Nov. 1, 1966 O. B. JOHNSTON ET AL 3,282,273

UNIFORM SPRAYING APPARATUS

Filed June 22, 1964 3 Sheets-Sheet 1

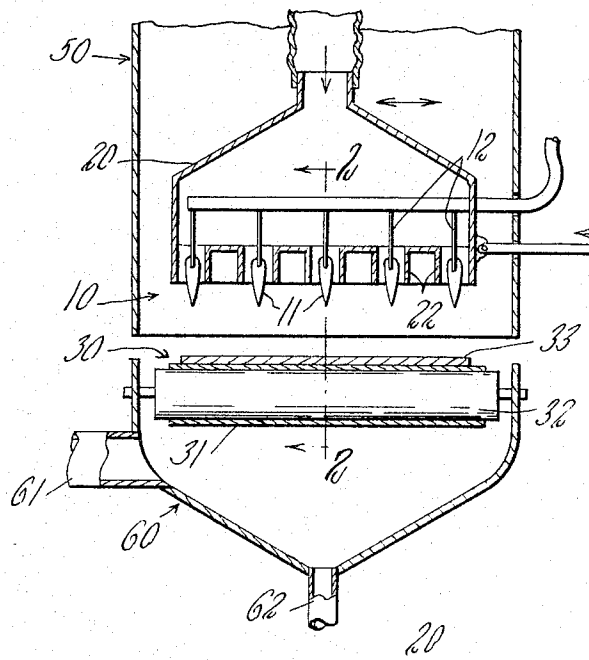


Fig. 1.

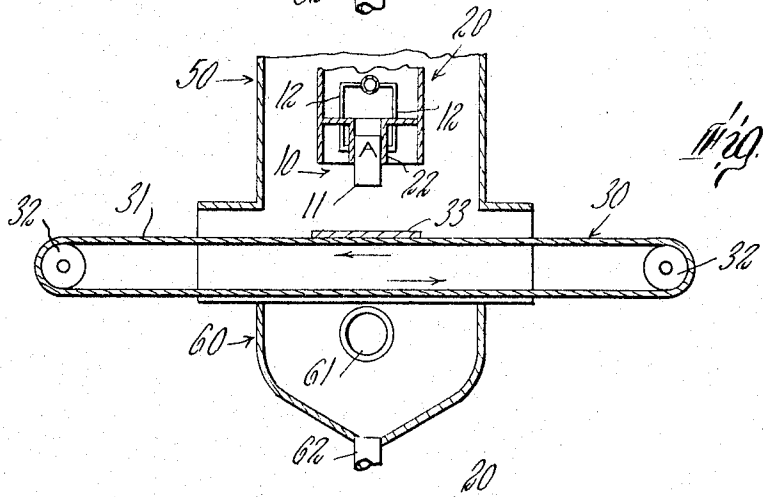


Fig. 2.

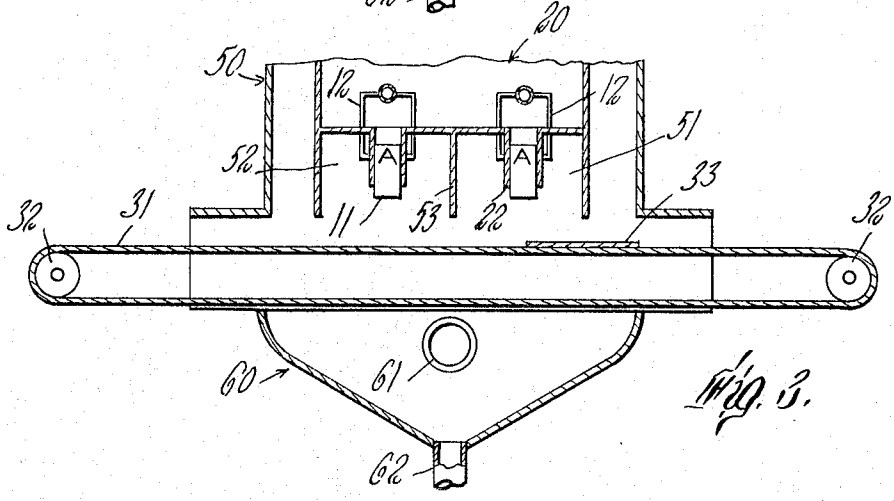


Fig. 3.

