May 7, 1963 H. SIGLER 3,088,391

LIQUID TREATMENT APPARATUS FOR PHOTOPOLYMER SHEET MATERIAL

Filed Jan. 23, 1958 5 Sheets-Sheet 1

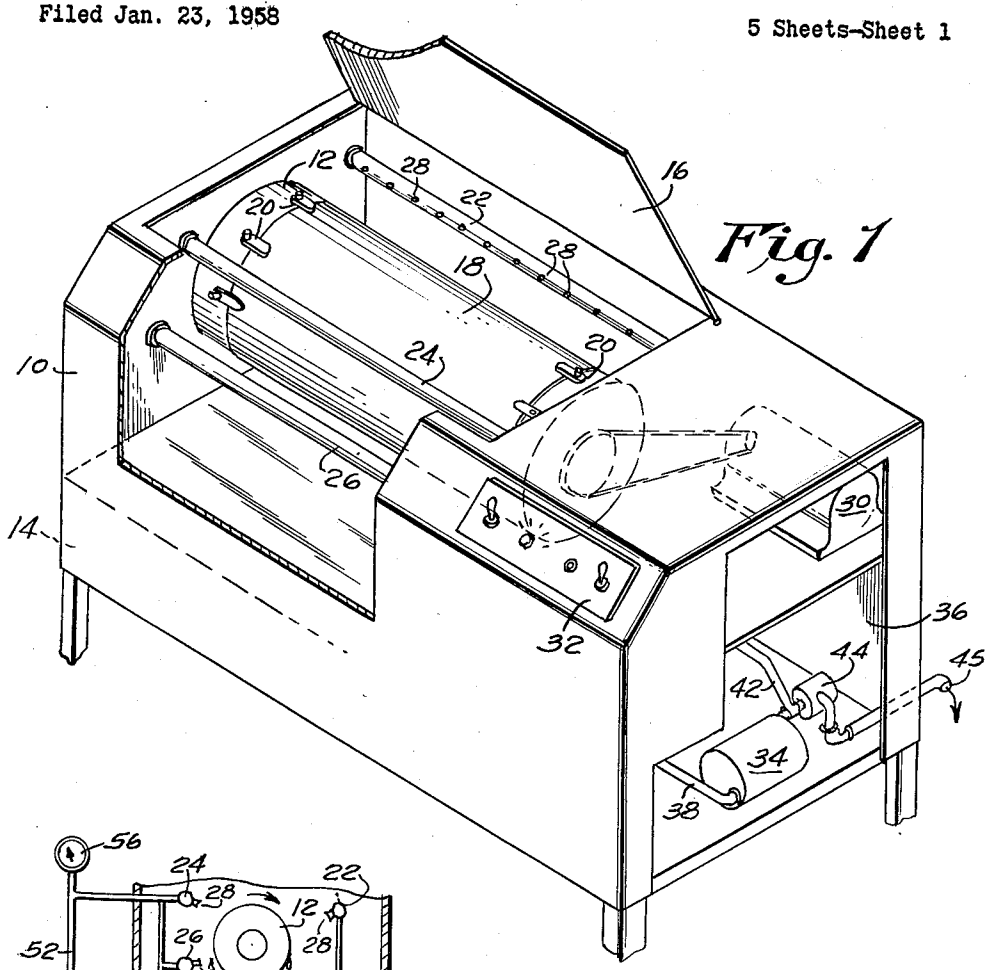


Fig. 1

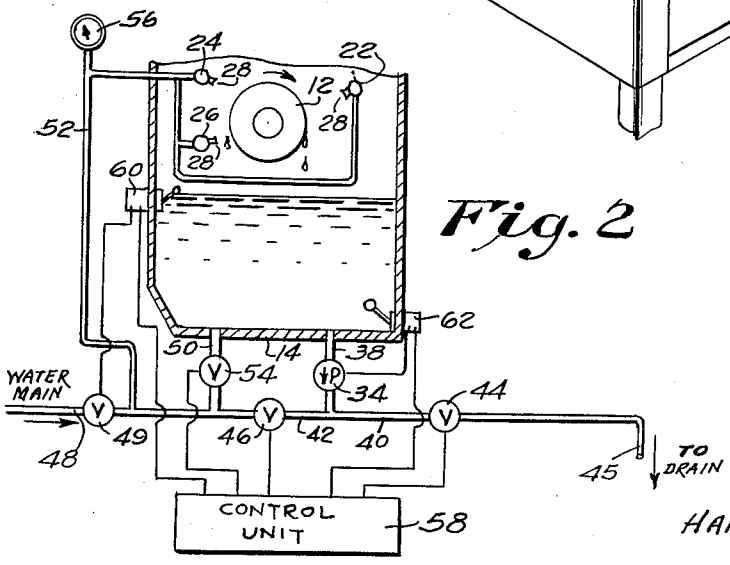


Fig. 2

HAROLD SIGLER
INVENTOR.

BY

Homer L. Montague
ATT'Y.

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LIQUID TREATMENT APPARATUS FOR PHOTOPOLYMER SHEET MATERIAL

Filed Jan. 23, 1958 5 Sheets-Sheet 2

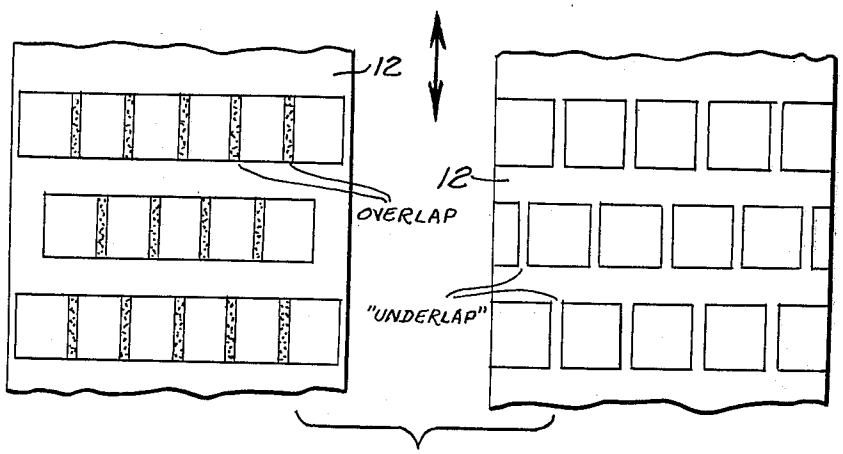


Fig. 3

	OFF	WATER FILL	LOAD	SPRAY	RINSE	DRAIN
VALVE 44	CLOSED	CLOSED	CLOSED	CLOSED	OPEN	OPEN
VALVE 46	"	"	"	OPEN	CLOSED	CLOSED
VALVE 49	"	OPEN	"	CLOSED	OPEN	"
VALVE 54	"	"	"	"	CLOSED	"
MOTOR 30	OFF	OFF	OFF	ON	ON	OFF
PUMP 34	OFF	OFF	OFF	ON	ON	ON

Fig. 4

HAROLD SIGLER
INVENTOR.

