Aug. 22, 1967 M. FRIEDEL 3,336,853

APPARATUS FOR TREATING SHEET-FORM MATERIALS

Filed Nov. 4, 1964 3 Sheets-Sheet 1

FIG. 1

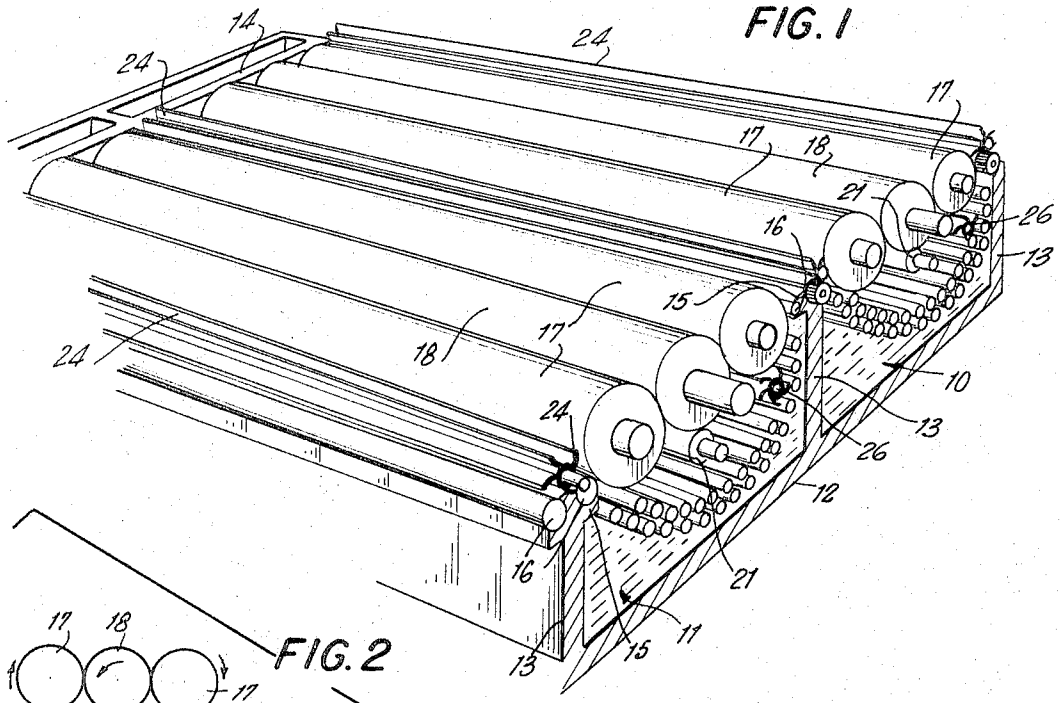
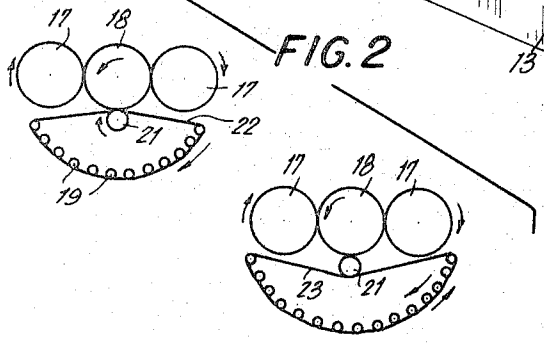