Nov. 1, 1966 O. B. JOHNSTON ET AL 3,282,273

UNIFORM SPRAYING APPARATUS

Filed June 22, 1964 3 Sheets-Sheet 2

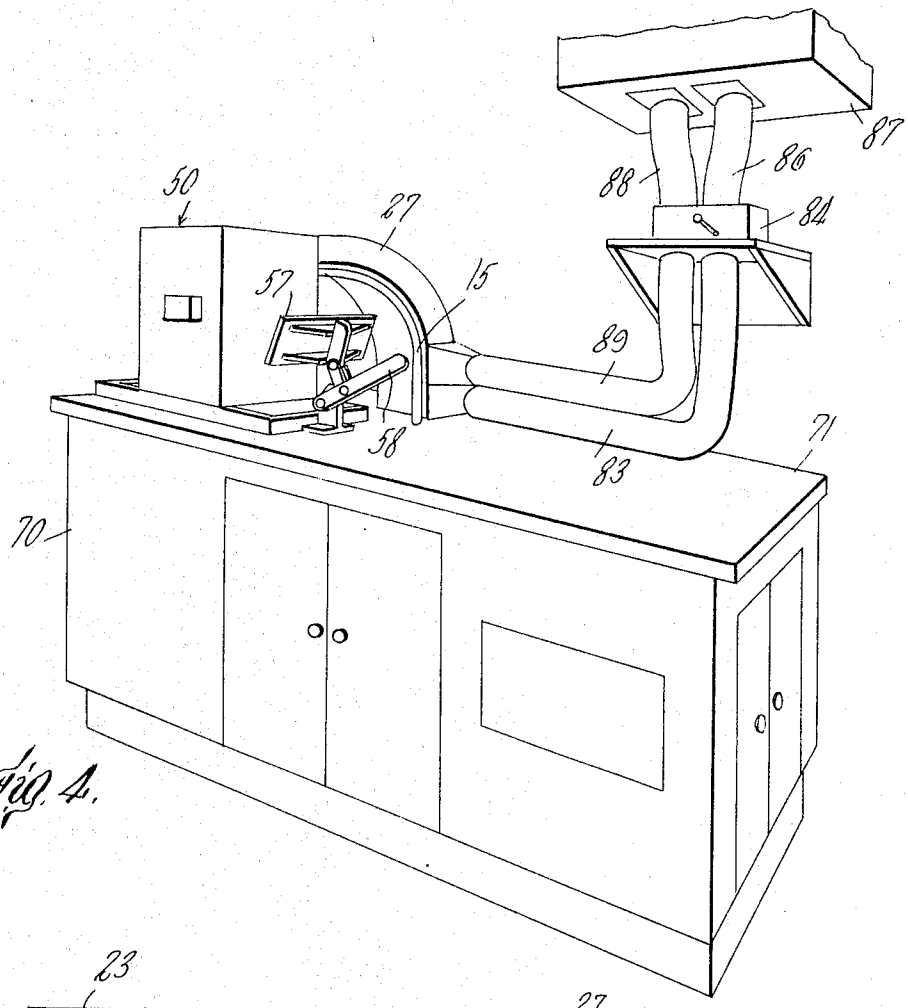


Fig. 4.

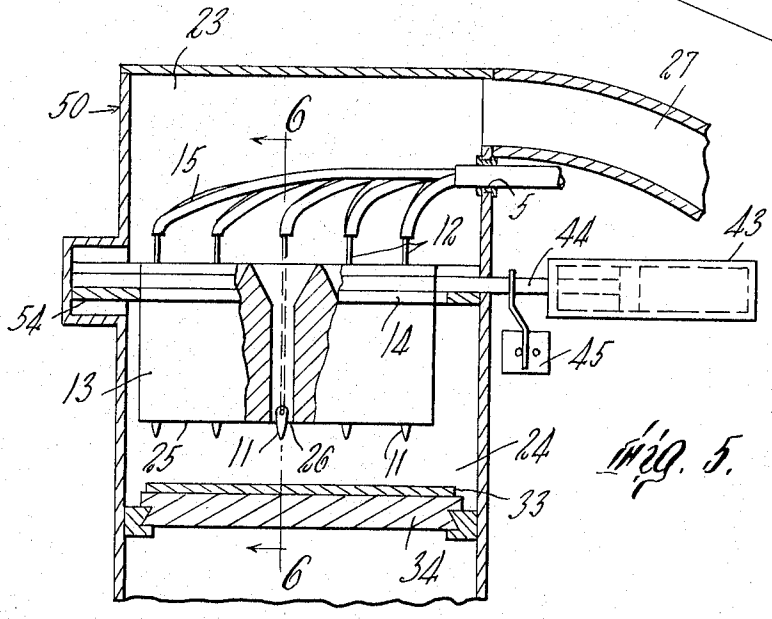


Fig. 5.

Nov. 1, 1966 O. B. JOHNSTON ET AL 3,282,273

UNIFORM SPRAYING APPARATUS

Filed June 22, 1964 3 Sheets-Sheet 3

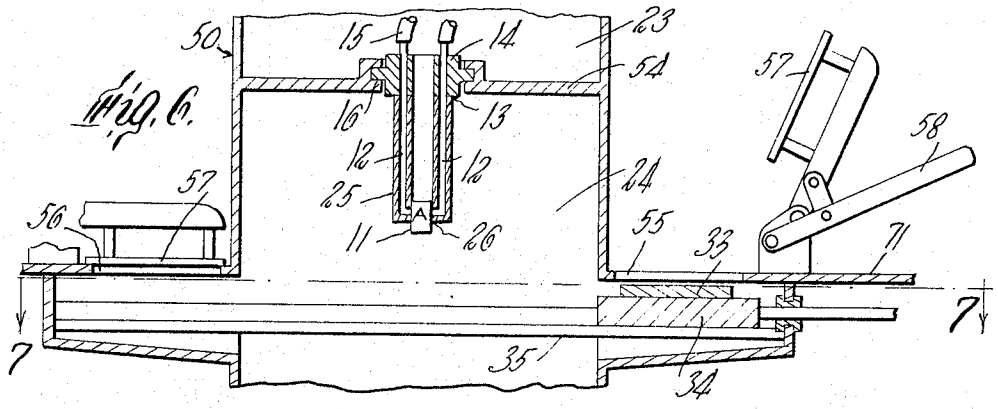


Fig. 6.

