Sept. 11, 1956 N. B. MEARS 2,762,149

METHOD AND APPARATUS FOR PRODUCING PERFORATED METAL WEBS

Filed April 27, 1953

2 Sheets-Sheet 1

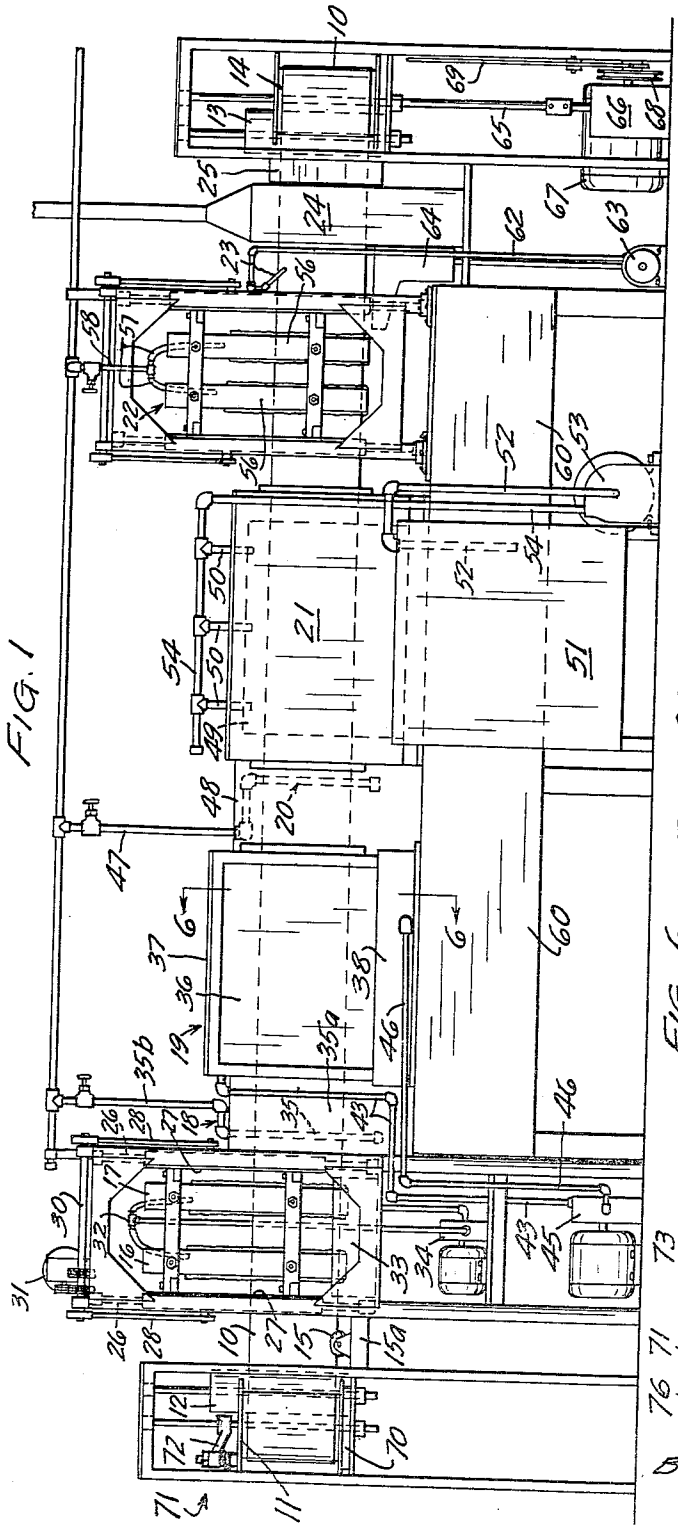


FIG. 1

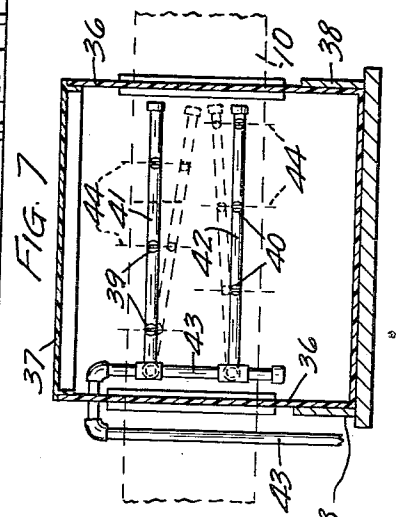


FIG. 7

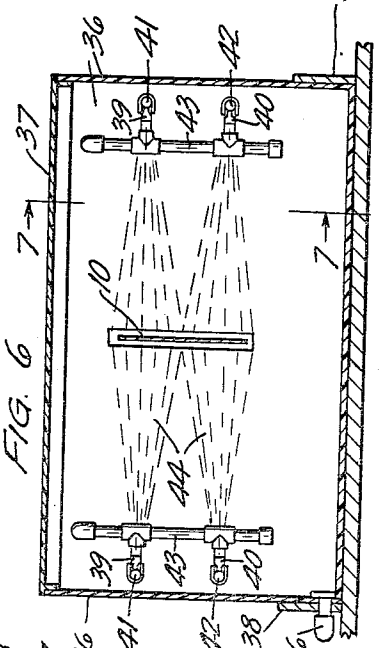


FIG. 6

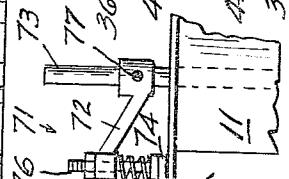


FIG. 8

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METHOD AND APPARATUS FOR PRODUCING PERFORATED METAL WEBS

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2 Sheets-Sheet 2

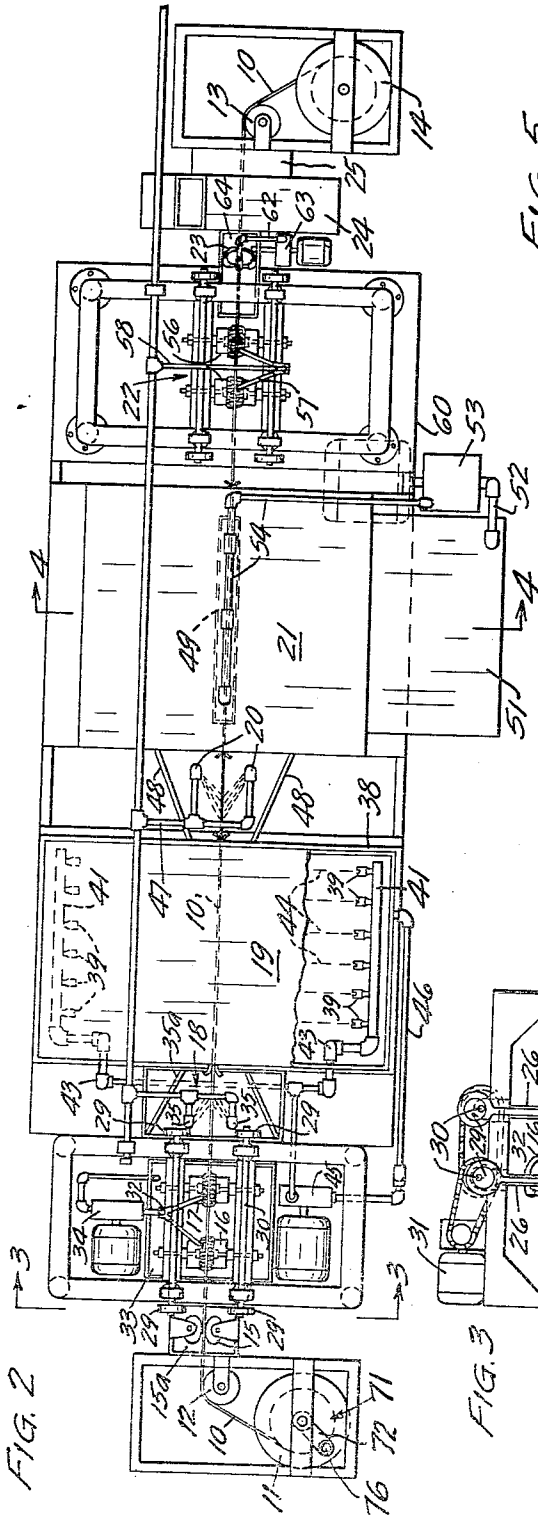


FIG. 2

