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Stievenart et al.

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[54] **APPARATUS FOR WET TREATMENT OF SHEET OR STRIP MATERIAL**

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[52] **U.S. Cl.** **118/223,** 178/248

[51] **Int. Cl.** **B05c 1/08**

[58] **Field of Search**.... 118/223, 246, 224, 258–259; 354/89, 318, 324

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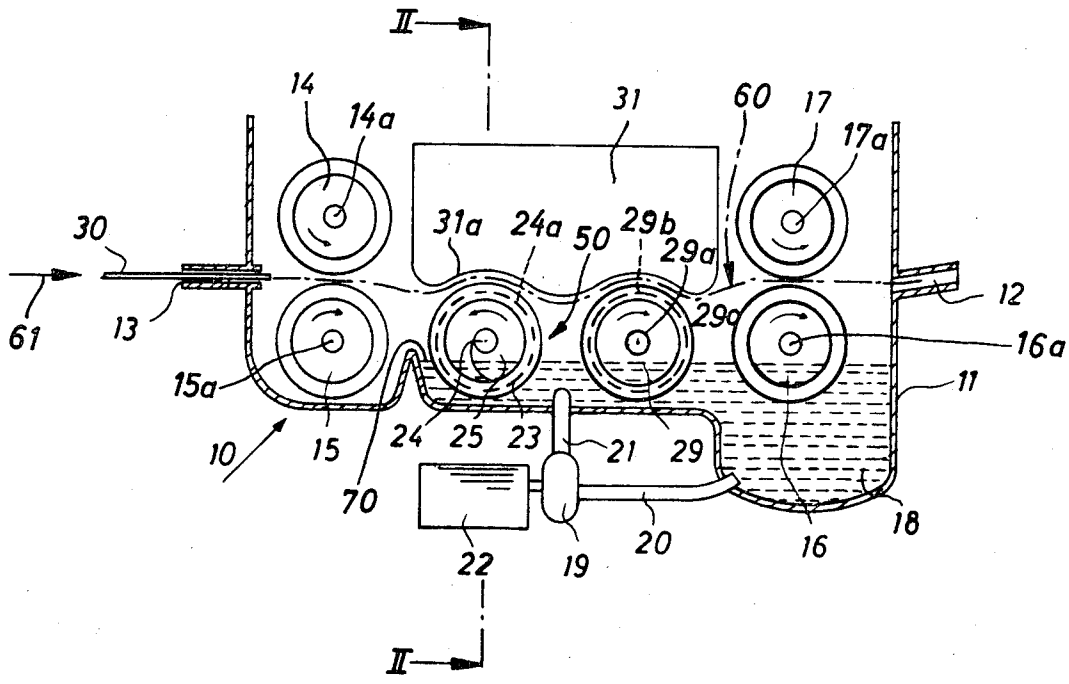
[57] **ABSTRACT**

Apparatus for wet treatment of sheet- or strip-shaped material which is provided at its underside with a photosensitive layer has a liquid-containing vessel with rolls which advance the material along a substantially horizontal path above one or more liquid applying devices whose hollow tubular housings rotate about horizontal axes and dip into the supply of liquid in the vessel to apply liquid to the underside of the material. Each housing contains a feed screw which rotates therewith and conveys a stream of liquid from openings at one end to openings at the other end of the respective housing. A pump draws liquid from the vessel and discharges the thus withdrawn liquid into the vessel at right angles to the direction of transport of material so that the chemical activity of liquid which is being fed by the pump decreases in a direction from one marginal portion toward the other marginal portion of the material. Each housing discharges liquid at the other marginal portion of the material whereby such liquid flows transversely of the path and its chemical activity decreases in a direction counter to that of the chemical activity of liquid which is being fed by the pump. This insures a more uniform treatment of each portion of the photosensitive layer.

