegee to remove excess solution from the film.

A further object is to provide in a film processing machine for continuous operation means for varying the duration of one step in the process without altering the others.

Another object is to provide in a continuous film processing machine, means for inserting or removing the film from various baths without affecting the continuity of operation of the machine.

Another object is to provide flexible and convenient driving means for the various parts of a developing machine.

Still another object of the invention is to provide developing apparatus which is efficient and convenient in its operation.

These and other apparent objects I attain in a manner which will be clear from a consideration of the following description taken in connection with the accompanying drawings, of which:

Fig. 1 is an elevational view, partly in section, of the apparatus of my invention.

Fig. 2 is a sectional view of the apparatus of Fig. 1 taken along the line 2—2, as indicated.

Fig. 3 is a plan view of the apparatus of Fig. 1 with part of the developing cabinet cut away.

Fig. 4 is a sectional view of one of the speed changing units employed in driving my apparatus.

Fig. 5 is a sectional view of the unit of Fig. 4 taken along the line 5—5, as indicated.

In my developing apparatus I preferably provide a plurality of tanks 10, 11, and 12 which are preferably filled with a developing solution, which may be of similar composition to those ordinarily employed in the art. The developing solution 13 in tank 10 is preferably of different concentration from the developing solution 14 in the tank 11 which is preferably of different concentration from the developing solution 15 in tank 12. Thus, the three developing solutions may be of increasingly greater concentration each suitable for a film exposed in a certain manner. If desired, however, the concentration of developer in all of the tanks may be the same. In any case, the apparatus is adapted to submerge continuously moving film into any one or all of the developing solutions in series or to remove the film from contact with any one or all of the solutions at will. It is also adapted to permit variation of the amount of film in each tank and the speed of passage of the film therethrough. By this means the apparatus is made very flexible and is adapted to process films of various types and films which have been over-exposed or under-exposed as well as those with normal exposure.

Rotatably mounted on a panel 16, which may be supported by the back wall of the tanks 10, 11, and 12, are reels 17 and 18 of exposed perforated film to be developed. The film 20 from reel 17 leads under a roller 21 and over a sprocket 22 which engages the film perforations and drives the film. The film 20 passes around the roller 23 of the elevator 24 within the tank 10, out over the driving sprocket 25, over the driving sprocket 26, under the roller of elevator 27 in tank 11, over driving sprockets 28 and 30, under the roller of elevator 31 of tank 12 and out over driving sprocket 32 and roller 33. The elevator 24 includes two bearing portions 34 and 35 at the ends thereof which enclose and fit loosely the rod 36, preferably of rectangular cross-section, which is supported at the bottom on the floor of tank 10 and at the top by a bracket 37 attached to the panel 16. The roller 23 is supported rotatably on the elevator 24 between the bearing portions. A rod 38 is attached to the top of the elevator 24, is slidably supported in the bracket 37, and terminates at the top in a knob 40. The rod 38 serves in manually raising and lowering the elevator 24 and also serves as an indicator of the position of the elevator in the tank. For the latter purpose the rod 38 is notched at regular intervals along its length. The elevators 27 and 31 are identical in construction to the elevator 24, just described, are provided with attached rods 41 and 42, respectively, similar to the rod 38, and slide on stationary rods 43 and 44, respectively. The elevators 24, 27, and 31 are freely movable on the rods 36, 43, and 44 and may be automatically raised and lowered in the respective tanks by means hereinafter described.