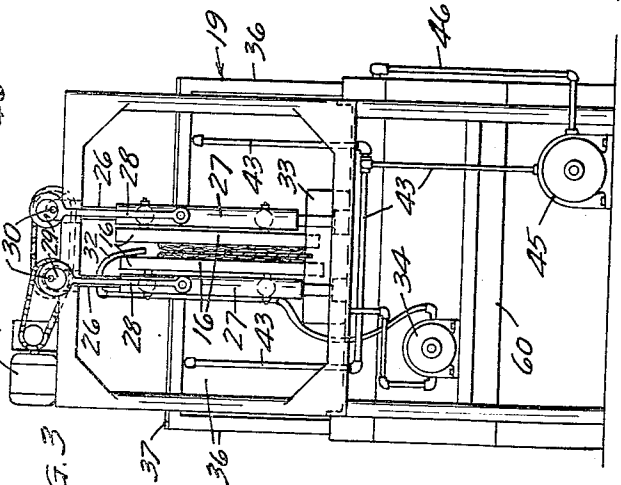


FIG. 3

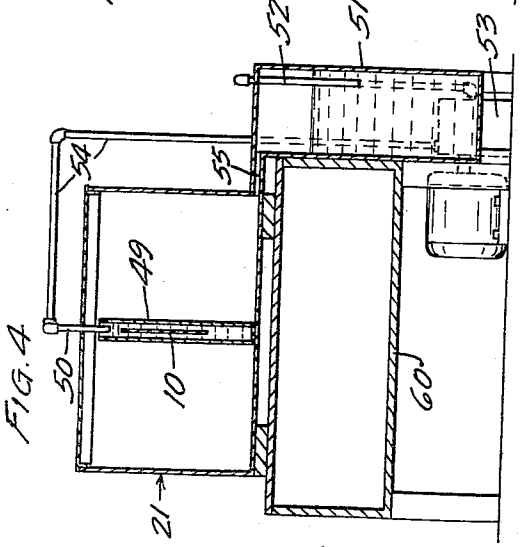


FIG. 4

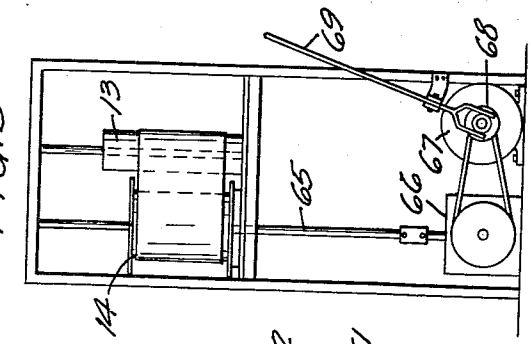


FIG. 5

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METHOD AND APPARATUS FOR PRODUCING PERFORATED METAL WEBS

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Application April 27, 1953, Serial No. 351,127

14 Claims. (Cl. 41—9)

In the manufacture of various articles of precision from thin metal blanks, sheets or webs requiring photographic reproduction of a pattern or design on the work and subsequent etching of the design or pattern to form precisely located perforations it has been considered necessary heretofore to perform a number of operations including the etching and preliminary and subsequent treatment steps separately and with intermediate handling and inspection of the work. Such manual operations greatly increase the cost of producing such articles. The present invention relates to improved methods and apparatus for performing the etching and certain preliminary and finishing operations continuously upon an elongated metal web having exposed areas and masked areas defined by an etching resistant coating.