FIG. 2



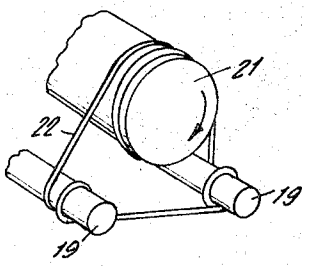


FIG. 3

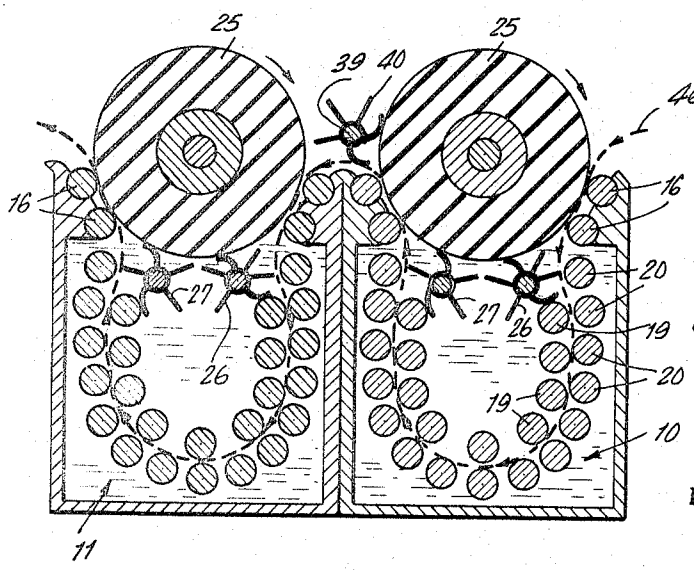


FIG. 4

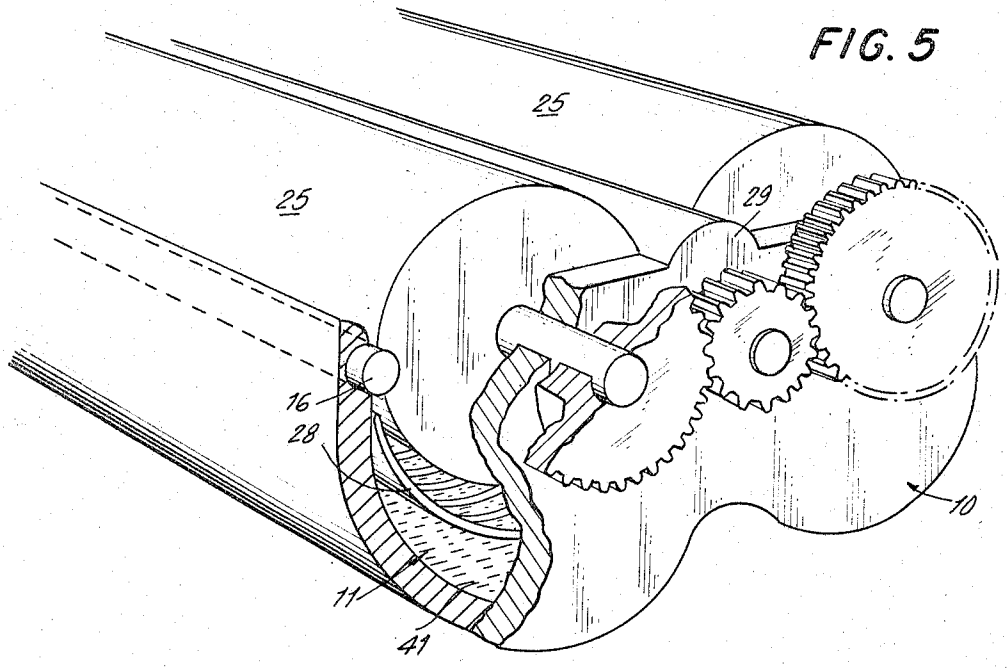
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APPARATUS FOR TREATING SHEET-FORM MATERIALS

Filed Nov. 4, 1964 3 Sheets-Sheet 2

FIG. 5



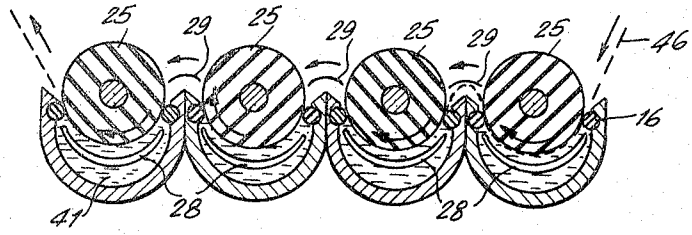


FIG. 6

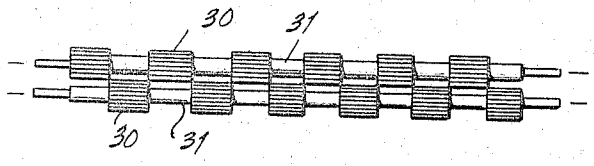


FIG. 8

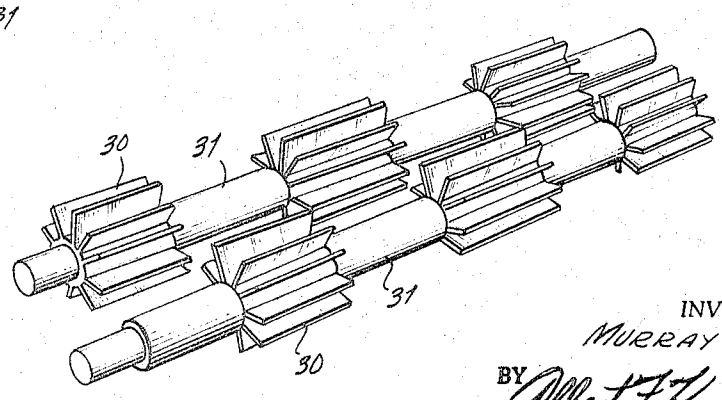


FIG. 9

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Aug. 22, 1967 M. FRIEDEL 3,336,853

