June 9, 1964 C. S. MARTZ ETAL 3,136,323

ETCHING MACHINE

Original Filed May 2, 1960 3 Sheets-Sheet 1

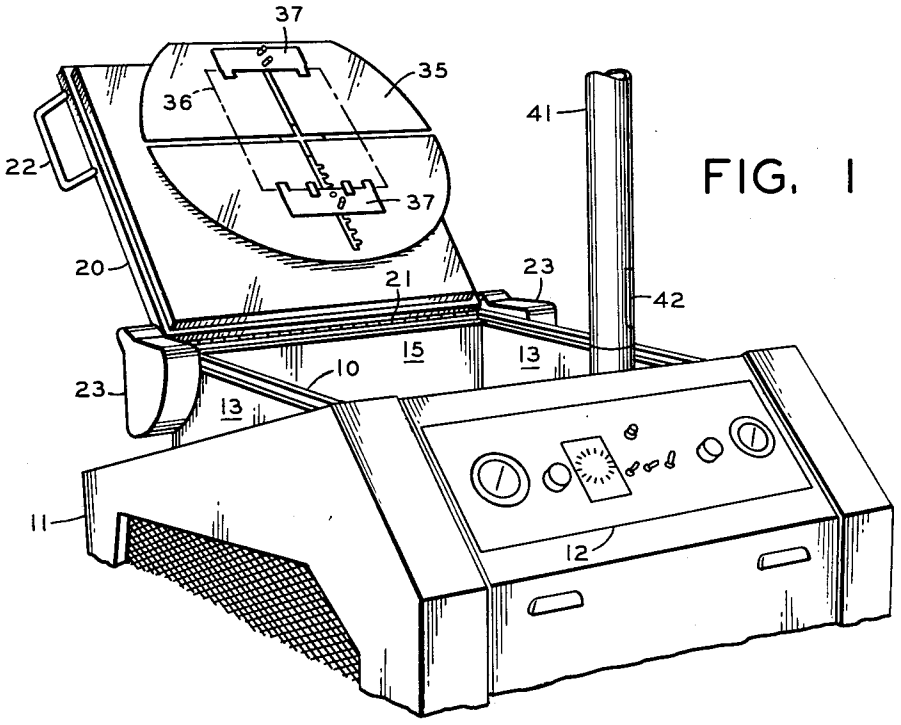



FIG. 1

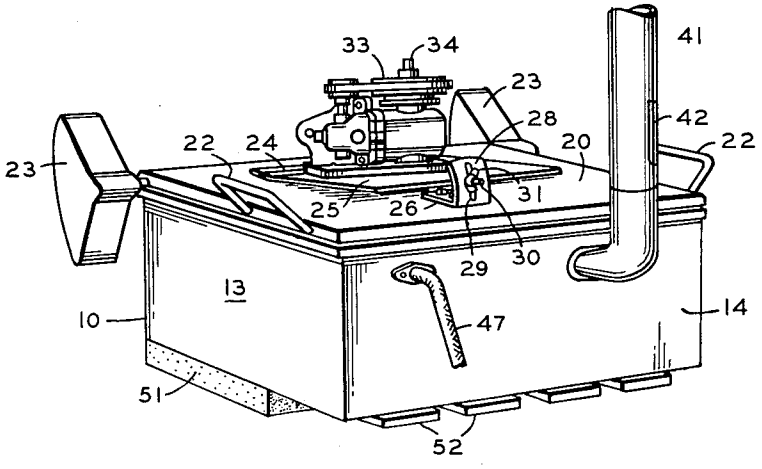



FIG. 2

INVENTORS
CHARLES S. MARTZ
MONROE R. HILLHOUSE
BY Cohn and Powell

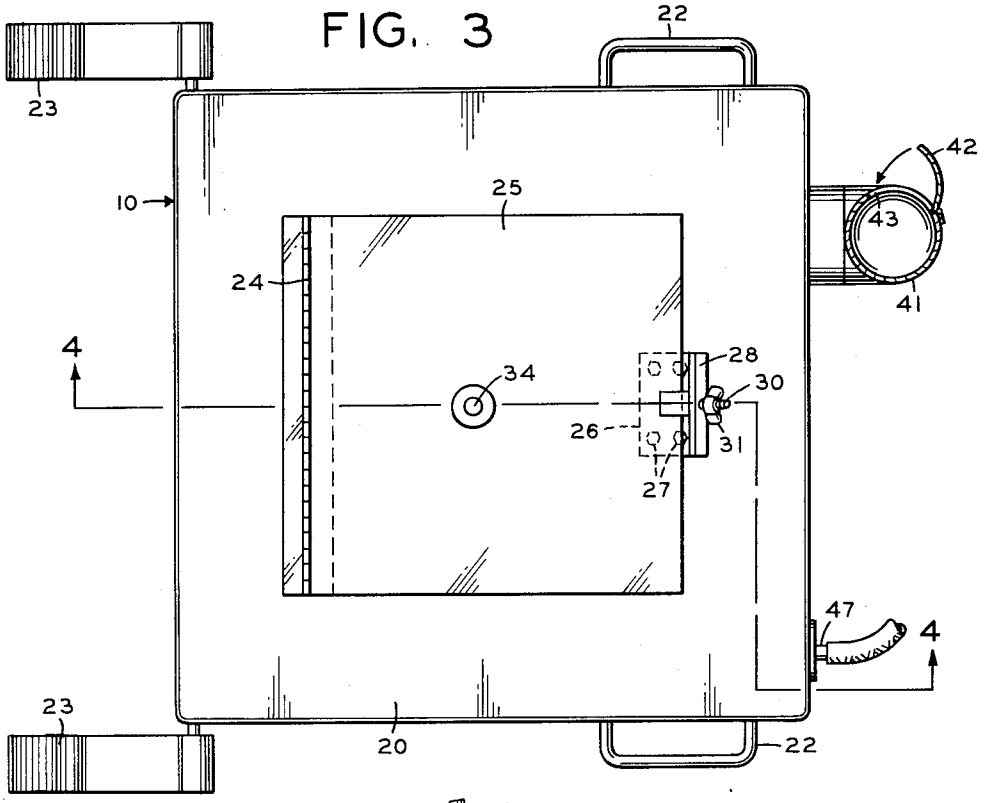
ATTORNEYS

June 9, 1964 C. S. MARTZ ETAL 3,136,323

ETCHING MACHINE

Original Filed May 2, 1960 3 Sheets-Sheet 2

FIG. 3



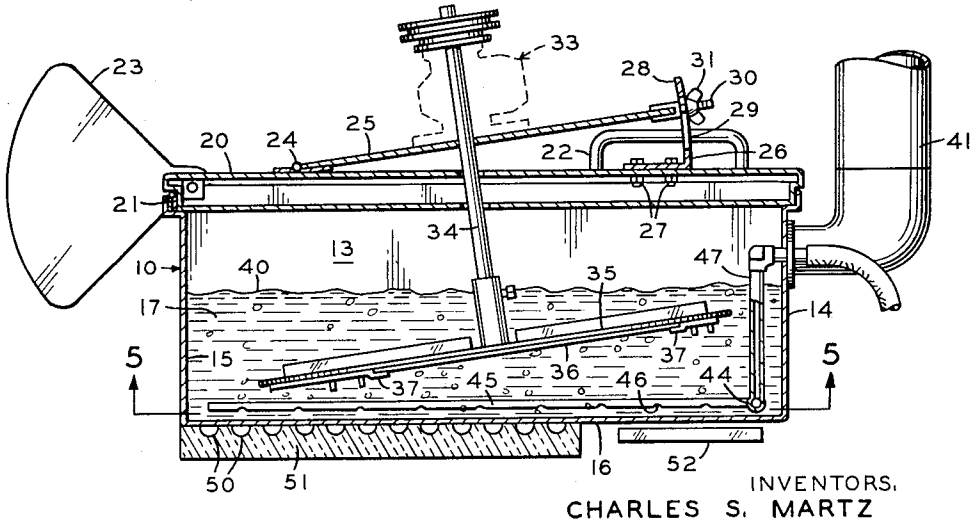




FIG. 4

INVENTORS.
CHARLES S. MARTZ
MONROE R. HILLHOUSE
BY Cohn and Powell
ATTORNEYS

June 9, 1964 C. S. MARTZ ETAL 3,136,323

ETCHING MACHINE

Original Filed May 2, 1960 3 Sheets-Sheet 3

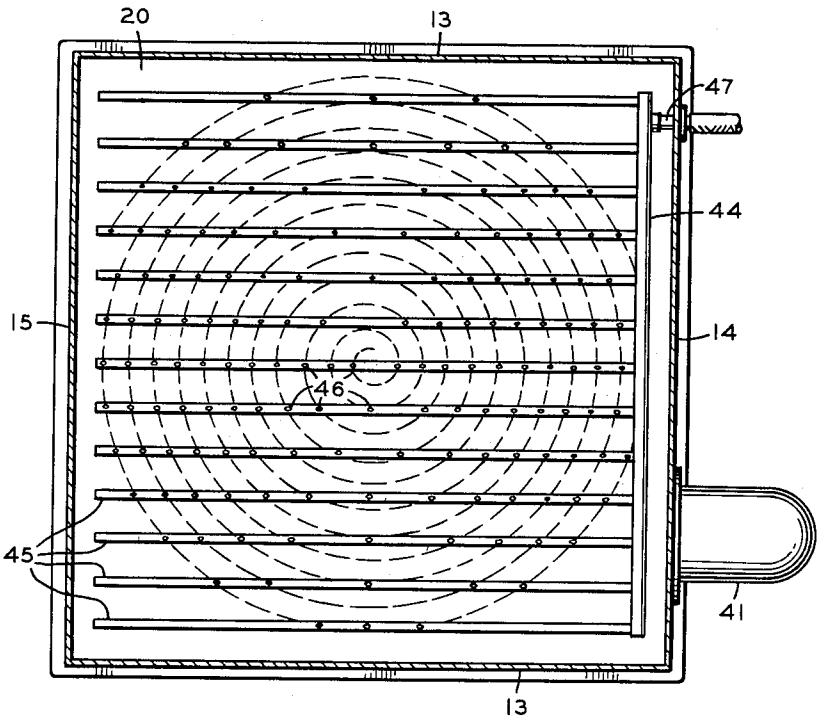



FIG. 5

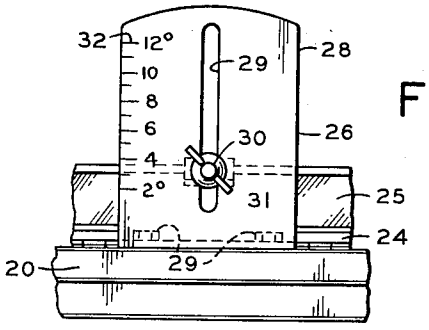



FIG. 6

INVENTORS
CHARLES S. MARTZ
MONROE R. HILLHOUSE
BY
Cohn and Powell
ATTORNEYS

United States Patent Office 3,136,323 Patented June 9, 1964



# 3,136,323
# ETCHING MACHINE

Charles S. Martz, Aurora, and Monroe R. Hillhouse, Verona, Mo., assignors to Tasopé Limited, Aurora, Mo., a corporation of Missouri

Original application May 2, 1960, Ser. No. 25,921. Divided and this application Apr. 29, 1963, Ser. No. 276,626

10 Claims. (Cl. 134—94)

