ELECTROPLATING APPARATUS

Filed July 15, 1965

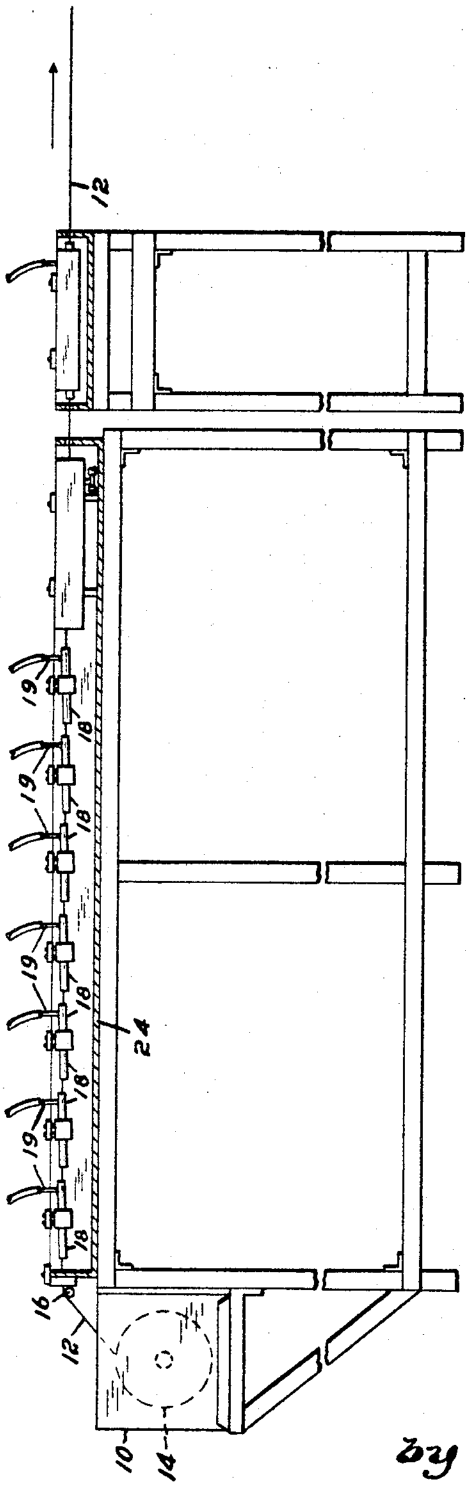

Fig. 1A.

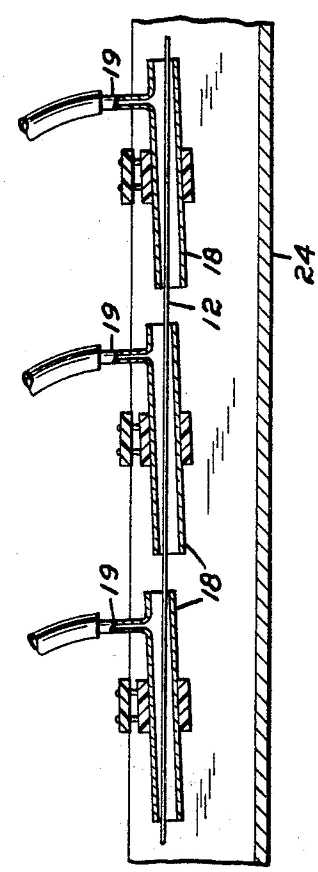

Fig. 2.