The principal objects of my invention are to provide a method and apparatus for automatically and continuously etching a predetermined aperture pattern through an elongated metal web whereby the cost of the perforated web is greatly reduced and perforations of precise size or sizes, accurately located are obtained.

A particular object is to provide treating apparatus of the class described which receives the web to be etched from a spool or reel and moves it continuously along a determined path under tension while subjecting it successively to suitable preliminary cleaning and then to etching, mask removal and drying treatment and finally winding the perforated web on a spool or reel. This continuous treatment may also include the automatic scanning of the perforated web to test for its light transmission properties and variations from a predetermined normal or standard perforation size requirement.

A further object is to provide an improved method of forming predetermined patterns of perforations in a metal web having exposed areas and masked areas defined by an etching resistant coating, the method comprising continuously moving the web along a determined path and in a substantially vertical plane while causing an etching fluid to impinge against the exposed areas of the web uniformly until the desired pattern penetrates completely through the web over the exposed areas.

Other objects will appear and be more fully pointed out in the following specification and claims.

Among the articles of manufacture which may be produced rapidly at reduced cost by the present invention are aperture masks for television tubes, fine screens for mechanical separation of solid particles, reticles for fire control and other precision instruments, electric shaving and clipper heads, ventilating screens, and other articles requiring precise location of minute perforations in metal blanks. For such articles the metal web or sheet is less than .02 inch thick and is usually within the range .001 to .006 inch thick. Pure metals, e. g., iron, steel, copper, silver, nickel or tin, or combinations of such metals, such as super nickel, are best suited for accurately controlled perforation by etching treatment and the web should be of uniform thickness and purity. Thin webs of this character are difficult to handle because of their malleability, flexibility and general tendency to be locally deformed as by wrinkles, creases and other indentations which destroy the accuracy and utility of the product. Moreover, after the photo-printing and development of the pattern or design in the etching resistant coating on the web care must be taken to avoid breaks in the coating prior to the etching treatment. By the present invention such detrimental deformations and breaks in the coating are avoided and important economies in the quantity production of perforated webs of various widths are obtained.

Referring to the accompanying drawings which illustrate, by way of example and not for the purpose of limitation, a preferred embodiment of my improved treating apparatus:

Figure 1 is a somewhat diagrammatic side elevational view of the apparatus;

Fig. 2 is a top plan view of the same;

Fig. 3 is an end view showing the preliminary cleaning and etching apparatus;

Fig. 4 is a cross sectional view taken approximately on the line 4—4 of Fig. 2;

Fig. 5 is an end elevational view of the power driven reel and speed control;

Fig. 6 is a fragmentary cross sectional view taken approximately on the line 6—6 of Fig. 1;

Fig. 7 is a vertical sectional view taken approximately on the line 7—7 of Fig. 6, and

Fig. 8 is a side elevational view showing the friction retarding device for the feed reel.

In the drawings the metal web, indicated generally by the numeral **10**, is withdrawn from a spool or reel **11** and passes over the periphery of a vertically disposed guide roller **12** from which it extends in a substantially vertical plane and with one longitudinal edge above the other to a second guide roller **13** and then is wound on a power-actuated reel **14**. As withdrawn from the reel **11** the web **10** carries an etching resistant coating (not shown) defining protected surface areas and exposed areas of the metal forming the pattern or design which is to be etched into or through the web. In the event that the etching is to be performed from both sides or faces of the web it will be evident that the design or pattern must be duplicated in registry on opposite faces of the web. Sufficient tension is maintained in the web **10** to retain it in the upright, straight line position as it is moved along a determined path continuously. The guide rollers **12** and **13** are preferably provided with rubber covered peripheries for contact with the web.