This invention relates generally to improvements in an etching machine, and more particularly to improvements in an apparatus involving an etching bath in which a protective bath additive is utilized.

This application is a division of separate copending application Serial No. 25,921, filed May 2, 1960, and entitled Etching Machine and Method of Etching.

The process of etching per se presents no problem. For example, a mixture of water, nitric acid and air will etch zinc. One of the first commercial zinc etching methods used a rocking tray or tub in which a water-acid solution flowed back and forth across the plate, the plate being exposed to air each time the solution passed over the plate. In this method, etching was relatively slow and because the bath contained no shoulder protecting chemicals, the lateral etch was almost as great as the vertical etch. Consequently powdering between bites was necessary in order to prevent the lateral etch.

Subsequently, paddle machines were introduced and plates were etched in every possible position, from vertical to horizontal. In such machines, powdering between bites was, of course, necessary. Air etching machines were developed, but none were popular because they presented no advantages over paddle systems.

Every photoengraver engaged in etching looked forward to the day when dry powdering could be eliminated. A machine and process was visualized which would allow "powder" to be put right in with the acid and water bath and yet provide side wall protection. When a bath additive was discovered in the early 1950's that would protect side walls, a paddle type etching machine very similar to those in daily use at that time was developed and used. While these paddle machines were ideal for conventional powder etching, they were far short of perfect insofar as automatic side wall protection was concerned.

In the above mentioned paddle type etching machines, the protective chemicals in the bath are known in the trade as "liquid powder" or bath additive. In powderless paddle or spray type etching machines in which the bath includes a bath additive, the bath is thrown onto the work plate. The zinc plate has an affinity for the oil constituting the bath additive and it forms a film over the surface. This film is porous and it is removed by the action of the acid through the pores to a minor degree. The major removal action however, is mechanical. The force of the paddle action beats the oil off. Because the sides of the etched images are largely parallel to the force, the sides of the images receive less paddle action and the film adheres to these sides while it is being beaten off the open plate bottom areas.