BY
Homer R. Montague
ATT'Y.

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LIQUID TREATMENT APPARATUS FOR PHOTOPOLYMER SHEET MATERIAL

Filed Jan. 23, 1958 5 Sheets-Sheet 3

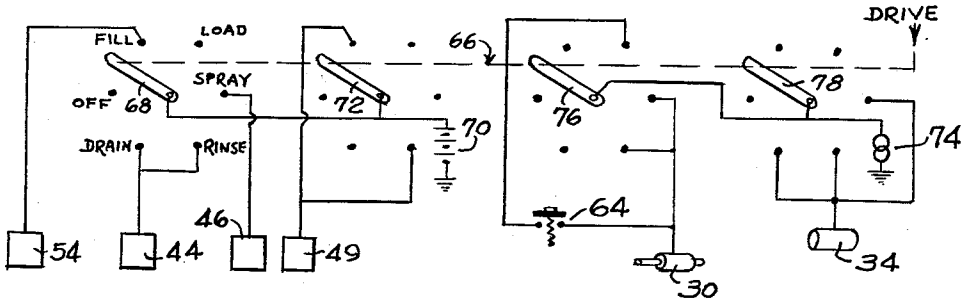


Fig. 5

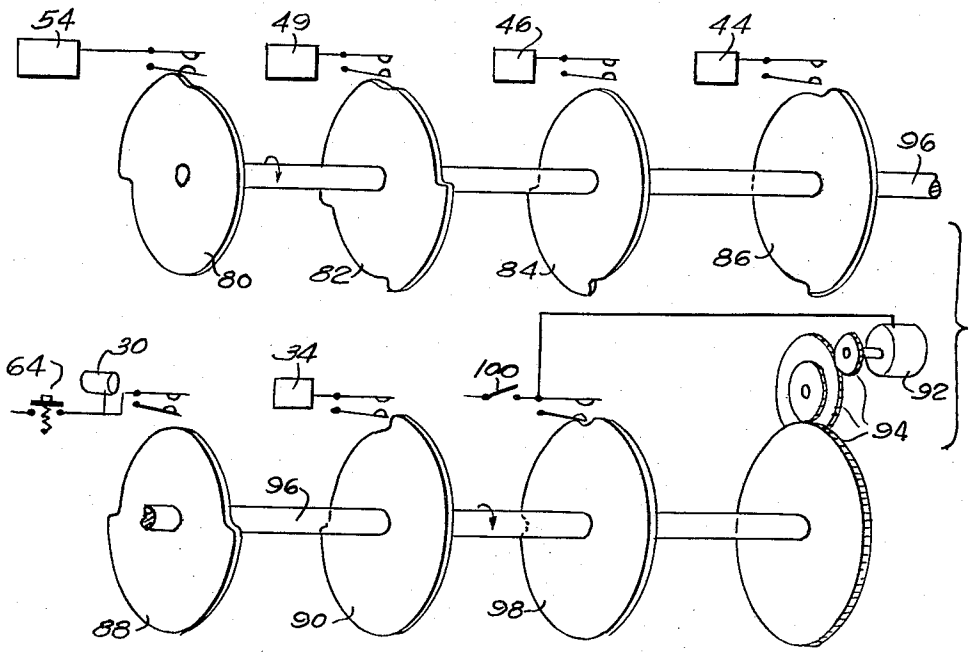


Fig. 6

HAROLD SIGLER
INVENTOR.

BY
Homer R Montague
ATT'Y.