In passing through one or more of the tanks 10, 11, and 12, the emulsion of the film absorbs a limited quantity of developing solution and generally tends also to carry some free excess solution on the surface of the film. It is desirable to remove this excess solution and leave only that which has been absorbed by the emulsion or exists as a thin uniform coating, and for this purpose I employ a squeegee 45 of novel construction. Adjacent the tank 12 is a vessel 46 with a partition 47 extending down into the tank nearly to the bottom thereof, and carrying a roller 48 at its lower end. The vessel 46 is filled almost to the top with mercury 50 or other suitable liquid which is immiscible in water and is of density large compared to that of water. The film 20 passes over the roller 33 down into the mercury 50, under the roller 48 and up on the other side of the partition 47 and out of the mercury. As the film moves into the mercury on the entering side of the squeegee 45, the solution clinging to the film tends to rise to the surface of the mercury because of the great difference in density of the two liquids. Then as the film moves lower into the mercury the pressure due to the head of mercury above becomes greater and greater. This pressure is applied uniformly over the film and forces any free excess solution upward into a region of lower pressure, and thence to the top of the tank. The removed developing solution 51 collects on top of the mercury 50 and runs back into the tank 12.

The film 20 rises from the mercury 50 and passes through a conduit 52 which makes a tight joint with the vessel 46 and partition 47 on the outgoing side of the squeegee. Supported on the conduit 52 is a vibrator 53 operated electrically and carrying a roller 54 which bears on the film. The operation of the vibrator causes the roller 54 and consequently the film 20 to be constantly vibrated with a small amplitude sufficient to loosen any small droplets of mercury which may be clinging to the film. When a liquid alloy of mercury and lead, or mercury and tin, or mercury and other suitable metal, which alloy is less fluid than mercury, is employed as the liquid 50 in the squeegee 45, it is found that the liquid does not cling to the film or in the perforations as is the case when mercury alone is used, and such a composition has been found advantageous to use.

After passing through the conduit 52, the film 20 passes over a roller 55 located in an elbow 56 which makes a tight joint with the conduit 52 and a developing cabinet 57 into which the film 20 passes through a hole 58. The film comes to the developing cabinet with its emulsion wet with developing solution, but with hardly any development having taken place in the tanks 10, 11, and 12 because of the relatively short time permitted in these tanks. It is desired to develop the emulsion by action of only the limited quantity of developing solution absorbed by the emulsion and to this end the film is kept for a relatively long time out of contact with any source of developing solution but with the absorbed solution still in the emulsion. This development step occurs while the film is in the developing cabinet 57. To protect the absorbed developing solution against oxidation and resultant deterioration which would result in the presence of air, the cabinet 57 and its connections are preferably made substantially gas tight and the chamber within the cabinet is filled with an inert gas, for example, nitrogen or helium, which has no effect upon the developing solution or the film.

The cabinet 57 may comprise a box-like structure of rectangular cross-section with double walls and thermal insulation 60 between the walls. Two doors 61 may be provided which, when open, expose substantially the whole interior of the cabinet, and which may be locked to seal the cabinet by latches 62. The temperature within the cabinet 57 may be controlled by means of pipes 63 which pass through the cabinet in a circuitous path and are adapted to carry cooling fluid such as brine which may be circulated through suitable well-known refrigerating equipment 64 which acts in response to the thermostat

65 within the cabinet to maintain constant the temperature in the cabinet 57.

Inert gas, preferably nitrogen, is contained under pressure in a tank 66 and is admitted to the interior of the cabinet 57 through a reducing valve 67 and a pipe 68. A vent pipe 70 controlled by a valve 71 connects with the interior of the cabinet 57.