The present machine and method constituting the invention has definite advantages over the prior known machines that splash the etching and protecting solution over a suspended plate with paddle or spray nozzles. It is an important object of the present invention to eliminate all paddles in the etching machine, and to etch the plate and protect the side walls of the images while the plate is completely submerged in the bath.

Another important objective is achieved by suspending the plate to be etched completely submerged in the etching bath at an angle to the plane of the bath surface and by rotating the plate while bombarding the plate face with a profusion of bubbles passed upwardly through the bath so as to impinge and roll upwardly on the plate. The protective film formed by the bath additive is in contact with the plate at all times because the plate is submerged in the bath. The air bubbles remove the bath additive in the open areas to be etched. In addition, the flow of the solution across the plate caused by the path of the bubbles and by the rotation of the plate also causes removal of the protective bath additive in the open areas to be etched, yet completely protects the side walls.



With the above described superior method and machine, a much smoother side wall protection is provided than can be had by any other known method or machine. These results are obtained because there is a controlled flow over the plate produced by choosing the particular plate angle and rotation which provides greatest side wall uniformity. Secondly, the gentle action of the air bubbles in rolling up the plate to be etched reduces the porosity of the protective bath additive on the side walls.

Another important object is to provide an etching machine in which there is complete freedom in bath replenishing because the precise depth of the bath is no longer a critical factor as it is in paddle type or spray nozzle type machines.

Still another important objective is achieved by the placement of tubes in the bottom of the tank, such tubes having air holes formed and arranged so that bubbles emitting from the air holes will rise upwardly through the bath in a pattern relative to the rotative axis of the work plate in order to eliminate or minimize distortion in the protection of side walls.

The present etching machine and method has many advantages over the paddle or spray nozzle type machines in that the paddle dip variable is eliminated. In etching machines using paddles, results are partially governed by the paddle dip, and hence the bath depth becomes critical since it regulates the amount of solution carried by the paddles. In the present invention, the work piece is completely submerged in the bath and the bath depth is not critical in the least.

There is also a complete elimination of paddle speed errors and an elimination of the necessity of synchronizing the speed of paddle shafts where two or more are utilized, and there is a complete elimination of paddle shaft leaks that might cause a change in the bath level and hence in the paddle dip.

In the splash type machine, gravity and centrifugal force represent difficult to control variables. The present invention provides a machine which eliminates these factors and provides side wall protection largely regulated by the gentle flow of bubbles toward the high side of a revolving work plate, thus providing fine grained side walls having less shoulder porosity.

Another important object is to provide an etching machine that is simple and durable in construction, economical to manufacture, efficient in operation, costs less to maintain, reduces bath cost because of the longer bath life obtained, and which can be easily operated by an etcher with only a minimum of instruction.

The foregoing and numerous other objects and advantages of the invention will more clearly appear from the following detailed description of a preferred embodiment, particularly when considered in connection with the accompanying drawings, in which:

FIG. 1 is a fragmentary, perspective view of the etching machine with the lid raised;

FIG. 2 is a perspective view of the etching tank and its appurtenant parts with the lid closed;

FIG. 3 is a top plan view of the machine illustrated in FIG. 2, but with the motor removed;

FIG. 4 is a cross-sectional view of the machine as seen along staggered line 4—4 of FIG. 3;

FIG. 5 is a cross-sectional view of the tank as seen along line 5—5 of FIG. 4, and

FIG. 6 is an enlarged, fragmentary front elevational view of the adjustment means.

Referring now by characters of reference to the drawings, and first to FIG. 1, it is seen that the etching tank generally indicated at **10** is mounted in and supported by a body or shell referred to at **11**. The body **11** serves to enclose certain operating mechanism below the tank **10** in a manner subsequently described, and serves to mount the control panel and instruments **12** at the front of the machine for ready access by the etcher during operation.

The etching tank **10** is substantially square in configuration having opposed side walls **13** and right angularly interconnected front wall **14** and rear wall **15**. The tank **10** includes a flat horizontal bottom wall **16**. The tank **10** is adapted to hold a supply of etchant or bath **17** (FIG. 4), the composition and nature of which will be later described.

A lid **20** is connected to the top of rear wall **15** by a hinge **21**, the lid **20** being adapted selectively to close or cover the open top of tank **10**. Attached to opposite sides of lid **20** are a pair of handles **22** to facilitate raising and lowering of such lid. Because the lid **20** and the parts carried thereby are relatively heavy, a pair of counterbalance weights **23** are attached to the lid **20** and extend beyond the other side of the hinge axis **21**. Obviously, the counterbalance weights **23** enable the lid to be lifted and lowered easily with only a minimum of effort.