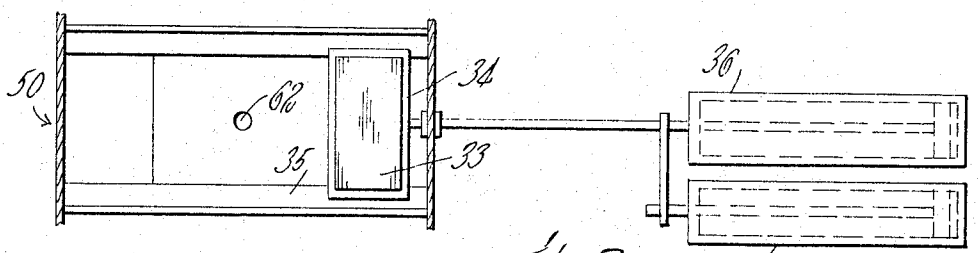


Fig. 7.

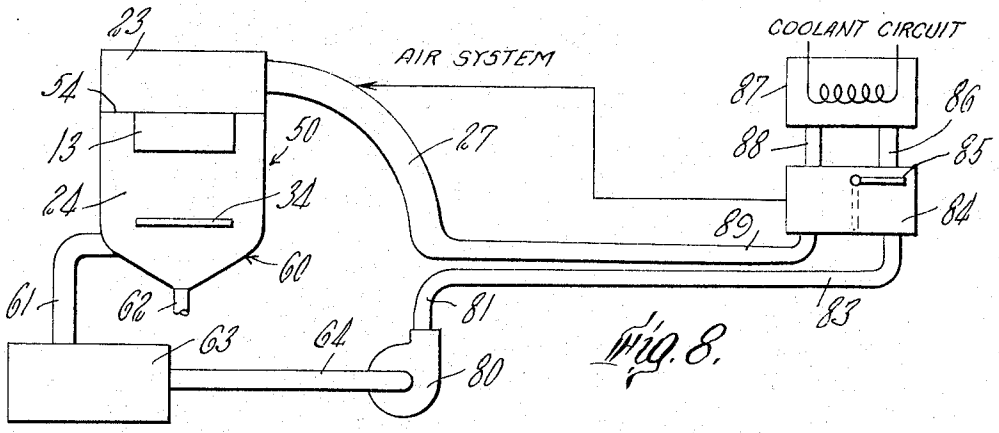


Fig. 8.

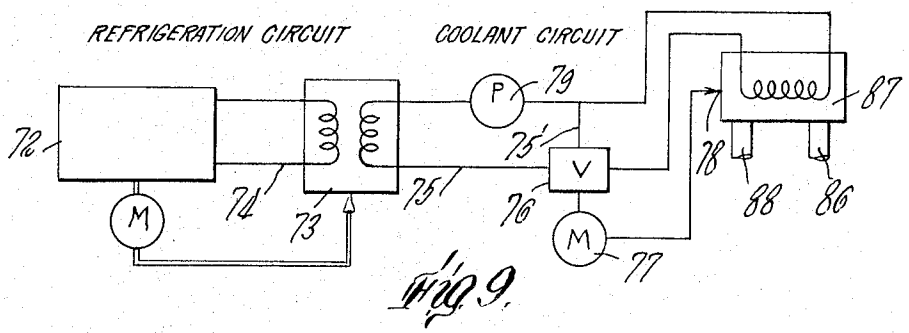


Fig. 9.

United States Patent Office 3,282,273 Patented Nov. 1, 1966

3,282,273

UNIFORM SPRAYING APPARATUS

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Filed June 22, 1964, Ser. No. 376,632
5 Claims. (Cl. 134—102)

This invention relates to improved apparatus for the spraying of liquids, so that an accurately uniform coating or film of a liquid may be applied to a comparatively large target area or workpiece surface. One particular use of the apparatus of this invention is in the application of etchant to the surfaces of workpieces, and equipment for this particular purpose will be shown and described herein by way of one example. However, in its broader aspects the present invention is not limited to etching, but may be used in applying thin films to sheets or surfaces, in spreading protective or decorative coatings, in washing, or in fact in almost any process where the uniform and controlled spraying of liquid over an extended surface or area is essential.

The general object of this invention therefore is to provide a means for the spraying of liquids in a uniform manner over relatively extended areas. Another object of this invention is to provide such spraying with a degree of control such that improved technical results are obtained in the workpieces or objects being sprayed, as in chemical etching. A further object is to provide such a spraying apparatus that substantial economies may be made in the amount and character of liquid used in the spraying.