13 Claims, 6 Drawing Figures



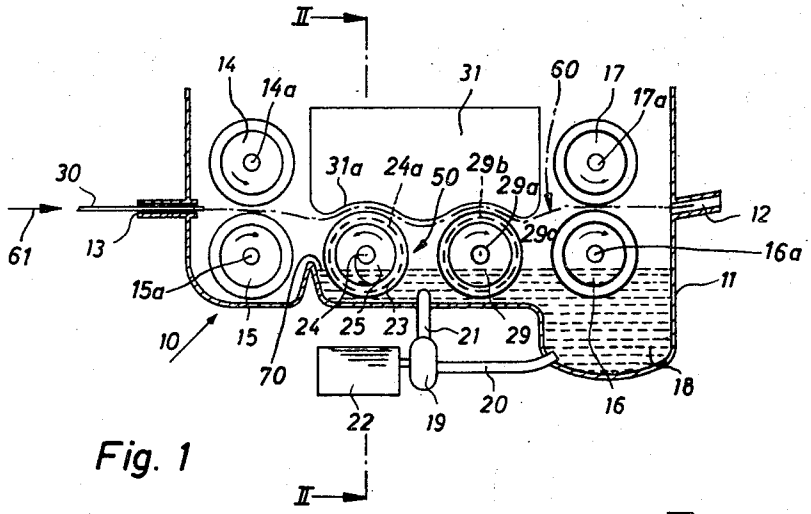


Fig. 1

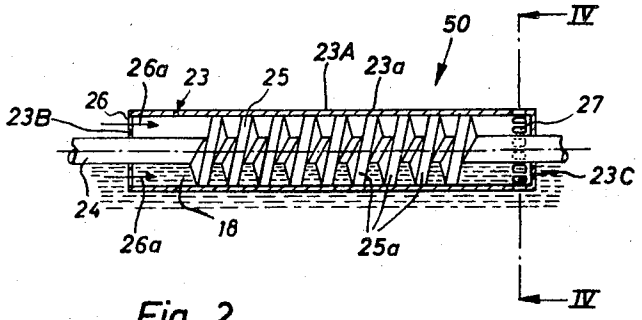


Fig. 2

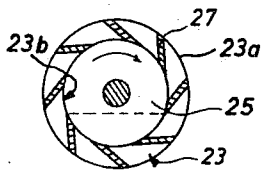


Fig. 4

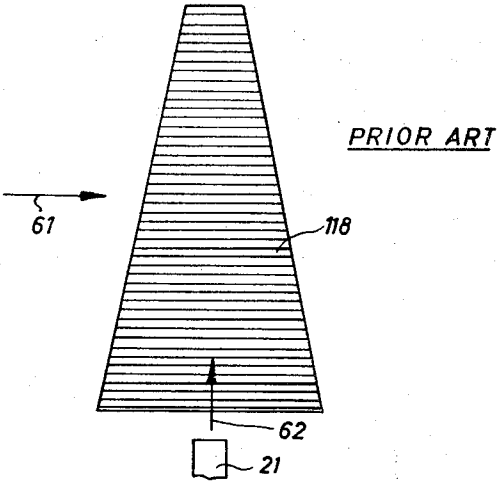


Fig. 3a

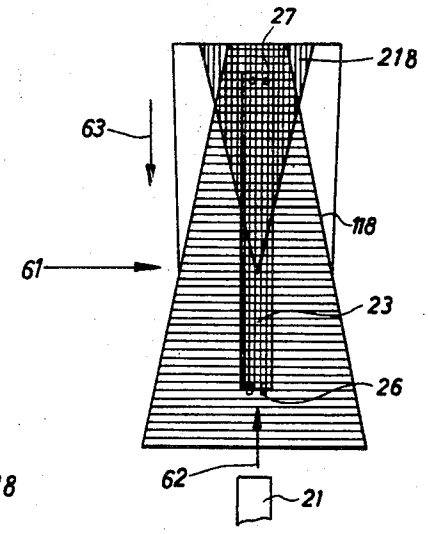


Fig. 3b

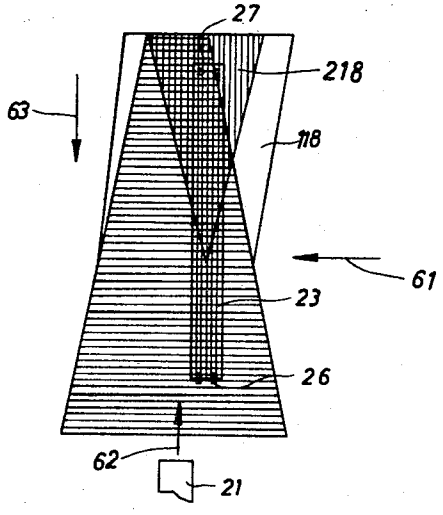


Fig. 3c

APPARATUS FOR WET TREATMENT OF SHEET OR STRIP MATERIAL

BACKGROUND OF THE INVENTION

The present invention relates to apparatus for wet treatment of sheet or strip material, such as photographic films or web-like carriers for photosensitive layers. More particularly, the invention relates to improvements in apparatus for wet treatment of running sheet or strip stock which is transported through a developing or like station wherein its photosensitive layer is treated with a liquid substance. Still more particularly, the invention relates to improvements in apparatus wherein at least one side of running sheet or strip stock is provided with a layer of liquid which is being withdrawn from a suitable supply by one or more rotary members whose peripheral surfaces are in contact with the material.

Apparatus of the just outlined character are often used in photographic processing laboratories, for example, as developing machines wherein a running sheet or strip is first contacted with an activating agent or accelerator and thereupon with a suitable stabilizing agent which is applied with a predetermined delay to terminate the development of photosensitive material. In such apparatus, the uniformity of treatment is of great importance, i.e., the chemical activity as well as the temperature of the liquid agent or agents should be uniform in all portions of the running sheet or strip. Even minor deviations of liquid temperature or chemical activity from a desired optimum value greatly affect the quality of the developing treatment.

Attempts to enhance the uniformity of treatment of photosensitive layers with one or more liquid agents include the provision of a device for circulating the agent which device cooperates with means for supplying a regenerated liquid. The circulating device is normally adjacent to one side of the path for sheet or strip material and serves to circulate the liquid substantially at right angles to the direction of travel of the material. A drawback of such circulating devices is that, when the width of a sheet or strip is considerable, the activity of circulated agent decreases appreciably from the one toward the other side of the path with the result that the development is non-uniform, often to such an extent that the final product is practically useless.

SUMMARY OF THE INVENTION

An object of the invention is to provide an apparatus for wet treatment of running sheet or strip materials wherein the characteristics of the liquid agent or agents can be maintained within an optimum range to thus insure a highly satisfactory uniformity in the quality of treated material.