As shown in Figs. 1 and 2, apparatus is provided along the path of the moving web for treating it. This apparatus may comprise a pair of rollers **15** adapted to coat the lower margin of the web as it leaves the reel **11** with a protective wax, cleaning mechanism including power actuated scrubbing members **16** and **17**, water sprays **18**, etching means contained in a chamber **19**, sprays **20** for removing the excess etching fluid from the web, a chamber **21** wherein a solvent for the etching resistant coating on the web is applied, scrubbing mechanism **22** for removing the etching resistant residue, sprays **23** containing a wetting agent, a drying chamber **24** and an electronic scanning device contained in a housing **25** for testing the light transmission properties of the perforated web at various points.

Preparatory treatment apparatus

In order to protect the lower margin of the web **10** against damage and undesirable etching, the rollers **15** are arranged to carry a molten wax on their peripheries which are partially submerged in wax in a heated receptacle **15a**, the peripheries of these rollers being disposed in rolling contact with the lower margin of the web

at opposite faces. These rollers have beveled peripheries and may be revolubly supported with their axes of rotation at an angle of approximately 45 degrees to the horizontal. The wax quickly solidifies on the web which is then moved between a pair of vertically extending scrubbing members **16** and then between similar scrubbing members **17**. Both pairs of scrubbing members are power actuated to oscillate in vertical planes and are preferably provided with fibrous facings for contact with the web, e. g., sheep skin with the wool in contact with the web. The scrubbing members at each side of the web are provided with fixed vertical guides **26** upon which tubular members **27** are slidable vertically. The scrubbing members are supported on the tubular members and the latter are oscillated relative to the guide members by pairs of links **28** connected to eccentric heads **29**. Horizontally extending shafts **30** support and rotate the eccentric heads and are operatively connected to an electric motor **31**.

As shown in Figs. 1, 2 and 3, a cleaning fluid or fluids is fed to the scrubbing members **16** and **17** through feed pipes **32** and the fluid is collected in a tray **33** from which it is withdrawn by a motor operated pump **34** and circulated through a pipe extending to the tray **33** and a delivery pipe connected to the feed pipes **32**. Suitable cleaning fluids for this preliminary treatment of the metal web are those used in the photo-engraving art for descumming photographically produced and developed images on the plates. One such fluid comprises a solution of nickel salts and a saponifying agent to which an abrasive substance such as pumice powder may be added. A suitable permanganate solution may also be used on the scrubbing members **17**. The metal web, after passing between the scrubbing members **16** and **17**, is washed by passage through water sprays **18** from a pair of nozzles **35** which are disposed to direct the water at high velocity obliquely against opposite sides of the web shortly before it enters the etching chamber **19**. The nozzles **35** are disposed above a suitable catch basin and are shielded by walls **35***a* and supplied with water through a pipe **35***b*.

Etching apparatus

My improved etching apparatus includes the spray chamber **19** of generally rectangular shape having transparent side and end walls **36**, a transparent and removable top **37** and an open top tank **38** containing a supply of suitable etching fluid, e. g., a solution of ferric chloride of the required concentration. The metal web **10** to be etched enters and leaves the etching chamber **19** through vertically elongated slots in opposite walls **36**. The etching fluid is caused to impinge against the exposed face or faces of the web **10** in the etching chamber by a series of nozzles **39** and **40**. The nozzles **39** are spaced along a supply header **41** and the nozzles **40** along a similar header **42** and both of these headers extend generally along and in parallel relation to the web **10**, the header **41** being at a lower elevation than the header **39**. These headers are branches of a supply pipe **43** and have swivel connections therewith so that the elevation of each of them may be adjusted by angular movement in a plane which is parallel to the exposed face of the metal web **10**, as indicated in broken lines in Fig. 7. As further indicated in Fig. 7, the nozzles **39** are staggered longitudinally of the web relative to the nozzles **40** and the several nozzle orifices are vertically elongated so that the sprays indicated by the numeral **44** impinge against the web **10** in vertically elongated patterns and substantially at right angles to the surface of the web. By this apparatus and method the sprays of etching fluid are distributed uniformly over the face or faces of the web as it moves through the etching chamber and a controlled rate of penetration of the web with resulting uniformity of perforation widths is obtained. For maximum rate of etching, the sprays may be duplicated at opposite faces of the web, as indicated in Figs. 2 and 6. The etching fluid is supplied to the pipes **43** under the required, e. g. 10 lbs. to 40 lbs. per square inch, pressure by means of a motor driven pump **45** which is supplied through a suction pipe **46** communicating wth the tank **38** containing the etching fluid. During the etching, the progress of the perforating operation may be observed through the transparent walls **36**, suitable illumination being provided at the side of the etching chamber opposite that where the observer is stationed.