Mounted on the top of lid **20** by a hinge **24** is a platform **25**. Adjustment means is provided for selectively raising and lowering the platform **25** about the axis formed by hinge **24**, and hence selectively determines the angular relation of platform **25** relative to lid **20**. This adjustment means includes an angle bracket **26** fixed by screws **27** to the top of lid **20**. Formed in the upstanding bracket portion **28** is an elongate vertical slot **29**. Extending through slot **29** is a threaded bolt **30** that is fixed to the forward edge of platform **25**. A wing nut **31** is threadedly attached to the end of bolt **30** and engages the vertical bracket portion **28**.

In order to adjust the angular position of platform **25**, the wing nut **31** is loosened and the platform is selectively raised or lowered within the range determined by the movement of bolt **30** in slot **29**. To facilitate accurate and quick placement of platform **25**, an angle scale **32** is provided on the bracket portion **28** alongside the slot **29**. The platform **25** extends laterally beyond the sides of bracket portion **28**, thereby enabling a direct reading on scale **32** of its angular position.

After the platform has been adjusted to the desired angular position, the wing nut **31** is tightened on bolt **30** against the bracket portion **28**, thereby clamping the platform **25** and maintaining it in such position.

A drive mechanism generally indicated at **33** and including an electric motor, speed reducer and interconnecting belt assembly is attached to and supported on the top of platform **25**. The drive means **33** includes a driven shaft **34** that extends downwardly through platform **25** and through lid **20** into the interior of tank **10** when the lid **20** is closed. It is seen that because the shaft **34** is rotatively mounted on the platform **25**, the angular position of such shaft **34** is changed upon adjustment of the angular position of platform **25**. The openings in lid **20** through which the shaft **34** extends, are of sufficient size to permit such angular adjustment.

Attached to the lower end of driven shaft **34** is a work plate holder **35** that is preferably circular in configuration as is best seen in FIG. 1. A zinc work plate **36**, shown in FIG. 4 in full lines and illustrated by broken lines in FIG. 1, is clamped to the underside of holder **35** by a pair of adjustable clamps **37** mounted on holder **35**. Obviously, the clamps **37** are adjustable toward and away from each other in order to accommodate work plates **36** of different sizes. In the preferred embodiment, and for reasons later discussed, the diameter of holder **35** is at least 4 to 8 inches larger than the greatest dimension of the work plate **36** held by clamps **37**.



When the lid **20** is closed over tank **10**, the holder **35** maintains the work plate **36** in an inclined position completely submerged in the etching bath **17**. The work plate **36** is held in substantially parallel relation with the platform **25** and is angularly adjusted relative to the bath level **40** upon angular adjustment of platform **25**. The preferred angular position of work plate **36** during etching operation in order to obtain optimum results is from two (2) degrees to twelve (12) degrees with respect to the substantially horizontal bath level **40**.

While submerged completely under the etching bath **17** in an angular relation to the bath level **40**, the drive means **33** operates through driven shaft **34** to rotate the work plate **36**. It has been found that optimum etching results are obtained when the work plate **36** is rotated from one-third (⅓) revolution per minute to ten (10) revolutions per minute.

A ventilating tube **41** is carried by an opening through the forward wall **14** above the top of bath level **40**, the ventilating tube **41** being adapted to carry off the fumes from the etching bath **17**. A door **42** is provided in the ventilating tube **41** for an opening **43** through which etchant can be introduced into tank **10** to replenish the bath **17** and raise the level **40**, if desired or necessary.

Located at the bottom of tank **10** and supported on the bottom wall **16** is an aeration assembly including a header **44** that operatively connects and communicates with a plurality of elongate, parallel air tubes **45** extending transversely of tank **10**. Each of the air tubes **45** is provided with a plurality of small air holes **46** on its underside. A feed line **47** is connected to the header **44** and also connects to a centrifugal pump (not shown). The pump, motor and refrigeration unit utilized by this etching machine are located under the tank **10** and within the body **11**.

Air is forced through the air tubes **45** and is emitted through air holes **46** in the form of fine bubbles that rise upwardly through the etching bath **17** and impinge and roll upwardly on the work plate **36**. In addition to this etching action of the bubbles as explained later, the air emitted through air holes **46** keeps the bath agitated and thoroughly mixed.