Another object of the invention is to provide an apparatus for wet treatment of sheet or strip material with novel and improved liquid applying means which complements the action of conventional liquid circulating devices to thus insure a greater uniformity in the chemical activity and temperature of one or more liquid agents.

A further object of the invention is to provide in an apparatus for wet treatment of running sheet or strip stock novel and improved means for circulating a liquid treating medium to thus insure that each portion of the stock is contacted by a liquid whose activity and/or temperature does not deviate appreciably from a desired value.

An additional object of the invention is to provide the apparatus with novel and improved means for applying liquid media to running sheet or strip stock and for simultaneously effecting a desirable circulation of liquid media in the body or bodies of liquid.

A further object of the invention is to provide the above outlined apparatus with novel and improved means which complements the liquid circulating action of conventional circulating devices and is capable of performing additional important functions.

The apparatus of the present invention is utilized for wet treatment of running sheet or strip material, particularly a material whose underside is provided with a photosensitive layer. The apparatus comprises a vessel containing a supply of a treating liquid (e.g., a developing solution) and having an inlet for introduction and an outlet for evacuation of sheet or strip material which travels in the vessel lengthwise along a path located above the supply of liquid, and at least one liquid applying device which is mounted in the vessel at a level below the path and includes an elongated tubular housing having at least one liquid-admitting opening in the region of one end and at least one liquid-discharging opening in the region of the other end. The housing is rotatable in the vessel about a substantially horizontal axis extending transversely of the path, and at least a portion of the housing dips into the supply of liquid so that its peripheral surface transfers a film of liquid from the supply to the underside of the sheet or strip material in the path. The liquid applying device further comprises liquid conveying means (preferably a feed screw) which is mounted in the housing to establish a flow of liquid from the liquid-admitting opening to and through the liquid-discharging opening when the housing rotates whereby the housing delivers liquid to that marginal portion of the running sheet or strip material which is remote from the region of admission of regenerated liquid into the vessel.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved apparatus itself, however, both as to its construction and its mode of operation, together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of certain specific embodiments with reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a longitudinal vertical sectional view of an apparatus which embodies the invention;