Upon emerging from the etching chamber, the web **10** is subjected to the water sprays **20** which remove the excess etching fluid. These sprays are supplied with water under pressure through a pipe **47** and are contained in a suitable housing **48**.

Coating removal and scrubbing apparatus

From the housing **48** the web **10** passes into the chamber **21** wherein it is submerged in a solvent for the etching resistant coating or masking material remaining on the web. Solvents suitable for this purpose are well known in the photo-engraving art. Some of them are applied in a hot condition, e. g., a 40% solution of sodium hydroxide (NaOH) at approximately 200 degrees F. As best shown in Figs. 1, 2 and 4, my treating apparatus includes a long, narrow tank **49** arranged to contain the web and a hot solvent and having vertically elongated slots in the ends of the tank for the passage of the web. These slots are substantially closed by squeegee-like web engaging members. The liquid solvent is continuously supplied through a plurality of branch pipes **50** which feed it into the top of the tank at a rate which insures the complete submersion of the web in the solvent. The latter is heated in a tank **51** from which it is withdrawn through a pipe **52** extending to a motor driven centrifugal pump **53** and the latter forces the hot solvent through a pipe **54** extending to the branch pipes **50**. The overflow solvent is returned to the tank **51** from the bottom of the chamber **21** through a pipe **55** (Fig. 4).

From the chamber **21** the web **10** passes to the scrubbing mechanism **22** which removes from the web the residue of the coating and solvent. This scrubbing mechanism includes pairs of vertically reciprocating members **56** which are provided with fine flexible bristles or other suitable facing material for contact with the web **10**. The members **56** are operated by motor actuated mechanisms similar to that hereinbefore described with reference to the scrubbing members **16** and **17**. A suitable cleaning fluid is continuously supplied to the working faces of the members **56** through branch pipes **57** extending from a water supply pipe **58**. Wash water carrying the coating residue is collected in an elongated tank **60** extending beneath the web **10** and scrubbing members **56** and also extending beneath the web where it is subject to the sprays **18** and **20**.

After passing between pairs of the scrubbing members **56** the web **10** is sprayed with a suitable wetting agent, such as the common "photo flow" solution. This solution is applied to the work by the spray pipes **23** which are supplied with a solution of the wetting agent from a pipe **62** extending to a motor driven pump **63** and the latter is supplied from a tank **64** extending beneath the web to receive the solution from the lower edge thereof. The thoroughly cleaned web then passes through the drier chamber **24** wherein warm dry air is blown against the web surfaces by a suitable fan.

As the final treatment, the dried web passes through the scanning chamber **25** containing an electronic scanning device which detects and indicates defects, if any, in particular units comprising the several portions of the web. A defect may be indicated when the perforations in any portion of the web vary from a predetermined desirable size, as indicated by its light transmission characteristics.

