

June 3, 1947.

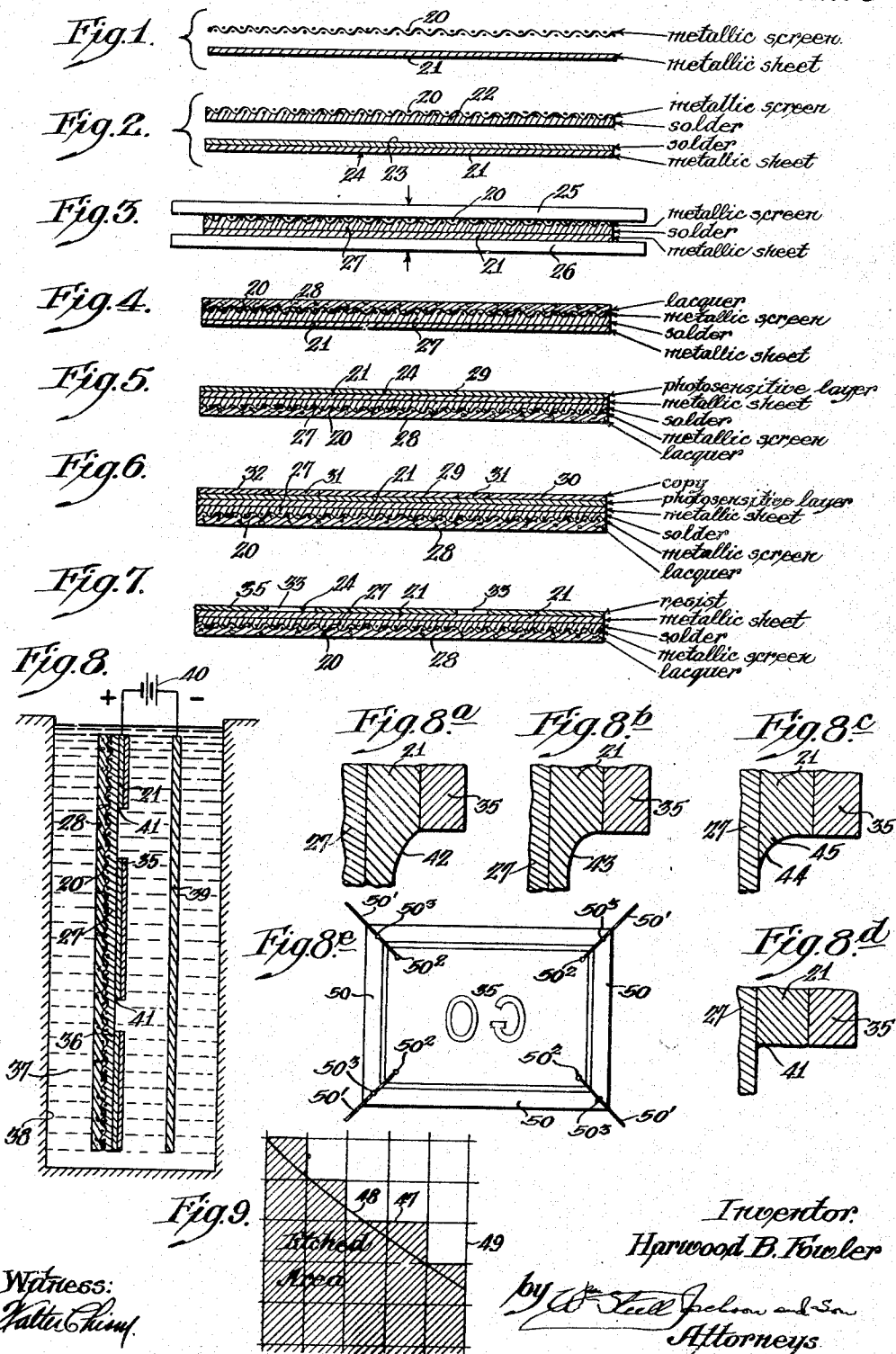
H. B. FOWLER

2,421,607

METHOD OF MAKING METALLIC PRINTING SCREENS

Filed April 3, 1942

2 Sheets-Sheet 1



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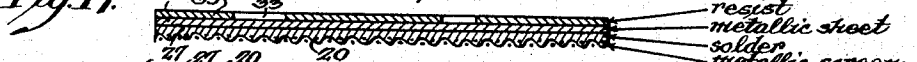
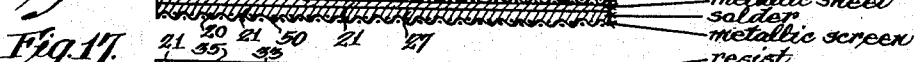
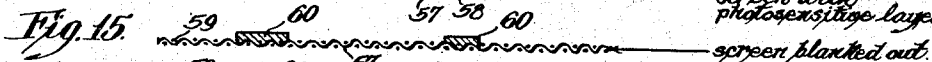
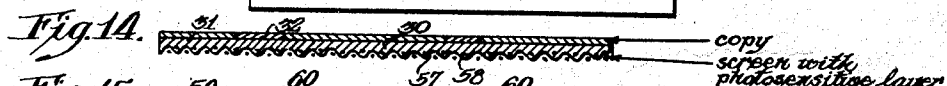
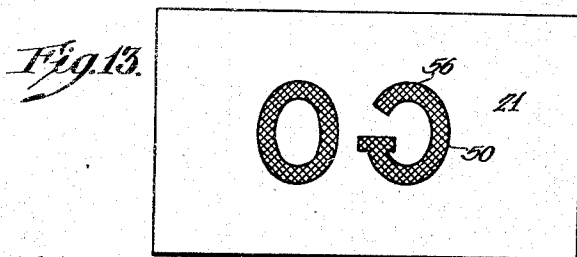
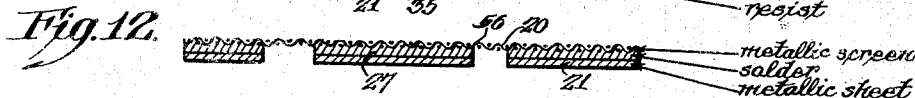
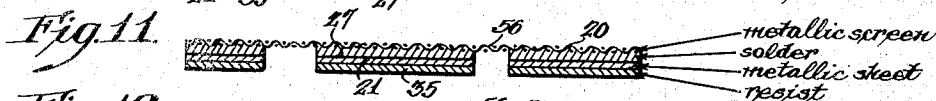
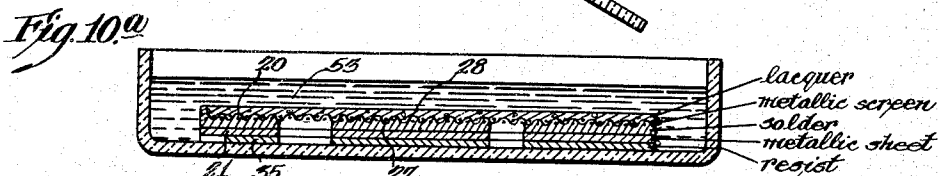
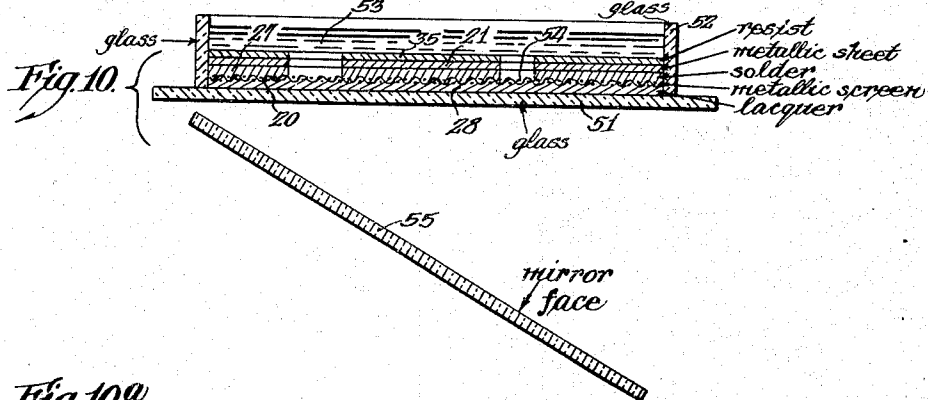
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METHOD OF MAKING METALLIC PRINTING SCREENS

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2 Sheets-Sheet 2



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METHOD OF MAKING METALLIC PRINTING
SCREENS

Harwood B. Fowler, Wayne, Pa.

Application April 3, 1942, Serial No. 437,543

3 Claims. (Cl. 101—128.4)

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The present invention relates to metallic printing screens and processes of manufacturing the same, and particularly to screens and processes for printing radium dial material.

A purpose of the invention is to secure more smooth and even printing edges in the designs on printing screens, avoiding or reducing saw-toothing at the printing edges of the designs.

A further purpose is to avoid the necessity of employing extremely fine mesh screens for minimizing raw-toothing in screen printing, and to permit the use of coarse screens for printing radium dial material and the like without causing objectionable saw-toothing.

A further purpose is to mask the non-printing portions of a metallic printing screen by a metallic sheet, preferably on the printing face of the screen, to secure the metallic sheet and the metallic printing screen together by a metallic uniting layer different from the metallic sheet, to etch the design in the metallic sheet, finishing with an etchant which does not substantially attack the uniting metal and subsequently to remove the uniting metal at the design portions of the screen, finishing with an etchant selectively attacking the uniting metal.

A further purpose is to etch a metallic printing screen from the printing face so that the most perfect etching of the design will be right at the printing face where etching starts.

A further purpose is to obtain a sharp etched edge in the design on a metallic sheet united to a printing screen by placing between the metallic sheet and the screen a metallic layer not substantially attacked by the etchant which finishes the etching of the metallic sheet, the metallic layer separating the metallic sheet from the screen at the points of etching.

A further purpose is to unite a metallic sheet and a metallic screen by an alloy containing zinc which will be relatively resistant to the etchant which finishes the etching of the metallic sheet, but will be easily attacked by any usual strong acid.

A further purpose is to make a commercial printing screen of metallic screen wire, soldered to a metallic sheet.

A further purpose is to produce a printing screen from metallic screen wire united by a metal to a sheet made of an alloy predominantly containing copper.

A further purpose is to laminate together a metallic screen and a metallic sheet by a metallic bond and to coat the face of the screen remote from the metallic sheet with a transparent resist, preferably a transparent lacquer, to delineate a design through the sheet, and subsequently to etch out the design through the uniting metal while inspecting the face of the screen remote from the metallic sheet through the transparent

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resist for the end point of the etching operation.

A further purpose is to etch a metallic printing screen in several bites to avoid break down of the resist.

A further purpose is to regulate the thickness of build-up in screen printing by securing on the printing face of the screen a metallic sheet of thickness variable with respect to the amount of build-up desired.

A further purpose is to reduce the waste of radium dial material used in printing.

Further purposes appear in the specification and in the claims.

In the drawings, I have illustrated a few only of the possible embodiments of the invention, the forms shown being chosen from the standpoint of convenience in illustration and satisfactory operation.

Figures 1 to 7 are diagrammatic sections illustrating successive steps in the construction of the screen of the present invention.

Figure 8 is a diagrammatic section showing electrolytic etching of the metallic sheet.

Figures 8a to 8d are diagrammatic fragments showing successive stages of etching in Figure 8.

Figure 8e is a diagrammatic front elevation of the anode in electrolytic etching.

Figure 9 is an enlarged diagrammatic plan view of a fragment of a screen, showing how saw-toothing develops.

Figures 10 and 10a are diagrammatic sections showing alternate techniques for etching of the uniting metal.

Figures 11 and 12 are diagrammatic sections showing further steps in completing the screen. Figure 13 is a bottom plan view showing the printing face of a finished screen.

Figures 14 to 17 are diagrammatic sections showing an alternate procedure for applying resist to the design face of the screen.

Figures 18 and 19 are diagrammatic sections showing printing with different thicknesses of build-up.

In the drawings, like numerals refer to like parts throughout.

In printing many types of pigments, including ceramic pigments for labeling bottles and jars, and in printing signs on metal and the like, and printing gauges, dials, indications and instructions on instruments, apparatus and equipment, it is frequently necessary to resort to screen printing of the type frequently described as "silk" screen printing.

The general process consists in blocking out all portions of the screen except those which are to print the design, and then placing the screen in close proximity to the work and passing the pigment through the screen and onto the work pref-

erably by a squeegee applied to the front or non-printing face of the screen.

Difficulty has been encountered in screen printing because of the fragile nature of silk screens, the present scarcity of silk and the comparatively high cost of obtaining satisfactory blocking out of the non-printing areas around the design.

Efforts have therefore been made to employ metallic screens. These have met with limited success because of the great difficulty in securing, at low cost, smooth and even edges where the blocked out areas meet the design, and the relatively high cost of transferring the design to the screen in any reasonably durable form.

At the present time a great deal of radium and other luminous dial materials (herein conventionally referred to as "radium dial materials") is applied to instruments, and this work is almost entirely done by hand because of the impossibility of obtaining the requisite high build-up and desired uniformity and precision by the methods of machine printing heretofore available. This hand application of radium dial materials is not only dangerous to the operator, who must carefully avoid all absorption of the radium by his body, but is also very slow and expensive. Approximately 30 to 40% of the radium dial material used in the manual process hardens on the brushes, is removed by the cleaning pads, and must be recovered and reworked. One of the important results achieved by the present invention is the avoidance of the danger incident to production of radium dials by the manual method and saving of the 30 to 40% radium dial material which has to be reworked in the manual process.

In order to accomplish these and other purposes explained more in detail below, the present inventor laminates together a metallic screen suitable for screen printing and a metallic sheet suitable for blocking out the non-printing areas, and unites the screen to the sheet by a uniting metal having different etching characteristics from the screen and from the sheet.

In Figure 1 are shown a metallic printing screen 20 and a metallic sheet 21. The screen may be of any suitable metal, preferably one of the corrosion resisting steels (often called corrosion resistant irons) such as stainless steel. Very satisfactory results are obtained with a screen of stainless steel containing 18 per cent chromium and 8 per cent nickel. Corrosion resistant steels or irons containing smaller amounts of chromium with or without nickel may be used with success, for example, 17 per cent of chromium and 2 per cent of nickel, or 16 per cent chromium without nickel.

While it is best to employ a screen of stainless steel or the like, it is possible to use a screen predominantly consisting of copper, and made up, for example, of copper, brass or bronze. This type of screen is less desirable than a screen of corrosion resisting steel, as it is softer and less immune to corrosion.

The mesh size for the screen may be of any usual screen printing mesh, for example, 165 mesh per linear inch (Tyler standard). As will be explained later, one of the important advantages of the invention is that much coarser meshes can be employed with satisfaction in the present invention than in the prior art.

The metallic sheet 21 preferably predominantly contains copper. Copper or a copper base alloy, such as brass or bronze, may be used with success.

The metallic sheet and the screen are joined

together by a uniting metal which will desirably be solder. As shown in Figure 2, the screen has been tinned or coated with a layer of solder 22 by a suitably hot iron and the upper surface of the metallic sheet 21 has been tinned as shown as 23. In tinning the metallic sheet 21, it is important to keep the lower surface 24 untinned.

While the screen 20 and the metallic sheet 21 are still very hot and the solder layers 22 and 23 are still molten or plastic, the screen and sheet are laminated together by pressure between suitable dies 25 and 26, as shown in Figure 3. A pressure of a few hundred pounds, as obtained in a hand press, is sufficient for this purpose. The dies 25 and 26 will desirably be heated, though the temperature need not be as high as the melting point of solder in every case. Where the dies are heated above the melting point of the solder, they will be allowed to cool sufficiently to permit the solder to harden before the pressure is released. The result as produced in Figure 3 is soldering together of the adjoining surfaces of the screen and the metallic sheet by a layer of solder 27 which extends between the interstices of the screen. In accomplishing this soldering, it is best to have the screen above the metallic sheet, so that solder will not necessarily fully fill the meshes of the screen for the entire thickness of the screen, although it will extend over the entire area.

The thicknesses of the solder layers 22, 23 and 27 are exaggerated in the drawing.

After suitable cooling of the laminated screen and sheet, and inverting of the laminated structure, the front or non-printing surface of the screen is coated with a resist 28, preferably a transparent resist as shown in Figure 4. The best transparent resist is a transparent lacquer such as nitrocellulose lacquer, ester gum lacquer or glycerol-phthalic acid lacquer. Any suitable transparent lacquer, which can later be dissolved away, may be employed.

The printing face 24 of the metallic sheet is then coated with a photosensitive layer 29 (Figure 5) as well known in the art. The photosensitive layer 29 may actually be several layers applied until the desired thickness of photosensitive layer is obtained as well known in the art. Any suitable photo-engraver's sensitizing solution of the cold enamel type may be used in making the photosensitive layer 29, as for example, dichromated gelatine. A highly satisfactory sensitizing solution of the cold enamel type is sold on the market as "Hess special" re-etching enamel.

After the photosensitive layer 29 has been properly dried (under protection from light strong enough to cause exposure), it is photographically exposed to the copy which contains the design to be transferred to the screen. The most convenient way to do this is by contact printing technique as shown in Figure 6. The copy 30 suitably reversed (because it is being photographed against the printing surface rather than the so-called front surface of the screen) is placed against the photosensitive layer 29, in a contact printing frame, if desired, and a strong light is applied for a time long enough to complete the exposure. Areas 31 where the design appears on the copy will protect the photosensitive layer immediately beneath them from exposure, but other areas 32, where the design is absent will permit transmission of light to expose the portions of the photosensitive layer immediately beneath. The copy 30 may be either a photo-

negative or a photo-positive transparency on film or glass.

After exposure the photosensitive layer is developed by any developer well known in the art (provided a developer is required) and washed with acid until the photosensitive layer at points 33 corresponding to the areas beneath the design 31 is removed and the surface 24 of the metallic sheet is exposed at such areas. In case "Hess special" re-etching enamel is to be used, Hess developer gives best results though any other photo-engraving developer may be employed. Elsewhere the photosensitive layer is converted by the exposure into a resist 35 as shown in Figure 7.

An important feature of the invention is the etching in at least two steps, the first of which etches through the metallic sheet and the second of which removes the uniting metal at corresponding points.

For etching through the metallic sheet, it is best to use an electrolytic etching process, though this is of course not essential. It is found, however, that electrolytic etching gives very rapid, sharp and straight-walled etching of the metallic sheet.

In Figure 8, the laminated screen and sheet form the anode 36 in an electroplating bath 37 contained within a vessel 38. A cathode 39 suitably of copper is connected in the circuit with a direct current source 40. The plating current will preferably be about 8 amperes and the voltage may be regulated accordingly. The electrolyte may be any suitable etchant which etches the copper sheet 21 preferentially to the solder layer 27 beneath it. Good results are obtained with chromic acid. The best chromic acid concentration is 10 per cent. Other suitable copper etchants which preferentially attack copper rather than solder, and do not destroy the resist, may be employed. Numerous copper etchants are listed in Metals Handbook (1939) 1472.

It has been found that the presence of the solder layer 27 between the metallic sheet 21 and the screen 20 aids greatly in obtaining a straight and smooth etched edge 41 of the copper.

It has been found that the etchant first produces a gradually filleted depression 42 near the edge of the resist as shown in Figure 8a. As the etching becomes deeper, this curve becomes sharper as shown at 43 in Figure 8b. Further etching results in a configuration as shown at 44 in Figure 8c. If the solder layer 27 is not present, it has been found that the tendency is to leave a curved projection 45 not removed by etching. If the etching is prolonged without any solder layer being present, the result is to obtain undercutting from the back and edge of the metallic sheet before the projection 45 is fully etched away.

The solder layer 27, however, not being substantially attacked by the etchant for the copper, tends to prevent undercutting while the copper etchant is attacking and removing the projection 45 until the comparatively straight etched wall 41 is obtained as shown in Figures 8 and 8d.

Thus it is evident that the square character of the etched edge of the metallic sheet is improved by the presence of the layer of uniting metal 27 not attacked by the etchant.

The layer of uniting metal 27 performs a further very important function during the copper etch. If the metallic sheet 21 and the screen 20 were in direct contact with one another during the copper etch, without any uniting layer being

present, the etchant would tend to crawl along the wires 46 of the screen beneath the copper and to follow the squares of the screen mesh in etching, producing a saw-toothed outline 47 (Figure 9), instead of following the line 48 of the design. This saw-toothed outline 47 attained in the prior art, is very undesirable as it is carried over into the outline of the final pigment build-up in printing.

It has been found that the presence of the solder layer 27, preventing all physical contact between the wires 49 and the metallic sheet 21 during the etching of the metallic sheet, eliminates the saw-toothing entirely and produces a smooth etched wall (which of course may be curved to suit the design) following the line 48.

By virtue of the fact that the uniting metal layer 27 is not copper and is resistant to copper etchants, the uniting layer of solder not only assists by uniting the metallic sheet and the metallic screen firmly together, but also aids greatly in obtaining a square etched wall of the copper sheet in depth and a smooth etched wall in length.

In order to attempt to avoid saw-toothing in screens where the metallic screen and the metallic sheet have been in direct contact during the etch, it has been necessary to employ very fine screen meshes. This does not in fact prevent saw-toothing, but it makes the saw-toothing so fine that it is not very noticeable in the build-up on the final printing. For this reason, it has been the prior practice of the inventor to employ screen mesh sizes of about 165 Tyler standard mesh per linear inch, and coarser screens could not be used without exhibiting very obvious saw-toothing.

This is a distinct disadvantage in printing certain pigments which are desirably of large particle size. For example, in printing radium dial materials, where the production of efficient luminous coatings necessitates the employment of particles of relatively large size, it has not been possible to obtain satisfactory printing through the fine screens needed in the prior practice to avoid saw-toothing, and accordingly, manual application of the radium dial material has been employed with corresponding great risk to workers who are likely to come into physical contact with the radium dial material.

By the present invention, the screen mesh, no matter how coarse it may be, exerts no undesirable effect upon the squareness or smoothness of the etched wall produced in the metallic sheet, since the solder prevents physical contact between the metallic sheet and the screen during the etching of the sheet. Thus, it has been possible in accordance with the present invention to produce etched screens of 100 mesh or even coarser without any saw-toothing taking place at the printing face. With such coarser screens, satisfactory printing of radium dial materials is possible not only for comparatively crude commercial uses, but more especially to meet the very exacting requirements of military aircraft instruments and those required in mechanized land warfare.

One of the important features of the invention is that the etching is started at the printing face.

The more the etching advances into the depth of the sheet, the more pronounced will its tendency be to deviate from the contour of the design.

Thus, if in spite of the precautions taken in

accordance with the present invention, some tendency to saw-toothing is evident, it is likely to develop only in the portions of the laminated screen and sheet which are relatively far from the printing face 24. Thus a certain amount of inaccuracy incident to high production methods can be tolerated without destroying the utility of the invention by marring the accuracy and smoothness of the outline at the printing face. Such slight inaccuracy will merely affect the etching in the region 44 which is relatively far removed from the printing face.

While the procedure above indicated for making the copper etch can be used satisfactorily, it is comparatively slow and ineffective. Much more rapid etching can be obtained if a solution of ferric chloride is initially employed in the electrolytic bath to etch through the copper until the uniting layer is first exposed. Ferric chloride etches much more rapidly than chromic acid and can be used quite efficiently up to about the stage shown in Figure 8c where the uniting layer has first been uncovered. It is not safe to use ferric chloride for etching beyond the stage of uncovering the uniting layer (except as noted below) as it will attack the uniting layer and will not discriminate between the copper and the uniting layer. Therefore the etching solution should be changed after reaching the stage of Figure 8c. The laminated screen and sheet should be washed, dried and then further electrolytically etched in chromic acid solution to remove the remaining copper, such as the curved projections 45.

Both ferric chloride and chromic acid have a tendency to break down the resist 35 if etching is carried on continuously from beginning to end. It seems to be a softening effect due to the water present rather than a direct chemical attack. It is found that this difficulty can be avoided by etching in a plurality of short bites, and drying the laminated screen and sheet between bites. Each drying is preferably preceded by a wash in water. Each drying tends to harden the resist so that it can withstand the action of the etchant during the next succeeding bite. For best results the copper should be removed, using several (preferably four or five) bites with ferric chloride solution and then several (preferably four or five) bites with chromic acid solution, washing and drying between each bite; by short bites, I mean bites of about five, ten or fifteen minutes.

It is very difficult to regulate the electrolytic etching and obtain uniform etching over the surface of the design, particularly near the end of the etch when most of the copper to be removed has been etched out. I have discovered that regulation of the electrolytic etching can be greatly improved if a current bleed is used. In Figure 8e, I show the printing face of the composite screen in the electrolytic solution with a current bleeding electrode 50, suitably of sheet iron or of tin plate, surrounding the laminated screen and plate and united to it by wires 50' soldered to the surface of the copper sheet 21 at 50², soldered to the bleeding electrode at 50³, and coated with a resist such as varnish to protect against attack by the etchant. Each of the wires 50' is of equal length from its soldered end at 50² to its point of origin connected to the source of electric energy so that the ohmic resistance to each corner of the bleeding electrode 50 will be equal. The bleeding electrode is very desirably in close proximity to the composite sheet—here

surrounding it in the same plane, and is approximately as far from the cathode as is the composite screen.

As the end of the copper etch approaches, in the condition between that shown in Figure 8c and 8d, the effective current density in the copper to be etched tends to increase to a tremendously high level.

The bleeding electrode maintains a constant relatively large area for current distribution, so that the electrolytic etching conditions change less markedly toward the end of the copper etch than would be the case if the bleeding electrode were not present. The bleeding electrode therefore operates as a balance or regulating device to maintain relatively constant etching conditions toward the end of the copper etch, when the effective current density from the standpoint of the copper being etched would otherwise increase to an abnormally high value, with a tendency to accelerate the copper etching up to an uncontrollable rate.

After etching through the copper sheet 21, the laminated screen and sheet is removed from the etchant, washed with water and dried.

Having removed the copper throughout the area of the design, it is necessary that the uniting metal layer 27 be removed also at corresponding points. This is accomplished by a second etching as shown in Figure 10 or 10a. The etchant for the second etching is one which will preferentially attack the solder rather than the metallic sheet or the screen. For this purpose, it is preferred to employ one of the usual strong mineral acids forming a soluble lead salt, preferably hydrochloric (muriatic) acid in concentrated form. Instead of hydrochloric acid, nitric acid is suitable, preferably in concentrations between 25 and 40%. Nitric acid is not particularly desirable as an etchant, where the screen predominantly consists of copper, and for a copper screen, hydrochloric acid is much more satisfactory. However, where a corrosion resistant steel screen is used, nitric acid is fairly satisfactory as a solder etchant, although it is less desirable than hydrochloric acid. Any other suitable solder etchant may be used.

It will be evident that the solder etchant should preferentially attack the solder rather than the metallic sheet or the screen. As already explained, the metallic sheet and the screen will preferably be of different metallic compositions, but this is not necessarily so as they could be of the same metallic composition, but of different composition from the solder. The solder of course protects the metallic screen from attack during the etching of the sheet, no matter what the composition of the metallic screen may be.

While ordinary solder, such as 50 per cent lead-tin solder, is very satisfactory for making the solder layer 27, it has been found that there is a little difficulty in removing ordinary lead-tin solder by etching with an etchant which does not seriously attack the copper during the time of etching.

In order to facilitate removal of the solder layer, it is therefore preferred to use as a solder an alloy containing zinc. Pure zinc is satisfactory for the layer 27, but very much better soldering results are obtained by an alloy containing about 37% lead, 37% tin and 25% zinc. Even much smaller percentages of zinc incorporated in lead or lead-tin alloys, greatly improve the etching, and advantage will be obtained by adding

any amount of zinc in excess of 1% to the metal of the layer 27.

It has been found that the removal of the solder layer 27 is a delicate operation, as too prolonged etching will tend to cause undercutting and weaken the joint between the copper sheet and the screen at areas which are blocked out. It is therefore desirable to use special etching technique by which the non-printing side of the screen is subjected to observation during the latter part of the etching.

In Figure 10, the laminated screen and sheet are placed with the printing surface uppermost on a suitably elevated glass plate 51 desirably surrounded by a confining wall 52. The etchant solution is shown at 53, where it can attack the solder over the area covered by the design, and remove it from between the interstices of the screen at points 54. Over-etching will cause the etchant to travel laterally in the space between the copper sheet and the screen.

To prevent over-etching, the non-printing face of the screen has been made subject to observation by using a transparent resist 28, suitably a transparent lacquer. By the mirror 55, it is then possible for the operator to view the bottom surface of the screen 20 in Figure 10 through the transparent resist 28. Usually the etching time should be about 20 minutes. As soon as the design is clearly delineated in the mirror and before the spreading of the design is possible, etching is stopped and the composite screen removed from the etchant, washed and dried.

The presence of the layer of lacquer 28 tends itself to prevent creeping since the etchant can not pass around under the screen during etching, but only attack the solder from the sides in order to spread laterally.

Various other techniques may be used to accomplish the etching and one such alternate technique is shown in Figure 10a. In this form, the composite screen is etched with its printing face down and the operator watches through the transparent lacquer 28 until the design is clearly delineated on the upper surface, at which time he removes the composite screen from the etchant before the etchant can undercut. The technique of Figure 10 is more efficient as the etchant will best etch downwardly.

Where very rapid etching is desired, possibly at the expense of a certain amount of accuracy, it is possible to accelerate the solder etch by employing as electrolytic etch with ferric chloride at the beginning of the solder etch, and then, after taking a short bite with ferric chloride, washing, drying, and finishing the etching in the manner already described using hydrochloric acid, nitric acid, or some other acid and a plain (not electrolytic) etch. Ferric chloride solution attacks stainless steel and other corrosion resistant steel to some extent, but it attacks the solder much more rapidly and can be used to accelerate the solder etch while doing comparatively little damage to the screen and to the edges of the copper sheet. The ferric chloride bite at the beginning of the solder etch should preferably not be more than about ten minutes long.

After washing and drying the fully etched composite screen, the lacquer is removed by a suitable solvent, for example acetone, in the case of nitrocellulose lacquer, so that the interstices of the screen 20 are exposed at the design areas as shown at 56 in Figure 11.

In case any difficulty is encountered in clearing the openings of the mesh at points 56, the com-

posite screen may be boiled in a suitable cleaning solution, such as a soluble phosphate cleaning solution.

The layer of resist 35 is next desirably removed from the printing face of the metallic sheet, as by a burnishing operation. The final product, as shown in Figure 12, consists of the screen 20 united to the metallic sheet 21 at the blanked out areas by the solder layer 27, and completely exposed in the design areas 56. If desired the entire composite screen may be lightly plated, for example, copper plated. The view shown in Figure 13 of the printing face illustrates the fact that the blanked out area is completely covered by the metallic sheet 21, the screen being visible only at the printing face in the design areas 56. It should be noted that the outline 50 of the design, as shown in Figure 13, is substantially free from saw-toothing, and is etched smoothly and squarely down, as shown in Figures 8d, 10 and 10a.

In some cases it may be desirable to apply the acid resist to the areas of the metallic sheet which are to be blanked out without the necessity of using a photosensitive layer on the metallic sheet. This can be accomplished, as shown in Figures 14 to 17, by printing the resist through a silk or wire screen. Figure 14 illustrates the copy 30 having design areas 31 and areas 32 to be blanked out. The copy 30 is a reverse print of the desired design in that it has light transmitting areas at 32 where it is desired to have the final design located, and light obscuring areas at 31 which are to be finally blanked out.

The copy 30 is used to make a contact print on a photographic layer 58 superimposed on a suitable silk or wire screen 57, as well known in the art. After the contact print has been exposed and developed, the screen 57 will be open and free from obstructions at areas 59 (Figure 15) which it is desired to have blanked out in the final product, and will be blanked out at areas 60, where it is desired to have the design in the final product.

The screen 57 is superimposed upon the composite screen of the invention whose metallic sheet is uppermost against the screen 57. A suitable resist, such as gelatine, is screen printed in the areas 59 to be blanked out, while it is excluded from the areas below the masking layer 60 (Figure 16).

The resultant product after tanning, or otherwise suitably hardening the resist, where required, will be the composite screen of the invention as shown in Figure 17, coated with a layer of resist 35 and having the design areas 33 exposed for etching. The product of Figure 17, after applying a suitable transparent lacquer coating to the exposed face of the screen, is ready for etching according to the procedures indicated in Figures 8 and 10 or 10a and treatment according to the subsequent steps of the invention.

In the prior art, great difficulty has been encountered in obtaining different thicknesses of build-up in the finished printing, and efforts have been made to control the build-up by changing the consistency of the pigment, changing the character of squeegee operation or other similar variations in procedure.

By the process of the invention, the thickness of build-up can be varied by changing the thickness of the metallic sheet 21 used in making the composite screen.

Figure 18 shows a composite screen just after completion of printing and lifting of the composite screen and sheet away from contact with the surface being printed. The surface on which

the printing has taken place is visible at 61 and the raised printing or build-up is shown as 62. In this case the metallic sheet 21' is relatively thick and therefore the screen 20 has been relatively far above the surface 61, on which build-up is taking place, during the printing. Correspondingly there is a high build-up at 62.

In Figure 19 the metallic sheet 21² in the composite screen is much thinner and therefore the build-up 62' on the surface 61 is not nearly so thick.

The solder layer 27 is practically invariable in thickness in all cases and, in fact, its thickness from the edge of the screen adjoining the metallic sheet is almost infinitesimal. Due to the necessities of drawing technique, the thickness of the solder layer 27 has been exaggerated in Figures 18 and 19.

The thickness of the metallic sheet 21 may vary between 0.0015 and 0.015 inch. For normal sign printing, the metallic sheet will usually be about 0.002 inch thick. For printing of radium dial material, it has been found to be desirable, and in fact, almost necessary, to use a thickness considerably greater and best results are obtained when the metallic sheet is about 0.005 to 0.008 inch thick. Using a metallic sheet of this thickness and with the other conditions as indicated herein, it is possible to obtain very satisfactory radium printing on the faces and dials of various instruments of military importance, with adequate thickness of build-up and adequately large particle size to obtain efficient luminosity, and with accurately defined and sharp edges as required to obtain the precision needed in printing on such instruments of importance to national defense.

The radium printing pigment employed with the composite screen of the present invention may be any suitable prior art radium printing pigment, but preferably of much higher viscosity than used heretofore for hand application. In such hand application, the radium printing pigment has normally been thinned to the consistency of ordinary paint. For the screen printing of the present invention, the radium printing pigment will normally be used at a viscosity about that of S. A. E. 120 oil. This normally requires no thinner. It is also preferable to employ a slow-drying lacquer, such as a four to seven hour lacquer, in the radium printing pigment used according to the present invention.

One of the advantages of the present invention is that requisite accuracy and control of build-up can be obtained by very rapid operations, but nevertheless the printing face of the screen is extremely resistant to wear and capable of making numerous impressions even on surfaces which are not of perfect regularity.

The user, by stocking various composite screens having different metallic sheet thicknesses, can be prepared to vary the build-up at will, without changing the operating technique used in printing, or departing from the usual squeegee procedure.

In view of my invention and disclosure variations and modifications to meet individual whim or particular need will doubtless become evident to others skilled in the art, to obtain all or part of the benefits of my invention without copying the structure shown, and I, therefore, claim all such in so far as they fall within the reasonable spirit and scope of my invention.

Having thus described my invention what I

claim as new and desire to secure by Letters Patent is:

1. The process of producing a printing screen having a design, which comprises laminating together a metallic screen and a metallic sheet by a uniting layer of a solder of different metallic composition, covering the exposed face of the screen with a transparent resist, blocking out the areas around the design by a resist applied to the exposed face of the metallic sheet, etching through the metallic sheet, finishing by an etchant preferentially attacking the metallic sheet and etching through the uniting layer, finishing by an etchant preferentially attacking the uniting layer, said transparent resist functioning to permit observation of the etching of the uniting layer by inspection therethrough.

2. The process of producing a printing screen having a design, which comprises laminating together a metallic screen and a metallic sheet by solder, coating the exposed face of the metallic screen by a transparent resist, coating the areas of the printing face of the metallic sheet other than the design areas with a resist, etching the design through the metallic sheet, finishing by an etchant preferentially attacking the metallic sheet, and etching the design through the solder, finishing by an etchant preferentially attacking the solder, said transparent resist functioning to permit observation of the etching of the solder by inspection of the opposite side of the screen therethrough.

3. The process of producing a printing screen having a design, which comprises soldering together in side by side relation a metallic screen of corrosion resistant steel and a metallic sheet predominantly containing copper, coating the exposed face of the screen with a transparent resist, protecting the areas around the design on the exposed surface of the sheet which is to be the printing face by a resist photographically applied, etching the design through the copper of the sheet, finishing by an etchant preferentially attacking the copper, etching the design through the solder, finishing by an etchant preferentially attacking the solder, said transparent resist functioning to permit observation of the face of the screen remote from the etching therethrough, and then removing the transparent resist.

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