United States Patent

[11] **3,601,029**

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[45] Patented **Aug. 24, 1971**
Continuation-in-part of application Ser. No. 751,861, Aug. 12, 1968, now Patent No. 3,538,835.

[54] **PHOTOGRAPHIC FILM AND PAPER PROCESSING APPARATUS**
7 Claims, 16 Drawing Figs.

[52] **U.S. Cl.** ..... **95/89 R,** 95/96
[51] **Int. Cl.** **G03d 3/02**
[50] **Field of Search** 95/89, 90.5, 94, 96, 97, 98

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Primary Examiner—Samuel S. Matthews
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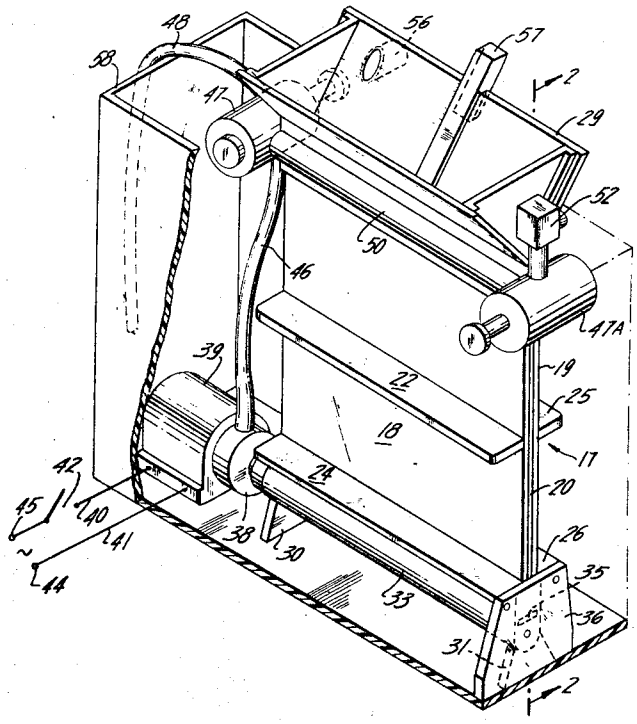
ABSTRACT: A photographic sheet material processing apparatus. The apparatus comprises an upright vessel of flat configuration having a narrow chamber filled with processing solution in which the material may be inserted. An applicator nozzle, below the level of the solution and in communication with the chamber and operated by a pump, directs a stream of the processing solution in the chamber against the emulsion side of the material, resulting in a laminar flow.



