

REPLACED SHEETS		SG
☒ Description	pages 1 to 7	
☒ Claim(s)	pages 13 to 22	
☒ Drawing(s)	pages 1/5 to 9/5	
☒ Abstract	pages 23 to 23	
DATE OF RECEIPT		

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IMPROVEMENTS IN OR RELATING TO CLAMPS AND THE USE THEREOF

5 This invention relates to a clamp.

In particular this invention relates to a
buoyancy activated clamp.

In addition this invention relates to a
cathode shield, electroplating apparatus and method
10 using a clamping means.

Known clamps are not very suitable for use
in automated processes.

In U.S. Patent No. 4879007 (to the same
assignee, and incorporated in this specification by
15 reference) a means for increasing the efficiency and
speed of automated electroplating is described.
Substrates to be electroplated are automatically
clamped at the top and brought in to be suspended over
an electrolyte bath. The substrates are then lowered
20 into the bath, at which time their lower edges contact
a cathode shield device floating on the top of the
bath. The weight of the substrates and the pressure
bearing down upon them is sufficient to overcome the
buoyancy of the shield and to move it down into the
25 electrolyte bath. Flexible substrates, however, even
if they are able to bear down enough on the cathode
shield to push it into the bath, tend to warp and
wobble, creating an uneven pattern of electroplating
on the substrate. This problem is usually overcome
30 by placing around the perimeter of flexible

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substrates, a rigid frame. This solution has a number of drawbacks : firstly, the substrates usually must be loaded by hand; secondly, the frame gets coated with metal as well, which metal must then be scraped off; and thirdly, in view of the above drawbacks, the electroplating process is rather slow.

The object of the present invention is to overcome the above disadvantages or difficulties or at least to provide public with a useful choice.

Accordingly, in a first embodiment this invention consists in a clamp comprising two levers pivotally attached to each other at a fulcrum wherein the clamp, when floating on top of a liquid, is in a first position but when submerged, by virtue of its buoyancy is caused to move to a second position.

In a second embodiment, the present invention consists in a method for the electrolytic deposition of a coating of metal on an electroplatable substrate as cathode in an electrolyte bath equipped with anode wherein the substrate is supported in a substantially vertical plane and is automatically clamped at its lower edge as it enters the electrolyte bath.

In a third embodiment, the present invention consists in a cathode shielding device for use in an electrolytic plating bath, said device comprising : an elongated trough adapted to be inserted in said bath;

said trough being provided with a plurality of clamps comprising two levers pivotally attached to each other at a fulcrum wherein the clamp, when floating on top of a liquid, is in a first position but when
5 submerged, by virtue of its buoyancy is caused to move to a second position;

said clamps being aligned substantially in parallel vertical planes transverse to the longitudinal axis of said trough, for securing one or more electroplatable
10 substrates in a substantially vertical plane with the lower edge of each of said substrates located below the plane in which lies the upper edges of said trough; and

said trough having a plurality of perforations in the
15 upper region of the sides thereof.

In a fourth embodiment, the present invention consists in an apparatus for electrolytic deposition of metal on a substrate comprising a container for electrolyte; a cathode bus bar; and a
20 clamping means, wherein an electroplatable substrate is attachable at an upper edge to the cathode bus bar and the clamping means clamps lower edge of any substrate attached to the cathode bus bar as the substrate enters the container.

Preferred embodiments of the invention will
25 now be described with reference to the drawings in which:

- Fig 1 is a schematic side view of the clamp of the present invention in a closed position.
- 5 Fig 2 is a schematic side view of the clamp of the present invention in an open position.
- Fig 3 shows in perspective view, partially cutaway, a cathode shield of the present invention.
- 10 Fig 4 is a cross-sectional view of a cathode shield incorporating the clamp and with an electroplatable substrate in place.
- Fig 5 is a perspective view partially cutaway showing the cathode shield of Fig 3 mounted in a plating bath.
- 15 Fig 6 is a schematic, cross-sectional view of a cathode shield of the invention installed in an unloaded condition in a plating bath.
- 20 Fig 7 is a perspective view of the cathode shield of the invention mounted in a frame with electroplatable substrates loaded.
- 25 Fig 8 is a perspective view of a cathode shield of the present invention showing one end of the shield in detail.