Uniform air distribution is most important in protecting side walls of the image evenly on the work plate **36**. Accordingly, the air holes **46** are formed in air tubes **45** at particular locations in order that the bubbles rise through the bath **17** and impinge on the work plate **36** in a definite pattern. More particularly, it has been found that for best results and for minimum of distortion in etching the image, the air holes must be staggered in a manner such that a circular pattern relative to the rotative axis of the work plate **36** is not formed. In other words, the air holes **46** are formed in tubes **45** so that no two air holes are formed the same distance from the rotative axis of the work plate **36**. In FIG. 5, it is seen that the arrangement of air holes **46** form a definite spiral pattern.

As is usual in etching machines and methods of etching, the temperature of the bath **17** must be maintained within certain specified limits of 65° to 85° Fahrenheit in order to obtain best results. Formed as a part of the bottom tank wall **16** are refrigeration coils **50** as is best seen in FIG. 4. Suitable insulation **51** is provided about such coils **50**. Also provided immediately below the bottom tank wall **16** are a plurality of heating elements **52**. Upon selective operation of the refrigeration coils

50 and the heating elements 52, either manually or automatically by control means, the bath temperature can be maintained at a desired operating point. Most etching is done at 76° to 79° Fahrenheit.

It is thought that the operation and functional advantages of the machine and method has become fully apparent from the foregoing detailed description of parts, but for completeness of disclosure such operation will be briefly described.

The protective bath additive is merely combined with water and nitric acid to provide an etching bath 17. The chemicals used in the bath additive are a thick organic oil, a petroleum solvent and a wetting agent. The heavy oil most widely used is Turkey Red oil (Sulfated Castor Oil), while the thin oils or solvent is kerosene or Solvesso 150 consisting of by percent volume 1.3% $C_9$ aromatics, 44.4% $C_{10}$ aromatics, 25.3% $C_{11}$ aromatics, 2.1% $C_{12}$ aromatics, 17.7% Indans and 6.5% naphthalenes, a product made by Standard Oil Company.

Solvesso 150 is a high purity mixture of substituted benzene compounds having the molecular weights indicated. For example, the designation of 44.4% of $C_{10}$ Aromatics is the representative percentage of substituted benzene compounds of all types and all isomers which are present having a $C_{10}$ molecular weight. This would, of course, involve the benzene ring which has six carbon atoms and additional side chains to total the additional four carbon atoms with the necessary hydrogen present for this type of hydrocarbon. Other refineries make similar products.

A protective bath additive can be produced by cutting one part of Turkey Red oil with two parts of Solvesso 150 and adding a small quantity of wetting agent, such as Naccanol or Santamerse, both consisting of 40% active alkly aryl sodium sulphonate and 60% sodium sulphate. The oils plus the wetting agent constitute that which is termed in the art "liquid powder" or bath additive.

Bath formulation is based on the size of the desired bath. The bath 17 that has been used successfully in the present machine and in the present method of an etching is a twelve gallon bath consisting of 83% water, 13% 42 degree Beaumé technical grade nitric acid and 4% bath additive.

In making the particular "powderless" etching bath, the tank 10 is filled with water to a preset water gauge and then the nitric acid is added. The water and acid go into solution. Because the acid heats the water 10 degrees to 20 degrees, the mixture is cooled to about 75 degrees Fahrenheit, and then the bath additive is introduced. The air pump is turned on and the air emitted through air holes 46 rise upwardly through the bath 17 to provide thorough agitation that mixes the oils, water and acid. Because the mixture is not a true emulsion, the oils wil rise to the surface of bath 17 if the air is turned off. Therefore, it is extremely important that the bath must be agitated before the work plate is placed into the bath or else the oil will cover the plate and attach itself so completely that the acid cannot etch the plate at all.

Assuming that the print on the work plate is properly exposed, developed and burnt-in, the first step is to paint out the large bare zinc areas with any lacquer preparation that will stand up under the acid and the oils in the powderless etching bath 17. This space painting is not absolutely essential to etching and will have little effect upon the actual etching process. Then, the dry plate is brushed thoroughly with a prepared mixture of nitric acid, water and a metal cleaning solution in order to remove scum. This de-scum solution is flushed off of the work plate and then the print is brushed or sponged with a pre-etch solution consisting of nitric acid and water. After pre-etching the work plate, the plate is flushed with water prior to gumming. Then a few drops of a regular gum arabic solution is dropped on the wet plate and brushed over the entire surface, thus eliminating oxidation and keeping the plate from drying out while being attached to the plate holder 35.