FIG. 2 is an axial sectional view of a liquid applying device substantially as seen in the direction of arrows from the line II—II of FIG. 1;

FIG. 3*a* is a diagrammatic fragmentary horizontal sectional view of a conventional apparatus, showing the changes in chemical activity of treating liquid in a direction at right angles to the direction of travel of sheet or strip material;

FIG. 3*b* is a similar diagrammatic sectional view of an apparatus which constitutes a slight modification of the apparatus shown in FIG. 1;

FIG. 3*c* is a similar diagrammatic sectional view of the apparatus shown in FIG. 1; and

FIG. 4 is an enlarged sectional view as seen in the direction of arrows from the line IV—IV of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIG. 1, there is shown an apparatus for wet treatment of sheet or strip material **30**, e.g., webs of photographic film or webs of flexible carrier material the underside of which is coated with a photosensitive layer. The apparatus is assumed to constitute a developer for photographic films or the like and is installed in a laboratory at a developing station **10**. A vessel **11** contains a supply **18** of developing or treating liquid and is provided with an inlet **13** for introduction and an outlet **12** for evacuation of sheet or strip material **30**. The material which is transported in the vessel **11** from the inlet **13** toward the outlet **12** advances along an elongated path **60** (indicated by a phantom line) which is located at a level above the supply **18** of liquid in the vessel **11**. The means for transporting the material **30** from the inlet **13** toward and through the outlet **12** comprises a first pair of advancing rolls **14, 15** which are mounted in the vessel **11** adjacent to the inlet **13** and a second pair of advancing rolls **16, 17** which are mounted in the vessel **11** adjacent to the outlet **12**. The rolls **16, 17** further serve to remove the surplus of treating liquid from the underside of the material **30** whereby such surplus flows along the lower roll **16** and back into the main body of liquid in the vessel **11**.

The shaft **15***a* of the roll **15** and/or the shaft **14***a* of the roll **14** is driven in the direction indicated by the arrow. Analogously, the shaft **16***a* for the roll **16** and/or the shaft **17***a* for the roll **17** is driven to rotate in the direction indicated by the arrow.

The apparatus further comprises means for circulating the treating liquid in the vessel **11**. Such circulating means comprises a pump **19** which is driven by a motor **22** (e.g., an electric motor) and draws liquid from the vessel **11** by way of a first pipe **20** having an intake end communicating with the interior of the vessel **11** in a region located below the advancing roll **16**. A second pipe **21** receives liquid from the pump **19** and discharges such liquid into the vessel **11** between the advancing rolls **15, 16** at one side of the path **60**. The apparatus also comprises means for admitting into the vessel or into the pipe **21** regenerated liquid at a rate which is necessary to maintain the supply **18** at a constant level **70**. The regenerated liquid is admitted to compensate for evaporation of liquid from the vessel **11**, to compensate for removal of some liquid by the material **30** which leaves the vessel **11** by way of the outlet **12**, and also to insure that the chemical activity of liquid in the vessel **11** remains at least substantially constant. The vessel **11** preferably further contains and/or is connected with suitable means for insuring that the temperature of the supply of liquid does not exceed or does not drop below a predetermined range of acceptable temperatures. Such means may include one or more thermometers and one or more heaters for liquid.