A preferred embodiment of the clamp of this invention is illustrated in figures 1 and 2. As clamps operable by buoyancy have not previously been

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known it will be understood that such a clamp could take on a number of configurations and the configuration shown in Figs 1 and 2 is purely by way of example. In figure 2, the clamp is shown as being made up of two levers 52, 54 which are pivotally attached to each other at a fulcrum 56. For some applications it may be desirable for the levers 52, 54, to be formed in two parts 58, 62 and 60, 64 on either side of the fulcrum, the first parts 58, 62 being buoyant and performing the clamping function and the second parts 60 and 64 performing an auxiliary function. In the open position shown in figure 2, gripping members 66 are spaced apart from each other. The second parts 60, 64 conveniently form, in the open position, a pathway to guide an object to be clamped into the space between the gripping members 66. The second parts of 60, 64 therefore act as guide members. The clamp is buoyant so it will float on the top of a liquid in the position shown in Fig 2.

When the clamp is forced downwards into the liquid the tendency for the buoyant first parts 58, 62 of the levers 52, 54 is to move in an upward direction until they reach the limit of upward movement which is defined by the gripping members being pressed together on either side of the object to be gripped (or pressed against each other if no object is present).

Upon return to the surface of the liquid the clamp will again assume an open position.

The clamp may of course be configured so that it clamps when floating and releases when submerged. This may most conveniently be achieved by

the gripping members being located on the second parts 60, 64 of the levers 52, 54. Alternatively, the gripping members could be located on the under side of the first parts 58, 62 of the levers 52, 54. As
5 mentioned above, the clamp's configuration is not limited to the example shown in figures 1 and 2 but can be configured to suit the overall function it performs in whatever apparatus it may be utilised in.

One particularly appropriate use of the
10 clamp of the invention is, however, as part of a cathode shield in an electroplating bath where the clamps hold electroplatable substrates in place and is advantageous in that very flexible substrates can be securely retained in the electroplating bath.

15 Figure 3 shows a perspective view, with one side partially cutaway to show details of the interior, of a shielding device shown overall as 4 according to a preferred embodiment of the invention. The shield 4 comprises an elongated trough 5 bounded
20 by sidewalls 6 and 8, and strut engaging members 10 and 12 and a floor 14. It will be understood that the strut engaging members 10, 12 need not be positioned at the ends of the trough but are most suitably so placed. The floor 14 is raised above the level of the
25 lower edges of the sidewalls 6 and 8 thus leaving an open compartment 16 beneath the floor 14 of the shield. Disposed within the shield are a plurality of clamps 18 which serve to secure the substrates which are to be electroplated. The lower edge of a
30 substrate 24 is received as shown in cross-section in Figure 3. As shown in Figure 3, the gripping members

are below the level of the upper edge of walls 6 and 8 by a distance "x". In general, the distance "x" is within the range of about 2 cms to about 10 cms and preferably in the range of about 3 cms to about 6 cms although values of "x" higher than or lower than this can be employed if desired. Preferably, however, the distance "x" is not less than about 1.5 cms.

The clamps 18 all pivot about a rod 70 which is secured at either end by the strut engaging members 10, 12 or in some other way so that the clamps may pivot freely. For convenience the entire of side walls 6, 8 need not be attached to the levers 52, 54, but can be formed in two parts as shown in figure 8. The lower part of the side walls 6, 8 will therefore be remain substantially vertical at all times, whereas as the upper part will be at an angle to the lower part when the trough is floating on top of the bath.

Referring again to figure 3, each of the sidewalls 6 and 8 has a plurality of perforations 26 in the upper regions thereof to permit electrolyte in the bath to flow therethrough into and out of the trough 5. The number and arrangement of these perforations is not critical although it is preferred that no perforations are present in either sidewall below the level the gripping members (see figure 4).

In the loaded condition the device 4 is immersed in the bath to the depth required by exerting a downwards pressure on the trough.

Referring to figure 8, a downwards pressure is conveniently exerted on the trough 5 by struts 72 attached to the cathode bus bar 38 (see figure 7).

The strut 72 has a strut end 74 which engages with a strut engaging member 10. The strut end 74 and strut engaging member 10 are shown as having corresponding V-shapes, but many have other corresponding shapes, such as a tooth arrangement. The strut 74 and the strut engagement member 10 must, however, engage in such a manner so that lateral movement in the strut 72 creates a corresponding lateral movement in the trough 5 and does not cause the strut 72 to become disengaged from the strut engaging member 10. To aid such an engagement, the strut end 74 is preferably provided with a retainer 76 to retain the strut 72 in position relative to the strut engaging member 10. The strut engaging member 10 could be formed by one of the clamps 18 in the trough 5 as illustrated in figure 7.

