Jan. 29, 1974 L. N. KOSOWSKY ET AL 3,788,963

APPARATUS FOR INTERMITTENT ELECTROPLATING STRIPS

Filed Jan. 13, 1972

5 Sheets-Sheet 1

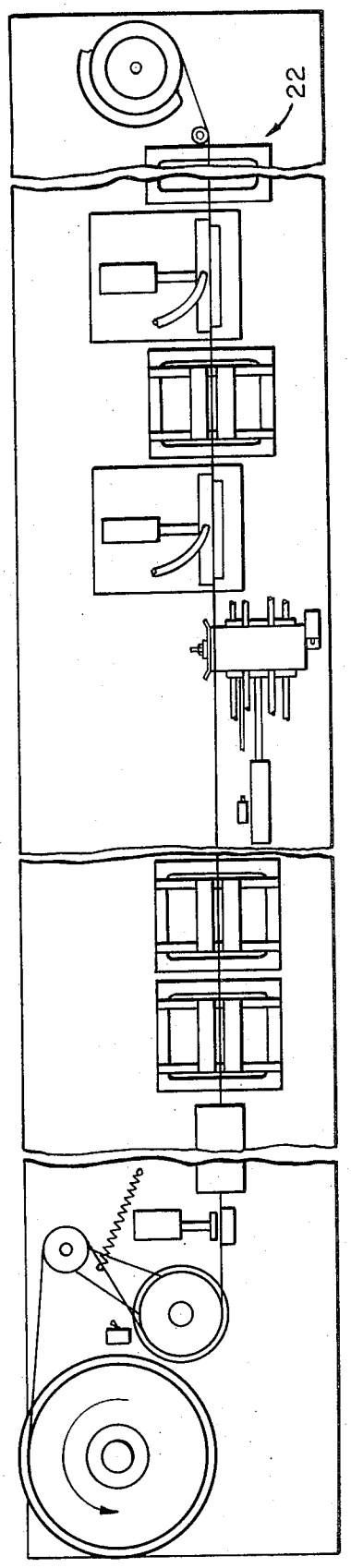


FIG. 2

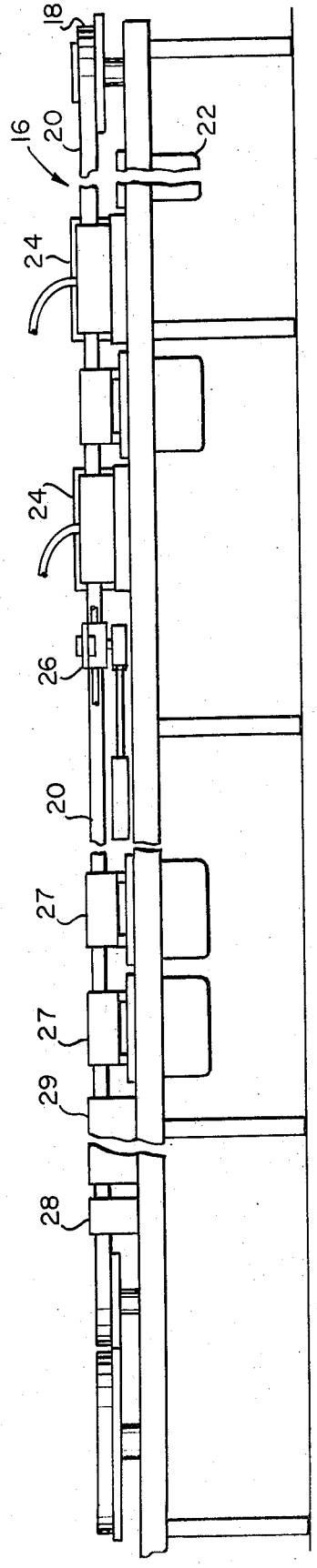


FIG. 1

APPARATUS FOR INTERMITTENT ELECTROPLATING STRIPS

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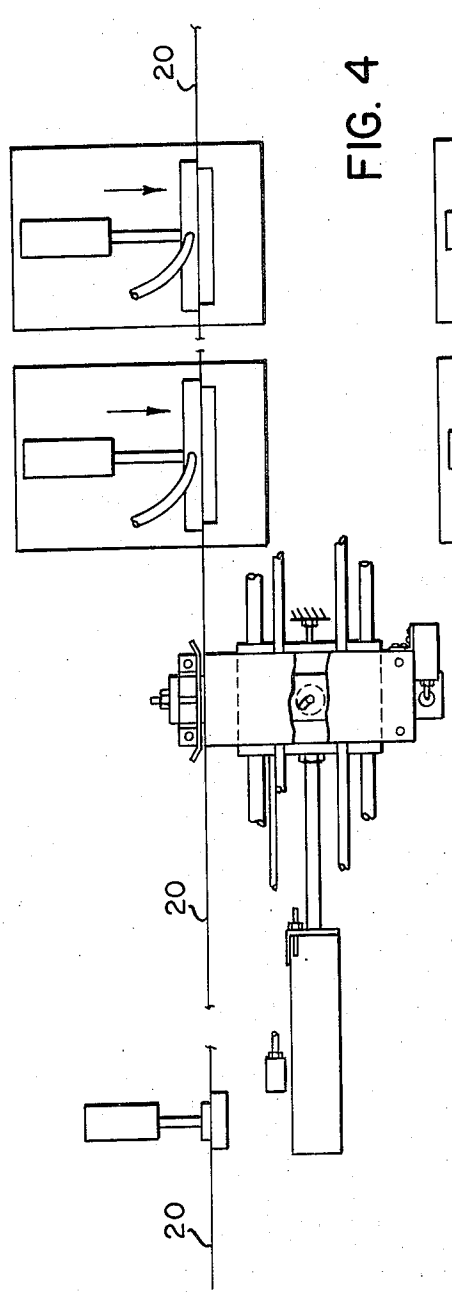