In accordance with a feature of the invention, the apparatus further comprises one or more novel liquid applying devices one of which is shown at **50**. This device is mounted in the vessel **11** at a level below the path **60** and includes a hollow tubular housing **23** in the form of a cylinder having a shell **23A** ((see FIG. 2) and two end walls **23B, 23C**. The axis of the housing **23** is preferably horizontal and extends transversely of the path **60**. The liquid applying device **50** further comprises liquid conveying means **25** here shown as a feed screw which is received in the interior of the housing **23** and has a shaft **24** forming part of drive means for rotating the device **50** in the vessel **11**. The threads **25***a* of the feed screw **25** sealingly engage the cylindrical internal surface **23***b* (FIG. 4) of the housing **23**. The housing **23** is mounted in the vessel **11** in such a way that about one-third thereof dips into the supply **18** of liquid whereby the peripheral surface **23***a* of the housing transfers a film of liquid to the underside of the material **30** in the path **60** when the shaft **24** is driven to rotate the parts **23** and **25** as a unit, preferably in a counterclockwise direction, as viewed in FIG. **1**. Thus, the peripheral surface **23***a* rotates counter to the direction (arrow **61**) of transport of material **30** along the path **60**.

The drive means for the liquid applying device **50** further comprises a gear **24***a* which is fixed to the shaft **24** and receives torque from a suitable motor (not shown) by way of a gear train. The housing **23** has one or more liquid-admitting first openings **26** which are provided in the end wall **23B** and an annulus of liquid-discharging second openings **27** which are provided in the shell **23A** adjacent to the end wall **23C**. As shown in FIG. **4**, the partitions between the second openings **27** are arranged to cause streams of liquid to flow from the housing **23** substantially tangentially of the peripheral surface **23***a*. The means for urging the underside of the material **30** in the path **60** against the peripheral surface **23***a* of the housing **23** comprises a stationary or movable biasing member **31** having an undulate bottom surface **31***a* and being mounted in the vessel **11** above the path **60**. The film of liquid which is transferred to the underside of the material **30** in the path **60** by the peripheral surface **23***a* adheres to the material **30** and advances therewith toward an additional or auxiliary liquid applying device **29** here shown as a roll or drum driven by a shaft **29***a* and a gear **29***b* so as to rotate clockwise, as viewed in FIG. **1**. The peripheral surface **29***c* of the drum **29** dips into the supply **18** of liquid in the vessel **11** and applies a film of liquid to the underside of the material **30**. At the same time, the peripheral surface **29***c* removes spent treating liquid from the underside of the material **30**. The gear **29***b* is driven by the aforementioned motor for the gear **24***a*, preferably at an RPM which is less than the RPM of the shaft **24**, i.e., the RPM of the additional liquid applying device **29** is less than that of the device **50**. Also, whereas the peripheral surface **23***a* rotates counter to the direction indicated by the arrow **61**, the peripheral surface **29***c* rotates in such direction. The RPM of the advancing rolls **15** and **16** is preferably less than the rotational speed of the liquid applying device **50**. Thus, the RPM of the device **50** preferably exceeds the RPM of each other device (**15, 29, 16**) which dips into the supply of liquid in the vessel **11**.

The shaft **24** of the feed screw **25** is sealingly surrounded by the end walls **23B, 23C** of the housing **23** so that the latter can receive liquid only by way of the openings **26**. About one-third of the diameter of the feed screw **25** extends into the supply **18** of liquid in the vessel **11**. When the gear **24***a* drives the shaft **24** in a clockwise direction, as viewed in FIG. **4**, the housing **23** rotates with the feed screw **25**. The liquid which has entered the housing **23** tends to remain in the lower part of the interior of the housing, even when the latter rotates with the feed screw **25**, whereby the openings **26**

draw or suck liquid from the surrounding supply **18.** The liquid which enters the housing **23** in the direction indicated in FIG. **2** by arrows **26***a* flows toward the openings **27** and is expelled from the housing by flowing tangentially or substantially tangentially of the peripheral surface **23***a*. The shell **23**A with its openings **27** acts not unlike the impeller of a radical pump and cooperates with the feed screw **25** to induce the flow of a continuous stream of liquid through the housing **23** from one side to the other side of the path **60,** i.e., in the direction in which the pipe **21** discharges liquid into the vessel **11** in the space between the advancing rolls **15** and **16.**