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6 Sheets-Sheet 1

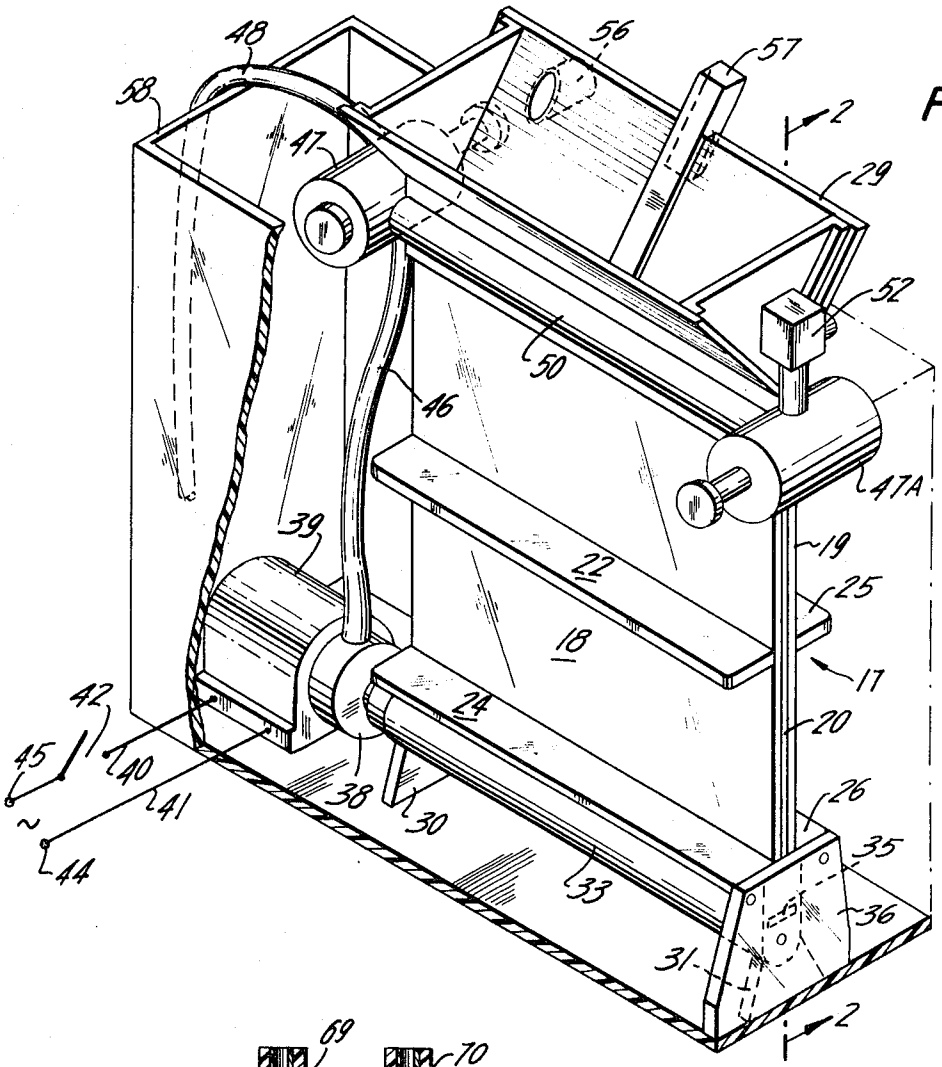

FIG. 1

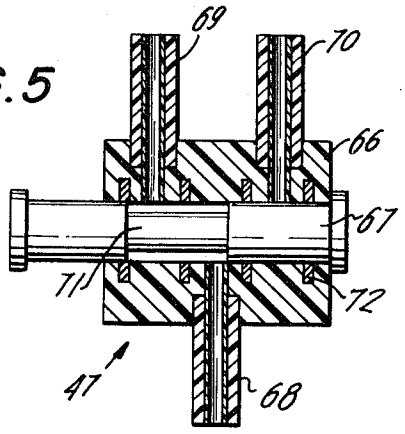

FIG. 5

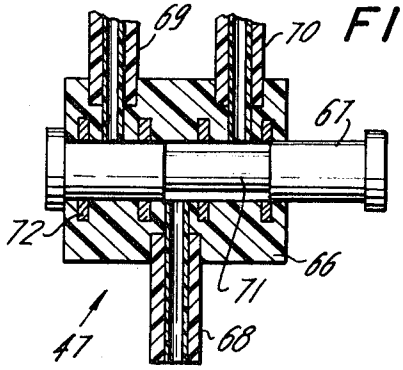

FIG. 6

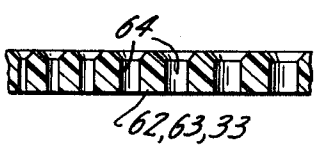

FIG. 7

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FIG. 2

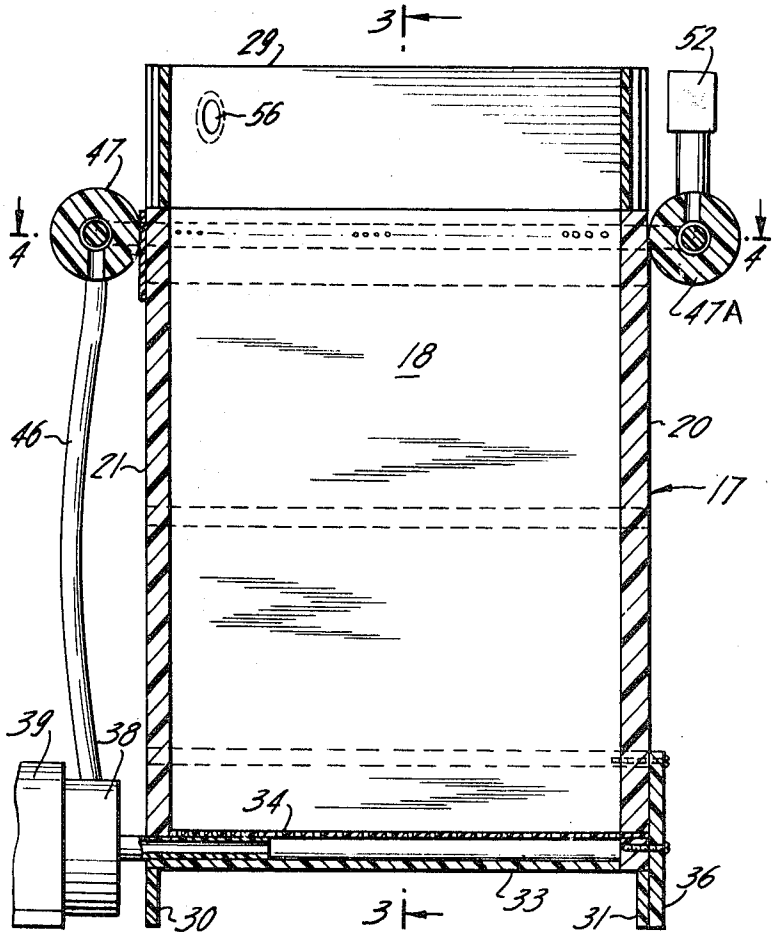
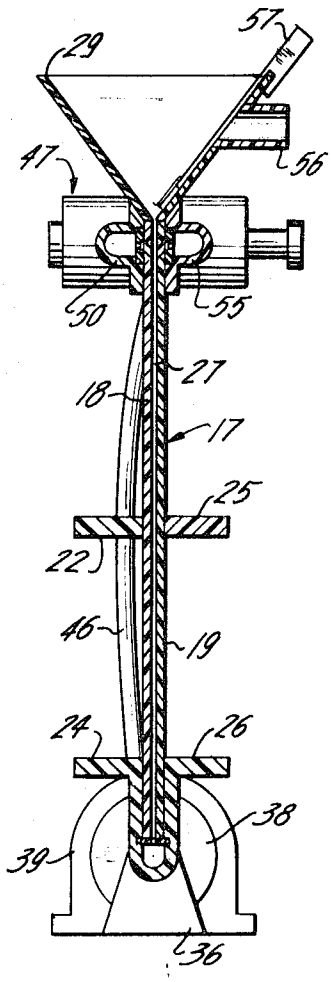