Still further objects and advantages of this invention will become apparent from the following general and detailed description and the claims, taken with the accompanying drawings in which are illustrated basic arrangements and one example of spraying equipment embodying the present invention and incorporating improvements for obtaining the objects set forth above.

In the drawings:

FIG. 1 is a diagrammatic transverse vertical sectional view of an arrangement of basic elements in spraying equipment according to this invention;

FIG. 2 is a corresponding side vertical sectional view of the arrangement of the elements of FIG. 1;

FIG. 3 is a similar side vertical sectional view of a modified arrangement of basic elements in spraying equipment according to this invention;

FIG. 4 is a perspective view of apparatus showing the general layout and some details of an installation of spraying equipment according to the present invention, designed for a particular purpose hereinafter described;

FIG. 5 is a vertical sectional view through the spraying chamber in the apparatus of FIG. 4 with associated mechanisms, showing how the arrangement of basic elements in FIG. 1 is applied in this particular installation;

FIG. 6 is a vertical sectional view through the spraying chamber in the apparatus of FIG. 4, at right angles to the section of FIG. 4, and corresponds to the arrangement of basic elements shown in FIG. 2;

FIG. 7 is a horizontal section on the line 7—7 of FIG. 6 on a reduced scale showing a mechanism for feeding work to the spraying area according to the invention and applicable to the particular installation shown in FIG. 4;

FIG. 8 is a schematic view showing the air flow or pneumatic system of the particular installation of FIG. 4, and

FIG. 9 is a schematic view or diagram showing a temperature control system for the apparatus of FIG. 4 and its relation to the air flow system of FIG. 8.

The basic elements of equipment according to this invention include a liquid spraying means **10**, a means supplying pneumatic propellent medium **20**, a work holder **30**, and an arrangement to cause a certain relative movement between the liquid spraying means and the work holder, this being partly included in the reciprocating mechanism **40** in the drawings. Also included as basic elements or arrangements may be an enclosure or chamber **50** for housing the liquid spraying means, propellent medium supply and work holder and a collector **60** for disposing of spent or excess liquid and propellent medium from within the enclosing chamber or housing. These reference numerals will be used throughout the drawings to indicate generally the parts, portions, or assemblies comprising these basic elements.

In the diagrams of FIGS. 1, 2, and 3, the liquid spray means **10** comprises a number of sprayheads **11** supplied by pipes or tubes **12** with liquid to be sprayed. For reasons that will later appear the feed of liquid to the sprayheads is kept at a constant or uniform rate. The pneumatic propellent medium may be air or other suitable gaseous medium depending upon the nature of the spraying to be done. For convenience hereafter it will be described as air unless a different meaning is obvious from the context. In the diagrammatic figures the propellent air is supplied through a conduit **20** to shields **22** surrounding each sprayhead **11**. The pressure and flow of the air as well as that of the liquid is kept uniform. Although the sprayheads and pneumatic propellent arrangements illustrated herein are of the type shown and described in the United States patent issued November 13, 1956, to Henri Coanda, No. 2,770,501, they may be of other designs exhibiting characteristics of consistent performance in the uniform atomizing and spraying of liquids supplied at uniform rates and using a flow of propellent gas under uniform pressure. The Coanda spraying apparatus has advantages in the excellent atomization of liquids being sprayed and the fact that relatively low pressure propellent air may be used.

In selecting the spray means, it should be considered that the propelling of liquid by air increases the energy by which droplets impinge on the work surface being sprayed. In etching apparatus as hereafter described, this greatly improves the etching reaction over that obtained by spraying the liquid alone without propellent air. Also, because of the continued air pressure on liquid already sprayed on a workpiece, pneumatic spraying will tend to spread any given amount of liquid over a greater work surface area than would be covered without the pneumatic propellant. These advantages mean that less liquid or less active liquid may be used in obtaining desired results on a work surface with an air propelled or pneumatic spray than must be used to obtain comparable results with liquid which moves from a source to the work surface as a function of kinetic energy stored in or imparted to it.

The work holder **30** indicated in FIGS. 1 through 3 is an endless belt **31** suitably guided and driven about a pair of rollers **32** to carry objects or articles **33** at a uniform rate past the sprayheads **11** at a fixed spacing therefrom. Of course, in case of lengths of materials such as photographic film the material to be sprayed may be self-supporting where is passes the sprayheads and in such an endless belt or similar carrier need not be used. Obviously, the surface being sprayed can have any contour as long as the desired fixed spacing from the spray means can be maintained.