APPARATUS FOR TREATING SHEET-FORM MATERIALS

Filed Nov. 4, 1964 3 Sheets-Sheet 3

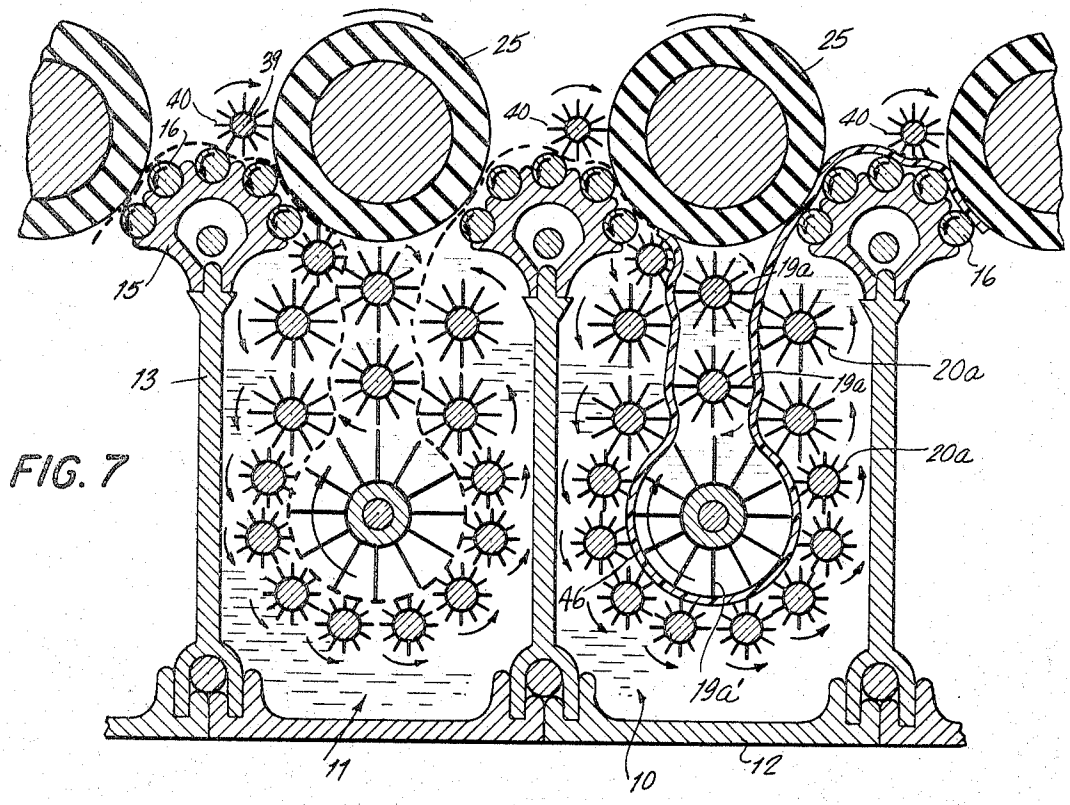


FIG. 7

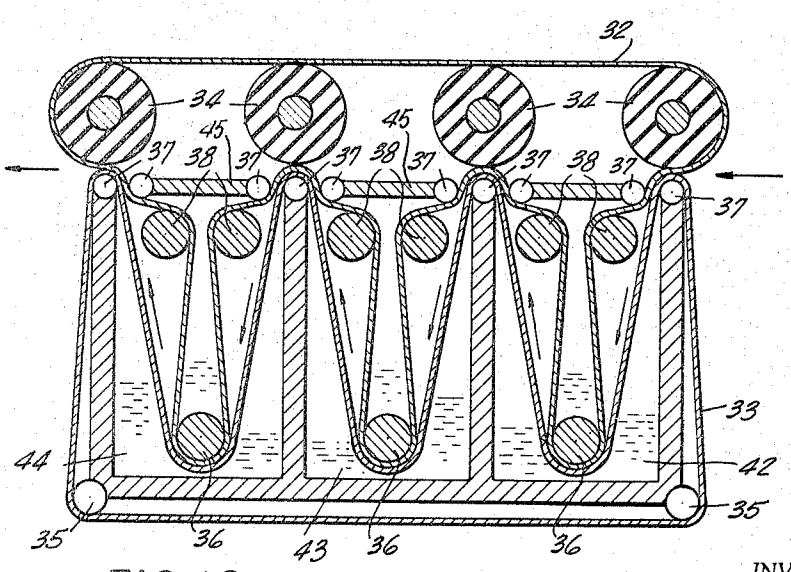


FIG. 10

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APPARATUS FOR TREATING SHEET-FORM MATERIALS

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6 Claims. (Cl. 95—94)

ABSTRACT OF THE DISCLOSURE

An apparatus for conducting sheet-form materials through fluids contained in a series of tank-like enclosures in which each of the enclosures are covered by a plurality of rollers in contact along a horizontal line of tangency. Drive means are provided for the rollers so that the sheet-form material can pass between them and into and out of the enclosures. Elongated flap rollers guide the sheet-form material through the fluids in the tanks.