FIG. 3



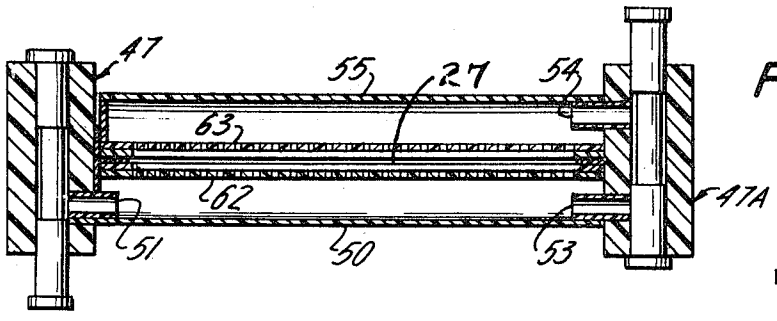


FIG. 4

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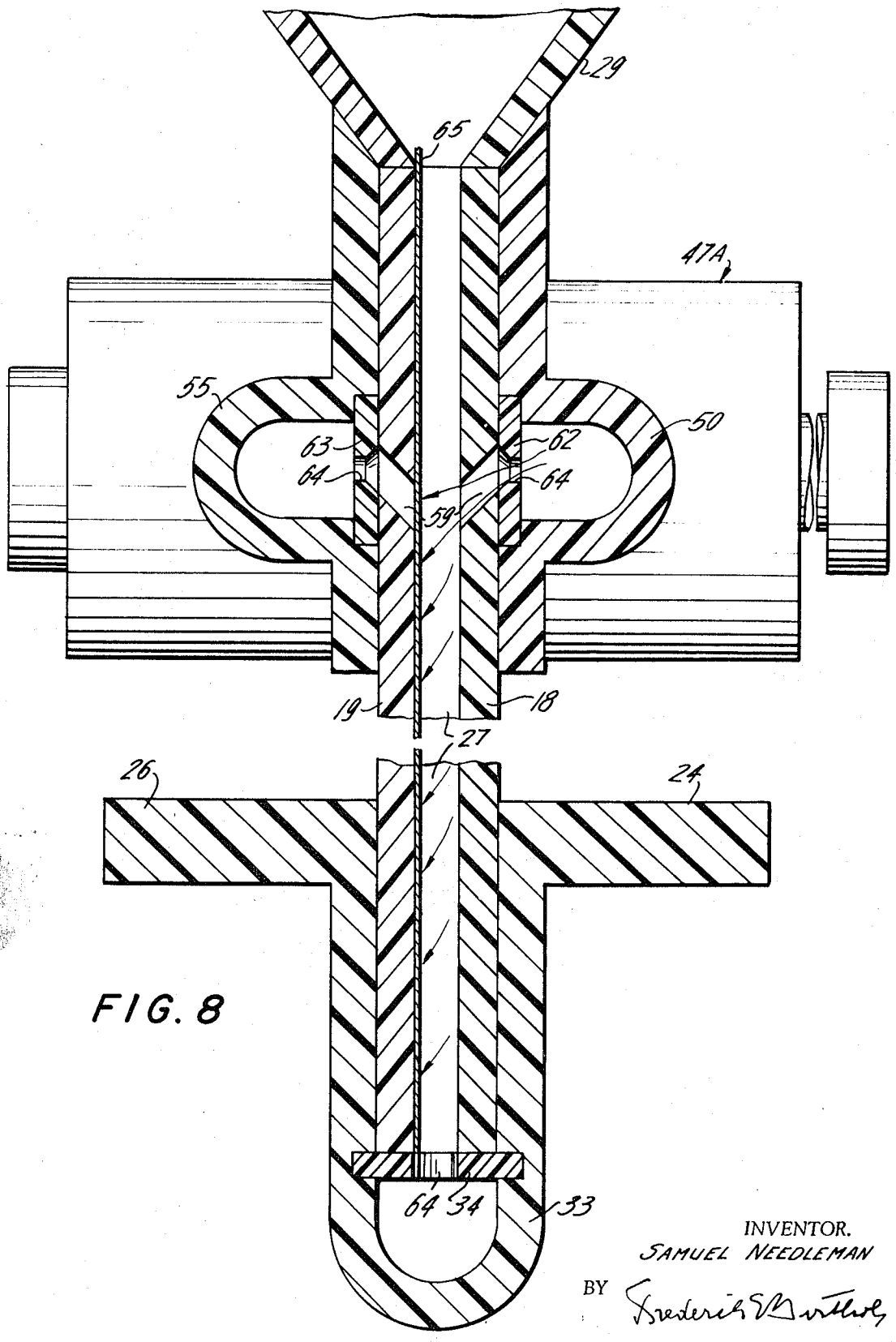

FIG. 8

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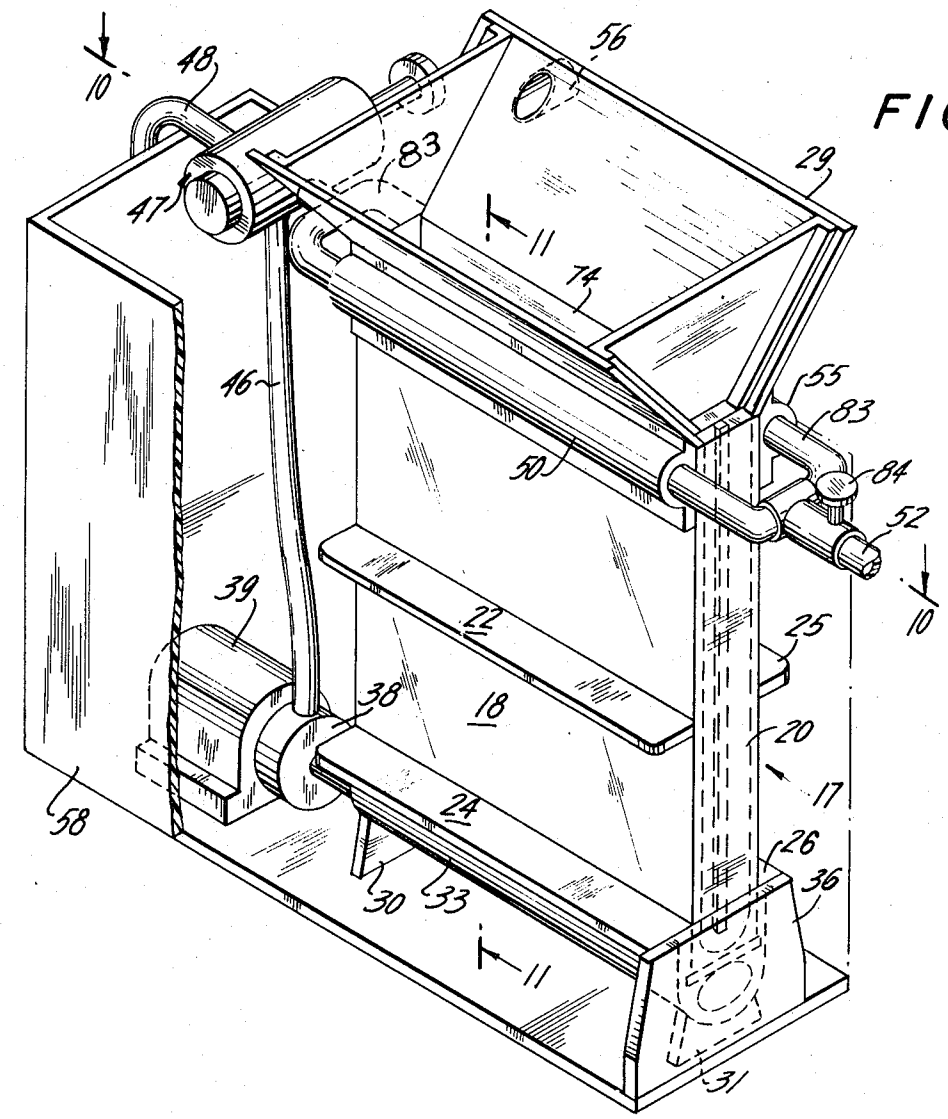