The film 20, upon entering the developing cabinet 57, passes over the first of a series of driving sprockets 72 associated with and attached to shafts 73 which extend across the cabinet at the top thereof. Each of the shafts 73 is rotatably supported at each side of the cabinet 57 in bearings 74, and passes out through the cabinet to connect with the driving means. Disposed alternately with the shafts 73 along the cabinet are the shafts 75 mounted similarly to the shafts 73 and having sprockets 76 attached on the ends thereof opposite to the ends of shafts 73 to which sprockets 72 are attached. On each of the shafts 73 are mounted a plurality of rollers 77 which may turn on the shafts 73, and on each of the shafts 75 are mounted a plurality of rollers 78 which may turn thereon. Near the bottom of the cabinet are a plurality of transversely extending stationary shafts 80 on each of which are rotatably mounted a plurality of rollers 81. The film 20 passes over the first sprocket 72, vertically downward and under one of the rollers 81, up and over one of the rollers 77, down and under a roller 81, and so on, until it passes under the last roller 81 on that particular shaft. The film then passes up over the driving sprocket 76 on the adjacent shaft 75, down and under the corresponding roller 81, up over a roller 78, and so on, until it has passed under the last roller 81 on that shaft. The film then passes up over the sprocket 72 on the adjacent shaft 73 and proceeds in this zigzag manner through the cabinet 57. At the outgoing end of the cabinet 57 the last roller 81 is omitted from its shaft 80 and the roller 82 is substituted therefor, which roller is mounted rotatably on an elevator 83 which slides on a vertical rod 84 of square cross-section mounted within the cabinet 57. Near the outgoing end the film 20 passes over rollers 78 on the shaft 75 and under rollers 81, then passes over the next to the last roller 78, down and under the roller 82, up and over the last roller 78, and out into the elbow 85. A conduit 86 connects with the elbow 85 and leads to a mercury seal 87 containing mercury 88 and constructed similarly to mercury squeegee and seal 45. The film 20 passes over a roller 90, under a roller 91 in the mercury seal 87, out of the mercury, over a roller 92, and over a driving sprocket 93. It is evident that where the film first comes into the inert gas, the gas is also sealed against leakage by the mercury squeegee 45 so that the interior of the developing cabinet 57 is completely sealed from the atmosphere without. The conduit 86 is provided with a door 94 which may be opened to facilitate threading the machine. A pressure gauge 95 connects with the interior of the conduit 86 to measure the pressure within the developing cabinet 57. Since the interior of the cabinet is completely sealed, the gas within soon becomes saturated with moisture and no further evaporation of water from the film takes place in the cabinet 57. This is a desirable condition, but if desired, the gas within the cabinet may be circulated through humidity control apparatus of well-known construction to maintain the relative humidity within the cabinet 57 at any desired value.

An auxiliary developing tank 96 containing developing solution is provided in which the film may be submerged for a short period of ordinary development if it should be found that the highlights of the scene need more development. The tank 96 is provided with an elevator 97 having an indicating rod 98 similar in construction to the elevators 24, 27, and 31. For convenience in determining the state of development of the film an inspection lamp 99 is preferably located under the film 20 and is adapted to be turned on and off as desired. Following tank 96, I provide a tank 100 containing acid stop and hardening solution 101 which may be of a composition similar to those well-known in the art. Following the tank 100 is a tank 103 which may contain fixing solution such as is well-known in the art, and following tank 103 is a tank 104 containing wash water. The film 20 passes over driving sprocket 93, under the roller of the elevator 97, and over the driving sprocket 105. Over each of the tanks 100, 103, and 104 are rotatably mounted a plurality of rollers 106 on the same shaft, and within each of the tanks one or more rollers 107, in number one less than the number of rollers 106, is weighted by a weight 108 and hangs on the film loop within the tank. After passing over sprocket 105 the film passes over one of the rollers 106 down into the tank 100, under the roller 107, up over the other of rollers 106 and on through the tanks 103 and 104 in similar manner. After passing out of the wash tank 104, the film 20 may go on through a dry-box, not shown, but constructed in a well-known manner, for the purpose of drying the film, following which the film is wound up on a reel.

For the purpose of driving the various parts of the machine I employ an electric motor 110 which connects through a variable speed transmission 111 with the shaft 112. Geared to the shaft 112 through suitable bevel gears 113 is the shaft 114 to which is attached the driving sprocket 105. Connected through bevel gears 115 with the shaft 112 is the driving shaft of a speed change unit 116, the driven shaft of which carries the sprocket 93. The driven shaft of the speed change unit 116 and the shaft 114 are supported in bearings mounted on the panel 117 which may be attached to the adjacent tanks for support.