The strut could alternatively extend upwards from the trough and engage with a strut engaging member on the cathode bus bar 38. Or, both the trough and the bus bar could be provided with struts which engage with each other.

Thus, in operating an electroplating process in accordance with the invention, the cathode bus bar 38, with the substrates 24 attached by means of clamp 39 and connecting harness 40 moves into position over the electrolyte bath 30 and the trough 5. The cathode bus bar 38 then lowers the substrates down towards the trough and the guide members (second parts) 60, 64, guide the lower edge of the substrates into the space between the gripping members 66. At the same time the strut 74 engages the strut engaging member 10. The bus bar continues to move downwardly and pushes the

trough, via the strut 74 into the electrolyte. As the clamps 18 become submerged the gripping members 66 close on either side of the substrates 24 to hold them in a substantially vertical plane. When electroplating is completed, the cathode bus bar 38 and attached substrates move upwardly and the trough, by virtue of its buoyancy, also moves upwardly. When the trough reaches the top of the electrolyte solution, the clamps 18 open and the gripping members move apart to release the substrates 24. The substrates are then lifted clear of the electrolyte bath and moved away by the cathode bus bar.

The struts 74 are conveniently placed one at each end of the trough 5, however more struts 74 could be provided if desired. If only one strut 74 is utilised the corresponding strut engagement member 10 would need to be exactly centrally placed.

A guide (not shown) may be situated on each side of the bath 30 to prevent gross lateral movement of the trough, but such a guide would obviously allow for the reciprocating motion which is part of the electroplating process as described below.

A feature of the clamp illustrated in figures 1 and 2, is that the guide members 60, 64 which form a steep sided V-shape when the clamp is in the open position, form a very wide V-shape when the clamp is in the closed position.

If the guide members were to retain a steep V-shape after immersion in the electrolyte, they might hinder electroplating by creating a "shadow" on the substrate. However, if the guide members were to

retain a wide V-shape, which would not interfere with the electroplating process, they would not so efficiently guide moving substrates into position.

5 The components of trough 5 and clamps 18 are advantageously prepared by injection molding or like means as a single unitary whole or in pieces which are assembled by melt sealing or like means from plastic material such as polyethylene, polypropylene and the like which impart sufficient buoyancy to the device 4
10 to enable it to float in the electrolyte 27 of the plating bath as shown substantially in cross-section in figure 6. The components of trough 5 and plates 18 may also be fabricated from plastic material such as polyvinyl chloride which is of a density such that
15 device 4 does not have sufficient buoyancy to float. In this event, material such as a block or blocks of polystyrene foam or polyurethane foam is attached to device 4, advantageously by placement of the appropriate amount of such foam block in compartment
20 16 (see figures 3, and 4), to impart sufficient buoyancy to the device 4 to enable it to float. The appropriate amount of auxiliary buoyant material required can be determined readily by a process of trail and error.

25 Figure 5 shows in partial cutaway a perspective view illustrating another manner in which the device 4 is mounted in a plating bath 30 in accordance with the invention. In this embodiment the strut 72 of device 4 is mounted in the second parts
30 60, 64 of a clamp 18. The struts 72 are attached to a cathode bus bar 38 (Figure 7) to which limited

reciprocating motion can be imparted in the direction indicated by the arrows by appropriate reciprocating drive means (not shown).

The reciprocating motion imparted to device
5 4 in the above manner encourages circulation of electrolyte around the substrates suspended in the plating bath. This motion takes place in the gap between twin anodes 36 and 36' shown in cross-section in figure 6 which anodes each extend substantially
10 across the width of bath 30 in a direction parallel to the longitudinal axis of device (4). These anodes 36 and 36' are not shown in figure 5 in order not to obscure the details of the manner in which the device 4 is mounted in bath 30.

15 The buoyancy activated clamp, the cathode shielding device using a clamp and using the clamp of the invention and the methods of utilizing said device in an electroplating bath have been described above by reference to various specific embodiments shown in the
20 drawings appended hereto. The scope of the invention is not limited to these particular embodiments, and various modifications which will be readily apparent to those skilled in the art can be made to said illustrative embodiments without departing from the
25 scope thereof.