As can be readily understood, the spray pattern of a single sprayhead which is stationary over a stationary object will not be uniform. That is, each sprayhead will produce a pattern in which much of the liquid being sprayed is concentrated at some central point or focus and the concentration decreases in all directions from the center. However, if the piece to be sprayed is moved in

a given direction, greater uniformity of distribution will be obtained in the direction of movement, especially if the movement is kept at a uniform rate. If, however, the sprayhead is simultaneously moved in a direction at right angles from the movement of the work, then most of the effects of lack of uniform distribution may be overcome. The relative motion between the work and the sprayhead can be achieved in various ways. Although it is possible to move the article being sprayed in two axes at the same time, it is found to be simpler and just as effective to move the work in one direction and to oscillate the sprayhead back and forth transversely to the direction of work movement. The reciprocating means 40 for the sprayhead assembly is shown as a suitably driven sliding shaft 42 connected to the sprayhead assembly 10. Suitable guides are provided for the sprayhead assembly to insure that the spacing between the sprayheads and the workpieces or target area remains constant during the reciprocation or oscillation. The degree of uniformity of spraying will depend upon the relative velocities of the work and the sprayer and therefore for best results, both the speed of movement of the work and the speed of oscillation or reciprocation of the sprayhead are adjusted and controlled to achieve the desired result.

Optimum results are obtained by a reciprocating motion in which acceleration and deceleration at each end of the stroke are as rapid as possible, with a minimum of pause, and the travel back and forth is kept at the same uniform rate. For example, in a machine having a spacing between centers of sprayheads of about two inches and a length of stroke in each direction adjustable from a minimum of about one inch to something over two inches, depending upon the type of work being performed, the reciprocation may take place at about 150 cycles per minute or five strokes back or forth every second, with no perceptible pause at the end of each stroke, excepting that needed to stop the motion and rereverse direction. This order of reciprication could be used with a workpiece surface being traversed past the sprayheads at about one inch per minute. The above rates of speed given are exemplary only and may be varied considerably to suit the requirements of particular spraying operations and to obtain the best results.

If the particular workpiece is massive or it is otherwise impractical or undesirable to move the workpiece, the sprayhead assembly alone may be moved in both a first axis and a second axis at an angle to the first axis at the same time, to integrate or cancel out the localized spraying effect. The effect desired may be described as obtained by reciprocating relative movement between the workpiece or target area and the sprayhead assemly regularly and periodically back and forth in a first direction while at the same time causing relative movement between the work and the sprayheads in a second direction substantially at right angles to the first direction, all of this while maintaining a uniform fixed distance between the sprayheads and the surface of the workpiece or target area.

For the sake of economy in the use of materials as well as to prevent undesired reaction of the surrounding atmosphere on the work being sprayed, the enclosure 50 may be regarded as a basic element. Because both liquid and air are being supplied through this encolsure during the spraying, provision should be made to dispose of or carry away excess or undesired liquid and air and for this purpose a collector 60, shown here in the form of a sump with an air discharge conduit 61 and a liquid drain pipe 62, are provided in the bottim of the enclosing chamber. In generic aspects of the invention, other collectors, such as suction scavening arrangements, might be used to remove liquid and dispose of the air, these being positioned above or to the side of the surface being sprayed and located to remove the liquid and air after the work has moved beyond the spraying area.

FIG. 3 shows a modification of the basic arrangement shown in FIGS. 1 and 2. In this form, there are in effect two compartments within the enclosure 50, compartment 51 holding a first set of sprayheads for spraying the work as it passes beneath, and compartment 52 holding a second set of sprayheads. A dividing wall 53 separates the compartments. The work may be sprayed with a first substance or solution in compartment 51, for example, an etchant, and then the reaction instantly stopped or changed by spraying with a second substance or solution, for example, a neutralizer from the sprayheads in compartment 52. The material discharged from the two sets of sprayheads may be collected in a common tank or drain from the sump and drain pipe 62, the liquid material being handled or treated in any desired manner. If air locks or seals are provided where the conveyor 31 enters and leaves the enclosing chamber 50, the air discharge conduit 61 may handle the air supplied to the spraying chamber and either discharge it to the atmosphere or recirculate it for use in providing continued pneumatic propellant pressure through the conduit 20, as will be described hereafter in connection with the illustrative example of etching equipment.

The basic method of spraying according to this invention should be clear from the above as inluding the requirements or steps of (1) maintaining a fixed distance between the liquid spray means (sprayheads) and the surface of a workpiece (2) providing a constant rate of flow of liquid to the sprayheads and a constant rate of flow of propellant gas to atomize and direct liquid from the spray means toward the workpiece (3) causing reciprocating relative movement between the spray means and the workpiece regularly back and forth in a first direction and simultaneously causing relative movement between said spray means and said workpiece in a second direction substantially at right angles to said first direction while maintaining the fixed distance between the spray means and the workpiece.

The basic arrangements and method described above, with certain novel additions and refinements, are incorporated in the chemical etching machine of FIGS. 4 through 9 inclusive. In this particular machine a base cabinet 70 encloses and supports practically all of the necessary equipment and controls. The cabinet in this exemplary illustration has a horizontal table top or work surface 71 near one end of which is located the spray chamber 50, most of which is located above the level of the work surface 71, but part of which, including the air and liquid collector, is located inside the cabinet. The top of the spray enclosure is in the form of a plenum chamber 23 and a horizontal supporting wall 54 supports the sprayhead assembly 13 and divides the enclosure to separate the plenum chamber from the spraying area proper, 24. The sprayheads 11, shown as of the Coanda type above-mentioned, are suspended in an aligned array at uniform spacings lengthwise of the elongated carrier member 14 and each head has its own pair of supply pipes 12 for liquid being fed thereto. The supply pipes extend upwardly through the carrier member 14 and have flexible tubing 15 secured thereto leading outwardly of the enclosure 50 as through an opening 5 and to a liquid feeding and metering device of a character later described. Also depending from the carrier member 14 is an air shield 25 having passages opening into the plenum chamber 23 and leading to individual openings 26 around each sprayhead for the discharge of propellent air at each sprayhead. The plenum chamber is supplied with air under a controlled and uniform pressure and velocity from a duct 27.