The speed change unit 116, which is employed in several places in the apparatus, is constructed as illustrated in Figs. 4 and 5, in which it is shown as connected to drive the sprockets of tanks 10, 11, and 12. It comprises a housing 118 into which projects at one end a driving shaft 120 and at the other end a driven shaft 121 in alignment with the shaft 120. Keyed to the shaft 120 within the housing 118 is a gear 122 of relatively large pitch diameter. Rotatably supported in the housing 118 is another shaft 123 carrying a gear 124 keyed thereto, of small pitch diameter relative to the gear 122, and meshed with the gear 122. Keyed to the other end of the shaft 123 is a gear 125 which meshes with another gear 126, preferably of the same pitch diameter, which is mounted rotatably on the shaft 121. The gears 122 and 126 have radial clutch teeth 127 and 128, respectively, which are adapted to mesh, respectively, with corresponding teeth 130 and 131 on the opposite ends of a movable clutch member 132 which is adapted to slide on the shafts 120 and 121 and which

is keyed for rotation with the driven shaft 121 but can rotate freely on the shaft 120. The member 132 is provided with a peripheral track 133 in which rides a pin 134 attached to a lever 135 which is connected for rotation with the shaft 136 which passes through the housing 118 and is connected to a lever 137 for controlling the movement of clutch member 132. When the member 132 is slid over into engagement with the teeth 127, the shafts 120 and 121 will be directly coupled. When the member 132 is in the intermediate position shown in Fig. 4, in which it engages neither teeth 127 nor teeth 128, the two shafts 120 and 121 are entirely disconnected. And when the member 132 is slid over into engagement with the teeth 128, the shaft 120 drives the shaft 121 at increased speed through gears 122, 124, shaft 123, gears 125, 126, teeth 128, 131, and member 132. Preferably the various gears are so proportioned as to result in shaft 121 rotating at about double the speed of shaft 120 when the unit is set for increased speed of shaft 121.

As employed in driving the sprocket 93, the lever 137 is connected by link 138 with one end of a hand lever 140 pivotally supported at 141 on the panel 117. Pushing in the hand lever 140 results in setting the speed change unit 116 so as to result in the sprocket 93 traveling at the same speed as the incoming shaft of the unit 116. When the lever 140 is in an intermediate position the sprocket 93 will remain at rest. When the hand lever 140 is pulled all the way out, the sprocket 93 rotates at twice the speed of the incoming shaft of the unit 116.

The shaft 112 continues over to the left side of the cabinet 57 where chain sprockets 142 and 143 are attached for rotation therewith. Mounted in bearing supports 139 and 149 opposite the shafts 73 and 75 is a shaft 144 to one end of which, above the sprocket 143 is attached for rotation therewith a chain sprocket 145. A chain 146 is in mesh with both sprockets 143 and 145. The shaft 144 drives the shafts 73 and 75 through the bevel gears 147 and 148, respectively.

Located opposite to the shafts of sprockets 22, 25, 26, 28, 30, and 32 is a shaft 150, at one end of which, under the sprocket 142, is attached for rotation with the shaft 150 a chain sprocket 151, and in mesh with both of the sprockets 142 and 151 is a chain 152. The shaft 150 drives the film sprocket 32 through bevel gears 153. The shaft 150 connects with a speed change unit 116, forming the driving shaft therefor. The driven shaft 154 of this speed unit drives film sprockets 28 and 30 through bevel gears 155 and 156 and forms the driving shaft for another speed change unit 116. The driven shaft 157 of this unit drives film sprockets 25 and 26 through bevel gears 158 and 160, respectively, and forms the driving shaft for another speed change unit 116. This last speed change unit has a driven shaft which drives film sprocket 22 through bevel gears 161. The housings of the speed change units 116 are mounted on a shelf 162 supported by the panel 16. Hand levers 163, 164, and 165 are pivotally mounted at 166, 167, and 168 on the face of panel 16 and are at their ends connected, respectively, to levers 137 of the three speed change units 116 by links 170, 171, and 172, respectively.