The inflow of liquid into the housing **23** can be enhanced by changing the configuration and/or the position of openings **26.** For example, the openings **26** can be designed to provide helical paths for admission of liquid into the housing **23.** Also, the openings **26** can be provided in the peripheral surface **23***a* adjacent to the end wall **23**B and may be arranged to induce a tangential flow of liquid into the housing. The just described openings **26** can resemble the openings **27** shown in FIG. **4** except that their orientation is opposite to that of the openings **27.** The extent to which the housing **23** dips into the supply **18** of liquid influences the rate of liquid flow from the openings **26** towards the openings **27.** It was found that the flow of liquid in the housing **23** is very satisfactory if about one-third of the diameter of the feed screw **25** dips into the liquid in the vessel **11.**

FIG. **3***a* illustrates the effect of circulation of treating liquid in a conventional apparatus. The direction of material transport is indicated by the arrow **61** and the direction of flow of liquid which issues from the pipe **21** is indicated by the arrow **62.** Thus, the regenerated liquid flows at right angles to the direction of transport of the material whereby its activity or effectiveness decreases in the direction of arrow **62** so that the treatment of photosensitive material along the remote marginal portion of the strip or sheet is much less intensive than along the marginal portion which is nearer to the outlet of the pipe **21.** The trapezoid **118** indicates the decrease in chemical activity of treating liquid in the direction in which the liquid flows from the pipe **21** toward the remote side of the vessel. Therefore, the development of material which is being treated by the liquid is unsatisfactory because it is much more intensive along the marginal portion which is closer to the pipe **21.** This is particularly felt when the material to be treated is rather wide and the quantity of treating liquid in the vessel is small.

FIG. **3***b* illustrates the effect of treatment of material **30** in an apparatus which embodies the present invention. The activity of liquid which issues from the pipe **21** decreases in the same way as described in connection with FIG. **3***a* (see the trapezoid **118**). However, the activity of liquid which has passed through the housing **23** and has entered the vessel **11** by way of the openings **27** is just as high or nearly as high as that of the liquid issuing from the pipe **21.** The liquid which issues from the openings **27** flows across the path **60** (arrow **63**) and its activity decreases in a direction toward the outlet of the pipe **21.** The decrease of activity of liquid issuing from the openings **27** is indicated by the triangle **218** which is superimposed upon the trapezoid **118** so that the overall effect of liquid on the photosensitive material at the underside of the running sheet or strip material **30** is substantially constant or uniform from one side to the other side of the path **60.** The flow of liquid as indicated by the triangle **218** (arrow **63**) is induced by the pipe **20** which draws liquid from the vessel **11** and feeds such liquid to the pump **19.** It is assumed in FIG. **3***b* that the axis of the pipe **21** is located in a vertical plane which includes the axis of the shaft **24.**

FIG. **3***c* illustrates the effect of treatment of material **30** in an apparatus which is identical or nearly identical with that shown in FIG.. **1,** i.e., wherein the pipe **21** is offset relative to the housing **23,** as considered in the direction of the arrow **61.** The triangle **218** represents the drop of chemical activity of liquid issuing from the openings **27** and flowing transversely of the direction of travel (arrow **61**) of the material **30.** The overall intensity of treatment is very similar to that described in connection with FIG. **3***b*, i.e., the chemical activity of liquid is substantially uniform all the way from the one to the other marginal portion of the material **30** in the vessel **11.** The only difference is that the triangle **218** is slightly shifted to the trapezoid **118,** as considered in the direction of material travel in the vessel **11.** This does not affect the quality of treatment due to timely integration during transport of material from the inlet **13** toward the outlet **12.**

The housing **23** of the liquid applying device **50** preferably consists of a metallic material which is provided with a coating of rubber or the like. The conveying means **25** preferably consists of a synthetic plastic material which can stand the corrosive action of liquid in the vessel **11.** The other rotary parts of the apparatus, especially those (**15, 29** and **16**) which dip into the supply **18** of liquid in the vessel **11,** preferably consist of a metallic material having a coat of rubber or another relatively soft substance which can produce sufficient friction for satisfactory transport of material **30** through the vessel.

The improved apparatus can be used with particular advantage for wet treatment of photosensitive material in a developing unit which operates with a relatively small quantity of a liquid medium. If the supply of liquid is relatively small, even minor fluctuations in chemical activity and/or temperature of the liquid medium might greatly affect the quality or intensity of treatment, regardless of whether the fluctuations are of localized nature or take place at timely spaced intervals. The improved apparatus insures a highly satisfactory mixing of the supply of liquid as well as a thorough dispersion of admitted regenerated liquid to thus reduce the likelihood of fluctuations in chemical activity and/or temperature.