This invention relates to an apparatus for treating sheet-form materials with fluids. In particular, this invention relates to an apparatus for developing a latent image on an exposed sheet of photosensitive material by subjecting the same to the action of a series of processing chemicals, generally in liquid form.

Numerous types of apparatus have heretofore been proposed for the automatic or semi-automatic processing of exposed photographic films, papers an the like. Although previously proposed developing apparatus has in many cases been commercially successful, and has found application in commercial photo-finishing operations, the various devices heretofore proposed have suffered from a number of disadvantages. Among these disadvantages may be mentioned the fact that such apparatus, generally, did not provide an effective seal to protect the processing liquids, and particularly the developer, from contact with the atmosphere. Photographic developers are reducing agents, whose function is to reduce the light-exposed silver halide particles in the photographic emulsion to metallic silver. As reducing agents, they are susceptible to oxidation by atmospheric oxygen, which action causes loss of strength and effectiveness in the developer. Another disadvantage of prior art devices is their inability to handle a wide variety of sizes of material ranging from very small pieces to large sheets.

In one common type of apparatus, the photosensitive sheet material is transported through by means of resilient mating rollers, for example, rubber-covered steel rollers. In one simple type of apparatus used for office photocopy machines and the like, a one-bath developer is used to process an image-transfer reversal method, and the positive and negative sheets are merely fed by hand, by way of suitable guides, through the developer solution and into the nip between a pair of such rolls. Once caught in the nip, the paper are drawn through the solution by the rolls and discharged from the apparatus. At the same time, as the papers are squeezed between the rolls, excess solution is squeezed off and returned to the reservoir of developer solution. Unless the sheets are long enough to bridge the distance between rollers the device is inoperative. In such an apparatus, also, the front end, where the paper is fed in, is open and unprotected from the atmosphere. In more complex devices, additional sets of rollers may be used at the feed end as well as at the discharge end, as well as within the machine, for transferring the sheet material from one part of the machine to the next. In any event, the non-mating faces of the rollers are generally spaced from the surrounding stationary housing to permit them to turn freely, and such spacing provides an avenue for ingress of air.

In another type of device that has been suggested, the chamber forming the reservoir for each processing solution is formed entirely of a pair of end plates and an even number of rollers, each of the rollers being in contact with its neighbors to form a closed chamber. As the rollers turn, sheet material can be fed into the chamber between a pair of adjacent rollers, without permitting substantial escape of liquid, and discharged from the chamber between another pair of rollers, also without substantial loss of liquid. This arrangement possessed certain advantages over those above described, particularly in that it practically eliminated atmospheric contamination. It also introduced, however, a number of serious disadvantages. Because the rolls were being used to form the entire chamber including the bottom, it was necessary to fashion them with great accuracy in order to avoid gravity-induced leakage between adjacent rolls whose line of contact was below the surface of the liquid. Moreover, this form of construction is quite expensive as compared with simple processing tanks and becomes increasingly so as the size of the device becomes larger. To keep the cost from becoming prohibitive it is therefore necessary to construct such a device in the smallest practicable size, and this in turn restricts the volume of the chamber for the processing fluid. With a small chamber, it is necessary either to use relatively concentrated solutions or to replenish them very frequently, or both. Concentrated solutions are objectionable because they make it more difficult to control the developing action and also because they result in a greater loss of processing chemicals in the amount of solution carried out of the bath by each piece of sheet material. Frequent replenishment to maintain the bath at required strength is time-wasting and objectionable.

An object of the present invention is to provide an improved apparatus for the treatment of sheet-form materials with fluids.

Another object of the present invention is to provide an improved apparatus for the processing of exposed photosensitive materials of a wide variety of sizes.

Still another object is to provide an apparatus in which access of the atmosphere to the interior of the apparatus is minimized or eliminated.

A further object of the present invention is to provide a photographic developing apparatus which is of inexpensive construction and reliable in operation.

Another object of the present invention is to provide an apparatus capable of accommodating relatively large volumes of dilute processing solutions without materially increasing the cost of construction of such apparatus.

A feature of the present invention is the use of a plurality of reservoirs, each of said reservoirs being an enclosure having a fluid-tight lower portion with stationary walls and bottom.

Another feature of the present invention is the use of a top which is formed at least partially by a plurality of contacting rollers.

Another feature of the present invention is the use of a construction in which the surfaces of said rollers are in sliding fluid-tight contact with adjacent stationary parts of the apparatus rather than being spaced therefrom.

Still another feature of the present invention is the use of auxiliary rollers to effect the transport of the sheet material through the reservoirs.

Another feature of the present invention is the use of rotors equipped with flexible vanes for effecting transport of the sheet material.

A further feature of the present invention is the use of an endless belt to effect transport of the sheet material.