FIG. 4

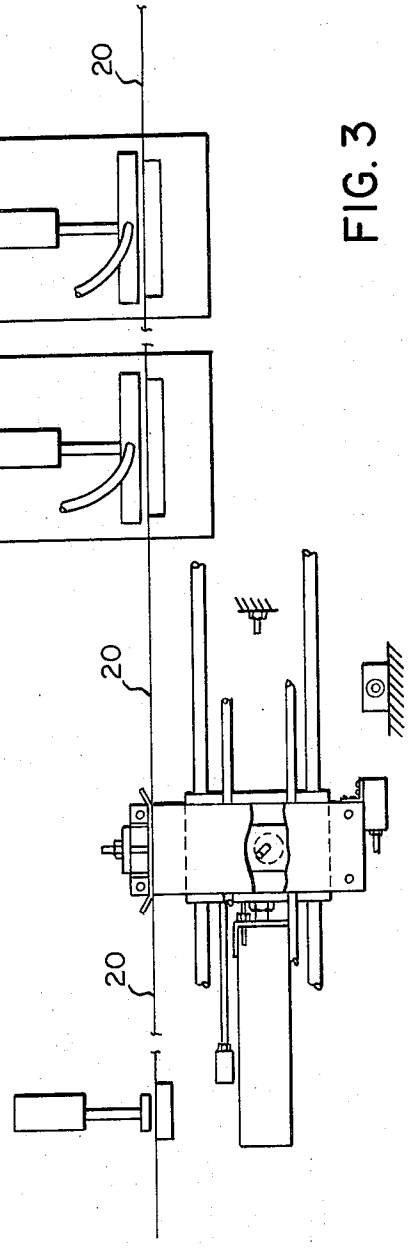


FIG. 3

APPARATUS FOR INTERMITTENT ELECTROPLATING STRIPS

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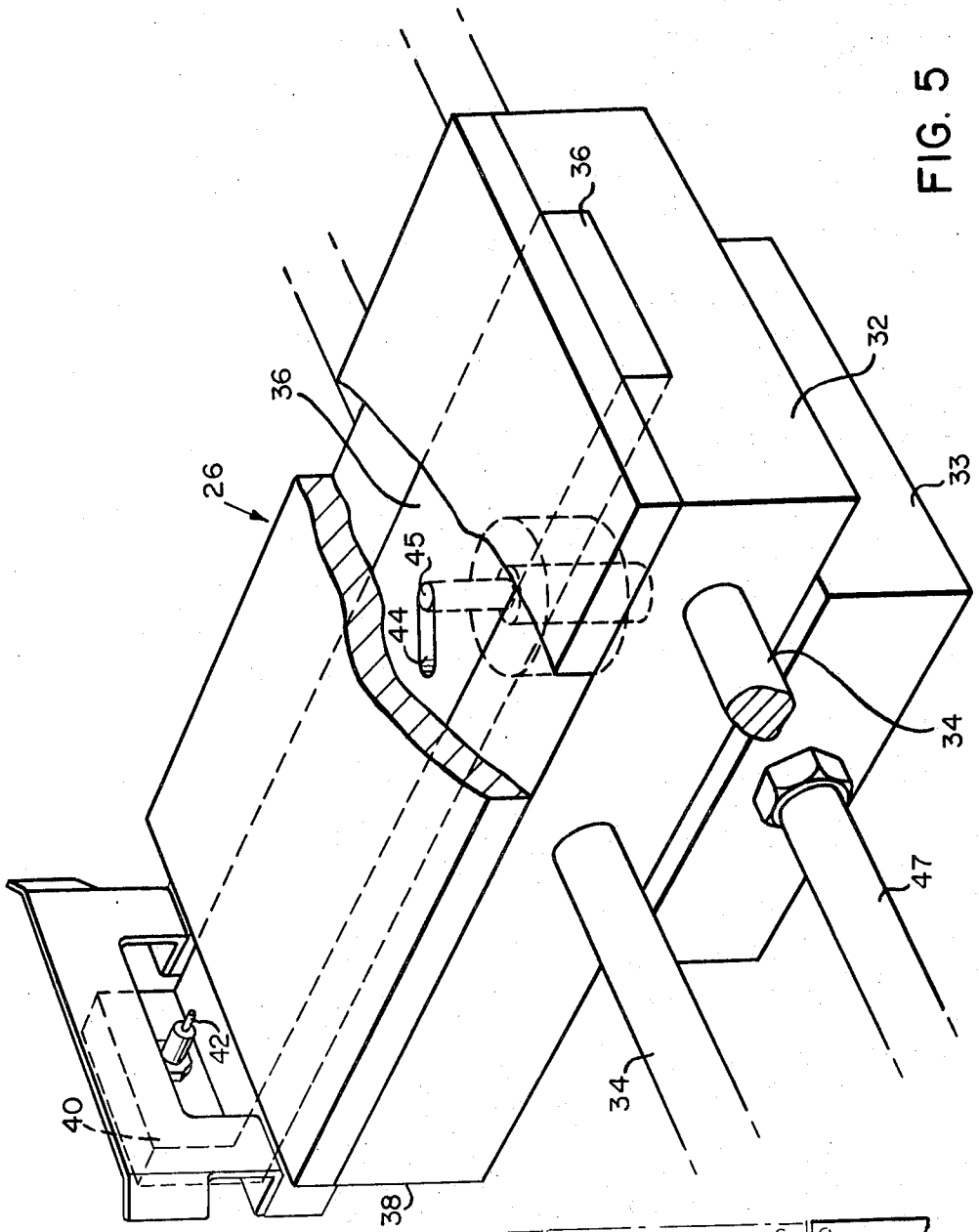