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LIQUID TREATMENT APPARATUS FOR PHOTOPOLYMER SHEET MATERIAL

Filed Jan. 23, 1958 5 Sheets-Sheet 4

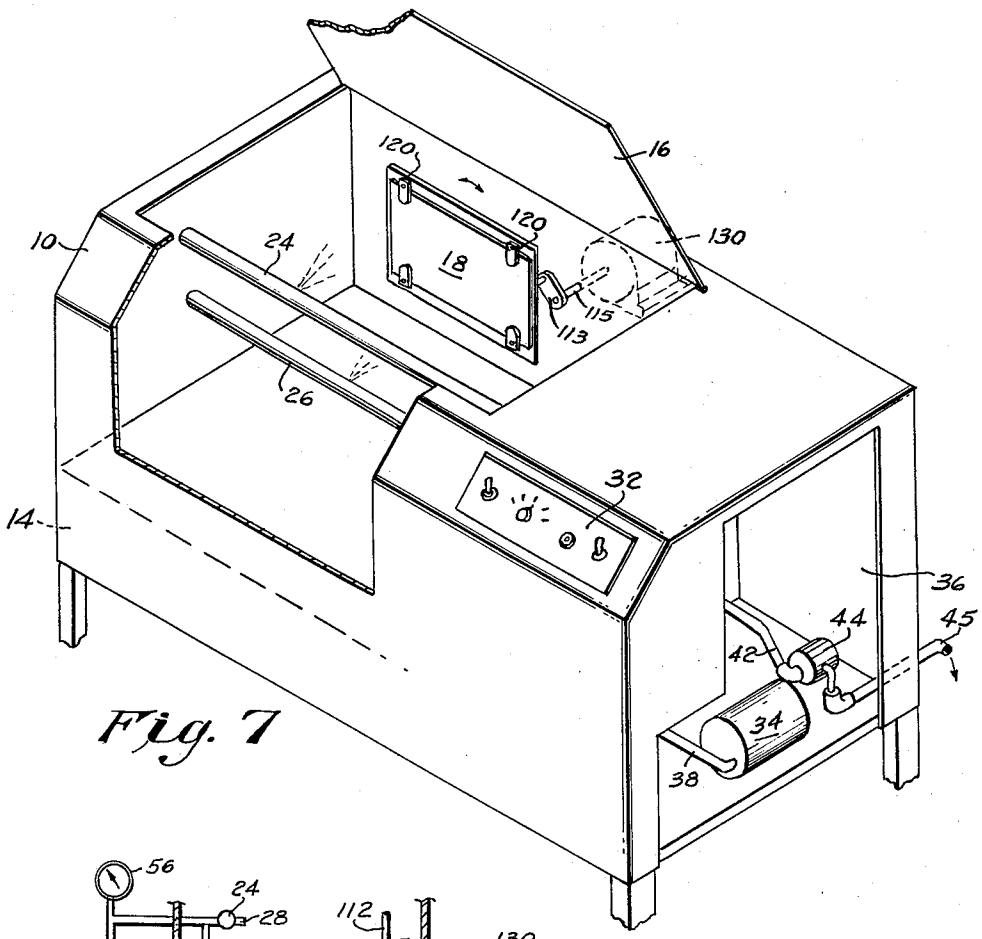


Fig. 7

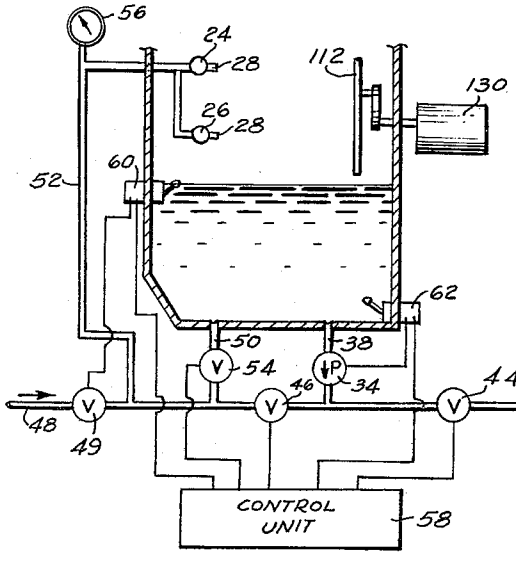


Fig. 8

HAROLD SIGLER
INVENTOR.

BY
Homer R. Montague
ATT'Y.

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LIQUID TREATMENT APPARATUS FOR PHOTOPOLYMER SHEET MATERIAL

Filed Jan. 23, 1958 5 Sheets-Sheet 5

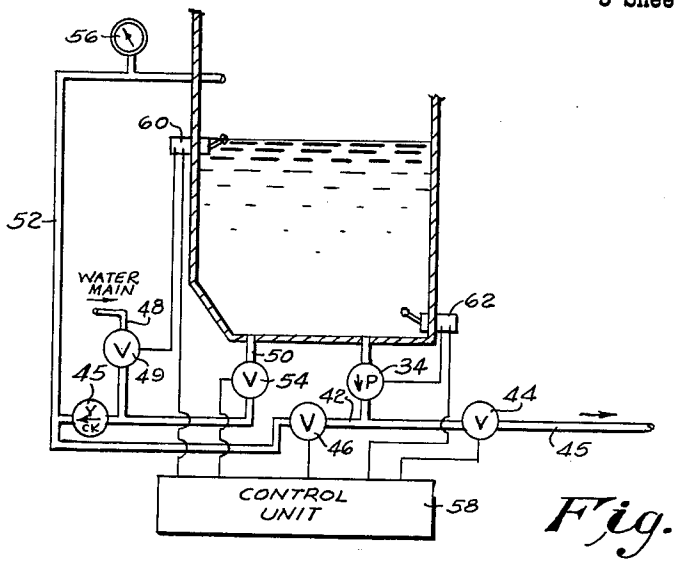


Fig. 9

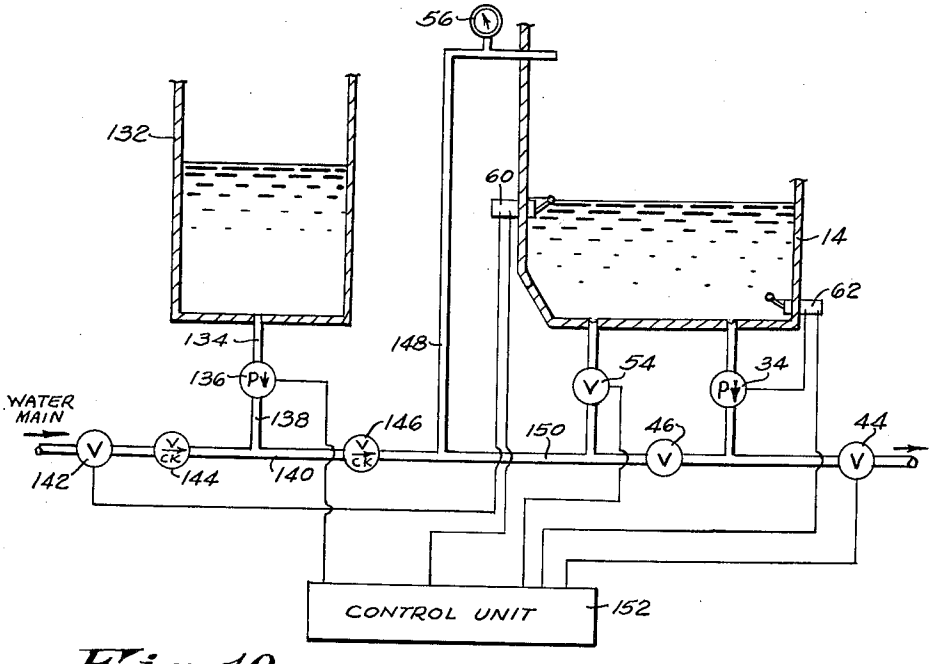


Fig. 10

HAROLD SIGLER
INVENTOR.

BY
Homer R. Montague
ATT'Y.