The invention consists of the construction, combination and arrangement of parts, as herein described and claimed.

In the accompanying drawings, forming a part hereof there are illustrated several forms of embodiment of the invention, in which drawings similar reference characters designate corresponding parts and in which:

FIGURE 1 is a perspective view of an apparatus according to one embodiment of the invention, with one of the end plates removed.

FIGURE 2 is a diagrammatic side elevational view, illustrating one method of driving the transport rollers of FIGURE 1.

FIGURE 3 is a fragmentary detail perspective illustrating the manner in which the transport rollers are connected to the transport-drive roller.

FIGURE 4 is a sectional side elevation of an apparatus according to another embodiment of the invention.

FIGURE 5 is a perspective view partially in breakaway section of an apparatus according to another embodiment of the present invention.

FIGURE 6 is a sectional side elevation of still another embodiment of the invention, similar in many respects to the embodiment of FIGURE 4.

FIGURE 7 is a sectional side elevation of still another embodiment of the invention.

FIGURE 8 is a side elevation of a pair of vaned rollers used in the apparatus according to FIGURE 6.

FIGURE 9 is a perspective view on a somewhat larger scale, of the vaned rollers of FIGURE 7.

FIGURE 10 is a sectional side elevation of an apparatus according to still another embodiment of the present invention.

In one particularly desirable embodiment the present invention contemplates a photographing developing apparatus comprising in combination, a plurality of reservoirs, each of said reservoirs being a chamber enclosed by stationary fluid-tight walls and bottom, and substantially enclosed on top by a closure consisting at least in part of a plurality of rollers, means for driving said rollers, means in a first of said reservoirs for receiving a sheet of photographic material entering between said rollers and transporting said sheet through said first reservoir and out of said reservoir, means for guiding said sheet to a second of said reservoirs and between the rollers on said second reservoir, and means for transporting said sheet through said second reservoir and out of said second reservoir.

Although the apparatus of this invention is designed primarily for the type of photographic processing in which a sheet material such as an exposed photographic film or paper is carried through a succession of different liquid processing solutions, it will be apparent to those skilled in the art from the following description that the invention may be used for other photographic and quasi-photographic processes, such as those employing a single bath, and those employing gaseous processing fluids such as ammonia vapor and the like.

Referring to the drawings and particularly to FIGURE 1; **10**, **11** indicates two adjacent reservoirs. The actual number of such reservoirs will depend in any given case upon the number of successive processing solutions (including rinses and the like) to which the photographic sheet material must be subjected.

The lower portion of each reservoir is a fluid-tight enclosure comprising a common stationary bottom **12**, spaced stationary vertical side walls **13**, and stationary vertical end walls **14**, all joined to form a fluid-tight chamber. The nearer vertical end wall is omitted in this view in order to show the internal parts of the apparatus more clearly.

The top of each reservoir of the apparatus is closed by an assembly comprising short inwardly projecting flanged portions **15**, on the walls **13**, small rollers **16** embedded in said inwardly projection portions **15**, larger

rolls **17** which are located horizontally inwardly of rollers **16** and in contact with said rollers **16** along a horizontal line of tangency, and a central roller **18** which contacts each of said rollers **17** along a horizontal line of tangency.

The ends of all of the aforesaid rollers are closely adjacent to or preferably in sliding contact with the end walls **14**. It will thus be seen that all of the moving parts of the enclosure are either in tangential rolling contact with other moving parts or in sliding contact with adjacent stationary member, to the end that no open spaces are left for access of air to the processing solutions in the reservoir.

At least one of rollers **17** and **18** is externally driven by any suitable means such as an electric motor (not shown). The remaining rollers may be rotated by similar external drive means, or by motion transmitted from the externally driven roller, for example, by gears, belts or the like or by direct frictional contact between the cylindrical faces of the rollers. In addition, the rollers and stationary members are formed of suitable anti-friction material such as Teflon or the like wherever they come in wiping contact with each other.

The lower part of each of the reservoirs **10**, **11**, is filled with an appropriate processing solution to a depth slightly short of the tops of the stationary sidewalls **13** and end walls **14**.

Inside each of the reservoirs is a transport apparatus in the form of two cooperating adjacent spaced banks of small rollers, illustrated as shown in FIGURE 1, as comprising upper rollers **19** and lower rollers **20**. All of the rollers in one of these banks are rotated in a common direction (either clockwise or counter-clockwise) while those rollers in the other bank are rotated in an opposite direction, so that the two banks of rollers cooperate to drive a piece of sheet material therebetween from one side of the reservoir, through the liquid and out the top at the opposite side thereof from the point of entry.

As shown in FIGURE 2, together with FIGURE 1, there is provided in this embodiment a central transport-drive roller **21**, located directly under central roller **18**. Transport-drive roller **21** may be driven from central roller **18** either through gears (not shown) by frictional engagement, or in any appropriate manner. If desired, roller **21** may be the driving and roller **18** the driven roller or various other arrangements may be employed, as will become more apparent hereinafter.