FIG. 5

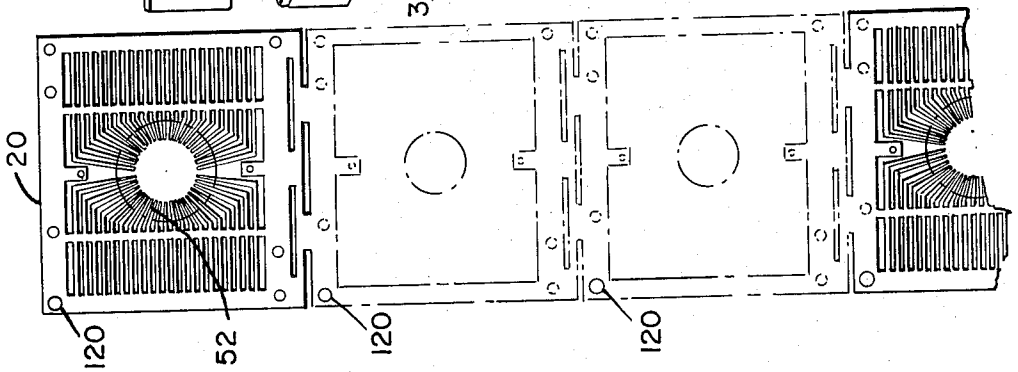


FIG. 7

APPARATUS FOR INTERMITTENT ELECTROPLATING STRIPS

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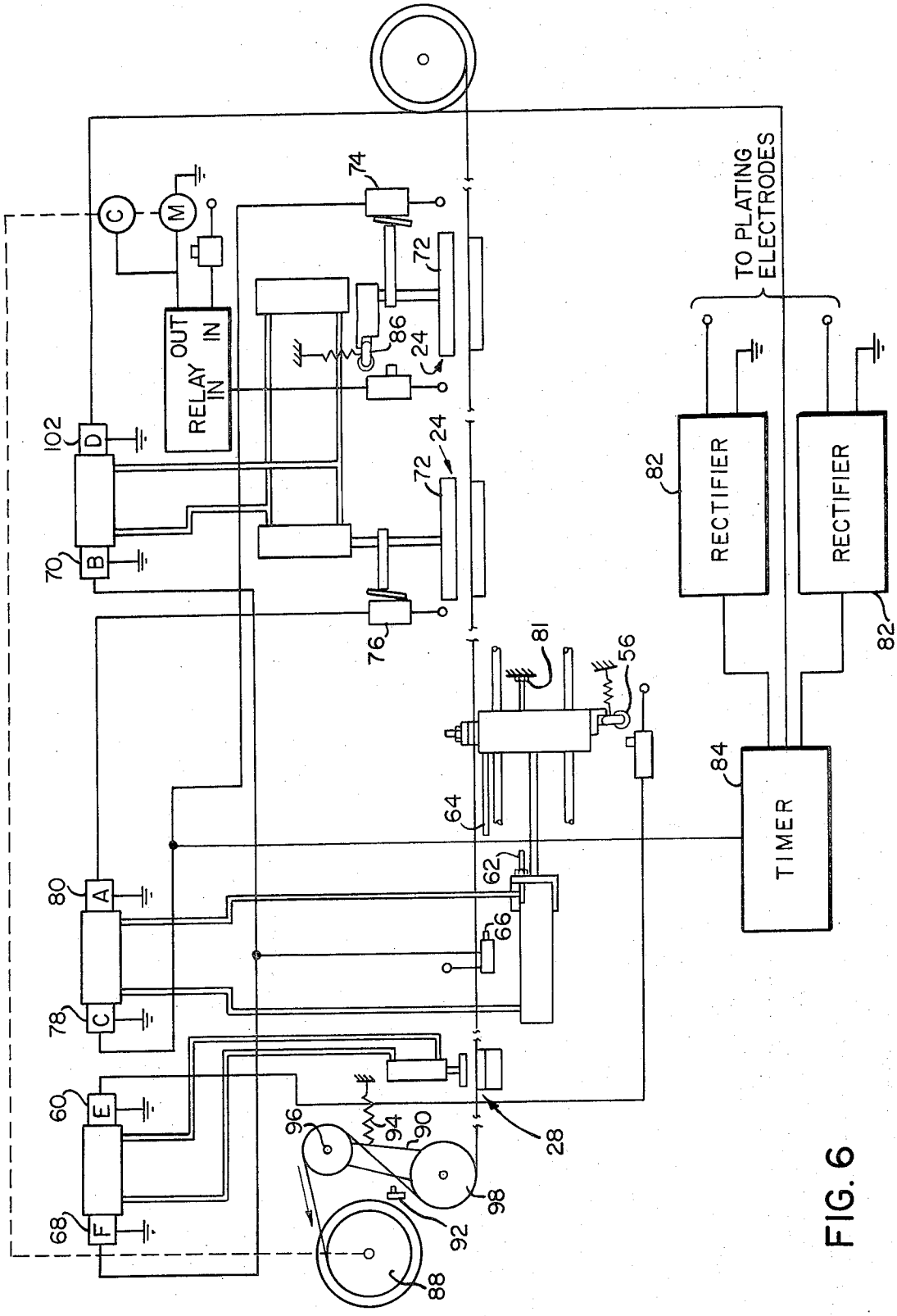