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3,088,391

LIQUID TREATMENT APPARATUS FOR PHOTOPOLYMER SHEET MATERIAL

Harold Sigler, Brooklyn, N.Y., assignor to Fairchild Camera and Instrument Corporation, a corporation of Delaware

Filed Jan. 23, 1958, Ser. No. 710,774
13 Claims. (Cl. 95—93)

This invention pertains to apparatus for the liquid treatment of sheet material and the like, and more particularly to an apparatus in which the material to be treated is subjected to a spray of one or more liquids or mixtures thereof. As will be preferred in most of the applications of the apparatus of my invention, the operation may be carried out automatically under control of pre-set means which determine the sequence and timing of the several phases of such operation.

While the apparatus of this invention may be employed in numerous different applications wherein it is desired to spray selected liquids against a surface of a sheet-like material, the invention will be described in connection with a particular application akin to the well-known processes of acid etching in the formation of metallic printing plates in the photo engraving art. As is known, the preparation of a metallic photoengraved plate includes the coating of an acid-soluble metal plate (such as magnesium or the like) with a light-sensitive coating. The coated surface is exposed to a suitable light source through a negative or other master having an image therein corresponding to the image that is desired to be engraved on the metal plate. Such exposure and the subsequent development of the light-sensitive coating result in an acid-resistant coating on the metal plate corresponding to the desired image. An etchant, usually a nitric acid solution, is then sprayed, splashed or otherwise directed against the surface of the plate to attack and eat away the metal of the plate except where it is protected by the resist. As the etching proceeds, the photoengraved image appears in vertical relief in the surface of the metal plate. After a satisfactorily deep etch is thus made, the resist is removed by a suitable wash, and the engraved plate is ready for use in any of several printing or duplicating processes.

A relatively new advance in the art of photoengraving is the use of sheet photopolymer material instead of the metal plate and its photosensitive coating. Such photopolymer materials as are here referred to are characterized by their ability to be locally hardened by the action of actinic rays such as of light or ultraviolet radiation. These materials, of which the prior art affords many examples, can be exposed to a light source through a negative or other suitable master to produce selective local hardening in accordance with the master image, and can thereafter be developed as by washing out the unhardened portions to produce a relief image suitable for matting or even for direct surface printing by letterpress, offset or other familiar printing techniques. It is the use of such photopolymer materials in sheet form to which the following description of the apparatus of the invention will be directed. However, the present invention is not limited thereto, and may be utilized in any of several other applications wherein a piece of sheet material is to be subjected to a spray of one or more liquids or mixtures thereof, as opposed to mere sequential immersion. It will be appreciated that

where the liquid treatment is achieved by means of a directed spray rather than by sequential immersion in a plurality of tanks holding different liquids or by sequential filling of a single tank by different liquids, considerably more difficulty is encountered in obtaining uniform exposure to the liquid from point to point over the surface of the material to be treated.

It is accordingly a primary object of the present invention to provide an apparatus for the liquid treatment of sheet material wherein such sheet material is subjected to a liquid spray.

Another object of the invention is to provide an apparatus for the liquid treatment of sheet material in which relative motion is imparted to the sheet and the source of a liquid spray directed toward the sheet.

An additional object of the invention is to provide an apparatus for the liquid treatment of sheet material wherein such sheet material is subjected to a liquid spray which originates at a plurality of spray nozzles so interrelated as to effect substantially uniform coverage of the entire area to be sprayed.

Yet another object of the invention is to provide an apparatus of the above type in which the sprayed liquid is recaptured for recirculatory spraying.

Still another object of the invention is to provide an apparatus of the above type including a plurality of sources of different liquids, and automatic means for spraying the sheet material in a predetermined time sequence selectively from such plural sources.

In accordance with one form of the present invention, the above and other objects are achieved by means of an apparatus including a housing which contains a rotary drum and a plurality of associated spray heads. Means are provided on the drum for clamping thereto the sheet to be treated, and a motor rotates the drum so that each element of the area to be exposed passes through the spray from the nozzles of each of the spray heads. An open-top tank is situated below the rotary drum so that the liquid sprayed against the sheet on the drum is recaptured. By means of a pump and a plurality of valves which are automatically selectively operated, the spray heads may be connected with a water main to supply fresh water to the spray nozzles, or alternatively the spray heads may be connected to a drain in the tank for recirculation of the liquid in the tank.

In the particular application to which the description below is directed, a caustic in the form of a powder, crystals or liquid concentrate is added to the water in the tank and the caustic solution is then recirculated through the spray heads. After a suitable time lapse, the automatic control means causes the caustic solution to drain from the tank, and the fresh water main is connected to the spray heads to wash the sheet on the rotary drum prior to removal therefrom.

In another form of the invention, the aforementioned rotary drum is replaced with a movable flat support plate which is connected to an eccentric drive means to provide orbital motion of the plate in its own plane. As before, the sheet to be treated is clamped to the movable support, the flat plate in this case, and the spray is directed toward the sheet in a manner which effects substantially uniform coverage of the area to be treated.

Also, an alternative form of liquid flow may be utilized in which the caustic is in the form of a liquid concentrate

in an auxiliary tank, and metered quantities thereof are introduced into the water stream passing to the spray heads.

With the above considerations and objects in mind, the invention itself will now be described in connection with a preferred embodiment thereof given by way of example and not of limitation, and with reference to the accompanying drawings, in which:

FIG. 1 is a perspective view, partly broken away for the sake of clarity of description, of the apparatus of the invention as a whole showing the general relationship between the several components thereof.

FIG. 2 is a schematic representation of the apparatus of the invention, showing the manner in which the several components thereof are interconnected.

FIG. 3 is a view of portions of the surface of the drum shown in FIGS. 1 and 2, showing two alternate spray patterns.

FIG. 4 is an operational chart explanatory of the sequence of operation of the apparatus shown in FIG. 2.

FIG. 5 is a wiring diagram of one form of the control means shown in FIG. 2.

FIG. 6 is a schematic diagram of an alternate form of the control means shown in FIG. 2.

FIG. 7 is a perspective view, partly broken away for the sake of clarity of description, of the apparatus of the invention as a whole and showing a sheet-support and drive means therefor alternative to that of FIG. 1.

FIG. 8 is a schematic representation of the apparatus of the invention similar to FIG. 2 but showing the alternative sheet-support of FIG. 7.