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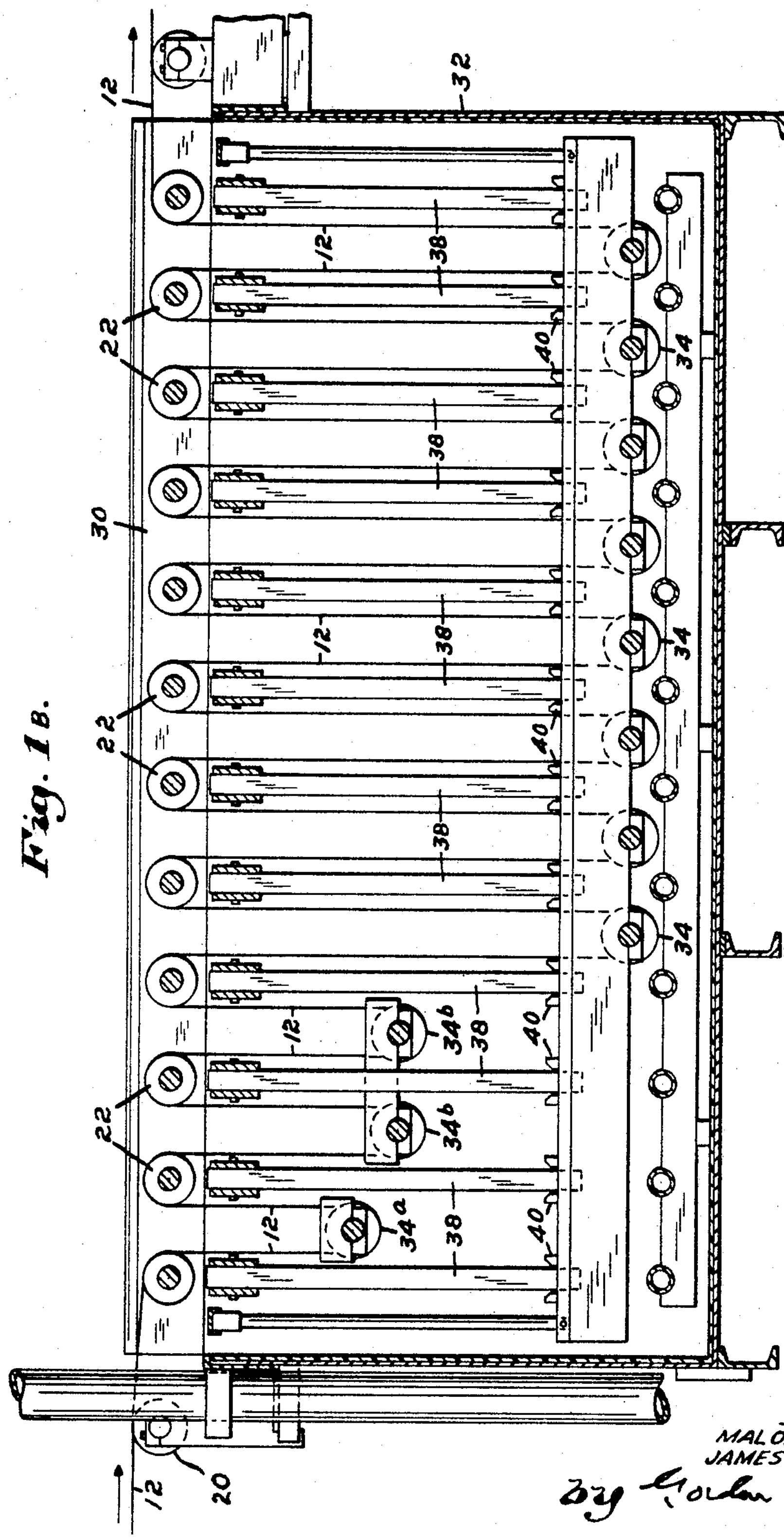

Fig. 1B.

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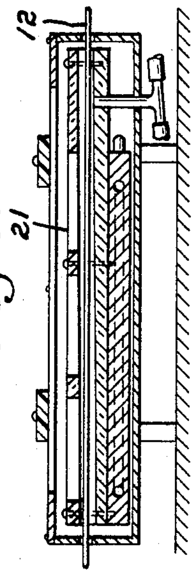

Fig. 3.