FIG. 6

APPARATUS FOR INTERMITTENT ELECTROPLATING STRIPS

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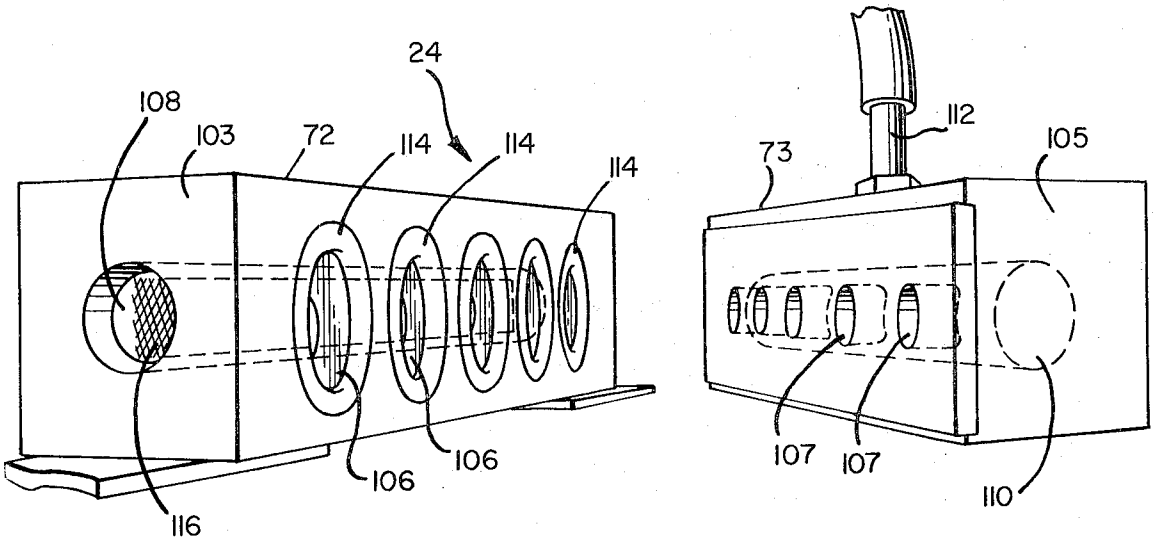