FIG. 9 is a schematic of a fluid-flow structure slightly different from and alternative to that of FIGS. 2 and 8.

FIG. 10 is a schematic of still another fluid-flow structure alternative to those previously shown.

Referring now to FIG. 1 of the drawings, the general arrangement of the apparatus is shown. Numeral **10** designates a casing or housing in which are contained the electrical circuit elements and liquid-carrying pipes required by the machine, and which serves as a support for the rotary drum **12** and the open top tank **14**. The hinged lid **16** forms a part of the top of housing **10** and, when in the position shown, affords access to drum **12** in order that a sheet **18** of the material which is to be treated may be secured thereon by means of clamps **20** or any other suitable means for releasably clamping the sheet to the drum. A plurality of spray heads **22**, **24** and **26** are shown positioned substantially parallel to the surface of drum **12** and extending the approximate length of the drum. Associated with each of the spray heads, which may as a matter of convenience be fastened to the inner sides of housing **10** as by brackets or the like, are a plurality of spray nozzles **28**. These nozzles may either form an integral part of the respective spray heads or may alternatively be removably secured thereto. As may be seen in both FIG. 1 and FIG. 2, nozzles **28** are positioned so as to direct a spray against the near surface of drum **12** when the several spray heads are filled with a liquid under pressure as will be described.

Drum **12** is caused to rotate by means of a motor **30** which may be directly connected thereto or by a gear reduction system not shown. As the drum is thus rotated, each line-element of the area of the sheet which is secured to the cylindrical surface of drum **12** passes through the areas of spray from each of the spray heads. Obviously, a greater or lesser number of spray heads than shown may be provided in accordance with the particular needs pertaining to a given application of the apparatus of this invention.

A control panel **32** is provided at the front of housing **10** for inclusion therein of the controls and indicator elements pertaining to the operation of the apparatus as will presently be described. A pump **34**, which may be of any suitable type for the pumping of liquids through the system of pipes forming a part of the invention, is seen within the compartment **36** along with motor **30**. The side panel of this compartment is shown removed in FIG. 1.

The manner in which the several liquid-carrying lines or pipes interconnect spray heads **22** through **26** with pump **34** and tank **14** may be better understood by referring to FIG. 2, wherein the input port of pump **34** is connected to a drain in the bottom of tank **14** by means of drain pipe **38**. The output port of pump **34** communicates with a recirculation pipe **42** and with an exhaust pipe **40**, the latter terminating in an exhaust port **45**. A normally closed electromagnetic valve **44** is inserted in exhaust pipe **40**, as is a similar electromagnetic valve **46** in recirculation pipe **42**.

A plurality of fill pipes **48**, **50** and **52** comprise the remainder of the liquid-carrying pipe system of the invention. In particular, fill pipe **48**, which includes a normally closed electromagnetic valve **49**, communicates between a water main (not shown) and fill pipes **50** and **52**. Fill pipe **50** is connected to a port in tank **14** and includes a normally closed electromagnetic valve **54**, while fill or spray head pipe **52** leads to the several spray heads **22** through **26**. If desired, a liquid pressure gauge **56** may be included in spray head pipe **52** in order that the operator of the apparatus may make certain that the pressure applied to the several spray heads is within an acceptable range. To aid in the control of this pressure, an adjustable valve (not shown) may be included in spray head pipe **52**.

Depending upon the sequence of energization of the several electromagnetic valves referred to above, fresh water may be supplied through fill pipes **48** and **50** to fill the tank with water to a desired level, or the fresh water may be directed from fill pipe **48** up into fill pipe **52** to be supplied to the several spray heads **22** through **26**. Where it is desired to recirculate the liquid in tank **14** through these spray heads, the fresh water supply may be cut off, and the liquid in the tank is drained out by means of pump **34** and conveyed through recirculation pipe **42** and fill pipe **52** to the spray heads. Finally, when the treatment of the sheet material clamped to drum **12** is completed, the liquid in tank **14** may be drained by means of pump **34** and its connection with a drain (not shown) by means of exhaust pipe **40**.

The sequence in which these valves are energized and de-energized is determined by the control unit **58** in conjunction with the liquid-level-sensing electric switches **60** and **62**. As may be seen in FIG. 2, each of the aforementioned electromagnetic valves is connected in an electric circuit with the control unit **58**. Only one side of the circuit for each of these valves is shown, it being understood that the return portion of each circuit may be made by a separate conductor or, and more conveniently, by means of a common ground in the frame of the apparatus as is well understood in the electrical art. Liquid level switch **60** is included in the control circuit of valve **49** and serves as a maximum level control. Switch **62**, on the other hand, serves as a minimum level control and is included in the control circuit of pump **34**. These two switches operate, respectively, to close valve **49** when the liquid level reaches switch **60** and to de-energize pump **34** when the level drops to switch **62**. The reason for the maximum level control is quite apparent, while that for the minimum level control is based upon the fact that many of the liquid pumps which are suitable for this particular application should not be run dry. By means of switch **62**, pump **34** is de-energized before the supply of liquid in drain pipe **38** is exhausted.

Before referring to the operational sequence of the apparatus in connection with the particular application chosen for purposes of illustration, as well as to the means for effecting same, reference will first be made to FIG. 3 and the nature of the individual spray nozzles **28**. In the interests of providing a uniform spray from these nozzles, a preferred form of spray to be produced thereby is that

of a solid cone or pyramid, as opposed to the commonly known hollow spray configuration as is produced by the nozzle usually found attached to a garden hose or the like. It is obvious that a solid form of spray applies liquid more uniformly to a greater area, other parameters being equal, than does a hollow form. Also for the sake of uniformity, a preferred form of spray is that in which the cross-section transverse to the direction of propagation is a square, the spray thus being a square pyramid. However, a fan-shaped spray having a rectangular cross-section with the longer dimension thereof parallel to the axis of the drum is also acceptable.