FIG. 9

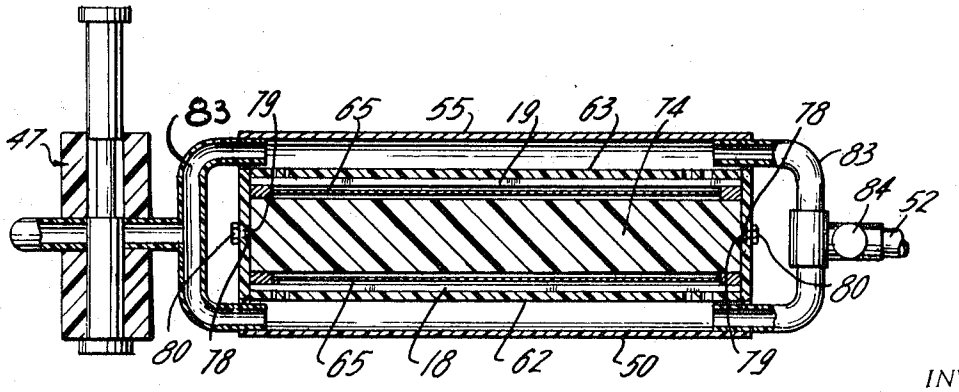

FIG. 10

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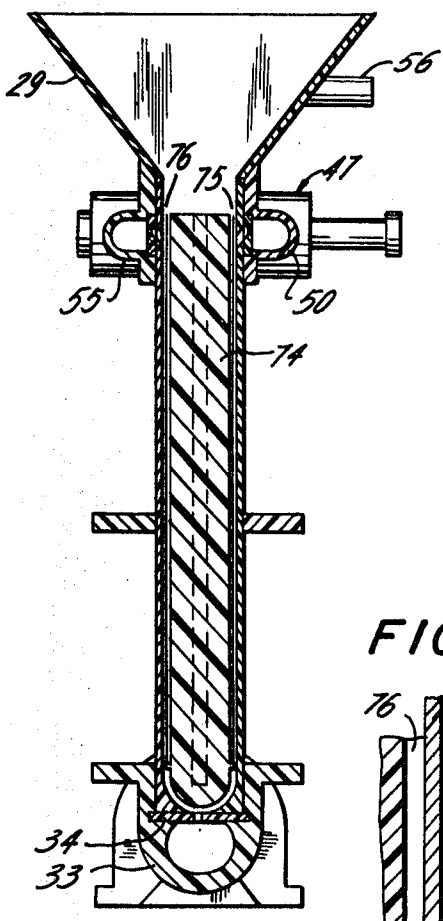
FIG. 11



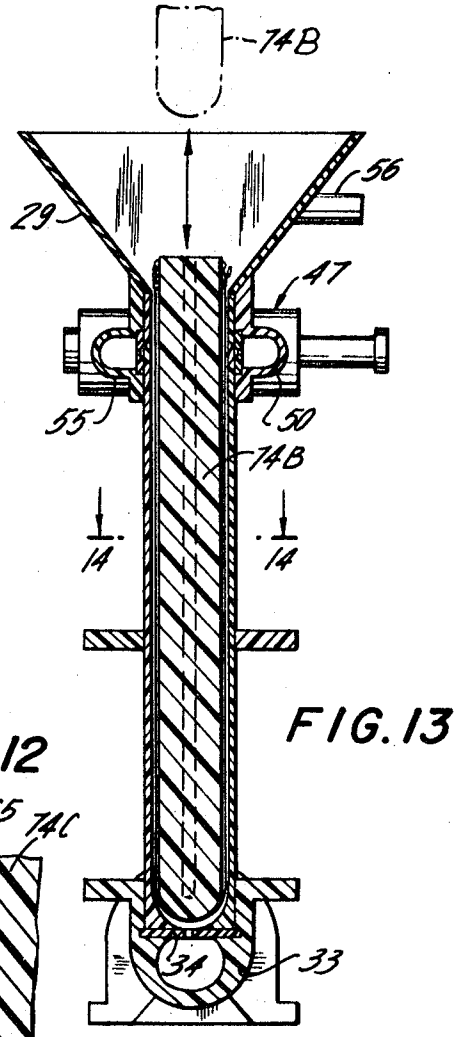
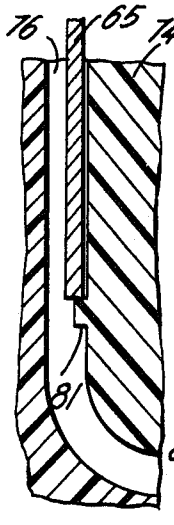