It will be apparent that when any one of the hand levers 163, 164, and 165 is pushed in to extreme position it will result in the driven shaft, on the left side of the corresponding speed change unit 116, in Fig. 3, running at the same speed as the driving shaft of that unit. When any one of these levers is in intermediate position the driven shaft of the corresponding speed change unit is at rest and all the sprockets driven by that unit and to the left thereof are at rest. When any one of the hand levers is pulled out to extreme position, the driven shaft of the corresponding speed change unit 116 rotates with double the speed of the incoming shaft and the sprockets driven by this unit and all to the left thereof rotate at double speed provided the speed change units to the left thereof are set for the same speed of driving and driven shafts. Needless to say, the gear and chain sprocket ratios throughout the apparatus are such that when all speed change units are set for the same speed of driving and driven shafts, all of the film driving sprockets throughout the machine rotate with the same speed. The driving mechanism described above provides a flexibility of control of the movement of film through the machine which results in very efficient and convenient operation thereof.

In the operation of the machine, a leader is first threaded through and the film 20, which is to be developed, is attached to the end thereof. With the doors 61 closed, the vent valve 71 is opened and inert gas is permitted by control of valve 67 to enter the cabinet 57 and flush out all air in the cabinet. The valve 71 is then closed and the valve 67 is preferably adjusted to allow a small inflow of gas into the cabinet sufficient to produce and maintain a pressure within the cabinet slightly above atmospheric pressure so as to prevent oxygen from the air outside from entering the cabinet. The refrigerating system is operated until the desired temperature within the cabinet is attained. It is assumed that, in accordance with common practice, tests have been made on small sections of the various scenes of the film to be developed and it has been determined what type of development is required on each of the various scenes in order to secure the best effect. Assume that the machine has been threaded so as to result in the set-up as illustrated in Fig. 1 and that the first scene requires the development that results from this set-up.

The machine is started by energizing the motor 110. As the film 20 moves through the developing solution 13 in the tank 10, the emulsion absorbs a limited quantity of developing solution determined by the concentration of the solution and by the time the film takes in passing through tank 10. After passing through the tank 10, the film 20 passes through the mercury squeegee and seal 45 where its excess developing solution is removed. It then enters the developing cabinet 57 where development of the image takes place by action of only the limited quantity of developing solution contained in the emulsion. During development the developing solution in the emulsion is protected against oxidation by the environment of inert gas through which it passes. The duration of the development period is determined by the speed of the film which is controlled by the variable speed transmission 111. The film then passes out of the cabinet 57 through the mercury seal 87, through the hardening solution 101 in tank 100, through the fixing bath in tank 103, is washed in tank 104, and is dried as in ordinary practice.

As the developed film first passes over the inspection lamp 99, the lamp may be lit and the film inspected. Should it be found that any fur-

ther development of the high-lights would be desirable the remaining film may be submerged in the developing solution in tank 96 without stopping the film. This is accomplished as follows. The hand lever 140 controlling the speed of sprocket 93 is pulled to the extreme outward position resulting in sprocket 93 traveling with twice the speed of the other sprockets. Film will begin to accumulate between the sprockets 93 and 105 and the weight of the elevator 97 will cause it to sink into the tank 96 taking the film with it and submerging it in the solution. Since the film still travels at the same speed in the cabinet 57, the increased length of film between sprockets 93 and 105 necessitates a shortened length of film between the sprocket 93 and the last sprocket in the cabinet 57. This shortened length of film is made possible by the action of the elevator 83 within the cabinet 57 which automatically is raised by film tension as the elevator 97 descends in the tank 96. When the elevator 97 has descended into the tank 96 a sufficient distance to result in the film being in the auxiliary developing tank 96 for the desired length of time, the hand lever 140 is pushed to the extreme inward position whereupon the sprocket 93 again rotates at normal speed and elevators 97 and 83 remain suspended in the positions they occupy at the time of shifting.