In the utilization of such solid sprays, it has been found that where adjacent nozzles on a given spray head are so relatively positioned that the sprays emanating therefrom tend to produce contiguous areas of spray on the surface under treatment, there is an interference between the adjacent sprays, and the result is usually an area between the two in which few, if any, high velocity spray droplets strike the surface to be treated In order to ensure the exposure to high velocity spray droplets of the entire area of the sheet clamped to drum **12**, the positions of the nozzles **28** on the several spray heads are staggered, as is indicated in FIG 3. Shown in this figure are two alternative forms of spray patterns, either of which may be used with equal success. In each of the representations of FIG. 3, a portion of the drum surface **12** has been flattened to show the pattern which would be laid down by the several nozzles of the three spray heads shown in FIGS. 1 and 2. It will be understood that the patterns shown would have been obtained while the drum **12** was stationary, rather than rotating as would normally be the case. In the one case the spray patterns effected by adjacent nozzles on a given spray head are deliberately overlapped to produce the aforementioned areas of interference; the spray areas effected by the nozzles of another and realtively staggered spray head are each approximately centered over one of the interference areas so as to effectively spray such area upon rotation of drum **12**. In the other case, the spray patterns effected by adjacent nozzles on a given spray head are "underlapped" or separated by areas to which no spray is directed; as before, the spray areas effected by the nozzles of another relatively staggered spray head are each substantially centered over one of the areas of "underlap" so as to effectively spray such area upon rotation of drum **12**.

Since the liquid treatment which forms the subject matter of the particular application chosen for purposes of illustration in this disclosure actually consists of a "washout" rather than a true etching, the amount of exposure of sheet **18** to the spray is relatively less critical. As long as each element of area thereon has received a sufficient amount of spray, the fact that other areas have received more spray exposure is, within limits easily tolerated, of little consequence. Thus, the spray patterns shown in FIG. 3 are instrumental in providing at least enough spray exposure to all areas of the sheet **18**, with some areas receiving more than enough.

Referring now to FIG. 4 of the drawings, the sequence of operation of the several elements of the apparatus of the invention is shown in chart form. The left-most column includes a designation of each of the electromagnetic valves referred to above, and also the motor **30** and pump **34**. In each of the rows corresponding to these several designations, the operational condition of the respective components is indicated in columnar lines for each of a plurality of steps in the operation of the apparatus of the invention. Specifically, before the apparatus is energized, valves **44**, **46**, **49** and **54** are in their normal closed state, and motor **30** and pump **34** are de-energized. Upon initiation of the operation of the apparatus, as by operating a main power switch or the like, valves **49** and **54** are opened to allow fresh water to fill the tank **14** to the level of switch **60**, at which level the latter will operate to de-energize and close valve **49**.

Once the tank **14** is filled with water, the controls again assume the positions pertaining to the "off" condition, with the exception that a manually operable switch **64** (shown only in FIGS. 5 and 6 and further referred to in connection with those figures) may be utilized to "inch" the drum **12** around a single turn or a portion thereof as the sheet **18** is being secured. Also during this step, termed "load" in FIG. 4, the caustic or other material with which sheet **18** is to be treated is added to the water in tank **14**. When this is completed, the automatic operation may be resumed.

During the "spray" cycle, both pump **34** and motor **30** are energized along with valve **46**, which is thus opened to allow recirculation of the caustic solution from tank **14** through recirculation pipe **42**, fill pipe **52** and spray heads **22**, **24** and **26**. After a predetermined time the "spray" cycle terminates and the "rinse" commences. In the latter cycle, motor **30** and pump **34** remain energized, but valve **46** is closed and valves **44** and **49** are opened. The respective results of the opening of these valves are to initiate the emptying of tank **14** by means of drain pipe **38**, pump **34** and exhaust pipe **40**, and the application of fresh water under the main pressure to spray heads **22** through **26** to rinse the caustic solution from sheet **18**. Due to the fact that the pressure produced at pump **34** is greater than that of the water main, the liquid in tank **14** does not tend to overflow, but rather drops in level as the rinse is accomplished.

The remaining cycle in the operation of the apparatus is that of draining the liquid remaining in tank **14** after the "rinse" cycle is completed. During this cycle, valve **44** remains open, and pump **34** remains energized to pump the remaining liquid therethrough. Since rotation of drum **12** is no longer necessary, motor **30** is de-energized in this cycle. This also allows removal of sheet **18** from the drum at this time.

It will be understood by those skilled in the art that the foregoing procedural steps are merely exemplary, and several changes may be effected therein within the scope of the inventive concept of the present invention. For example, the "load" cycle, while perhaps a convenience in some applications, may prove unnecessary, since loading of the machine with the sheet material to be treated and with the caustic or other agent may be accomplished with the apparatus in the "off" cycle. Thus, the "load" cycle may be eliminated. Also, the "water fill" cycle may immediately follow the "drain" cycle where it is desirable to re-fill the tank with fresh water at the conclusion of the processing of a given piece of sheet material. Thus, the spent solution is drained out of the tank, and fresh water is brought into the tank to make the apparatus ready for more immediate use in the processing of a subsequent piece of the sheet material.

Having described the over-all structure of a preferred form of the apparatus of the present invention, as well as the operation thereof, reference will now be made to two alternative forms of the control unit indicated generally by the numeral **58** in FIG. 2. The first of these is shown in FIG. 5, wherein a six-position rotary switch indicated generally by numeral **66** comprises four decks with a wiper arm and six stationary contacts for each deck. Reading from the left in this diagram, wiper arm **68** serves to connect a suitable source of current indicated at **70** sequentially to valve **54**, valve **46** and valve **44** as switch **66** is operated clockwise through the six positions corresponding to the six operational cycles indicated as column headings in FIG. 4. As may be seen, valve **54** is energized only during the "fill" cycle, valve **46** is energized only during the "spray" cycle, and valve **44** is energized during both the "rinse" and "drain" cycles. Similarly, wiper arm **72** connects source **70** to valve **49** during the "fill" and "rinse" cycles.

Wiper contact arm **76** connects a suitable source **74** of electrical power (preferably an alternating current source for connection to motor **30** and pump **34**) directly

to motor **30** in the "spray" and "rinse" cycles, while the connection between source **74** and motor **30** during the "load" cycle depends upon the closing of manually operable switch **64**. As previously stated, switch **64** serves to "inch" drum **12** through all or a portion of a revolution to allow sheet **18** to be secured thereto. Contact arm **78** connects source **74** to pump **34** during the "spray," "rinse" and "drain" cycles. While not shown in FIG. 5, means such as a suitable motor and gearing arrangement may be provided for effecting the automatic advancement of rotary switch **66** through its several positions in proper sequence. Alternatively, switch **66** may be manually operated by a suitable knob on control panel **32**. In either case, whether the operation proceeds automatically or manually, the selection of the valves and other components which are to be operated during a given cycle is predetermined and automatically effected by the circuit connections shown in FIG. 5.