FIG. 13

FIG. 12



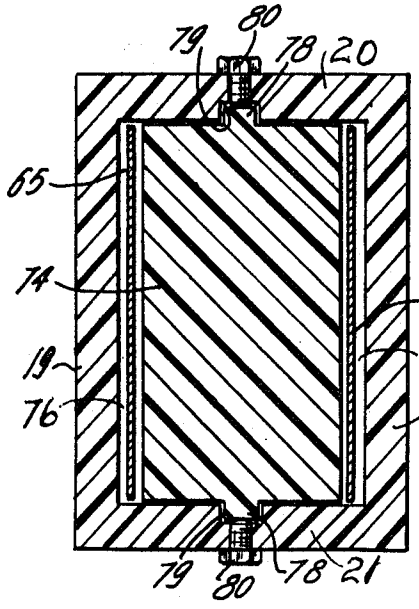


FIG. 14

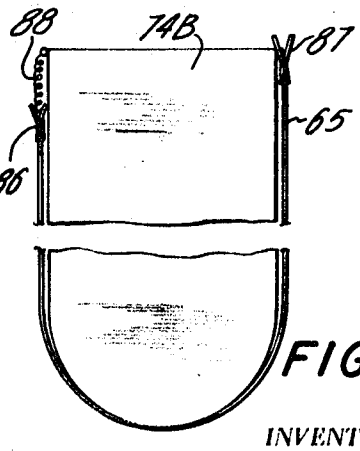


FIG. 15

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6 Sheets-Sheet 6

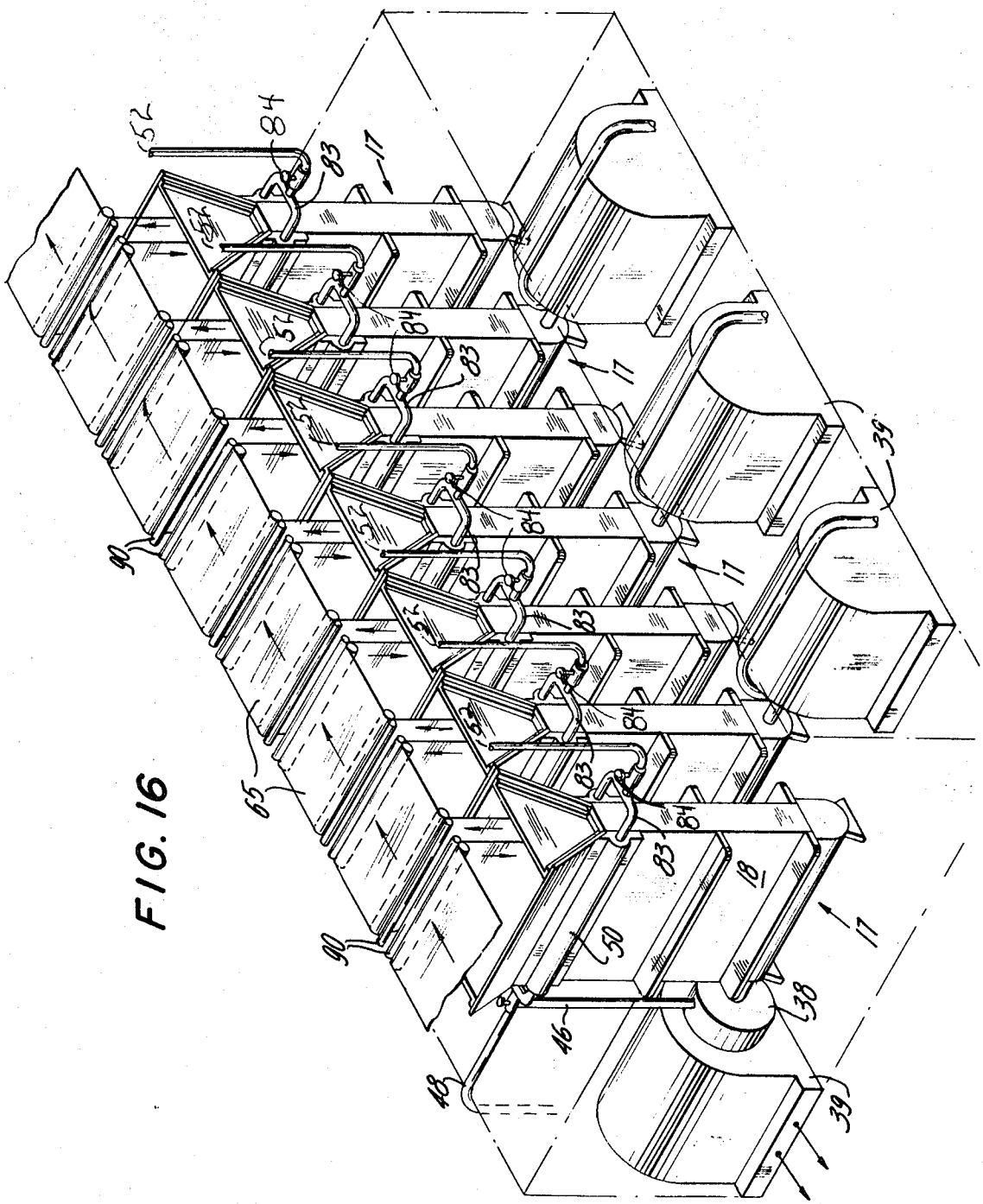

FIG. 16

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PHOTOGRAPHIC FILM AND PAPER PROCESSING APPARATUS

This application is a continuation-in-part of my pending application, Ser. No. 751,861 filed on Aug. 12, 1968 now U.S. Pat. No. 3,538,835

This invention relates to the art of photography and, more particularly, to an apparatus and method for the processing of photographic sheet material, such as film or paper.

In the treatment of photographic materials with various solutions for the development of the latent image and the fixation thereof, it is extremely important that the particular solution be uniformly applied to the emulsion surface in order to prevent uneven action of the reducing agents. Unevenness results in streaks and blemishes which cannot be readily corrected once development has progressed.

It is also important that good surface contact of the solution be achieved in order to obtain consistently satisfactory results. In the processing of multilayer material as used in color photography, it is particularly necessary that such interface contact be established between solution and emulsion surface to provide satisfactory penetration in order to uniformly develop all layers.

Various types of apparatus and methods have been proposed with the above stated objectives in mind. In present practice, tray development and tank development are generally used. In both methods, the material is immersed in the photographic processing solution and is either moved therein, or the solution is agitated, to reduce the surface tension and increase effective contact with the material. Such agitation inherently produces turbulence of the solution. Both types of apparatus require relatively large amounts of solution with respect to the area of the material to be processed, and, as such, are inefficient, wasteful, and time-consuming.

Attempts have been made to employ a narrow developing tank of smaller volume as, for example, that shown in U.S. Pat. No. 3,427,949 (R.D. Knight et al. in which the solution is applied from the bottom up while expelling the previous contents of the tank. The stated objective is to obtain laminar flow which would assure far better contact than can be obtained in conventional tank or tray development. However, true laminar flow cannot be obtained where the fluid medium encounters obstacles, such as supports for the material, in its passage, inasmuch as any impediment of the flow will create turbulence. To minimize such turbulence, the flow over the surface of the material must be extremely slow, thus limiting the usefulness to very small sizes of relatively stiff material. In conventional sizes, such as 8 ×10 inches, the above inflow outflow-type development would produce either unacceptable turbulence or, if the flow is slowed down, an uneven development due to the slow and progressive contact of the processing solution with the large emulsion surface.

It is a primary object of this invention to provide an apparatus and method of procedure for processing photographic sheet material which results in uniform development of the latent image, even over very large areas.

A particular feature of the invention is that the apparatus constructed in accordance therewith assures penetration of the processing solution for proper chemical action on all the emulsion layers.

It is a particular advantage of the invention that the processing of photographic materials may be effected at greater speeds and with a minimum amount of solution required, resulting in economy of operation.

It is a further object of the invention to provide a photographic processing apparatus which is capable of handling all sizes of sheet material, whether in the form of separate sheets or a continuous roll.

Other objects, features, and advantages will be apparent from the following description of the invention, pointed out in particularity in the appended claims, and taken in connection with the accompanying drawings, in which:

FIG. 1 is a front elevational view, in perspective, of the processing apparatus. Portions of a climatizing tank in which it may be placed are cut away for clearer illustration.

FIG. 2 is a sectional view of the apparatus taken along lines 2—2 of FIG. 1.

FIG. 3 is a sectional view taken along lines 3—3 of FIG. 2.

FIG. 4 is a top sectional view taken along lines 4—4 of FIG. 2.

FIG. 5 is a sectional view of a simple valve, shown in one position, used for regulating the direction of flow of the processing solutions.

FIG. 6 is a similar view with the valve mechanism shown in the other position.

FIG. 7 is a partial sectional view of a baffle plate which is pat of the solution applicator.

FIG. 8 is an enlarged, exploded, sectional view depicting the processing chamber of the apparatus and the construction of the solution applicators.

FIG. 9 is a front elevational view, in perspective, of a modified form of the apparatus, adapted for dual action in processing two sheets of photographic material or a length of roll film.

FIG. 10 is a top sectional view taken along lines 10—10 of FIG. 9.