FIG. 8

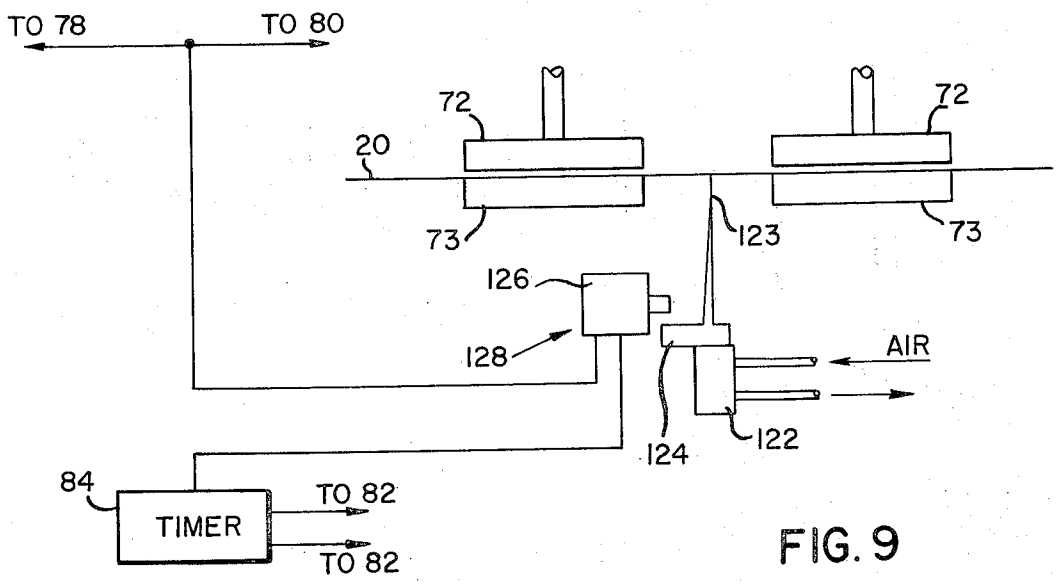


FIG. 9

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3,788,963

APPARATUS FOR INTERMITTENT ELECTROPLATING STRIPS

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Int. Cl. C23b 5/68
U.S. Cl. 204—206 19 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus for electroplating selected areas on consecutive segments of metal strip, the apparatus comprising means to advance the strip, means for isolating inertial movement of the strip to hold the strip in a fixed position at all times advancement is not required, and an electroplating cell formed of two parts adapted to clamp together hydraulically isolating all but the aforesaid selected areas from contact with the electroplating fluid. In one embodiment of the invention there is an electronic means to sense whether the proper advancement of the strip has been achieved.

BACKGROUND OF THE INVENTION

(A) Field of the invention

This invention relates to apparatus and process for electroplating a plurality of pre-selected isolated areas on incremental segments of an elongate metal strip while maintaining the rest of the strip out of contact with the electroplating bath and providing for the controlled advancement of the strip as each segment is positioned for exposure to the electroplating bath.

(B) 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 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 electroplating of such partially masked items is finished, the masking material is removed, leaving 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.

The most suitable apparatus of the solution of such problems are disclosed in the commonly-owned and copending United States patent applications U.S. Ser. Nos. 90,632 and 95,995 filed by Kosowsky et al on Nov. 18, 1970 and Dec. 8, 1970, respectively. Such apparatus uses seal means to selectively isolate the surfaces of sheet which are to be exposed to contact with the electroplating fluid. The latter of these applications describes means to continuously electroplate an elongate suitable for use on very large runs of a strip with a particular metallic pattern; however, it has been found to be inconvenient to modify the sealing parts of such apparatus to accommodate a series of smaller runs on strips of different configurations. Another drawback to this continuous plating-type of apparatus is that it requires a relatively large amount of space because the various processing steps must be carried out as the strip moves through processing stations elongated to compensate for the movement of the strip. Therefore, it is desirable, for smaller orders and for providing apparatus that requires less space, to construct apparatus for the intermittent electroplating of elongate strips which will allow the strips to be advanced step-by-step and, consequently, to be stationary during the electroplating procedure.

Other 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 receptical 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 densities. Current densities which are too high will result in deposits of poor quality. 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 suitable concentrated cation concentration at each of the discrete areas being plated. Without a suitable high concentration; it would be impossible to obtain a high quality plating in a desirable 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 compact 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 intermittently advanced along a processing line.

A further object of the invention is to provide apparatus as described above which has a positive mechanical relationship between an advancement mechanism and a strip engagement means incorporated therein to assure the disengagement of the strip during a stroke of the advancement means.

Another object of the invention is to provide apparatus for intermittent processing of an elongate strip which provides means to hold said strip fast against spurious movement throughout said processing.

Another object of the invention is to provide electroplating apparatus for intermittent electroplating of a strip which comprises means to automatically confirm the satisfactory advancement and positioning of said strip on each advancement thereof.

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

The above objects have been substantially accomplished by providing a novel electroplating apparatus having mechanical locking means associated with a number of serially arranged processing stations through which segments of an elongate metal strip is passed as the strip is intermittently advanced. These mechanical locking means serve to assure there will be no transmission of movement between the electroplating bath and wind-up systems. Such movement would result in the placement of gold on the wrong part of the strips being electroplated. Such wrong placement must be avoided because of the high cost of gold.

In this application and accompanying drawings there is shown and described a preferred embodiment of the invention and suggest various alternatives and modifications thereof, 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. These 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.

FIG. 1 is a schematic elevation of a part of a production line whereon selected portions of a strip of metal are electroplated.

FIG. 2 is a plan view of the production line shown in FIG. 1.

FIGS. 3 and 4 are a more detailed plan view of that portion of the apparatus wherein the strip is electroplated and engaged for advancement.

FIG. 5 is a perspective view partially cut away of the advance mechanism.

FIG. 6 is a schematic diagram of the control system.