As an alternative to the control unit components shown and described in connection with FIG. 5, the cam-operated switches of FIG. 6 may be employed. By the proper phasing of the relative rotational positions of the operating or raised portions of the cam surfaces of cam wheels **80** through **86**, the desired operational sequence as heretofore described is obtained in the energization of valves **44**, **46**, **49** and **54**. Similarly, the aforementioned sequential operation of motor **30** and pump **34** is obtained by means of the proper relative rotational positioning of the cam surfaces of cam wheels **88** and **90**. As in the previously described form of control unit, manually operable switch **64** may be operated to aid in securing sheet **18** to drum **12**.

A cam motor **92** is included in the alternative form of control unit shown in FIG. 6 in order to provide motive means for producing the required rotation of the several cam wheels just described. Through suitable gearing indicated generally by numeral **94**, such rotation is transmitted to cam shaft **96** under the control of cam **98**. This latter cam has two points at which its associated switch is permitted to open, viz., at the "off" position and during the "load" cycle. In order to restart cam motor **92** after either of these two positions has been reached, an additional manually operable switch **100** is provided. It will be understood that while the power source or sources for the several valves, motors and the pump are not shown in FIG. 6, the description of FIG. 5 serves to illustrate the manner of providing an operating voltage in each of the circuits associated with the cam switches in FIG. 6.

FIG. 7 shows the apparatus of the invention in a manner similar to that of FIG. 1, but with an alternate form of the sheet-supporting means. Here, instead of the drum **12** with the associated clamps **20**, the sheet **18** is placed on a flat plate **112** and is secured thereto by means of clamps **120**. The rotary shaft **115** of motor **130** has a crank arm **113** secured thereto, and the latter is connected to plate **112** by a suitable pin or the like as shown. Plate **112** is supported at a plurality of additional points by suitable means not shown to effect orbital or eccentric motion of the plate upon rotation of motor shaft **115**. An example of such support means is a plurality of pins perpendicularly mounted in the back side of plate **112** for relative rotation therewith, the pins each being mounted on a rotary disc which is parallel to the plate and which provides a radius of circular motion for each of the pins equal to the radius arm of crank **113**.

As may be seen in FIG. 8, spray nozzles **28** of spray heads **24** and **26** are directed toward plate **112** so as to spray the near surface thereof (or a sheet thereon) in a manner similar to that of FIGS. 1 and 2. Spray heads **24** and **26** are preferably positioned at equal distances from plate **112**, and the spray pattern of the several nozzles may readily take either of the forms shown in FIG. 3. The relative spacing of the areas sprayed by the spray heads is chosen in accordance with the length of the crank arm **113** in such manner as to effect over-all coverage of the sheet to be treated as discussed in connection with FIG. 3. The criterion necessary for satisfactory results is that, as before, each element of the area to be treated must pass substantially centrally through the spray pattern of at least one of the several spray heads. That is to say, since each of the elements of such area must be exposed to high velocity spray droplets, plate areas which initially pass through the aforementioned zones of interference in the spray pattern must also pass through zones which are free of the interference caused by adjacent spray nozzles.

Other than as described in the two preceding paragraphs, the apparatus of FIGS. 7 and 8 is substantially the same as that of FIGS. 1 and 2, and like elements are identified by identical reference numerals. Similarly, the two forms are alike in operation, except as just described.

FIG. 9 shows an alternative form of the liquid supply piping of FIGS. 2 and 8, the difference lying in the fact that recirculation pipe **43** is connected directly back to spray head pipe **52** in FIG. 9, whereas recirculation pipe **42** in the former figures has a portion in common with fill pipes **48** and **50**. Also, check valve **45** serves to further isolate recirculation pipe **43** from the water main **48**. The operation of this form of the supply structure is the same as that previously described for the first-disclosed structure.

The apparatus of FIG. 10 is similar to those of FIGS. 2, 8 and 9 in that it provides recirculatory operation, but it also affords a continuous flow operation. To the extent that the elements of FIG. 10 are employed solely for recirculatory operation, the same reference numerals are used as were present in the previous figures. Among the newly added elements are the tank **132** in which is contained a liquid concentrate form of the caustic or other agent to be employed in the wash process. A drain pipe **34** communicates with the bottom of tank **132** and is connected to the input of a metering pump **136**, whose output connection **138** joins a fill pipe **140** as shown. Fill pipe **140** is connected at one end to a water main or other suitable source of fresh water. A valve **142** in fill pipe **140** serves to shut off the flow of water from the main when the valve is closed. Suitable check valves **144** and **146** are also included in fill pipe **140**, respectively preventing the caustic from entering the water main and providing an isolating means for recirculatory operation to prevent the application of the recirculation pressure to pump **136** in the reverse direction. The egress side of check valve **146** is connected to both the spray head pipe **148** and to the combined fill and recirculation pipe **150**.

In the operation of the apparatus of FIG. 10, it is obvious that the recirculatory portion functions in the manner described above in connection with FIG. 2, except that valve **142** replaces valve **49**. As to continuous flow operation, control unit **152** has an additional function over those of control unit **58** in that at the times when it is desired to introduce a caustic spray into the spray heads, valve **142** is opened and metering pump **136** is operated to mix metered amounts of the concentrate in tank **132** into the water stream flowing to spray head pipe **148**.

The invention has been described above in considerable detail, and particularly with reference to its application to the developing or "washing" of exposed sheets of photopolymer materials. However, it will be apparent to those skilled in the art that the invention is likewise applicable to any other process in which a sheet material is to be subjected to a spray of one or more liquids or mixtures thereof. Hence the invention is not to be considered as limited to the particular details given, nor to the specific application to which reference has been made during the description of the apparatus, except insofar as may be required by the scope of the appended claims.