The carrier member 14 and therefore the entire sprayhead assembly is caused to move in a reciprocating motion in guides 16 carried by the horizontal wall 54. The reciprocating motion in this case may be obtained by movement of a piston in an air cylinder 43, the piston

rod 44 being secured to one end of the sliding carrier member 14 and provided with appropriate means such as an alternating reversing limit switch 45 to control the periodicity and extent of reciprocating movement of the piston in the air cylinder. Such arrangements for obtaining controlled reciprocating movement are varied and well known and therefore need not be further described here. It is enough to say that the length of the reciprocating stroke and its frequency can be adjusted to meet the requirements of any specific job. The purpose of the reciprocating motion is to provide the integrating effect described earlier, to eliminate any nonuniformity of spray patterns in an axis perpendicular to the direction of the travel of work. Assuming the work is traversed at a uniform rate in one axis, integration to eliminate spray pattern nonuniformities thus is provided for in both axes of the part being sprayed.

Referring particularly to FIG. 7, the work holder in this form of the invention is shown as a carriage 34 slidably carried in ways 35 in the bottom of the chamber 50 at a level below that of the work surface 71 on the base cabinet. This work carriage is moved from below a loading opening 55 in the table top 71, through the spraying area 24 of the spraying chamber and to a position below an unloading opening 56 on the other side of the housing 50. The openings 55 and 56 may be closed in a sealed fashion by suitable doors 57 operated by hand levers 58. Motion of the carriage 34 through the spraying area is controlled by an air cylinder 36, at times and at speeds governed by a hydraulic control cylinder 37 and the wishes of the operator. Assuming that the carriage is empty and is in position under the loading opening 55, the door 57 is opened, the work is inserted onto the carriage, the door closed, and the air cylinder 36 is caused to be actuated by the operator at a selected speed controlled by the cylinder 37. The carriage will slide in the ways 35 and reach a position under the unloading opening 56, at which time the door above it may be opened and the work removed. The operator can then reversely actuate the air cylinder to drive the carriage back to its original location. Arrangements and controls for driving the carrier are, like those for reciprocating the sprayhead carrier 14, of a nature so well known as not to require detailed description. The uniform carriage movement integrates out any nonuniformity of the spray pattern in the direction of travel of the carriage. The above-described drive is but one arrangement that might be used. With other arrangements for driving after unloading, the workpiece carrier may be reloaded at the "unloading" station and then returned to its original position, with spraying also taking place during a controlled speed return movement. In some cases there might be a single loading and unloading station and the carriage could be moved back and forth into and out of the spraying chamber, the workpieces being subjected to two passes at a controlled speed under the sprayheads, or to a single pass, by cutting off the spray liquid when the carriage is being moved in one direction or the other.

Particularly advantageous results are obtained if the pneumatic propellent medium is recirculated and its temperature is carefully controlled. FIG. 8 shows schematically a closed loop temperature controlled system of this type used in the apparatus of FIG. 4. The pneumatic system is powered by a blower 80. Air from the outlet of the blower passes through a duct 81 which may be located near the end of the plenum chamber duct 27 at or below table level. The parts of the air system so far described are not seen in FIG. 4 because they are located either in back of or under the cabinet. From the duct 81 a duct 83 leads to an air mixing chamber and valve 84. From this mixing chamber and valve, depending upon the position of the valve setting, all or part of the air will flow through a duct 86 to and through a heat exchanger 87, into the duct 88, and again through a portion of the air mixing chamber and valve 84, from which it exits into a duct 89 leading to the plenum chamber supply duct 27. Depending upon the temperature control demand and therefore the position of the valve 85 in the air mixing chamber and valve 84, all of the air may pass from duct 83 through the chamber and valve and then exit into duct 89 without any of the air being routed through the heat exchanger 87. This is part of the temperature control later described.

Air from the duct 27 flows into the plenum chamber 23 and through the openings 26 in the sprayhead assembly to propel the liquid. After the air passes out of the sprayhead assembly and serves to atomize and propel the liquid etchant against the work in the spraying area 24, it flows into the air discharge conduit 61. Entrained liquid is is carried by this air and therefore, after going through the discharge conduit 61, it is passed through a filter chamber 63 which separates the entrained liquid from the air. From the filter chamber 63 the cleaned air then is passed as through a conduit 64 to the blower 80, completing the air circuit.