When the next scene appears, if it is desired to remove the film from the auxiliary developing tank 96, the hand lever 140 is pulled out to intermediate position, stopping sprocket 93. The sprocket 105 continues rotating and quickly takes up the film in tank 96, raising the elevator 97. Coincidentally slack appears in back of the sprocket 93 which is taken up by the descending elevator 83. When the film has been lifted out of the solution in tank 96 the hand lever 140 is again thrown to extreme inward position and all the film continues at normal speed.

In order to permit change of the quantity of developing solution absorbed by the emulsion, I preferably make the developing solution in the tank 11 more concentrated than that in the tank 10, and that in the tank 12 more concentrated than that in the tank 11. Should it be desired, then, to increase the quantity of developing solution absorbed by the emulsion it is only necessary to shift the film from tank 10 to tank 11 or to tank 12. Shifting from the tank 10 to the tank 11 may be accomplished by pulling hand lever 164 out to its extreme position, causing sprockets 26, 25, and 22 to all rotate with double the speed of sprocket 28. Film will therefore accumulate between the sprockets 26 and 28 and the weight of the elevator 27 will submerge the film in the tank 11. When the film has been submerged to the desired level as indicated on the rod 41, the hand lever 164 is thrown to its extreme inward position and all sprockets rotate at normal speed. The hand lever 163 is then pulled out to intermediate position, stopping the sprocket 22, whereupon the film in the tank 10 is quickly taken up and the elevator 24 is raised out of the tank 10 by film tension. When the film is out of the solution in the tank 10, the hand lever 163 is pushed to its extreme inward position and all sprockets rotate with normal speed. The film has in this manner been shifted from the tank 10 into the tank 11. It will be clear how a similar operation of the hand lever 165 instead of the hand lever 164 would result in shifting the film from the tank 10 into the tank 12. It is also apparent that if the film is not raised out of the tank 10, but is submerged in the other tanks as above described, it is possible to run the film through two or all three tanks, if desired, and by stopping the descension or elevation of the elevators in the various tanks the time taken by the film in passing through the respective tanks may be varied at will.

Assuming the film submerged in the tank 11 and lifted out of the tank 10, if it is desired to shift the film back to the tank 10, the hand lever 163 is pulled to its extreme outward position, causing the sprocket 22 to travel with double speed, whereupon film accumulates between the sprockets 22 and 25 and the elevator 24 descends, submerging the film in the tank 10. When the film has been submerged to the extent desired the hand lever 163 is thrown to its extreme inward position, whereupon all sprockets rotate at normal speed. To lift the film out of the tank 11 the hand lever 164 is thrown to intermediate position in which the sprockets 22, 25, and 26 are all stopped. The continued rotation of the sprocket 28 then takes up the film in the tank 11 and causes the elevator 27 to be raised. When it has risen to the desired level, the hand lever 164 is thrown to the extreme inward position in which all sprockets again rotate at normal speed.

If it is desired to change the time of development within the developing cabinet 57, the speed of the film is changed by means of the variable speed transmission 111, and it will be obvious that the lengths of film undergoing processing in the various other steps of the process can be readjusted to maintain the time of processing in these other steps the same as it was prior to changing the film speed. It will be apparent that my apparatus provides flexibility of control of the duration of the various steps of the film processing while the film is continuously being processed.

If desired, the shifting of the various levers for the purpose of controlling the various steps of the process, normally performed manually, may be done automatically by provision of suitable electric relay means energizing suitable electromagnetic switching apparatus in response to notches or other preformed marks on the film 20 in a manner somewhat similar to that in which printing lights are changed in the continuous printing of motion picture film.