FIG. 7 illustrates a typical strip processed on the apparatus of the invention.

FIG. 8 illustrates the plating cells used with the apparatus of the invention.

FIG. 9 is a schematic diagram showing a warning-control mechanism useful as part of the apparatus of the invention.

It will be obvious to those skilled in the art from reading the following description that the control system described is partly hydraulic. The description hereinbelow refers to the solenoid actuators of valves for the hydraulic fluid system rather that the hydraulic conduits and pumping associated therewith. The latter are shown in sufficient detail in FIG. 6 to define the apparatus being described for all those skilled in the art.

Referring to FIGS. 1 and 2 it is seen that electroplating production line **16** comprises a supply roll **18** of perforated metal strip **20** which is to be electroplated. The strip is fed through a number of cleaning baths illustrated schematically at **22** but not shown in any detail because such cleaning steps are old in the art and do not form any part of the present invention. After passing through the cleaning baths, the metal strip is electroplated in at least one of electroplating stations **24**, then engaged by an intermittently actuated positive action advance mechanism **26** and pushed forward through post-electroplating treatment baths **27** and oven **29**. Thence strip **20** passes through a vise member **28** and into a spooling apparatus **30**.

FIGS. 3 and 5 illustrate advance mechanism **26** in more detail. Advance mechanism **26** comprises a block **32** mounted for travel along support rods **24**. This block **32** encloses means to carry an advance bar **26** which protrudes from one side **38** of block **32** and carries a pin support member **40** and an advance pin **42**. Advance bar **36** is adapted for controlled lateral movement within block **32** by means of a cam slot **44** therein, as described in more detail below.

FIG. 7 shows a portion of a metal strip **50** which is foraminous enough to allow the passage of electroplating fluid therethrough and on which it is desirable to electroplate a metal, say gold only on the surface **52** indicated within the dotted circles **54** on each segment of the strip.

Referring now to the schematic diagram of FIG. 6 together with the other drawings, the operation of the apparatus is described as follows starting with the forward movement of advance mechanism **26**.

As advance mechanism **26** is moved forward by the action of an operating rod **47** of pneumatic cylinder **48** (i.e. to the left in FIGS. 3 and 4), the first ½ inch of travel causes pin **45** which is fastened to support block **33** to be pulled to the right (as shown in FIG. 5) in cam slot **44** thereby pulling advance bar **36** and advance pin **42** to the right. Top block **32** does not move until it is engaged by pin **45** at the right end of the cam slot. By this time, advance pin **42** will have entered a hole in strip **20**, thereby engaging it for forward movement as this ½ inch forward motion of advance mechanism **26** is completed, the mechanism also actuates a one-way roller actuator **56** (see FIG. 6). Actuator **56**, in turn, actuates a limit switch **58**. Limit switch **58** causes the opening of vise **28** through the energizing of solenoid **60**.

At this point in time the strip can be moved forward and starts its advance in unison with the entire advance mechanism **26** until it engages a mechanical stop **62** and probe **64** engages limit switch **66**. Switch **66** actuates solenoids **68** and **70**. The former solenoid causes vise **28** to grip strip **22**. Solenoid **70** causes movable plating heads **72** of electroplating cells **24** to press against strip **22**. As plating heads **72** move toward the strip **20**, they close a normally open switch **74** and open a normally closed switch **76**. Switch **74** activates solenoid **78** and switch **76** deactivates solenoid **80**. Thus the pneumatic cylinder **48** is actuated and operating rod **47** moves to the right in FIG. **6**, thereby retracting the advance mechanism.

As the advance mechanism starts to retract, the advance pin **42** is pulled out of engagement with the strip **20** before the pin starts to move with the advance mechanism. The first half-inch of movement of support block **33** merely causes the pushing of advance bar **36** to the left by cam slot **44** and cam pin **45**, as shown in FIG. 5. Thereupon blocks **32** and **33** become engaged and the advance mechanism moves to its original position where it strikes another mechanical stop **81**.

Switch **76** also turns on rectifiers **82** through a timer **84** which controls the time during which current is supplied to electroplating stations **24**.

The movement of movable electroplating cell members **72** has been seen to actuate switches **74** and **76**. This movement also depresses a one-way roller actuator **86**. Actuator **86** monmentarily closes to actuate a magnetic clutch (not shown) which in turn allows engagement of a continuously running motor drive with take-up reel **88** of spooling apparatus **30**. Reel **88** will rotate, thereby winding up strip **20**, until idler arm **90** is swung forward to contact shutoff switch **92**. Idler arm **90** is biased by spring biasing means **94** and, as the strip is wound upon reel **88**, idler arm **90** is pulled forward to contact switch **92**. The

strip is maintained under appropriate tension at all times by the biased idler arm as it is carried around rolls **96** and **98**.

The spring **94** also serves to pull idler arm **90** and most notably roll **96** backwardly away from shutoff switch **92** when the take-up reel is not turning. This allows an increment of strip **20** to be held under continuous tension as it is fed past vise **28** during the advancement of strip **20**.