FIG. 11 is a sectional view taken along lines 11—11 of FIG. 9.

FIG. 12 is a partial enlarged view, in section, of a dividing insertable support for the sheet material.

FIG. 13 is a view similar to FIG. 11 showing a modification utilizing a dividing insert which supports a length of sheet film.

FIG. 14 is a partial sectional view taken along lines 14—14 of FIG. 13.

FIG. 15 is a view of the dividing insert, partially cut away, illustrating the arrangement of clips for holding a length of sheet material placed around it.

FIG. 16 is a schematic view, in perspective, showing the arrangement for continuous processing of roll-stock sheet material.

Essentially, the apparatus herein disclosed comprises an upright vessel of oblong shape open at the top, the walls of which form a narrow processing chamber. The chamber is so dimensioned as to freely accommodate the sheet material inserted therein and, together with a filling trough, contains a volume of processing solution sufficient for accomplishing the processing step. The bottom of the chamber has a drain conduit connected to the inlet or suction side of a pump. Attached to the wall of the chamber, facing the emulsion side of the sheet material, and in communication with the inside thereof, is an applicator which, by means of a nozzle placed at a critical angle and supplied from the outlet or pressure side of the pump, directs a uniform stream of the processing solution in the chamber against the emulsion side of the sheet material. Thus the liquid in the processing chamber is recirculated and at the same time applied, under pressure, to the emulsion surface.

It will be seen as the description of the apparatus and the method of its operation further progresses that the salient feature of the invention, namely, the direct, forceful application of the processing solution at a uniform pressure in a streamlined flow against the emulsion surface of the sensitized material produces a new and unexpected result.

Referring to the drawings: considering FIGS. 1 through 4, and 8, it is seen that the apparatus consists of an upright vessel 17 of oblong structure having a front wall 18, rear wall 19, and narrow sidewalls 20 and 21. Reinforcing ribs 22 and 24 for the front wall and 25 and 26 for the backwall are provided to insure the necessary rigidity and strength for the vessel. The walls define a narrow processing chamber 27 (FIGS. 3 and 8) which terminates on top in a trough 29 which, in communication with the chamber 27, provides an inlet for the processing solution and also serves as a reservoir thereof. The vessel is supported on legs 30 and 31 which are attached to drain channel 33 which forms the bottom part of the vessel 17.

The construction of the drain channel 33 includes a baffle plate 34, the function of which will be described later. Suffice it to say that the plate 34 is accessible through the slot 35 which is closed against leakage of fluid by means of the removable end plate 36.

At the side of the vessel 17 and in communication with the drain channel 33 is the pump 38 which is driven by the motor 39. Conductors 40 and 41 and the switch 42 are shown merely as a schematic representation to illustrate that the motor 39 is supplied from a source represented by terminals 44 and 45 and that its operation may be started and stopped by actuation of the switch 42.

The outlet or pressure side of the pump 38 connects by a suitable conduit 46 to a valve 47. The latter, as depicted in detail in FIGS. 5 and 6, is of extremely simple construction and serves to direct the outflow from the conduit 46 into two selectable directions. In one position of the valve, the flow is directed to the drain pipe 48 and, in the other position, to the front applicator 50 with which the outlet 51 of the valve 47 communicates (FIG. 4). Since the applicator 50 is one of the predominant features of the apparatus in accordance with the invention, a more detailed consideration thereof will be given after describing the remaining component elements.

A second valve 47A, similar in construction to the valve 47, is attached to the other end of the applicator 50. The valve 47A has for its inlet a fitting 52 which may be connected 15 any desired source as, for example, wash water which, as it is well known, is used as a step in the processing of photographic materials. The first outlet 53 of the valve 47A connects to the applicator 50 and the second outlet 54 thereof connects to the back applicator 55. The latter is illustrated in the sectional view of FIG. 4.

The trough 29 has an overflow outlet 56 and it is seen that a retainer 57 may be supported on the edge thereof for the purpose of holding certain sizes of sheet material inserted in the processing chamber 27. As will be seen from the description of the operation, the retainer 57 need only be used with such materials which have a length shorter than that of the processing chamber 27. If desired, the entire apparatus may be placed in a climatizing tank 58 and partially submerged in water which is maintained at a constant temperature by any well-known means.

In considering the applicator mechanism, reference should be had to FIG. 8. The enlarged view shows that both the front wall 18 and the back wall 19 of the vessel 17 are provided with downwardly slanting channels 59 each of which, as will be seen, acts as a nozzle to direct a stream of solution circulating in the confines of the applicators 50 and 55 against the sheet material 65. As mentioned before, the confines of these applicators are connected to the pump 38. Under pressure within these confines and in the path of the liquid are the baffle plates 62 and 63 which, as seen in FIG. 7, comprise a flat member provided with a series of apertures 64, forming Venturi tubes progressively increasing diameter and flared at one end. The flared ends of the apertures 64 communicates with the respective channel or nozzle 59. The baffle plates 62 and 63 are so inserted in the slots provided for them that the aperture of smallest diameter is always at the end where the liquid supply is being delivered.

In other words, considering the applicator 50 which is located at the front wall 18 of the vessel 17, and will be referred to as the primary applicator inasmuch as it faces the emulsion side of the sheet material 65, the baffle plate 62 thereof is so oriented that the aperture 64 of the smallest diameter is located near the outlet 51 of the valve 47 (FIG. 4). Conversely, the baffle plate 63 of the secondary applicator 55 is so oriented that its aperture 64 of largest diameter is at the outlet 54 of the valve 47A.

At the bottom of the vessel 17 the drain 33, which is formed by the U-shaped configuration in the joining of the front wall 18 and backwall 19, terminates the chamber 27. A plate 34 of identical construction with that of the plates 62 and 63 and is so placed as to have its aperture of smallest diameter near the inlet or suction side of the pump 38. As can be seen, the plate 34 may also serve as the support for the sheet material 65. It will be explained later that the function of the baffle plates 62 and 63, with flared apertures 64 of varying diameter, is an important one in equalizing the pressure over the side of the chamber 27 so that the turbulent liquid in the applicator 50 will be converted to a uniform streamlined or laminar flow in the nozzle 59, whereby it is applied against the surface of the sensitized material 65 in the chamber 27.