The invention provides an improved cathode shield device for use in an electroplating bath and process. The device is very easy to load, relatively simple in construction and contributes significantly
30 to the economics of an electroplating operation by reason of the time and labor which is saved by its utilization. Furthermore, the device is particularly useful with very light and flexible substrates which

are not sufficiently securely retained during the electroplating process in previously disclosed cathode shields. In addition the buoyancy activated clamp is a significant contribution to the art in that no external clamping means is required. This makes the buoyancy activated clamp particularly useful in automated processes.

CLAIMS :-

1. A clamp comprising at least two levers pivotally attached to each other at a fulcrum wherein the clamp, when floating on top of a liquid, is in a first position but when submerged is caused, by virtue of its buoyancy to move to a second position.
2. A clamp as claimed in claim 1 wherein the first position is an open position and the second position is a closed position.
3. A clamp as claimed in claim 1 wherein the first position is a closed position and the second position is an open position.
4. A clamp as claimed in claim 1 wherein each lever has first and second parts, each part being situated on opposite sides of the fulcrum.
5. A clamp as claimed in claim 4 wherein the second part is at an obtuse angle to the corresponding first part of each lever.
6. A clamp as claimed in claim 4 or claim 3 wherein one of the two parts of each lever extends upwardly when the clamp is floating.



7. A clamp as claimed in claims 2-6 further comprising a gripping member situated on each of the at least two levers wherein when the clamp is in a closed position the gripping members are adjacent each other and on either side of any object to be clamped and in an open position are spaced apart from each other.

8. A clamp as claimed in claim 4 wherein a gripping member is situated on the first parts of each of the levers.

9. A clamp as claimed in claim 4 wherein a gripping member is situated on the second parts of each of the levers.

10. A clamp as claimed in any one of claims 7-9 wherein the second parts of each lever form guide members which when the clamp is in the open position, guide an object to be clamped into the space between the gripping members.

11. A clamp as claimed in claim 10, wherein the guide members form a substantial V-shape, each member extending upwardly and outwardly from the space between the gripping members when the clamp is in the open position.



12. A clamp claimed in claim 10 or claim 11 wherein the angle between the guide members is smaller when the clamp is in the open position than when the clamp is in the closed position.

13. A method for the electrolytic deposition of a coating of metal on an electroplatable substrate as cathode in an electrolyte bath equipped with anode wherein the substrate supported in a substantially vertical plane and is automatically clamped at its lower edge as it enters the electrolyte bath.

14. A method as claimed in claim 13 wherein the substrate is automatically clamped by a clamp or clamps of the type claimed in any one of claims 1-12.

15. A method as claimed in claim 13 or claim 14 wherein the substrate is automatically clamped by a plurality of clamps in a trough or forming part of a trough, the clamps being aligned substantially in parallel vertical planes transverse to the longitudinal axis of the trough.

16. A method as claimed in any one of claims 13-15 wherein the substrate is automatically clamped when a downward force is exerted on the trough.



17. A method as claimed in claim 16 wherein the frame exerts a downward force on the trough through a strut or struts extending either downwardly from a cathode bus bar which struts engage with the trough, or upwardly from the trough which struts engage with the cathode bus bar; or extending downwardly from the cathode bus bar and upwardly from the trough which struts engage with each other.

18. A method for the electrolytic deposition of a coating of metal having uniform thickness on an electroplatable substrate as cathode in an electrolyte bath equipped with anode, wherein said substrate is supported in a substantial vertical plane in an elongated trough, wherein the lower edge of said substrate is located below the plane in which lies the upper edges of said trough wherein the substrate is held in the trough by providing clamp comprising two gripping members situated on either one of two levers pivotally attached to each other at a fulcrum, wherein the clamp, when floating on top of a liquid, is in an open, or a closed, position but when forced into the liquid is caused, by virtue of its buoyancy to move, if it were open to or towards a closed position, or if it were closed to or towards an open position, the gripping members, in the closed position, adjacent each other and on either side of an object to be clamped when such an object is presents and in the open position being spaced apart from each other.



19. A method in accordance with claim 18 wherein said trough is provided with a plurality of perforations in the upper region of the sides thereof.

20. A method in accordance with claim 18 or claim 19 wherein said metal is copper and said substrate is a printed circuit board.

21. A cathode shielding device for use in an electrolytic plating bath, said device comprising :
an elongated trough adapted to be inserted in said bath;

said trough being provided with a plurality of clamps as claimed in any one of claims 1-12;

said clamps being aligned substantially in parallel vertical planes transverse to the longitudinal axis of said trough, for securing one or more electroplatable substrates in a substantially vertical plane with the lower edge of each of said substrated located below the plane in which lies the upper edges of said trough; and

said trough having a plurality of perforations in the upper region of the sides thereof.