The air pump is started in order to cause agitation of the bath 17 before the lid 20 is closed. It is assumed that the platform 25 has been adjusted as described previously in order to maintain the work plate 36 at the desired angle in the etching bath 17 when the lid 20 is closed.

The lid 20 is then closed, and the work plate 36 is completely submerged in the etching bath 17. The drive means 33 is energized so as to rotate shaft 34 and hence rotate the work plate 36 at the desired revolutions per minute.

The zinc work plate has an affinity for the oil constituting the bath additive and such oil forms a film over the surface. This film is porous and it is removed by the action of the acid through the pores to a minor degree. However, the major etching action is accomplished by the air bubbles that move upwardly through the bath 17 into impingement with the work plate 36. As the air bubbles engage the work plate 36 and roll upwardly thereon from the low side to the high side because of the plate inclination, the air bubbles remove the oil in the open areas to be etched, allowing the acid to act. As any bubble moves along the work plate, the bath following the bubble again covers the plate and the protective oil or bath additive again provides side wall protection.

Furthermore, as a result of the bubbles moving upwardly on the work plate and because of the rotation of such work plate, the bubbles flow from the low side to the high side of the plate in a curved path across the plate. The curve of the flow is counter to the direction of the plate rotation because the flow is in one direction and the plate is turning away from the flow. The curve is determined by the speed of rotation and the size of the work plate. With the work plate tilted there is less action on the side opposite to the direction of the flow. The greater side wall protection is formed on the high side of the image, and because rotation of the work plate puts all sides of all images on the high side, the side walls are evenly protected. This produces better protection and again aids in producing shoulders or side walls with less porosity. When porosity is eliminated or greatly reduced, halftone etching, especially fine line halftones, take on added quality.

It has been found that the plate holder 35 must have a four to eight inch larger diameter than the diagonal of of the largest work plate 36 to be etched. Without the larger holder, air bubbles striking the work plate at the plates low position tend to be forced off of the plate in a direction opposite to the plate flow and it is also found that the bubbles leaving the work plate on the high side tend to pick up speed and distort the protection. With the larger holder 35 as defined above, bubbles on the low side are fed to the work plate 36 evenly and the accelerated speed at the top is on the holder 35 rather than on the work plate.

It is seen that the air trapped under the revolving work plate 36 is trying to escape at all times. Even though the bubbles flow to the top of the plate, there can be more air trapped than can flow off at the high side. If the bubbles merge, and they certainly do if the plate is perfectly flat rather than being inclined, air pockets tend to insulate the plate from the bubble action. If this happens, the protective chemicals in the bath attach themselves to the plate, thereby forming cone shaped bumps on the plate bottom. The ideal plate angle then is partially governed by the air volume, i.e., the bubbles must impinge and roll up the work plate 36.

The immersion time is dependent upon the type of plate, the depth etch desired and the type of bath. For example, a halftone flat may be etched in 2 to 4 minutes. A deep line plate on 11 point zinc may take 1 hour or more.

Although the invention has been described by making detailed reference to a single preferred embodiment, such detail is to be understood in an instructive, rather than in any restrictive sense, many variants being possible within the scope of the claims hereunto appended.

We claim as our invention:

1. In an etching machine, a tank for holding an etching bath containing a protective bath additive, a holder in said tank adapted to retain a workpiece submerged in the bath at an angle to said path level, means attached to said holder for rotating said holder and said workpiece, and means in the bottom of said tank for passing bubbles of a fluid lighter than the etching bath liquid upwardly through the bath so as to impinge and roll upwardly on the inclined and submerged workpiece.

2. In an etching machine, a tank for holding an etching bath containing a protective bath additive, a holder in said tank adapted to retain a workpiece submerged in the bath, means mounting said holder for rotating the workpiece, means operatively connected to the holder for adjustably changing the inclination of said workpiece relative to the bath level while submerged in said bath, tubes disposed in the bottom of said tank, the tubes being provided with a plurality of air holes, and means attached to said tubes for passing air in the form of bubbles upwardly through the bath so as to impinge and roll upwardly on the inclined and submerged workpiece.

3. The combination and arrangement of elements as recited above in claim 2, but further characterized in that the said air holes are arranged in a pattern so that no two air holes are located the same distance horizontally from the rotative axis of said inclined and submerged workpiece.