The construction of the valves 47 and 47A will now be described inasmuch as their simplicity and ease of actuation contribute to the efficient operation of the processing apparatus in accordance with the invention. Since both valves are identical only one, such as 47, need be illustrated. As shown in FIGS. 5 and 6, the valve body 66 consists of a cylindrical block having a center cylindrical bore which accommodates a slidable valve rod 67. Pipes 68, 69 and 70 communicate with the bore of the body 66. The rod 67 has a portion 71 or narrower diameter and of such length as to extend between the inlets of pipes 68 and 69 in one position, as shown in FIG. 5, or between the inlets of pipes 68 and 70 in the other position, as shown in FIG. 6. The portion 71 of narrower diameter thus permits the flow of liquid between the pipes which are thereby in communication. The body 66 has grooves in which packing rings 72 are located so as to provide a seal at such portions where the rod 67 slides in the bore of the body 66. It is thus seen that by sliding the rod 67 into one position or the other, the flow may be directed alternately between the pipe 68 and one or the other of the pipes 69 and 70, respectively.

Prior to describing the modification of the construction of the developing apparatus shown in FIGS. 9 through 16, the operation of the apparatus herein described will now be considered. A photographic sheet material 65 which may be either paper or film of suitable size to be accommodated within the chamber 27 is inserted from the top through the opening provided by the trough 29 and is allowed to rest on the baffle plate 34.

If the sensitized material to be processed is not of sufficient length to rest on the baffle plate 34 and, at the same time, to reach above the nozzle 59, it may be attached to the holder 57 by means of an adhesive tape. In practice, metallized Mylar type of the type marketed under the trade name Scotch Brand0850, has proved very useful. Through the trough 29, the chamber 27 is filled, at least to a height above that of applicator nozzle 59, with a processing solution. It is important to note that in this manner the sensitized material is submerged in the processing solution so that, as will be seen, a laminar flow is produced within the body of the surrounding processing solution. To start processing, the switch 42 is closed to energize the motor 36 which, in turn, actuates the pump 38. The valve 47 is so positioned that the conduit 46 communicates with the primary applicator 50 and the valve 47A is so positioned as to close the other end of the applicator 50, namely, in the position shown in FIG. 4. It is to be understood that the fitting 52 connects to a water supply which may be controlled by a suitable valve. The water supply at this instant would, of course, be closed. By virtue of the actuation of the pump 38, the processing solution is forced to flow through the nozzle 59 of the applicator 50, providing a local high-velocity stream in the relatively stationary surrounding fluid. This stream under pressure is directed against the emulsion side of the material 65 and along the entire width thereof. The pressure of the stream of photographic solution presses the material 65 against the back wall 19 of the chamber 27 and, as the liquid is recirculated, a true laminar flow of the processing solution covers the emulsion surface of the material 65. The reason for this is that, by virtue of the baffle plates 34, 62, and 63 having apertures of variable size placed in the manner above described, the pressure of liquid flow over the surface of the material 65 is substantially equalized. Near the inflow 51 of valve 47 where the pressure is greatest—nearest to pump 38—apertures 64 in the baffle plate 62 are the smal-

lest. As these apertures become progressively larger in the direction of the applicator **50**, transverse to the material, where the pressure diminishes, equalization occurs by virtue of the increased diameter of these apertures. This construction results in a substantially even application of processing solution to the material surface so that uniform development thereof is achieved.

It is to be noted that the nozzle **59** forms an acute angle in the downward direction. THe relatively large inner diameter of the applicator nozzle **50** faces the flared apertures **64** which act as Venturi tubes, assuring an even flow through the nozzle **59**. In practice, it has been found that a **45** degree angle of the nozzle gives very satisfactory results.

The narrow processing chamber **27** contributes to obtaining the necessary pressure at which the solution is applied and, by virtue of its smooth, uninterrupted surface, all tendency of turbulence is eliminated. Turbulent flow of liquid, which is a characteristic of prior art developing apparatus, is one of the difficulties encountered in obtaining uniform development of sensitized material. No turbulent flow can exist in the apparatus herein disclosed.

Upon expiration of the necessary time for the particular processing of the material, the valve **47** is placed in the other position so that the contents of the vessel will be drained through the pipe **48**. If desired, the drained solution may be directed into a recovery vessel so that it may be reused. The next application which is generally the washing, takes place when the valve **47A** is placed in such position that the inlet fitting **52** is in communication with the secondary applicator **55**. The pump **38**, being energized will draw the ash water through the fitting **52** which is then applied to the back of the material **65** in a similar uniform stream, filling the vessel with the wash solution. By suitably positioning the valves **47** and **47A**, the wash solution may also be drained out of the outlet pipe **48**. This process may be repeated by filling the vessel with the proper solutions required for complete processing of the material.

During the washing cycle, valve **47A** is alternately actuated so that the primary and secondary applicators **50** and **55** are in communication with the wash water inlet, thus washing both front and back of the sensitized material **65**. Leaving valve **47** in the drain mode and shutting off the water supply, the wash water may also be drained out through drainage pipe **48**. By replacing valve **47** in its original position, the apparatus is ready for the ensuing processing step.

As a matter of fact, as will be seen in connection with the description of the modification shown in FIGS. **9** to **16**, direct application of processing solutions may be simultaneously applied over both of the applicators **50** and **55**. Identical reference characters denote similar component elements as used in connection with figures previously described.

Referring to FIG. **9**, the vessel **17** is similar in construction, except that the walls are spaced farther apart, enclosing a larger cavity which, by means of an insertable support **74** (FIGS. **11**, **12**, **13** and **14**) consisting of a solid oblong shaped block, is divided into two effective processing chambers, namely, a front chamber **75** and a back chamber **76** (FIG. **11**).

The width of these chambers is such as to freely accommodate the sheet material **65** placed therein. On each side of the support **74** (FIGS. **10** and **14**) are guide strips **78** which fit into corresponding slots **79** cut into the walls **18** and **19** of the vessel **17**. Retainer bolts **80** may be provided to engage the guide strips **78** so as to permit partial insertion of the support **74**. The latter, in accordance with the embodiment of the invention, is provided on both sides with a ledge **81** (FIG. **12**) for the support of sheet material **65**. By virtue of the insertable support **74**, two processing chambers are provided so that two pieces of sheet material may be processed simultaneously. For this purpose, valve **47** is connected to a U-shaped pipe fitting **83** which joins together the front and back applicators **50** and **55**. Valve **47A** is replaced by a similar pipe fitting **83A** which joins the other ends of applicators **50** and **55**. In inlet to **83A** is provided at **52**, including a valve **84** to prevent outflow of the processing solution. However, when open, the valve **84** permits inflow of the wash water through **52** when the ensuing processing step calls for washing of the material.