As illustrated in FIGURES 1 and 2, central roller **18** rotates counter-clockwise, while rollers **17** and **21** rotate clockwise. A cord or belt **22** is looped around drive roller **21** and around each of the upper transport rollers **19** in the manner illustrated in fragmentary fashion in FIGURE 3, causing the upper transport rollers **19** to rotate in a clockwise direction.

A second cord **23** is looped over drive roller **21** and over each of the lower bank of transport rollers **20** as indicated in FIGURE 2 causing the lower bank of transport rollers **20** to rotate in a counter-clockwise direction. The result of the combined driving of the upper transport rollers **19** in a clockwise direction and of the lower transport rollers **20** in a counter-clockwise direction is that the neighboring portion of these rollers move in the same direction and drive a piece of photographic sheet material inserted between the two banks of rollers. In the embodiment as illustrated, the sheet material will be carried generally from the upper right to the lower left as seen in FIGURE 1, along a curved path which carries it down into the body of liquid processing solution, through the same in a curved path, and upwardly out of the solution and thence out of the reservoir itself and into the atmosphere.

Although the means provided for rotation of the transport rollers **19** and **20** have been illustrated as an arrangement of cords, it will be obvious to those skilled in the art that the same effect may be achieved by other equiva-

lent means such as gear drives, chain and sprocket drives, etc.

As the sheet material leaves the first chamber or reservoir, it emerges in an upward direction. In order to direct the sheet downwardly into the second reservoir it is practical and within the purview of this invention, to rely on the operator to turn the leading edge of the emerging sheet manually downwardly into the next reservoir. Preferably, however, means are provided to automatically guide the upwardly-emerging sheet as it leaves the reservoir, downwardly into the next reservoir without attention on the part of the operator.

One such means is illustrated in FIGURE 1, in the form of vaned rollers, or flap-rollers **24**. These rollers comprise a relatively narrow cylindrical core **39**, and a plurality of flexible resilient vanes **40**, projecting radially from the core and extending substantially the entire axial length of the roller. Flap-rollers **24** rotate clockwise as seen in FIGURE 1, and the sheet material is fed in under the first flap-roller and above the corresponding embedded roller **16**, so that it is drawn by the rotation of the flap-roller into the first reservoir. On emerging from the first reservoir, the upwardly moving leading edge of the sheet material is engaged by the flaps or vanes of the next flap-roller and deflected downwardly until it bears against the initial large roller **17** of the next reservoir. This roller is also rotating clockwise as shown in FIGURE 1, with the result that its surface adjacent the sheet is travelling leading edge of the sheet material is directed downwardly into the second reservoir. Once inside the second reservoir it is transported therethrough by upper and lower transport rollers **19** and **20** in the manner set forth above in the description of the first reservoir. In this way, the sheet material is automatically transported successively through the various processing solutions without attention on the part of the operator after it is once fed into the first reservoir.

Inside each of the reservoir **10**, **12**, there may be provided one or more additional flap-rollers **26**, to further guide the leading edge of the sheet material to the proper entry between the upper bank of transport rollers **19** and the lower bank of transport rollers **20**.

It will be noted that all of the rollers across the top of each reservoir are in rolling contact with one another. The only sliding or frictional engagement between the moving rollers and the adjacent stationary parts of the apparatus is at the flanged portions **15** and at each end of each of the rollers.

To prevent access of air to the processing solutions in the reservoirs, it is preferable to provide a close fit between each of the above mentioned moving surfaces and the adjacent stationary surfaces so that the moving surface and the adjacent stationary surface are in continuous wiping contact. These wiping contact areas may be lubricated in any suitable manner. To avoid any possibility of contamination of the sheet material or processing solutions by lubricants, however, it is preferred to fashion at least one of each of these mating surfaces of an inherently low-friction material such as polytetrafluoroethylene polymer (Teflon) or the like or to provide a friction-reducing layer of such a material on one or both of the surfaces.

A somewhat different embodiment of the invention is illustrated in FIGURE 4. In this embodiment, rollers **17** and **18**, on the top of each reservoir are replaced by a single large roller **25**. It will be noted that the surface of roller **25** near the feed end of each reservoir moves downwardly, while that near the discharge end moves upwardly, so that the motion of the surface presented to the sheet material being processed is the same as the motion of the corresponding roller **17** in the embodiment of FIGURE 1.

Also shown in FIGURE 4 are additional flap-rollers **27**, which guide the sheet material **46** emerging from between upper and lower transport rollers **19** and **20**, to

the discharge point which lies in the nip between roller **25** and contacting roller **16**.