When timer **84** signals the end of the electroplating cycle, rectifiers **82** are shut off and solenoid **102** is energized thereby activating the movable sectors **72** of plating stations **24** to retract into their open positions. Switch **74** opens, switch **76** closes to activate solenoid **80** and start another cycle.

It will be noted on careful study of the above-identified apparatus and procedure for the operation thereof, that the strip while being intermittently carried through the processing apparatus is mechanically isolated during each processing step so that spurious movement thereof, whether it be vibratory or inertial, cannot be transmitted along the tape. Thus during the wind-up procedure, a vise **28** carefully isolates spooling apparatus **30** from the rest of the system. Similarly, when vise **28** is open to permit advancement of the strip, the strip is positively engaged for forward motion by advance pin **42**. As the advance pin ceases its forward motion, vise **28** and electroplating cells again clamp the strip to prevent motion thereof.

FIG. 8 is a perspective view of an electroplating station **24** the perspective being exaggerated to better show the detail of the various parts thereof. The station comprises a movable plating head **72** and a stationary plating head **73**. Movable plating head comprises a housing **103** and a row of apertures **106** on that face of housing **103** which faces plating head **73**. Plating head **73** has a housing **105** having another row of aperture **107** in register with, and smaller than apertures **106**. Each set of apertures is connected to central conduits **108** or **110**. The former conduit provides means to distribute incoming plating solution to aperture **106**; the latter conduit forms means to receive plating fluid through apertures **107** and to discharge this outgoing plating solution through conduit **112**.

Piping attachments to head **72** are not shown. Those skilled in the art will be able to arrange whatever piping, preferably flexible piping, that is required to supply solution to the assembly. The terminals of conduits **108** and **110** can be used or may be plugged when other supply conduits are machined into the housing.

The contact between plating head **73** and **72**, on their gripping metal strip **20** being electroplated, is a sealing contact provided by resilient elastomeric O-rings **114** which are inserted in housing **103** about the periphery of apertures **106**. These O-rings protrude slightly and thereby form means to sealingly contact the strip being processed so that plating solution contacts only that part of the strip defined by circular apertures **107**. The pressure of these O-rings **114** is counteracted on the other side of strip **20** by a rubber face plate **116** which is inset in the face of housing **105**. Thus when plating heads **72** and **73** are brought into pressured contact with strip **20** in an additional vise-like clamping action, they form a conduit which may be as wide as is necessary to electroplate any desired portion of the plate on either side of the strip. The particular area electroplated will depend on the size selected for apertures **106** and **107**. In the illustrated case, the intention is to avoid any electroplating on that side of the strip adjacent apertures **107**, and to plate a circular area as indicated in FIG. 7 on that side of the strip adjacent apertures **106**.

In the electroplating process, the metal strip being plated will form the cathode. The anode is advantageously a screen **116** placed in conduit **108**.

A particularly advantageous feature is incorporated into the preferred embodiments of the invention whereby the electroplating function can be stopped and the apparatus shut down if some malfunction of the system causes the strip to be out of position at the time the electroplating step is to take place. FIG. 7 illustrates the fenestrated nature of the strip being processed. There are, of course, a large number of points on each repeating portion of the strip which could be used in the operation described hereinbelow. However, to minimize the possibility of malfunction, a relatively isolated aperture like aperture **120** in FIG. 7 is usually selected for the operation.

With reference to FIG. 9, it is seen that strip **20** is in a given position, that position being so that the central aperture in the strip pattern is in register with the hole **107** of FIG. 8. Mounted along strip **20** is a probe or pin **123** operated by a solenoid-actuated pneumatic cylinder **122**. Probe **123** is so mounted that, if it is not pushed forward during the plating cycle, an operating arm **124** attached thereto will not be carried forward sufficiently to close a normally open limit switch **126**. If limit switch **126** does not close, the rectifiers will not be made operable and electroplating will not commence. The effect of this failure in the cycle will be to stop the cycle.

Probe **123** is mounted along the processing line so that it will only advance forward if it meets a hole, e.g. aperture **120**, in metal strip **20**. Thus it is so placed that it meets that hole only when the center aperture is in proper register with the plating heads.

FIG. 9, schematic in detail, shows how the sensing pin assembly **128** works in relation to FIG. 6. The air supply to the pneumatic cylinder for pushing the pin forward is provided through the action of solenoid **70**, i.e. the same action that moves the movable plating heads **72**. FIG. 9 shows the normally open switch **126** left in that position, because of the failure of pin **123** to penetrate strip **20** because of incorrect registration of pin and strip aperture **120**.

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. Apparatus for electroplating pre-selected portions of a continuous metallic strip, said apparatus comprising

(A) advancement means including (1) means adapted to mechanically intrude into the plane defined by said strip, to engage said strip and move it forward an incremental distance from an initial position of said advancement means, and (2) means adapted to disengage said means from said strip and return said advancement means to said initial position;

(B) an electroplating cell adapted to clamp and seal portions of the surface of said strip to hydraulically seal portions of said strip against exposure to electroplating fluid and to hydraulically seal a plurality of other pre-selected portions of the surface to be electroplated into a conduit forming means to supply electroplating fluid to said plurality of surfaces.