22. A cathode shielding device for use in an electrolytic plating bath, said device comprising :
an elongated trough mounted in a frame, said frame being provided with drive means for imparting



reciprocal movement in a horizontal plane within said frame and to said trough mounted in said frame; said trough being provided with clamps for securing one or more electroplatable substrates in a substantially vertical plane with the lower edge of each of said substrates located below the plane in which lies the upper edges of said trough, said clamps being as claimed in any one of claims 1-12; and said trough having a plurality of perforations in the upper regions of the sides thereof.

23. A cathode shielding device as claimed in claim 20 or claim 22 wherein said elongated trough is fabricated from buoyant plastic material.

24. A cathode shielding device as claimed in any one of claims 21-23 wherein said elongated trough is fabricated from polypropylene or polyethylene.

25. A cathode shielding device as claimed in any one of claims 21-24 wherein said elongated trough is provided with auxiliary buoyancy material.

26. A cathode shielding device as claimed in any one of claims 21-25 wherein the substrate is a printed circuit board.



27. An apparatus for the electrolytic deposition of a metal on an electroplatable substrate comprising a container for electrolyte; a cathode bus bar; and a clamping means, wherein an electroplatable substrate is attachable at an upper edge to the cathode bus bar and the clamping means clamps the lower edge of any substrate attached to the cathode bus bar as the substrate enters the container.

28. An apparatus as claimed in claim 27, wherein when the container contains electrolyte, the clamping means clamps the lower edge of any substrate attached to the frame as the substrate enters the electrolyte.

29. An apparatus as claimed in claim 27 or claim 28, wherein the clamping means comprises a plurality of clamps.

30. An apparatus as claimed in claim 29, wherein the clamps are in a trough or forming part of a trough and are aligned substantially in parallel vertical planes transverse to the longitudinal axis of the trough.

31. An apparatus as claimed in claim 29 or claim 30, wherein the clamping means clamp the lower edge of substrate when a downward force is exerted on the trough.



32. An apparatus as claimed in claim 31, wherein the cathode bus bar exerts a downward force on the trough through a strut or struts extending either downwardly from the cathode bus bar which struts engage with the trough, or upwardly from the trough which struts engage with the frame, or downwardly from the cathode bus bar and upwardly from the trough which struts engage with each other.

33. An apparatus as claimed in any one of claims 27-32, wherein the clamps are clamps of the type claimed in any one of claims 1-12.

34. An apparatus for electrolytic deposition of metal on a substrate, said apparatus being comprised of a container for electrolyte, a cathode and an anode mounted in said container, and a cathode shielding device, said cathode shielding device comprising :
an elongated trough in said container;
said trough being provided with a plurality of clamps as claimed in any one of claims 1-12;
said clamps being aligned substantially in parallel vertical planes transverse to the longitudinal axis of said trough, for supporting one or more electroplatable substrates in a substantially vertical plane with the lower edge of each of said substrates located below the plane in which lies the upper edges of said trough; and



said trough having a plurality of perforations in the upper regions of the sides thereof.

35. An apparatus for electrolytic deposition of metal on a substrate, said apparatus being comprised of a container for electrolyte, a cathode and an anode mounted in said container, and a cathode shielding device, said cathode shielding device comprising :

an elongated trough;

said trough being provided with clamps for securing one or more electroplatable substrates in a substantially vertical plane with the lower edge of each of said substrates located below the plane in which lies the upper edges of said trough; and

said clamps being as claimed in any one of claims 1-12
said trough having a plurality of perforations in the upper regions of the sides thereof.

36. An apparatus as claimed in claim 34 or claim 35, wherein said elongated trough is fabricated from buoyant plastic material.

37. An apparatus as claimed in any one of claims 34-36, wherein said elongated trough is fabricated from polypropylene or polyethylene.

38. An apparatus as claimed in any one of claims 34-37, wherein said elongated trough is provided with



auxiliary buoyancy material.

39. An apparatus as claimed in any one of claims 34-38, wherein said substrates are printed circuit boards.

40. A clamp substantially as herein described with reference to the accompanying drawings.

41. An apparatus for the electrolytic deposition of a coating of metal on an electroplatable substrate substantially as herein described with reference to the accompanying drawings.

42. A cathode shield substantially as herein described with reference to the accompanying drawings.