FIGURES 5 and 6 illustrate another embodiment of the apparatus. This embodiment is of somewhat simpler construction than the embodiments previously described, in that the upper and lower transport rollers **19** and **20** are omitted. In this embodiment the motive power is provided by driven rollers **25**, which bear against the small idler rollers **16**, and thereby grip the sheet material (not shown) and transport it through the bath **41**. The sheet material may be allowed to follow the curved configuration of the bottom of the reservoir **10**, **11**. Preferably, however, in order to avoid the possibility of contamination by sediments and the like, the sheet material is guided through the bath at a level somewhat above the bottom of the reservoir, for example, by curved comb-like guide members **28**. As the leading edge of the sheet material is guided into the nip between roller **25** and roller **16** at a point near the discharge end of the reservoir **10**, it is engaged by roller **25** in reservoir **11** and drawn through so that the progress of the sheet material does not stop when the trailing edge passes clear of the nip near the feed end of the reservoir.

Between each successive pair of reservoirs is provided a stationary guide member **29** which serves to direct the sheet material as it is discharged upwardly from a first reservoir and deflect it downwardly into the feed point of the succeeding reservoir.

It may be noted that in the embodiment shown in FIGURES 5 and 6, there is no sharp line of demarcation between the sidewalls and the bottom of each reservoir as the sidewalls merge gradually into the bottom to form a generally U-shaped trough. When reference is made in the claim and elsewhere herein to stationary sidewalls and bottom, it is not meant to imply that the sidewalls and the bottom are sharply separated, and such reference is intended to include a structure such as that illustrated in FIGURES 5 and 6.

FIGURE 7 illustrates still another embodiment of the invention. The embodiment of FIGURE 7 is generally similar to that of FIGURE 4, except that all of the transport rollers are flap-rollers instead of the solid rollers **19** and **20** of FIGURE 4. Thus, instead of solid lower transport rollers **20**, as shown in FIGURE 4, there is provided a lower bank of flap-rollers **20***a*. Similarly in place of solid upper transport rollers **19** as illustrated in FIGURE 4, there is provided an upper bank of flap-rollers **19***a*, including in this case a large flap-roller **19***a'*, which takes the place of several solid rollers **19**.

FIGURES 8 and 9 illustrates a preferred form of flap-roller which is particularly advantageous where the flap-rollers are used in opposed, cooperating pairs, for example, flap-rollers **19***a* and **20***a* of FIGURE 7. As shown in FIGURES 8 and 9, each roller comprises spaced vaned portions **30** on the core portions **31**, and the two opposing rollers are nested in such a way that the vanes of one roller lie between the vanes of the other. Preferably, the path of the extremities of the vanes on the two rollers should form slightly overlapping circles, that is, the vanes of one roller should penetrate slightly into the open space adjacent the core portion **31** of the other roller. This overlapping insures that both sets of vanes will be in contact with the sheet material passing between the rollers. A slight penetration into the open space suffices in most cases. It is generally undesirable to have the vanes of one roller penetrate deeply into the space adjacent the bare portion **31** of the other roller because, unless the vanes are extremely flexible, such an arrangement may lead to scratching and distortion of the sheet material.

FIGURE 10 illustrates still another embodiment of the invention, in which the transport of the sheet material through the various reservoirs is accomplished with the aid of continuous belts **32** and **33**. These belts perform in general the same function as the rollers **19** and **20** of

the embodiments of FIGURES 1–4, and flap-rollers **19***a*, **19***a'* and **20***a* of FIGURE 7.

In the apparatus to FIGURE 10, upper belt **32** is led over rollers **34**, at least one of which is a powered roller, and down into and out of each successive reservoir successively over suitable belt guide rollers **36** and **37** as shown. Lower belt **33** is led under the bottom of the reservoirs **42**, **43**, **44**, for example, by way of bottom rollers **35**, and into and out of each successive reservoir in generally parallel facing relationship with upper belt **32**. Inside each of the reservoirs **42**, **43**, **44**, belts **32** and **33** are separated by means of separation rollers **38**, so as to allow access of the processing solutions to the sheet material between the belts. A plate **45** is used with rollers **37** to cover the reservoir.

In using the apparatus as illustrated in FIGURE 10, the sheet material to be processed is fed into the apparatus between belts **32** and **33**, at the point where they come together at the right hand side of the apparatus as shown in FIGURE 10. The sheet material is then frictionally engaged by the belts and carried downward into the solution in the first reservoir **42**. As the belts **32**, **33**, are separated by separation rollers **38**, the processing solution flows freely around the sheet material. As the sheet material moves through the reservoir it is carried between the belts out of the first reservoir **42**, and into the second reservoir **43**, and so on through each of the reservoirs.