2. Apparatus as defined in claim **1** wherein said means to mechanically engage said strip is operably connected to said advancement means by cam operating means, said cam operating means pulling said engagement means into engagement with said strip on the initial portion of each advance stroke of said advancement means and pushing said engagement means out of engagement with said strip on the initial portion of each return stroke of said advancement means.

3. Apparatus as defined in claim **1** wherein said electroplating cell comprises one stationary plating head, one removable plating head, and elastomeric sealing means forming apertures for electroplating fluid on opposed faces of said plating heads.

4. Apparatus as defined in claim **3** wherein said electroplating cell comprises one stationary plating head, one removable plating head, and elastomeric sealing means

forming apertures for electroplating fluid on opposed faces of said plating heads.

5. Apparatus as defined in claim 1 wherein said means to mechanically engage said strip is operable connected to said advancement means by cam operating means, said cam operating means pulling said engagement means into engagement with said strip on the initial portion of each advance stroke of said advancement means and pushing said engagement means out of engagement with said strip on the initial portion of each return stroke of said advancement means.

6. Apparatus as defined in claim 5 wherein said electroplating cell comprises one stationary plating head, one removable plating head, and elastomeric sealing means forming apertures for electroplating fluid on opposed faces of said plating heads.

7. Apparatus as defined in claim 1 wherein said strip is foraminous and said electroplating cell is adapted to form with said strip a continuous conduit for electroplating fluid, said conduit communicating with each side of said pre-selected portions to be electroplated.

8. Apparatus as defined in claim 7 comprising means to wind up said strip and also comprising vise means adapted to clamp and immobilize said strip when said advancement means is not advancing said strip, said vise being positioned between (a) said winding means and (b) said advancement means and said electroplating cell.

9. Apparatus as defined in claim 1 comprising means to wind up said strip and also comprising vise means adapted to clamp and immobilize said strip when said advancement means is not advancing said strip, said vise being positioned between (a) said winding means and (b) said advancement means and said electroplating cell.

10. Apparatus as defined in claim 9 wherein said wind-up means comprises (1) a first roll, pivotally mounted on an idler arm and biased to take up slack of said strip when said strip is advanced through said vise means and (2) means to release said first roll during rotation of a wind-up roll.

11. Apparatus as defined in claim 9 wherein the apparatus intermittently and selectively electroplates sequential sections of a strip of metallic sheet material, each said section having an opening in the same relative sequential position with respect to each other said section and a displacement sensor operably connected to the electroplating apparatus and forming means to inactivate electroplating apparatus if said sensor does not sense said opening.

12. In apparatus of the type utilized to intermittently and selectively electroplate sequential sections of a strip of metallic sheet material, each said section having an opening in the same relative sequential position with respect to each other said section, the improvement wherein a probe is adapted to enter each said opening as each said section of strip is positioned for proper selective electroplating and wherein said probe is a displacement sensor operably connected to the electroplating apparatus and forming means to inactivate said electroplating apparatus when apparatus does not operate in a mode allowing probe to move into said opening.

13. Apparatus as defined in claim 12 comprising an electroplating cell having one stationary plating head, one removable plating head, and elastomeric sealing means forming apertures for electroplating fluid on opposed faces of said plating heads.

14. Apparatus as defined in claim 12 wherein said displacement sensor forms means to engage and advance said strip.

15. Apparatus as defined in claim 14 comprising an electroplating cell having one stationary plating head, one removable plating head, and elastomeric sealing means forming apertures for electroplating fluid on opposed faces of said plating heads.

16. Apparatus as defined in claim 14 wherein said means to mechanically engage said strip is operably connected to said advancement means by cam operating means, said cam operating means pulling said engagement means into engagement with said strip on the initial portion of each advance stroke of said advancement means and pushing said engagement means out of engagement with said strip on the initial portion of each return stroke of said advancement means.

17. Apparatus as defined in claim 1 wherein the apparatus intermittently and selectively electroplates sequential sections of a strip of metallic sheet material, each said section having an opening in the same relative sequential position with respect to each other said section and a displacement sensor operably connected to the electroplating apparatus and forming means to inactivate electroplating apparatus if said sensor does not sense said opening.

18. In apparatus of the type utilized to intermittently and selectively electroplate sequential sections of a strip of metallic sheet material, each said section having a mark in the same relative sequential position with respect to each other said section and a sensor operably connected to the electroplating apparatus and forming means to inactivate electroplating apparatus if said sensor does not sense said mark.

19. In apparatus of the type utilized to intermittently and selectively electroplate sequential sections of a strip of metallic sheet material, each said section having an opening in the same relative sequential position with respect to each other said section and a displacement sensor operably connected to the electroplating apparatus and forming means to inactivate electroplating apparatus if said sensor does not sense said opening.

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FREDERICK C. EDMUNDSON, Primary Examiner

U.S. Cl. X.R.

204—224 R