While I have shown a developing apparatus having provision for the processing of only one length of film at a time, it is understood that the apparatus may be adapted, by change in proportions and provision of additional driving sprockets and rollers, etc., to accommodate a plurality of separate lengths of film which can be processed simultaneously. It is further understood that various other changes and modifications in design and construction of my apparatus and in the method herein disclosed may be made by those skilled in the art without departing from the spirit and scope of the invention defined in the appended claims.

I claim as my invention:

1. The method of developing film comprising: wetting said film with a developing solution to cause absorption of said solution by said film; removing excess unabsorbed solution from the surface of said film; subsequently conducting said film into a chamber filled with gas inert to said developing solution; and carrying out substantially the entire development of said film while surrounded by said gas by action of the developing solution contained in said film.

2. Apparatus for developing film comprising, in combination: means for wetting said film with a developing solution to cause absorption of said solution by said film; a chamber filled with gas inert to said developing solution; and means for passing the film containing developing solution through said chamber, whereby development of said film takes place in said chamber.

3. Apparatus for developing film comprising, in combination: a tank containing developing solution; a developing chamber filled with gas inert to said developing solution; and means for moving said film first through said developing solution and then through said developing chamber.

4. Apparatus for developing film comprising, in combination: a tank containing developing solution; a developing chamber filled with non-oxidizing gas; sealing means for said chamber adapted to substantially prevent the escape of gas but permit passage of said film therethrough; and means for moving said film successively through said developing solution and through said developing chamber.

5. Apparatus for developing film comprising, in combination: means for wetting said film with a developing solution to cause absorption of said solution by said film; means for varying the quantity of solution absorbed by said film; a developing chamber filled with gas inert to said developing solution, sealing means for said chamber adapted to substantially prevent the escape of gas but permit passage of said film therethrough; and means for moving said film containing developing solution through said developing chamber.

6. Apparatus for developing film comprising, in combination: a tank containing developing solution; a developing chamber filled with inert gas; means for supplying inert gas to said developing chamber; sealing means for said chamber adapted to substantially prevent the escape of gas therefrom but permit passage of said film therethrough; means for moving said film successively through said developing solution and through said developing chamber; means for changing the length of film in said tank; and means for changing the velocity of said film.

7. Apparatus for developing film comprising, in combination: a tank containing developing solution; a developing chamber sealed from the atmosphere; means for supplying said chamber with gas inert to said developing solution; an entrance conduit for said film leading into said developing chamber; a vessel containing liquid sealing said entrance conduit, said liquid being immiscible with water and of density large compared with that of water; and means for successively moving said film through said tank, downward into said liquid, out of said liquid into said entrance conduit, through said entrance conduit, and into said chamber.

8. In film processing apparatus, the combination of: a plurality of film processing baths; means for moving said film successively through said baths including an entering film driving sprocket and an outgoing film driving sprocket associated with each of said baths; means acting by gravity on the film between said sprockets associated with each of said baths tending to submerge said film in said baths; and means for simultaneously changing by the same amount the speed of rotation of the entering sprocket associated with any selected bath and of all the film driving sprockets associated with preceding baths, without changing the speed of rotation of the outgoing sprocket of said selected bath.

9. In film processing apparatus, the combination of: a first film processing bath; a second film processing bath; means for moving said film successively through said first and second baths including an entering film driving sprocket and an outgoing film driving sprocket associated with each of said baths; means acting by gravity on the film between the sprockets associated with each of said baths tending to submerge said film in said baths; a driving shaft connected to rotate the outgoing sprocket associated with said second bath; a second shaft connected to rotate said entering sprocket associated with said second bath and said outgoing sprocket associated with said first bath; a third shaft connected to rotate said entering sprocket associated with said first bath; a speed change device driven by said first shaft and driving said second shaft; a second speed change device driven by said second shaft and driving said third shaft; each of said speed change devices providing means for changing the speed of rotation of the shaft which it drives relative to the speed of rotation of the shaft which drives it.

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