With an entirely sealed, closed-loop pneumatic system, a gas can be used that is inert, chemically, to the liquid being sprayed, or to the work being processed, or both. Not only this, but by proper control of the input and exhaust rate from the chamber. A chemically inert atmosbe creatted in the spraying chamber and maintained by keeping the gas input at a rate not greater than the exhaust rate from the chamber. A chemically inert atmosphere is useful where the spraying might be deleteriously affected by undesirable substances in ordinary air. Sub-atmospheric pressure in the spraying chamber will improve the atomization of the liquid being sprayed and the transfer of the atomized liquid to the workpiece or target area.

Air friction and turbulence occurring principally in the blower 80 and because of compression in parts of the air flow system, cause the air temperature to rise. Three loops of temperature control have been provided in the exemplary apparatus to provide accurate control of air temperature and of the etchant temperature to a preselected level set by the operator. The schematic coolant control diagram (FIG. 9), shows the refrigeration, heat exchangers, and temperature control of the coolant and refrigerant and relation to the heat exchanger 87 in the air circuit.

The first control loop includes a refrigerant compressor 72 and refrigerant-coolant heat exchanger 73 in the refrigerant circuit 74. Control of the temperature of this loop is obtained in the usual manner by a sensor responsive to temperature in the heat exchanger 73, governing action of the compressor 72.

The second control loop includes the heat exchanger 73, common to the refrigerant circuit and to the coolant circuit 75, which may carry a mixture of water and antifreeze as the cooling medium. A three-way valve 76 driven by a control motor 77 in accordance with the demands of a sensor 78 in the coolant circuit at a point sensitive to the temperature in coolant-air heat exchanger 87, governs the mixture of the coolant circulating in this loop, directing it either through the circulating pump 79 and heat exchanger 73 or through the heat exchanger 87 as well. Circulation of coolant through the heat exchanger 87 is made only when called for by sensor 78.

The third control loop is the air circulation system, including the heat exchanger 87. This loop responds to a unit sensing the temperature for example in the duct 27 leading to the plenum chamber. Other locations of this temperature sensing unit may be found desirable. Such sensing unit commands the motor-driven butterfly valve 85 in the air mixing chamber and valve 84, as above described, directing all or part or none of the air from duct 86 through heat exchanger 87 before it reaches the plenum chamber supply duct 27.

In cases where it is desired that the liquid be applied

at an elevated temperature, the heat exchanger 87 can be furnished with a heater, properly controlled to maintain the air temperature at a desired raised level so that the liquid propelled at the sprayheads will be effectively raised to a corresponding temperature.

Temperature control systems of the kind or type desired may be varied at will and are readily understood in the temperature control art. Ultimate control of only the circulating air temperature is characteristic of preferred apparatus according to this invention. With properly designed sprayheads, the etchant or other liquid is atomized into extremely fine particles. Finely atomized particles have an area to mass ratio of a high numerical value. Thus, the time required for the liquid to receive thermal energy from the propellent air is reduced to an infinitesimal amount. Consequently, the liquid temperature is accurately and readily controlled by controlling the temperature of the propellent air only. The temperature of the liquid being sprayed therefore can be controlled with extreme accuracy and can be changed from one desired temperature to another virtually instantaneously by resetting the air temperature control.

Since the liquid being atomized can have its temperature rapidly changed to the desired working temperature by the pneumatic propellant at the point of spraying, it can be stored in the liquid supply vessel at a temperature most suitable to maintain its desirable chemical and physical characteristics until just before use. Storage temperature in the liquid supply vessel can be maintained readily by an automatically controlled heating or cooling system.

The air pressure at the sprayheads can be adjusted over a wide range by means of a control valve (not shown) which may be located in the air flow system, preferably in the system between the blower and the plenum chamber. Control of the rate of flow of etchant or other liquid going to the sprayheads is also desirable to obtain optimum results with the equipment. Such a controlled supply of liquid may be obtained in many ways and through various mechanisms so only the desired characteristics of the liquid feeding and metering unit will be here described There will be a suitable supply vessel or source for the liquid and the liquid will pass therefrom through a feeding and metering device in the form of a pump which will deliver the liquid at an even and controlled rate uniformly to all of the flexible tubes 15 leading to the pairs of supply pipes 12 for the sprayheads 11. The liquid feeding and metering device must be such that the rate of flow can be set and maintained at any desired level.

Although a particular fluid metering device is not herein described in detail, one that has been found eminently suitable for use with spraying equipment according to this invention is being made the subject of a patent application Serial No. 376,749, filed concurrently herewith by Orin B. Johnston and entitled "Fluid Metering Device."

After being atomized and sprayed, some of the excess spent etchant is carreid by the air flow to the discharge conduit 61. Most of the excess etchant falls by gravity into the sump and through drain pipe 62 can be drawn off to a container outside of the equipment. However, when technical requirements permit, the recovered etchant can be recycled. Although automatic recovery and recycling of the etchant is not here shown, it is obvious that it can be provided for if desired.

In view of the fact that air pressure, air flow and temperature, etchant flow and temperature, carriage speed and sprayhead oscillatory frequency and travel can be readily adjusted, a liquid spraying system according to this invention is ideally suited for complete automation.