In the apparatus of FIGURE 10, it is desirable that the last reservoir contain a fairly efficient rinse, so as to prevent contamination of the first processing solution by material carried back from the last reservoir by the belts. Providing this precaution is taken, contamination of one solution by another is negligible, owing to the squeeze action that takes place as the belts are compressed between rollers **34** and rollers **37** in passing from one reservoir to the next.

By virtue of its construction as above described, the apparatus of this invention is adapted to automatically and continuously or intermittently process sheet-form photographic materials, without special attention or skill being required of the operator. The construction of the apparatus is such that access of the atmosphere to the processing solutions is effectively minimized or eliminated. The design of the apparatus permits the use of large volumes of relatively dilute processing solutions if so desired without unduly increasing the cost of the construction. Moreover, the above advantages are obtained without resorting to a construction necessitating the maintenance of a liquid-proof seal between two tangentially contacting cylinders whose line of tangency is below the surface of the contained liquid. The sheet transport means permits a wide variety of sheet sizes and shapes to be fed through the baths without changing the apparatus.

While this invention has been described with reference to certain preferred embodiments and illustrated by way of certain drawings, these are illustrative only, as many alternatives and equivalents will readily occur to those skilled in the art without departing from the spirit and scope of the invention. The invention is therefore not to be construed as limited, except as set forth in the appended claims.

Having thus fully described the invention, what is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A photographic developing apparatus comprising a plurality of enclosed fluid receiving reservoirs each comprising spaced side walls, spaced end walls interconnecting the side walls and a bottom, a closure for the top of each reservoir including a plurality of rollers in horizontal contact with each other journaled at their ends in the end walls, a curved recess in each of the side walls with at least a portion of the rollers adjacent the side walls in horizontal wiping contact with said recess in the side walls, means for driving at least one of said rollers, means in a first of said reservoirs to receive a sheet of photographic material entering between a first two of the closure rollers, means to transport the said sheet through the reservoir and out of the said reservoir between a second two of the closure rollers, means to guide the sheet into a second of said reservoirs between the first two closure rollers on the second reservoir and means in the said second reservoir for transporting said sheet through the said second reservoir and out of the said second reservoir between the second two of the closure rollers on the second reservoir.

2. A device according to claim **1** in which the sheet receiving means includes a flap roller comprising an elongated core and a plurality of resilient vanes extending radially therefrom, disposed in wiping contact with at least one of the closure rollers and the sheet guide means comprises a second flap roller disposed between the adjacent closure rollers of the first and second reservoirs.

3. A device according to claim **1** in which the sheet guide means is an elongated curved plate disposed below the adjacent closure rollers of the first and second reservoirs.

4. A photographic developing apparatus comprising a plurality of enclosed fluid receiving reservoirs each comprising spaced side walls, spaced end walls interconnecting the side walls and a bottom, a closure for the top of each reservoir including a plurality of rollers journaled at their ends in the end walls with the rollers adjacent the side walls in horizontal wiping contact with said side walls, means for driving at least one of said rollers, means in a first of said reservoirs to receive a sheet of photographic material entering between a first two of the closure rollers, means to transport the said sheet through the reservoir and out of the said reservoir between a second two of the closure rollers, means to guide the sheet into a second of said reservoirs between the first two closure rollers on the second reservoir and means in the said second reservoir for transporting said sheet through the said second reservoir and out of the said second reservoir between the second two of the closure rollers on the second reservoir, said reservoir closure including a horizontally disposed flat plate having an arcuate recess on each of its edges carried between the closure rollers.

5. A photographic developing apparatus comprising an enclosed fluid reservoir comprising spaced side walls, spaced end walls interconnecting the side walls and a bottom, a laterally extending flanged portion at the upper edge of each side wall, a closure for the top of the reservoir including a plurality of rollers journaled at their ends in the end walls with the rollers adjacent the side walls in horizontal wiping contact with the flanged portions of the said walls, means for driving at least one of said rollers, means including a series of transversely disposed elongated driven members in said reservoir to receive a sheet of photographic material inserted between a first two of the reservoir closure rollers wherein the elongated members are flap rollers comprising an elongated core and a plurality of outwardly extending resilient vanes on said core and means to transport the said sheet through the reservoir and out of the said reservoir between a second two of the closure rollers.

6. A photographic developing apparatus comprising an enclosed fluid reservoir comprising spaced side walls, spaced end walls interconnecting the side walls and a bottom, a laterally extending flanged portion at the upper edge of each side wall, a closure for the top of the reservoir including a plurality of rollers journaled at their ends in the end walls with the rollers adjacent the side walls in horizontal wiping contact with the flanged portions of the said walls, means for driving at least one of said rollers, means including a series of transversely disposed elongated driven members in said reservoir to receive a sheet of photographic material inserted between a first two of the reservoir closure rollers wherein the longated mem-

bers comprise rollers and flap rollers, and means to transport the said sheet through the reservoir and out of the said reservoir between a second two of the closure rollers.

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