Finally, the web is guided by the roller **13** to the reel **14**. This reel comprises a spool which is fixed on a vertical shaft **65** and the later is adapted to be continuously

rotated through speed reduction gearing in a housing **66** and a belt drive extending from an electric motor **67**. The belt drive is preferably of the **V** type having a speed control pulley **68**, the sides of which are relatively movable, one to and from the other, under control of a lever **69** whereby the rate of movement of the web to the power-driven reel **14** may be adjusted. Sufficient tension is maintained in the web **10** as it passes from the reel **11** to the reel **14** to maintain it in substantially straight line movement in a substantially vertical plane. Suitable retarding friction is created largely by the weight of the web carried by the reel **11** which rests on a friction support **70** and by a brake indicated generally by the numeral **71** (Figs. 1, 2 and 8). This brake has an arm **72** which is fixed at one end on an axial shaft **73** and carries a friction shoe **74** engaging the upper end surface of the reel **11**. A coiled spring **75** is arranged to bias the shoe **75** toward the reel and is confined on a vertically movable bolt **76** carrying the shoe on its lower end. The pressure applied by the shoe is adjustable by means of a set screw **77** connecting the arm **72** to the shaft **73** which is fixed against rotation. Some additional frictional resistance to the movement of the web is caused by the scrubbing members **16** and **17** and **56** and, to a lesser extent, by the squeegee contact members carried by the ends of the solvent tank **49**.

The rate of travel of the web along the path described is adjusted to insure the complete and uniform penetration of the etching solution through the web over the exposed area thereof. It will be evident that the rate of travel of the web is dependent on the length of the etching chamber which affects the duration of the spraying treatment as well as on the thickness of the metal to be perforated, aperture size requirements, kind of metal to be etched and other ascertainable conditions.

Having described my invention, what I claim as new and desire to protect by Letters Patent is:

1. The method of forming predetermined patterns of perforations in a thin elongated metal web having exposed areas and masked areas defined by an etching resistant coating which comprises continuously moving said web endwise along a determined path while continuously causing an etching fluid to impinge in the form of fluid pressure induced fine sprays against the exposed areas of the moving web equally at all points along each longitudinally extending elemental area of the web until the desired pattern penetrates completely through the web.

2. The method according to claim 1 wherein the metal web is maintained under tension and in the same substantially vertical plane during its movement along said path.

3. The method according to claim 1 wherein the respective sides of the web have registering areas of etching resistant coating and the etching fluid is applied in the form of sprays simultaneously to both sides of the web.

4. The method of forming predetermined patterns of perforations in a thin elongated metal web having exposed areas and masked areas defined by an etching resistant coating which comprises continuously moving said web endwise along a determined path and maintaining it under longitudinal tension and in a substantially vertical plane while causing an etching fluid to impinge against the exposed areas of the web uniformly and repeatedly until the desired pattern penetrates completely through the web, and then removing the etching resistant coating from the web while it is in continuous motion along said path.

5. The method of forming a predetermined pattern of perforations in a thin elongated metal web having exposed areas and masked areas defined by an etching resistant coating which comprises continuously moving said web endwise along a determined path and with one longitudinal edge above the other while successively applying an etching fluid from a plurality of sources to a multiplicity of longitudinally spaced exposed areas of the

web until the desired pattern of perforations penetrates completely through the web, and while the web is in continuous motion along said path and removing the excess etching fluid and remaining portions of the etching resistant coating from the web.

6. The method according to claim 5 wherein the metal web is maintained under tension during its movement along said path.

7. For a thin metal web having exposed areas and masked areas defined by an etching resistant coating, treating apparatus comprising, means for supporting the web in a substantially vertical plane and with one longitudinal edge above the other, means for maintaining the web under tension and for moving it continuously along a determined path, an etching chamber adapted to contain said web in its movement along said path, spray means disposed in said chamber to deliver streams of etching fluid against the exposed areas of the web therein uniformly for forming perforations in the web, a second chamber disposed to receive the perforated web, means in said second chamber for applying to the web a solvent for the protective coating and means for cleansing and removing the coating and solvent from the surface of said web disposed successively along said path.