The double chamber basic arrangement shown in FIG. 3 may be incorporated in apparatus according to FIGS. 4 through 9 of the drawings by providing two adjacent spray chambers, one applying etchant to the workpiece and the other providing a neutralizing liquid. As the carriage moves the workpiece from the etchant chamber to the neutralizing chamber, any residual etching effect caused by etchant remaining on the part will be stopped rapidly. The neutralizing and etching fluids can be chemically balanced to a low hydrogen ion value through appropriate metering and it is possible to control this balance automatically so that the two fluids can be mixed and discharged into a sewer. A third, a fourth, or more chambers could be provided beyond the first two, for carrying out successive spraying operations such as washing, drying, coating, etc.

As will be evident from the foregoing description, certain aspects of this invention are not limited to the particular details set forth, and it is contemplated that various and other modifications and applications of the invention will occur to those skilled in the art. Therefore, it is intended that the appended claims shall cover such modifications and applications as do not depart from the true spirit and scope of the invention.

What is claimed as new and is desired to be secured by Letters Patent of the United States is:

1. Equipment for pneumatic spraying of a liquid on workpieces comprising

an enclosing cabinet with a spraying chamber therein,

a sprayhead in said cabinet extending into said spraying chamber,

said sprayhead having means supplying thereto at a constant rate a liquid to be sprayed,

means supplying a propellent gas to said sprayhead at a constant rate to atomize and propel liquid therefrom into said spraying chamber in the form of a spray having a localized nonuniform spray pattern,

means reciprocating said sprayhead back and forth in a first direction normal to the spray from said sprayhead, transverse of said spraying chamber,

a holder supporting workpieces in said spraying chamber maintaining them at a fixed distance from said sprayhead in the direct path of liquid sprayed from said sprayhead,

said holder including means for moving said workpieces through said spraying chamber at a uniform rate in a second transporting direction normal to the spray from said sprayhead, transverse of said spraying chamber and substantially at right angles to said first direction of reciprocation concurrently with said reciprocation and

means in said spraying chamber for collecting gas and sprayed liquid from said sprayhead passing beyond said workpieces,

the said means reciprocating said sprayhead and said means for moving said workpieces in transporting direction concurrently being timed so that the localized non-uniform spray pattern reaching said workpieces is cancelled out and uniform distribution of the sprayed liquid is obtained on the workpieces.

2. Equipment for pneumatic spraying of a liquid on workpieces comprising

an enclosing cabinet,

a wall in said cabinet dividing it into a plenum chamber and a spraying chamber,

a plurality of spaced sprayheads in said cabinet, each extending from said plenum chamber into said spraying chamber, each sprayhead having means supplying thereto a liquid to be sprayed,

means supplying air to said plenum chamber and from said plenum chamber to each sprayhead to atomize and propel liquid from each sprayhead into said spraying chamber in the form of a spray,

means reciprocating said sprayheads in unison back and forth in a first direction transverse of said spraying chamber,

means for supporting workpieces in said spraying chamber at a fixed distance from said sprayheads in the direct path of liquid sprayed from said heads, including means for moving said workpieces through

said spraying chamber in a second transverse direction at right angles to said first direction of reciprocation and

means in said spraying chamber for collecting air and sprayed liquid passing beyond said workpieces.

3. Equipment according to claim 2 comprosing in addition a closed loop duct system connected to said spraying chamber and to said plenum chamber, said duct system receiving air from said means for collecting air and including means pumping such air under pressure from said spraying chamber through said system and back to said plenum chamber so that air supplied to atomize and propel liquid from the sprayheads is collected and recirculated by the system for repeated use in spraying.

4. Equipment according to claim 3 comprising in addition filtering means in said duct system for removing entrained liquid from the air collected in said spraying chamber so that air pumped back to said plenum chamber is free from such entrained liquid.

5. Equipment according to claim 2 further including means controlling the temperature of the air supplied from said plenum chamber to said sprayheads said means constituting the sole means to control the effective temperature of the liquid being sprayed.

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CHARLES A. WILLMUTH, *Primary Examiner.*

R. L. BLEUTGE, *Assistant Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,282,273 November 1, 1966

Orin B. Johnston et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 61, for "is" read -- it --; same line 61, after "such" insert -- case --; column 3, line 38, for "rereverse" read -- reverse --; line 39, for "reciprication" read -- reciprocation --; line 52, for "assemly" read -- assembly --; line 65, for "encolsure" read -- enclosure --; line 69, for "bottim" read -- bottom --; line 71, for "scavening" read -- scavenging --; line 73, for "the side" read -- one side --; column 4, line 21, for "propellant" read -- propellent --; line 30, for "propellant" read -- propellent --; column 6, line 15, strike out "is"; line 26, strike out "rate from the chamber. A chemically inert atmos-" and insert instead -- rates, a "vacuum" or sub-atmospheric pressure can --; line 27, for "creatted" read -- created --; column 7, line 41, after "described" insert a period; line 57, for "carreid" read -- carried --.

Signed and sealed this 5th day of September 1967.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents