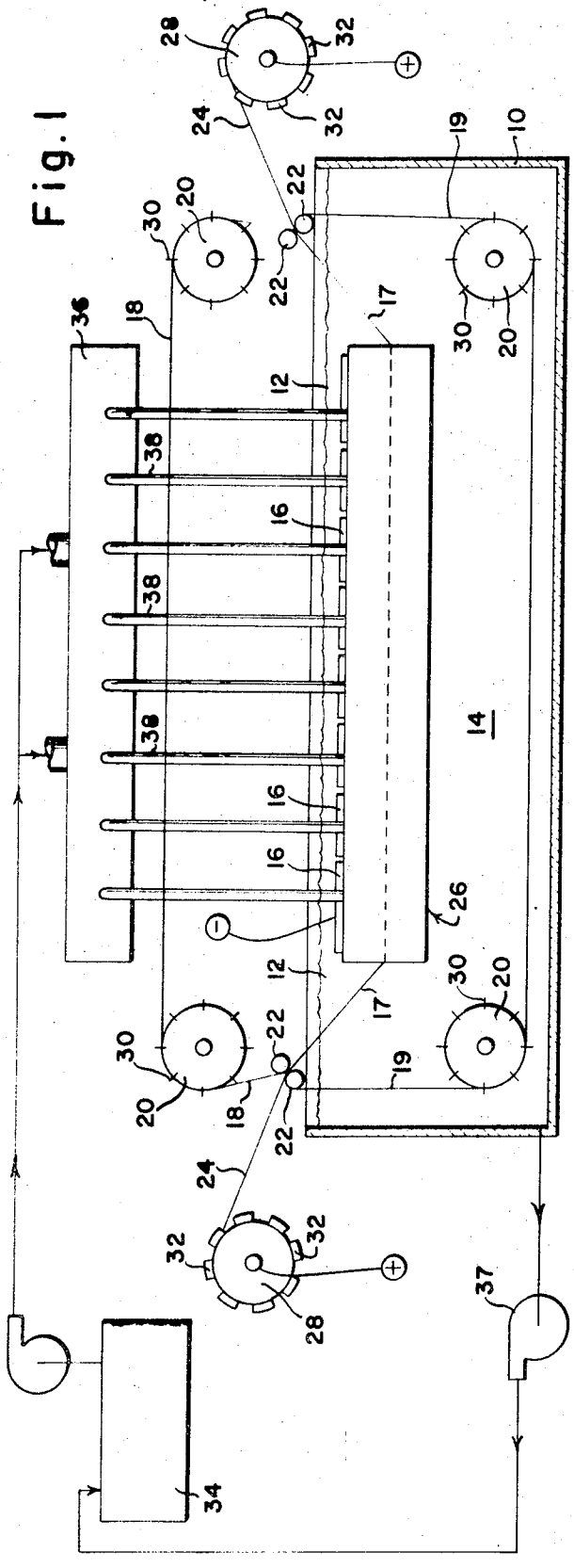
July 17, 1973 L. N. KOSOWSKY ET AL 3,746,630

APPARATUS FOR SELECTIVE ELECTROPLATING OF STRIPS

Filed Dec. 8, 1970 2 Sheets-Sheet 1

Fig. 1



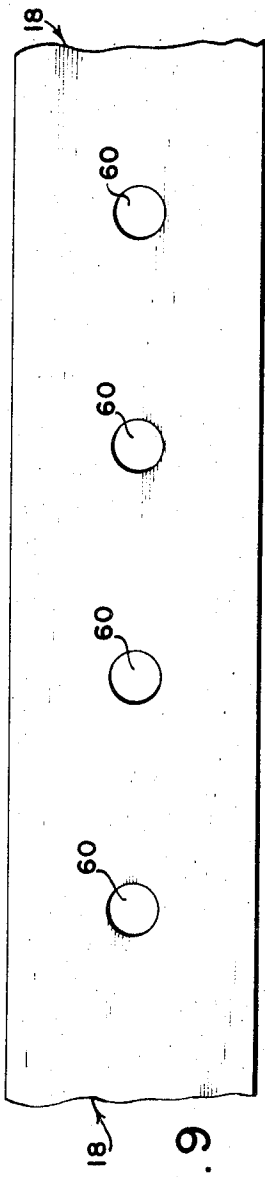


Fig. 9

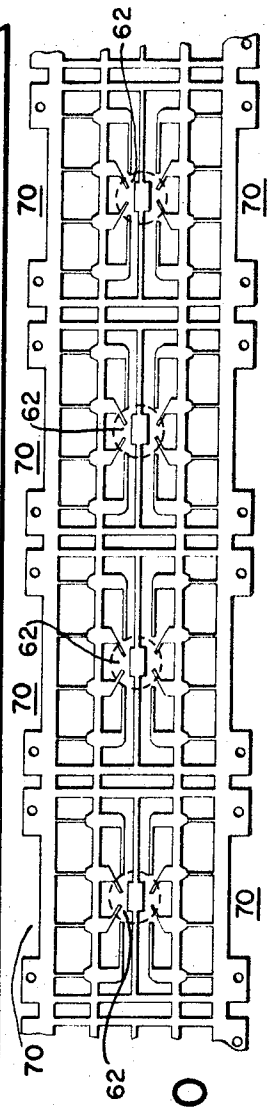


Fig. 10

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APPARATUS FOR SELECTIVE ELECTROPLATING OF STRIPS

Filed Dec. 8, 1970 2 Sheets-Sheet 2

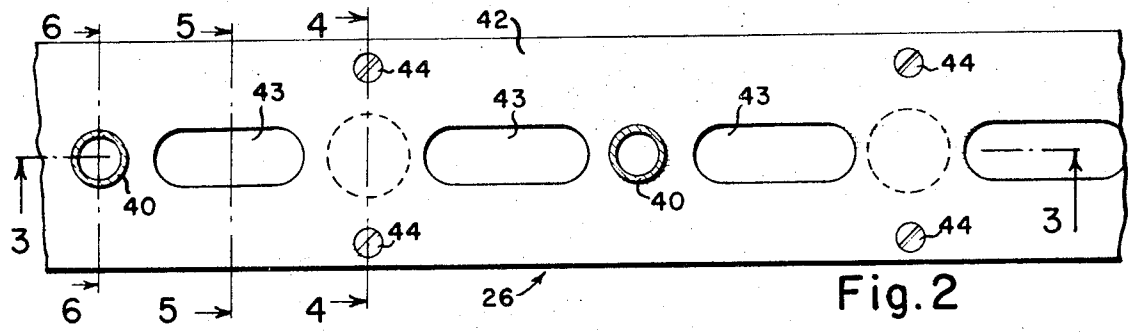


Fig. 2

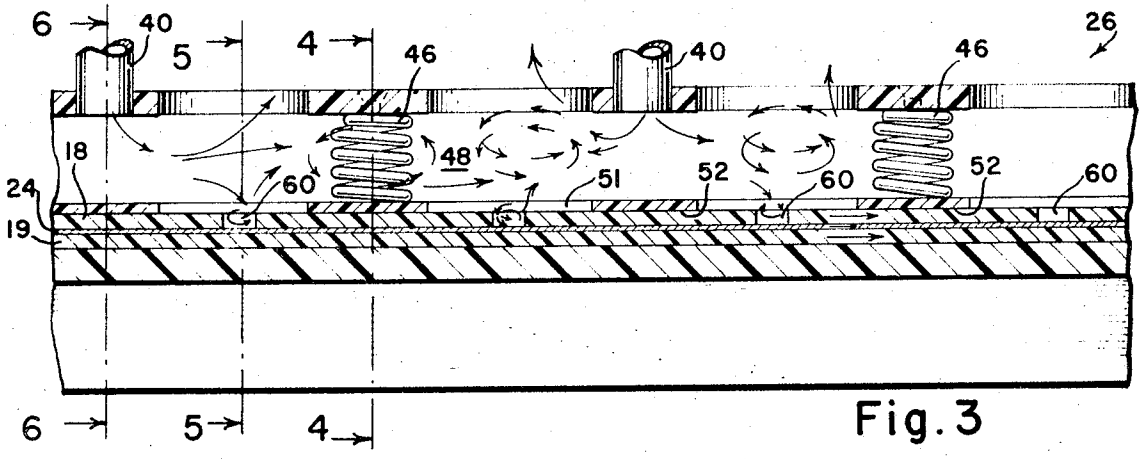


Fig. 3

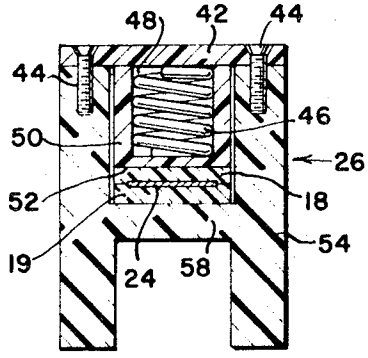


Fig. 4

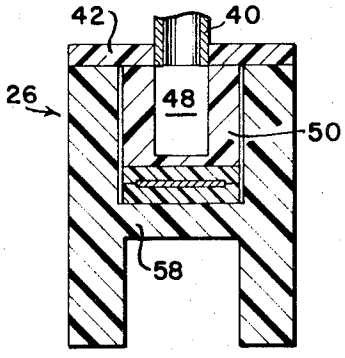


Fig. 6

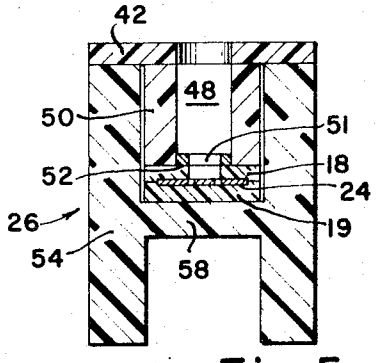


Fig. 5

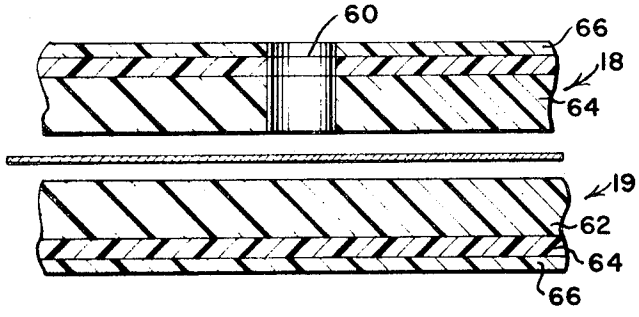


Fig. 7

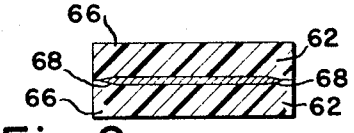


Fig. 8

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3,746,630

APPARATUS FOR SELECTIVE ELECTROPLATING OF STRIPS

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Int. Cl. C23b 5/68; B32p 1/12
U.S. Cl. 204—206 15 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus for continuously electroplating pre-selected portions on the surface of continuously-moving metal strips wherein the strips are carried through an agitated bath of electrolyte while biased between sealing webs which have apertures allowing electrolyte to contact only the aforesaid pre-selected surface portions.

BACKGROUND OF THE INVENTION

(1) Field of the invention

This invention relates to apparatus and process for continuously and uniformly electroplating a plurality of pre-selected isolated areas of an elongate strip while maintaining the rest of the substrate out of contact with the electroplating bath.

(2) The prior art

In many electroplating operations, e.g., operations wherein microcircuits are electroplated with gold, there is a need to minimize the amount of expensive metal utilized by closely restricting its deposition to only those surface areas where its presence is essential. It is desirable, however, that such selective deposition of the metal be achieved without resorting to procedures which greatly restrict the production rate of an electroplating facility or to procedures which greatly increase the handling costs of the items being electroplated.

It has been known to use organic coatings to mask those areas of metallic substrates on which electroplating is not required and thereby avoid those areas being electroplated. After the electroplating step is finished, the masking material is removed, leaving the discrete electroplated zones. Such a process requires expensive coating and stripping steps. These steps add to the cost of the electroplating operation and also increase the probability that some of the costly work product will have to be scrapped because of damage incurred during the manufacturing operations.

Previous suggestions have been made for accomplishing the electroplating of small selected areas, but these suggestions have been limited to small-scale, repair-type operations wherein the rigorous requirements of high-rate or continuous manufacture need not be considered. All of these prior suggestions are believed to be "batch-type" processes. For example, Ehrhart, in U.S. Pat. No. 3,071,521, discloses a single grommet-sealed chamber for use in repairing printed-circuits. Swanson, in U.S. Pat. No. 2,698,832, discloses a somewhat similar device utilizing a reservoir for an electroplating solution adapted to empty, by gravity flow, into a receptacle for receiving the solution. Neither of these inventions has suggested a way whereby a large number of discrete areas can be carried out continuously at optimum current densities. Indeed, neither inventor, in solving his own particular problem, has been faced with problems as complex as those involved in the electroplating of a plurality of isolated areas on a continuously-advancing strip of substrate.

Ramirez et al., in U.S. Pat. No. 2,974,097, disclose means for continuously plating areas along the edges of a

continuous strip. It should be noted, however, that the areas being electroplated are continuous areas running along the entire length of the strip, not a plurality of small areas on the faces of the strip. Thus, the problems of solution distribution and isolation are much simpler than those encountered by the instant inventors.

All electrodeposited metals have crystalline structures which manifest themselves in the physical properties and appearance of the plated metal. In order to achieve plated deposits of suitable properties, it is necessary to control the current density at which the plating is carried out. Excessive current densities will result in deposits of poor quality. However, current densities which are too low will result in excessively long plating cycles and markedly reduce the production rate of the plating operations. A particular problem encountered in constructing apparatus which is suitable for continuous and simultaneous electroplating of a large number of selected areas is to assure maintenance of a suitably concentrated cation concentration at each of the discrete areas being plated. Without a suitably high concentration, it would be impossible to obtain a high quality plating in a desirably short time.

In commercial work, preparation of surfaces for plating is often as important as the electroplating step itself. This is especially so in electroplating surfaces for use in microcircuit components. Thus, special care should be exercised in the construction of apparatus to assure that the surfaces to be electroplated are processed with minimal contact by machine parts or by an operator's hands. This requirement has increased the difficulty of providing suitable apparatus for the electroplating of a large number of selected areas along a single, but extensive, substrate.

SUMMARY OF THE INVENTION

Therefore, it is an object of the instant invention to provide apparatus which can quickly and conveniently effect the uniform electroplating of a large number of pre-selected, discrete, surface zones of a strip of substrate as it is advanced along a processing line.

Still another object of the invention is to provide apparatus having compact means for maintaining the desired concentration of, and agitation of, the electroplating solution.

A further object of the invention is to provide novel means to protect some areas of such sheet from contact with electroplating solution as it is continuously advanced therethrough.

Another object of the invention is to provide a novel process for electroplating pre-selected and isolated face zones on a strip of substrate to be plated.

Other objects of the invention will be obvious to those skilled in the art on reading the application.

The above objects have been economically and conveniently achieved by construction of electroplating apparatus which provides for the maintenance of suitably high cation contents in the immediate vicinity of all of the isolated surfaces being electroplated.

More particularly, the above objects have been attained by construction of such apparatus comprising a continuous sealing web held in sealing contact with the strip to be electroplated and having cut-outs or apertures in the web. The apertures define the areas of the strip which are to be electroplated. Synchronizing means are provided to advance the strip and sealing web in the desired register. This advance is most advantageously achieved in a seal box which holds the web in biased contact with the strip being electroplated and also provides means to distribute the flow of electrolyte solution.

The high cation contents are maintained, even while plating from an acid-gold solution at current densities of 15 to 25 amps per square foot and above, by providing

such a high flow of fluid proximate the surfaces being plated that excellent agitation is achieved. The ability to use the apparatus at such high current densities markedly increases the line speed which is possible, while still obtaining platings of good quality.

ILLUSTRATIVE EXAMPLE OF THE INVENTION

In this application and accompanying drawings are shown and described a preferred embodiment of the invention. Various alternatives and modifications thereof, are suggested, but it is to be understood that these are not intended to be exhaustive and that other changes and modifications can be made within the scope of the invention. The suggestions herein are selected and included for purposes of illustration in order that others skilled in the art will more fully understand the invention and the principles thereof, and will be able to modify it and embody it in a variety of forms, each as may be best suited in the condition of a particular case.

In the drawings:

FIG. 1 is a schematic diagram illustrating the use of the apparatus of the invention.

FIG. 2 is a plan view of a part of the seal box in which the sheet to be electroplated is carried through the electroplating bath.

FIG. 3, as is indicated by line **3—3** of FIG. 2, is a section of the apparatus shown in FIG. 2 showing the position of the metal sheet carried through.

FIG. 4, as indicated by line **4—4** of FIG. 2, is a section of the apparatus shown in FIG. 2 showing a sheet-biasing means.

FIG. 5, as indicated by line **5—5** of FIG. 2 is a section of the apparatus shown in FIG. 2 showing the electrolyte-solution access path.

FIG. 6, as indicated by line **6—6** of FIG. 2, is also a section of the apparatus shown in FIG. 2 and shows electrolyte access paths.

FIG. 7 illustrates an exploded "sandwich" of a strip between sealing webs and shows some detail of the foamed strips which selectively seal the metal substrate surface during its passage through the apparatus.

FIG. 8 shows some detail of the compressive edge seal achieved by the foam strips.

FIG. 9 shows a plan view of the foamed strip.

FIG. 10 shows a plan view of a metallic strip of the type to be selectively electroplated.

Referring to FIG. 1, it is seen that a tank **10** is used to maintain electrolytic solution **14** at a level **12** sufficient to cover silver anodes **16**. An upper sealing web **18** and a lower sealing web **19**, each in the form of a flexible and compressible belt, are carried over indexing rolls **20** and idler rolls **22**. These sealing webs form a protective covering for metal strip **24** as it enters solution **14** and seal box **26**. The sandwich **17** formed by web **18**, metal strip **24** and web **19** is carried through seal box **26** under a compressive biasing force, as will be described more fully below. When the sandwich emerges from seal box **26** and solution **14**, the sealing webs are pulled away from the metal strip and carried back around indexing rolls **20**. The metallic strip **24**, having been electroplated, is carried off over a cathode contact roll **28** to further processing or packaging procedures.

Cathode contact rolls **28** are positioned at each end of the bath and are in electrical contact with metal strip **24** so that strip **24** acts as the actual cathode in the selective electroplating operation.

Each cathode contact roll **28** and indexing roll **20** is driven from a common motor by drive means which is conventional, forms no novel part of the invention, and is not shown in the drawings. The use of a common drive source helps obtain what will be shown to be a necessary synchronism between the advancement of metal strip **24** and sealing webs **18** and **19**. This synchronization is further aided by positive-drive advancing means in the form of teeth **30** on indexing rolls **20** and teeth **32** on cathode contact rolls **28**. These teeth, as will be seen below, fit certain apertures or cut-outs in the strip or web that they engage. Thus they provide a means for achieving a positive advancement of the strip and webs. Such a positive advancement helps to avoid slippage and contributes to attaining the required synchronous advance of the strip **24** and the webs **18** and **19** within which strip **24** is carried through seal box **26**.

Seal Box **26**, in addition to acting as a seal means, is a flow distributing means whereby flow is directed into agitated flow paths proximate metal strip **24**. Electrolytic solution is stored in reservoir **34** and pumped therefrom, into a manifold box **36** from which it is distributed via hoses **38** to distributing pipes **40** (see FIGS. 2, 3, and 6) entering seal box **26**. The solution then flows out into tank **10** and is re-circulated to reservoir **34** via pump **37** and conduit **39**.

FIGS. 2 through 5 illustrate the configuration of the seal box **26** through which the metal strip **24** and sealing webs **18** and **19** are carried. FIG. 2 shows the top cover plate **42**. It has a series of elongated slots **43** for egress of electrolytic solution from the apparatus after it has been forced below cover plate **42** through distributing pipes **40**. At spaced intervals along cover plate **42** are screws **44**. Along cover plate **42** and between screws **44** are positioned springs **46**.

FIG. 4, showing a section of the sealing box **26**, illustrates how springs **46** fit into an enlarged section of a channel **48** within a seal bar **50** to bias the bottom face **52** of seal bar **50** against upper sealing web **18**. This biasing action causes sufficient compression of the compressible sealing webs to seal the web-contacted surfaces of the metal strip from contact with plating solution. Seal bar **50** is slideably mounted within seal housing **54**. Screws **44** are used to fasten cover **42** into housing **54**, and thereby provide means to compress spring **46** to the desired biasing level.

Referring to FIGS. 2, 3, and 5, it is seen that bottom face **52** of biased seal bar **50** also is cut out to provide elongated apertures **51** for the electrolytic solution to reach the sandwich formed by sealing webs **18** and **19** and metal strip **24**. Apertures **51** are in the general shape of the elongated slots **43** and are positioned below elongated slots **43**.

Were the device being illustrated to be adapted for plating both sides of a workpiece, bridge **58** which forms a web-supporting surface in seal housing **54** would also have a series of elongated slots therein and lower sealing web would have apertures corresponding to apertures **60** in upper sealing web **18**.

In the embodiment of the invention being described electrolytic solution is pumped into seal box **26** through distributing pipes **40** at a high velocity. The velocity is sufficient to cause a great deal of turbulence in channel **48** and this turbulence liquid is also carried through apertures **60**, in upper sealing web **18**, to contact only those areas **62** of metal strip **24** which are exposed by apertures **60**. Flow paths of the electrolytic solution are generally shown on FIG. 3.

FIGS. 9 and 10 show plan views of the upper sealing web **18** and strip **24**. Apertures **60** in web **18** define the passage through which agitated liquid from channel **48** reaches strip **24**. When these apertures are biased against strip **24**, and when they do not move in relation to the strip, but are synchronized to move along with it, the areas **62** on the strip will be selectively electroplated whereas other areas of strip **24** will not be electroplated. In the illustrated embodiment of the invention the aperture-free bottom sealing web provides means to seal bottom surface of strip **24** against contact with electrolytic solution.

FIGS. 7 and 8 show details of the construction of the sealing webs **18** and **19**. These webs consist of a laminated structure having a neoprene foam layer **62**, a nylon-textile reinforcing fabric **64** and a protective and lubrica-

tive cover layer **66** formed of a poly (tetrafluoroethylene) polymer such as that sold under the trade designation Teflon by E. I. du Pont de Nemours and Company, Inc. In FIG. 8, it is seen that neoprene foam compresses under moderate pressure to form a protective liquid seal along edges **68** of strip **24**. Cover layer **66** material aids in the ease of passage of the sandwich **17** through seal box **26** because of its low coefficient of friction.

The required synchronized advance of sheet **24** and apertures sealing web **18** is facilitated by the engagement of teeth **32** on cathode contact rolls **28** with the slots **70** along the sides of sheet **24** and the engagement of teeth **30** on indexing rolls **20** with the apertures. Teeth **32** and **30** are advanced the same circumferential distance per unit time and this assures that, once the apertures **60** in web **18** and the areas **62** in strip **24** have been brought into desired registration with one another, the relative rotation of rolls **28** and **20** will maintain that registration.

While the instant invention has been described with respect to electroplating processes, it will be realized that it also can be used in etching processes. Etching is the reverse of electroplating with metal being removed from, rather than added to, the strip being processed. Similar problems are encountered in each process. For example, it is necessary to obtain good agitation of electroplating solution to maintain a high concentration of cation next to the strip being electroplated, such agitation is required during etching to maintain a suitably low concentration of cation next to the strip being etched.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

What is claimed is:

1. Electroplating apparatus suitable for selectively electroplating discrete areas of a strip, said apparatus comprising:

(a) a sealing means comprising a continuous sealing web, in sealing contact with said strip and having apertures therein defining the areas to be electroplated;

(b) means to synchronously advance said apertures and said substrate and maintain said discrete areas and said apertures in register with each other;

(c) cathode contact means allowing said substrate to act as a cathode during said synchronous advance; and

(d) means to direct agitated electroplating solution into said apertures as they advance, and wherein said means to synchronously advance said apertures and said strip comprise:

(1) a cathode contact roll comprising means to engage and advance said metal strip, and

(2) an indexing roll comprising teeth for engaging said apertures.

2. Apparatus as defined in claim **1** adapted for plating discrete areas on two sides of a foraminous sheet, wherein said sealing means is formed of two webs, each comprising a compressible polymeric foam with the webs overlapping the lateral edges of said strip to be electroplated and, on compression, forming means to protect such edges from contact with said electroplating solution, wherein opposed apertures of said two webs are in register forming a common conduit for said solution.

3. Electroplating apparatus suitable for selectively electroplating discrete areas of a strip, said apparatus comprising:

(a) a sealing means comprising a continuous sealing web, in sealing contact with said strip and having apertures therein defining the areas to be electroplated;

(b) means to synchronously advance said apertures and said substrate and maintain said discrete areas and said apertures in register with each other;

(c) cathode contact means allowing said substrate to act as a cathode during said synchronous advance; and

(d) means to direct agitated electroplating solution into said apertures as they advance, and wherein said sealing means comprises an elongate seal box comprising:

(1) means to support said sealing web and said strip to be electroplated, and

(2) an elongate seal bar forming means to press said web and strip against said support means, said seal bar comprising apertures forming means for passage of electrolyte solution.

4. Apparatus as defined in claim **3**, wherein said seal bar comprises a channel therein, said channel forming means to position and hold springs which are biased between the bottom of said channel and a housing to which said seal bar is attached.

5. Apparatus as defined in claim **3**, wherein said sealing means comprises biasing means bearing against said seal bar and a housing in which said seal bar is retained.

6. Apparatus as defined in claim **5**, wherein said housing comprises means to adjust the degree of biasing pressure on said seal bar.

7. Electroplating apparatus suitable for selectively electroplating discrete areas of a strip, said apparatus comprising:

(a) a sealing means comprising a continuous sealing web, in sealing contact with said strip and having apertures therein defining the areas to be electroplated;

(b) means to synchronously advance said apertures and said substrate and maintain said discrete areas and said apertures in register with each other;

(c) cathode contact means allowing said substrate to act as a cathode during said synchronous advance; and

(d) means to direct agitated electroplating solution into said apertures as they advance;

wherein said apparatus is adapted for plating discrete areas on two sides of a foraminous sheet, wherein said sealing means is formed of two webs, each comprising a compressible polymeric foam with the webs overlapping the lateral edges of said strip to be electroplated and, on compression, said webs forming means to protect such edges from contact with said electroplating solution and wherein opposed apertures of said two webs are in register forming a common conduit for said solution; and wherein said sealing means comprises an elongate seal box comprising:

(1) means to support said sealing webs and strip to be electroplated; and

(2) an elongate seal bar pressing said webs and strip against said support means, said seal bar comprising apertures forming means for passage of electrolyte solution.

8. Electroplating apparatus suitable for selectively electroplating discrete areas of a strip, said apparatus comprising:

(a) a sealing means comprising a continuous sealing web, in sealing contact with said strip and having apertures therein defining the areas to be electroplated;

(b) means to synchronously advance said apertures and said substrate and maintain said discrete areas and said apertures in register with each other;

(c) cathode contact means allowing said substrate to act as a cathode during said synchronous advance; and

(d) means to direct agitated electroplating solution into said apertures as they advance, and wherein said sealing means comprises an elongate seal box comprising:

(1) means to support said sealing web and strip to be electroplated, and

(2) an elongate seal bar pressing said web and strip against said support means, said seal bar comprising apertures forming means for passage of electrolyte solution.

9. Apparatus as defined in claim **8**, wherein said seal bar comprises a channel therein, said channel forming means to position and hold springs which are biased between the bottom of said channel and a housing to which said seal bar is attached.

10. Electroplating apparatus suitable for selectively electroplating discrete areas of a strip, said apparatus comprising:

(a) a sealing means comprising a continuous sealing web, in sealing contact with said strip and having apertures therein defining the areas to be electroplated;

(b) means to synchronously advance said apertures and said substrate and maintain said discrete areas and said apertures in register with each other;

(c) cathode contact means allowing said substrate to act as a cathode during said synchronous advance; and

(d) means to direct agitated electroplating solution into said apertures as they advance,

and said apparatus being adapted for plating discrete areas on two sides of a foraminous sheet, wherein said sealing means is formed of two webs, overlapping the lateral edges of said strip to be electroplated and, on compression, forming means to protect such edges from contact with said electroplating solution and wherein opposed apertures of said two webs are in register forming a common conduit for said solution.

11. Apparatus as defined in claim **10**, wherein said sealing means is positioned in a bath of re-circulating electroplating solution.

12. Apparatus as defined in claim **8**, comprising two said sealing webs, one adapted to contact each side of said strip during passage through electrolyte solution;

a chamber for holding electrolyte solution and means to recirculate said solution through said chamber;

a seal box mounted in said chamber and comprising support means for said webs and said strip, and

a biasing means to bias said webs and said strip against said support means.

13. Apparatus as defined in claim **8**, wherein said sealing means comprises biasing means bearing against said seal bar and a housing in which said seal bar is retained.

14. Electroplating apparatus suitable for selectively electroplating discrete areas of a strip, said apparatus comprising:

(a) a sealing means comprising a continuous sealing web, in sealing contact with said strip and having apertures therein defining the areas to be electroplated;

(b) means to synchronously advance said apertures and said substrate through an electroplating zone and maintain said discrete areas and said apertures in register with each other;

(c) cathode contact means allowing said substrate to act as a cathode during said synchronous advance; and

(d) a plurality of discharge means arranged serially along said electroplating zone to direct agitated electroplating solution into said apertures and against said discrete areas as they advance through said zone.

15. Apparatus as defined in claim **14** wherein said sealing means comprises a compressible belt of polymeric foam and means for compressing said belt against said substrate to be electroplated.

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U.S. Cl. X.R.

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