What is claimed is:

1. An apparatus for the liquid treatment of sheet material, comprising a movable plate, means on said plate for releasably securing such sheet material to a surface thereof, means for orbitally moving said plate in its own plane, a plurality of elongate hollow spray heads substantially parallel to and substantially equally spaced from said plate, each of said spray heads having a plurality of spray nozzles of the type which emit a spray which is uniform in cross-section, the spray nozzles on each of said spray heads being relatively positioned to effect overlapping areas of spray on the said surface of said plate, the spray nozzles on the several spray heads being relatively positioned to effect a spray pattern in which each of the areas of overlap created between adjacent spray nozzles on a given spray head also passes substantially centrally through the area sprayed by a single spray nozzle of at least one of said spray heads upon said orbital motion of said plate, and means communicating between said spray heads and a source of liquid under pressure for delivering such liquid to said spray heads.

2. An apparatus for the liquid treatment of sheet material, comprising a movable plate, means on said plate for releasably securing such sheet material to a surface thereof, means for orbitally moving said plate in its own plane, a plurality of elongate hollow spray heads substantially parallel to and substantially equally spaced from said plate, each of said spray heads having a plurality of spray nozzles of the type which emit a spray which is uniform in cross-section, the spray nozzles on each of said spray heads being relatively positioned to effect areas of spray on the said surface of said plate separated by unsprayed areas, the spray nozzles on the several spray heads being relatively positioned to effect a spray pattern in which each of said unsprayed areas passes substantially centrally through the area sprayed by a single spray nozzle of at least one of said spray heads upon said orbital motion of said plate, and means communicating between said spray heads and a source of liquid under pressure for delivering such liquid to said spray heads.

3. An apparatus for the liquid treatment of sheet material, comprising a movable plate, means on said plate for releasably securing such sheet material to a surface thereof, means for orbitally moving said plate in its own plane, a plurality of elongate hollow spray heads substantially parallel to and substantially equally spaced from said plate, each of said spray heads having a plurality of spray nozzles of the type which emit a spray which is uniform in cross-section, the spray nozzles on the several spray heads being relatively positioned to effect a spray pattern in which areas on said surface of said plate defined by the near peripheries of adjacent areas of spray from a pair of spray nozzles on a given spray head each pass substantially centrally through the area sprayed by a single spray nozzle of at least one of said spray heads upon said orbital motion of said plate, and means communicating between said spray heads and a source of liquid under pressure for delivering such liquid to said spray heads.

4. In apparatus for the liquid treatment of sheet material, a movable support for the sheet material, means on said movable support for releasably securing such sheet material flat upon a surface thereof, a plurality of spray nozzles directed toward said surface, the spray nozzles being relatively positioned to effect solid areas of direct spray on the said surface separated by zones of non-uniform spray caused by the inter-relation of the spray patterns of adjacent spray nozzles, means for moving said support repetitively in a predetermined cyclical path such that each element of area of said sheet passes through at least one such solid area of direct spray at least once during each cycle, and means connecting said spray heads to a source of liquid under pressure for delivering such liquid to said spray heads.

5. Apparatus for the liquid treatment of a sheet of photopolymer material or the like, comprising a movable support for such sheet, means on said movable support for releasably securing the sheet flat upon a surface thereof, a plurality of spray heads mounted in spaced relation to one another and providing a plurality of solid spray nozzles directed toward said surface, the spray nozzles of each of said spray heads being relatively positioned to effect separate areas of direct spray on the said surface, means for moving said support cyclically in a predetermined path such that each element of area of said sheet passes through a direct spray area from at least one of said spray nozzles, and means connecting said spray heads to a source of liquid under pressure for delivering such liquid to said spray heads.

6. Apparatus as set forth in claim 5, in which the movable support for the sheet to be treated comprises a plate member and means for moving said plate member orbitally in its own plane.

7. Apparatus as set forth in claim 5, in which the means connecting said spray heads to said source of liquid under pressure includes an open-top tank positioned under said movable support, a fill pipe communicating between said tank and said source of liquid under pressure, a valve in said fill pipe, liquid pumping means having an input and output, a drain pipe communicating between said tank and said input, an exhaust pipe, a recirculation pipe communicating between said output and said spray heads, a valve in said recirculation pipe, and means for controlling the operation of said valves, said liquid pumping means, and said sheet support moving means, in a predetermined time sequence.

8. Apparatus as set forth in claim 7, in which said support moving means, said liquid pumping means and said valves are all electromechanical devices, and in which said controlling means comprises electrical switching means for connecting said electromechanical devices to a source of electrical power in said predetermined time sequence.

9. Apparatus as set forth in claim 8, in which said electrical switching means comprises a plurality of rotatable cams for operating said switching means.

10. Apparatus as set forth in claim 5, in which the movable support comprises a rotatable cylindrical support, and in which said spray nozzles are spaced from one another in staggered relation both circumferentially and in the axial direction of said support to effect said separate areas of direct spray on the surface of said support; and in which the means for moving said support comprises means for rotating said support about its own axis.

11. Apparatus in accordance with claim 4, in which the movable support comprises a rotatable cylindrical support, in which said spray nozzles are distributed lengthwise along at least one elongate hollow spray head positioned parallel to said support and extending substantially the axial length thereof, and in which the means for moving said support comprises means for rotating it about its own axis; a housing for said support and said spray head including an open-top tank positioned under said support, said connecting means comprising a fill pipe communicating between said tank and said source of liquid under pressure, a valve in said fill pipe, liquid-pumping means having an input and an output, a drain pipe communicating between said tank and said input, an exhaust pipe communicating between said output and an exhaust port, a valve in said exhaust pipe, a recirculation pipe communicating between said output and said spray head, a valve in said recirculation pipe, and means for controlling the operation of said valves, said liquid-pumping means and said support-rotating means in a predetermined time sequence.

12. Apparatus in accordance with claim 11, wherein said support-rotating means, said liquid-pumping means and said valves are all electro-mechanical devices, and said controlling means comprises electrical switching means for connecting such electro-mechanical devices to

at least one source of electric power in said predetermined time sequence.

13. Apparatus as set forth in claim 5, in which the movable support comprises a rotatable cylindrical support, in which said spray heads are elongate hollow spray heads positioned parallel to the surface of said support and each extending substantially the axial length thereof, the spray nozzles of the respective spray heads being relatively stepped axially of said cylindrical support; and in which the means for moving said support comprises means for rotating said support about its own axis.

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