The drive means for the liquid applying device **50** may be of the reversible type. This is desirable in connection with the treatment of certain types of materials. If the direction of rotation of the device **50** shown in FIGS. **1, 2** and **4** is reversed, the liquid will flow through the housing **23** in a direction from the openings **27** toward the openings **26.** In such apparatus, the openings **27** are preferably replaced by openings similar to the openings **26** and are provided in the end wall **23**C of the housing **23.**

The apparatus may comprise two or more liquid applying devices **50.** For example, the drum **29** can be replaced with a liquid applying device having a hollow housing and liquid conveying means in the hollow housing.

A feed screw **25** may alternatively or additionally be included in an advancing roll which is mounted in the vessel **11** in such a way that about one-third thereof dips into the liquid. The wet treatment apparatus may then be of a type wherein the photographic film is dipped into the liquid, too and which has no liquid applying devices.

Further there exists the possibility to rotate the hollow tubular housing **23** and the feed screw **25** at different velocities by separate drive means for the shaft **24** and the tubular housing. The direction of rotation of the feed screw is determined in accordance with the conveying direction of the threads **25***a*.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features which fairly constitute essential characteristics of the generic and specific aspects of our contribution to the art and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the claims.

What is claimed as new and desired to be protected by letters Patent is set forth in the appended claims:

1. In an apparatus for wet treatment of running sheet or strip material, combination comprising a vessel for a supply of treating liquid, said vessel having an inlet for introduction and an outlet for evacuation of material whereby the material which travels lengthwise between said inlet and said outlet advances along a predetermined path; at least one elongated roll mounted in said vessel and including an elongated hollow cylindrical housing having a peripheral surface contacting the material in said path, an internal surface, at least one liquid-admitting first opening in the region of one end and at least one liquid-discharging second opening in the region of the other end thereof, said housing being rotatable about a substantially horizontal axis extending transversely of said path and at least a portion thereof dipping into said supply of liquid; and liquid conveying means including a feed screw provided in said housing and arranged to establish a flow of liquid from said first to said second opening, said feed screw having threads in at least partial sealing engagement with said internal surface of said housing.

2. A combination as defined in claim **1,** wherein said peripheral surface transfers liquid from said supply to the underside of material in said and the underside of material in said path is provided with a photosensitive layer.

3. A combination as defined in claim **1,** further comprising means for rotating said feed screw relative to said vessel.

4. A combination as defined in claim **1,** further comprising at least one liquid applying device mounted in said vessel at level below said path, said device being rotatable in said vessel about a second axis extending transversely of said path and having a peripheral surface dipping into said supply of liquid and contacting the material in said path, and drive means for rotating said housing and said additional device about the respective axes.

5. A combination as defined in claim **4,** wherein said drive means includes means for rotating said housing at a first RPM and means for rotating said device at a lower second RPM.

6. A combination as defined in claim **5,** wherein said feed screw which rotates with said housing at said first RPM.

7. A combination as defined in claim **1,** further comprising drive means for rotating said housing so that said peripheral surface rotates counter to the direction of transport of material along said path.

8. A combination as defined in claim **7,** wherein approximately one-third of said housing dips into said supply of liquid.

9. A combination as defined in claim **1,** wherein said first and second openings are respectively located at a first and a second side of said path, and further comprising means for circulating the liquid of said supply in a direction from said first toward said second side of said path.

10. A combination as defined in claim **1,** wherein said second opening is provided in said peripheral surface of said housing.

11. A combination as defined in claim **10,** wherein said second opening is arranged to discharge liquid substantially tangentially of said housing.

12. A combination as defined in claim **1,** wherein said housing has a cylindrical shell and two end walls, said first opening being provided in one of said end walls.

13. A combination as defined in claim **1,** further comprising means for advancing sheet or strip material along said path, said means for advancing comprising a first pair of rolls in the region of said inlet and a second pair of rolls in the region of said outlet, said housing being located between said first and second pairs of rolls.

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