4. In an etching machine, a tank for holding an etching bath containing a protective bath additive, a hinged lid over said tank, a platform hinged to said lid, drive means mounted on said platform including a drive shaft extending through said lid, a holder attached to said drive shaft and adapted to hold a workpiece submerged in the bath when the lid is closed, means attached to the platform to adjust the hinged position of said platform and thereby adjust the angle of the workpiece relative to the bath level while submerged in said bath, and means in the bottom of said tank for passing bubbles of a fluid lighter than the etching bath liquid upwardly through the bath so as to impinge and roll upwardly on the inclined and submerged workpiece, and for causing said bubbles to rise upwardly in a pattern in which no two bubbles at the elevation of the bubble passing means are located the same distance horizontally from the rotative axis of said workpiece.

5. In an etching machine, a tank for holding an etching bath containing a protective bath additive, a hinged lid over said tank, a platform hinged to said lid, a drive means mounted on said platform including a drive shaft extending through said lid, a holder attached to said drive shaft and adapted to hold a workpiece submerged in the bath when the lid is closed, means attached to the platform to adjust the hinged position of said platform and thereby adjust the angle of the workpiece relative to the bath level while submerged in said bath, and means in the bottom of the tank for passing bubbles of a fluid lighter than the etching bath liquid upwardly through the bath so as to impinge and roll upwardly on the inclined and submerged workpiece.

6. In an etching machine, a tank for holding an etching bath containing a protective bath additive, a hinged lid over said tank, a platform hinged to said lid, a drive means mounted on said platform including a drive shaft extending through said lid, a holder attached to said drive shaft and rotatable therewith, said holder being adapted to hold a workpiece submerged in the bath when the lid is closed, means attached to the platform to adjust the hinged position of said platform and thereby adjust the angle of the workpiece relative to the bath level while submerged in said bath, and a plurality of tubes disposed in the bottom of said tank, the tubes being provided with a plurality of air holes, and means attached to said tubes for passing air in the form of bubbles upwardly through the bath so as to impinge and roll upwardly on the inclined and submerged workpiece.

7. In an etching machine, a tank for holding an etching bath containing a protective bath additive, a hinged lid over said tank, a platform hinged to said lid, a drive means mounted on said platform including a drive shaft extending through said lid, a holder attached to the drive shaft and adapted to hold a workpiece submerged in the bath when the lid is closed, means attached to the platform to adjust the hinged position of said platform and thereby adjust the angle of the workpiece relative to the bath level while submerged in said bath, and a plurality of tubes extending across the botom of the tank, the tubes being provided with a plurality of air holes arranged in a pattern so that no two air holes are located the same distance horizontally from the rotative axis of said inclined and submerged workpiece.

8. The combination and arrangement of elements as recited above in claim 7, but further characterized in that the air holes are located in a spiral pattern relative to the rotative axis of said inclined and submerged workpiece.

9. In an etching machine, a tank for holding an etching bath containing a protective bath additive, a hinged lid over said tank, a platform hinged to said lid, a drive means mounted on said platform including a drive shaft extending through said lid, a holder attached to said drive shaft and adapted to hold a workpiece submerged in the bath when the lid is closed, said drive means operating to rotate said workpiece substantially one-third revolution per minute to ten revolutions per minute, means attached to the platform adjusting the hinged position of said platform and thereby adjusting the angle of the workpiece approximately two degrees to twelve degrees relative to the bath level while submerged in said bath, and a plurality of tubes extending across the bottom of said tank, the tubes being provided with a plurality of air holes on the underside of said tubes, the air holes being arranged in a spiral pattern relative to the rotative axis of the workpiece, and means connected to the tubes for blowing air through the air holes to provide a plurality of bubbles that pass upwardly through the bath to impinge and roll upwardly on the inclined and submerged workpiece.

10. In an etching machine, a tank for holding an etching bath containing a protective bath additive, a holder in said tank adapted to retain a workpiece submerged in the bath, the holder being of greater size than the largest dimension of the workpiece, means mounting said holder for rotating the workpiece, means operatively connected to the holder for adjustably changing the inclination of the workpiece relative to the bath level while submerged in said bath, tubes disposed in the bottom of said tank, the tubes being provided with a plurality of air holes, and means attached to said tubes for passing air in the form of bubbles upwardly through the bath so as to impinge and roll upwardly on the inclined and submerged workpiece.

**References Cited** in the file of this patent

UNITED STATES PATENTS

| | | |
|---|---|---|
| 1,001,031 | Hilliard | Aug. 22, 1911 |
| 1,016,487 | Freer | Feb. 6, 1912 |
| 1,313,233 | Grass | Aug. 12, 1919 |

FOREIGN PATENTS

| | | |
|---|---|---|
| 272,160 | Germany | Dec. 24, 1912 |
| 341,704 | Germany | Oct. 6, 1921 |