8. For a thin metal web having exposed areas and masked areas defined by an etching resistant coating, treating apparatus comprising, a roll having a substantially vertical axis of rotation for supporting the web to be treated, a reel disposed to receive the perforated web and having a substantially vertical axis of rotation, a motor operatively connected to said reel for winding the web thereon and for moving the web along a determined path, friction means for retarding the withdrawal of the web from said roll, an etching chamber disposed to receive the web from said roll and to contain a portion of the web in its movement along said path toward the reel and spray means disposed in said chamber to deliver streams of etching fluid against the exposed areas of the web therein uniformly.

9. For an elongated metal web having a succession of longitudinally spaced exposed areas and masked areas defined by an etching-resistant coating on both sides thereof; treating apparatus comprising, an etching chamber having vertically elongated openings at opposite ends for the passage of said web into one end of said chamber and out from the opposite end thereof, means for continuously moving said web with one longitudinal edge above the other longitudinal edge longitudinally through said openings and chamber at a controlled rate of speed, and etching means operative within said chamber to cause etching fluid to impinge against the exposed areas at both sides of said web while such areas are in continuous motion through said chamber whereby the duration of the etching treatment applied to successive exposed areas of the web is determined by the time of passage of such areas through said chamber.

10. For a thin elongated metal web having exposed areas and masked areas defined by an etching-resistant coating, treating apparatus comprising a roll carrying a supply of the web to be treated, means for guiding the web from said roll along a determined path, first and second chambers spaced along said path and disposed to successively receive the web from said roll, etching means operative in said first chamber to apply etching fluid to the exposed areas of the web successively, means in said second chamber for applying to the etched web a solvent for the etching-resistant coating, and power-actuated means operatively connected to said web for continuously moving it at a predetermined speed successively through said first and second chambers, the duration of the treatment of the successive areas of the web being determined by the rate of movement thereof through said chambers.

11. For a thin elongated metal web having exposed areas and masked areas defined by an etching-resistant

coating; treating apparatus comprising, a roll carrying a supply of the web to be treated, means for guiding the web from said roll along a determined path, first and second chambers spaced along said path and disposed to successively receive the web from said roll, etching means operative in said first chamber to apply etching fluid to the exposed areas of the web successively, means in said second chamber for applying to the etched web a solvent for the etching-resistant coating, cleaning means for removing the coating and excess solvent from the surfaces of the moving web, driving means for the web engaging it at a position spaced along said path from the cleaning means, and power-actuated means operatively connected to said driving means for continuously moving the web at a predetermined speed successively through said first and second chambers and then to and beyond said cleaning means.

12. For an elongated blank having exposed areas and masked areas defined by an etching resistant coating, treating apparatus comprising, means for supporting said blank for longitudinal movement along a determined path with a face of the blank exposed for treatment, cleaning means including power actuated scrubbing members and sprays disposed to clean said face of the blank in its movement along said path, etching means operative to cause etching fluid to impinge against the cleaned face of the blank during its movement along said path and means for continuously moving said blank along said path at a controlled rate of speed whereby the duration of the cleaning and etching treatment is determined by the rate of travel of the blank along said path.

13. The method of forming predetermined patterns of perforations in an elongated thin metal web having a succession of longitudinally spaced exposed areas and masked areas defined by an etching-resistant coating which comprises, continuously moving said web in a substantially vertical plane with one longitudinal edge above the other longitudinal edge, at a controlled velocity endwise through and then out of an etching zone while causing an etching fluid to impinge against the exposed areas of the moving web equally at all points along each elemental longitudinal area thereof until the patterns penetrate completely through the web and continuously removing the remaining etching resistant coating from the successive etched areas upon the passage of the web from the etching zone.

14. The method of forming predetermined patterns of perforations in an elongated metal blank having a succession of longitudinally spaced exposed areas and masked areas defined by an etching resistant coating which comprises, continuously moving said blank endwise in a substantially vertical plane through and out of a cleaning zone and then through and out of an etching zone and cleaning the successive exposed areas of the blank while in the cleaning zone and applying an etching fluid to said exposed areas of the blank for the period of time required for the passage of each of the successive exposed areas through the etching zone.

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