Another type of insertable support **74B** (FIGS. **13** and is) may be used which has a smooth outer surface without the ledge **81** so that a length of film strip may be placed completely around it. For this purpose, the top portion of the support **74B** is equipped with retaining clip **86** and **87**. One of these is resiliently supported by means of the spring **88**. In this manner, the film strip **65** is held tightly around the support **74B**. The entire emulsion surface of the film strip is thus surrounded by processing solution and, on both sides of the support, is bathed by applicators **50** and **55**, respectively, with individual uniform streams of the processing solution. After completion of the processing cycle the support **74B** is simply slid out from the vessel and the developed sensitized material is removed and may be placed on a rack for drying.

With reference to the arrangement shown in FIG. **10**, it is to be noted that baffle plates **62** and **63** are so positioned that the holes of smallest diameter are always near the inflow or pressure side of the system. It is seen that in baffle plates **62**, the aperture of smallest diameter is to the left.

It should also be mentioned that the processing vessels are preferably constructed of lightweight, chemically inert plastic materials, as for example the acrylic resin materials marketed under the trade name "Lucite." However, stainless steel may also be used with equal efficiency. If desired, at least one side, e.g., the wall **18** which faces the emulsion side of sheet material **65**, may be made transparent so that the sensitized surface of the sheet material therein can be exposed to actinic radiation for a second exposure as is necessary in the processing of reversible-type color materials. This is accomplished without taking the material out of the processing chamber.

It is a well-known fact that heat plays an important role in the processing of all types of photographic material. Elaborate systems are often used to maintain the solutions at an even temperature. In the embodiment shown, the liquid temperature is substantially uniform inasmuch as, in the recirculation provided by the pump, the liquid is expelled and drawn in at the same point. Therefore, temperature differentials which may exist in the vessel are greatly minimized.

Referring to FIG. **16**, an arrangement is shown for processing a continuous roll of sheet material which may be either film or paper. For the sake of simplicity of illustration the supply roll of material is omitted and arrows indicate the travel of the length of material from one of the processing vessels into the other. A plurality of rollers **90** are placed above the assembly to guide the length of sheet material **65**. These rollers may be placed on suitable supports (not shown here in order to make the illustration clearer). Suffice it to say that seven processing vessels of the type disclosed in FIG. **9** are placed in tandem, side by side, each identical in construction. The interconnecting pipe fittings **83** are used for replenishment of vessels intended for processing solutions, such as the first, third, fifth, and seventh vessels; whereas similar fittings in the second, fourth, and sixth vessels are used for application of wash water.

In the processing of certain color material, there are generally seven distinct steps in the order recited: developing; washing; application of stop fix; washing; bleach; wash; and application of stabilizer. The arrangement of the processing vessels shown in FIG. **16** represent these steps. The first vessel **17** would contain the developer; the second vessel, the wash; etc. It must be remembered that each vessel is provided with an insert similar to that of **74B** which has neither a ledge **81** nor retaining means **86**, **87**, and **89**, so as to allow free movement of the continuous roll of sensitized material **65**. Thus the inserts **74B** act as retaining and guiding means for the length of sheet material. The latter is folded over this supports which are then placed into the respective containers. Thereafter, the pumps are started in operation and the continuous length of sheet material is pulled over the rollers **90** in the direction shown by the arrows while the particular processing step is

taking place in each of the individual vessels. During this operation, the inlet pipes **83** which terminate in suitable supply tanks (not shown here) are used for replenishing used-up processing or wash solutions. This is effected by simply opening the valves **84**. While only a simple switch **42** is shown in FIG. **1**, by way of example, for the timely actuation of the motor **39**, and thereby the pump **38**, it will be evident that this can be replaced by automatic timers of various kinds, e.g., the electronic type disclosed in my pending application. By means of such timing, the duration of each operation may be preset and the function of the apparatus programmed for any desired material.

The invention in its broader aspects is not limited to the specific embodiments herein shown and described but changes may be made within the scope of the accompanying claims without departing from the principles of the invention and without sacrificing its chief advantages.

What is claimed is:

1. Apparatus for processing photographic sheet material comprising an upright vessel having walls defining a narrow chamber of sufficient width to accommodate the material to be processed, said vessel being open at the top for the insertion of said material and the introduction of the processing liquid, an outlet conduit at the bottom of said vessel connected to the inlet side of a pump, at least one liquid applicator attached to said vessel having a nozzle in communication with said chamber and located below the level of the solution therein, said applicator having a plurality of Venturi tubes along the width of said chamber and in communication with said nozzle and being connected to the outlet side of said pump whereby, upon actuation of said pump, a stream of the liquid in said chamber is directed through said nozzle against said material producing a substantially laminar flow thereacross as said liquid is being recirculated during operation of said pump.

2. Apparatus in accordance with claim **1** wherein said applicator nozzle has a downward angular tilt of 45° in facing said sheet material.

3. Apparatus in accordance with claim **1** wherein said Venturi tubes are of progressively varying diameter for compensating for the pressure differential along the length of said applicator.

4. Apparatus in accordance with claim **1** wherein said outlet conduit includes pressure equalizing means in communication with said chamber for compensating the pressure differential of liquid flow along the length of said conduit.

5. Apparatus in accordance with claim **1** wherein, said applicator comprises a tubular housing placed along the outer wall of said vessel, said housing having a channel accommodating a baffle plate, a plurality of flared apertures in said plate, said apertures being of progressively larger diameter in the direction farthest removed from said pump and so oriented as to communicate with said nozzle facing inwardly of said chamber, said flared apertures in said baffle plate forming said Venturi tubes for equalizing the fluid pressure over the surface of said material.

6. Apparatus for processing photographic sheet material, particularly a length of film strip, comprising an upright vessel having walls defining an oblong cavity open at the top and of a height sufficient to envelop one-half of the length of the film strip to be processed, an oblong insertable support adapted to be placed within said cavity and of such thickness as to form between the inner walls of said vessel dual chambers of sufficient width to freely accommodate the thickness of a film strip placed around said support, an outlet conduit at the bottom of said vessel connected to the inlet of a pump attached to said conduit, a liquid applicator on each side of said vessel, each including a nozzle in communication with the interior of the respective chambers, said applicators being below the level of the processing solution in said vessel and connected to the outlet side of said pump, whereby upon actuation of said pump a stream of the processing solution filling said chambers is directed upon each side of said film strip facing the walls of said chamber, said stream producing a substantially laminar flow of processing solution over said sides as the liquid is being recirculated during operation of said pump, said insertable support having a resilient supporting means for holding said film strip taut around the sides thereof.

7. Apparatus in accordance with claim **6** wherein said insertable support has a ledge for the support of sheet material.