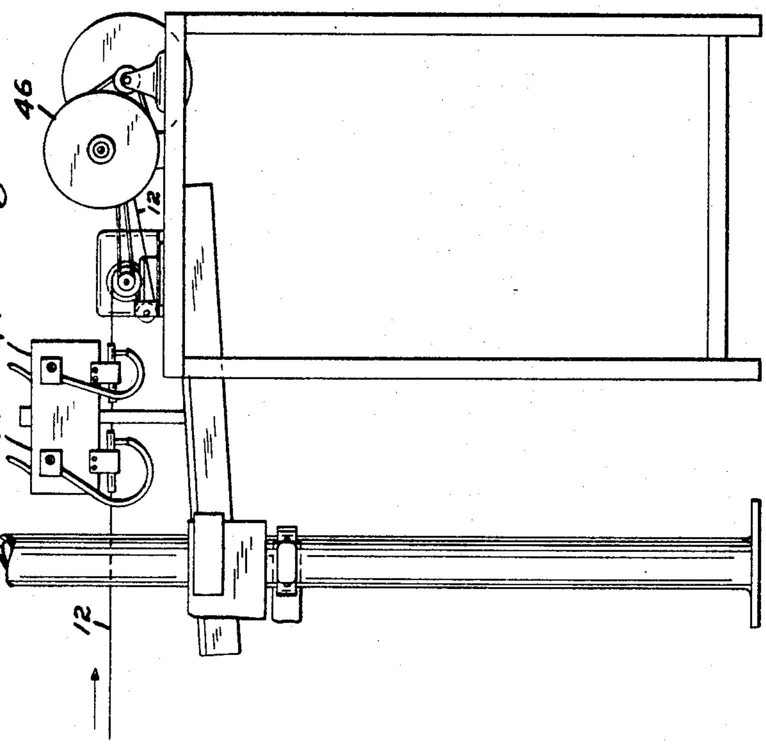

Fig. 1c.

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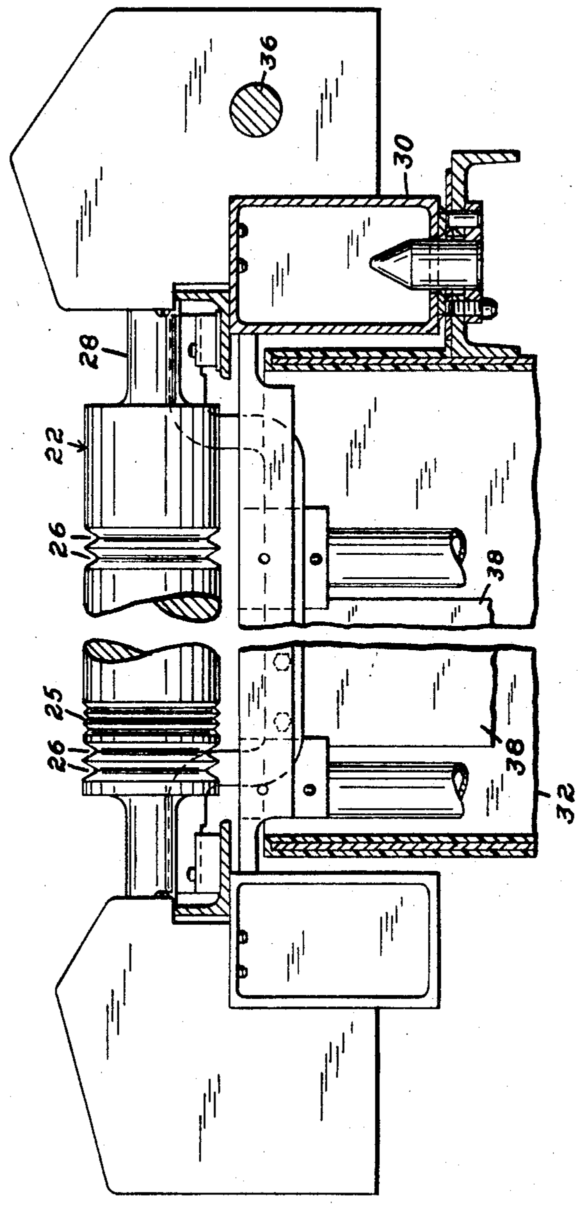

Fig. 4.

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United States Patent Office

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ELECTROPLATING APPARATUS

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U.S. Cl. 204—207 6 Claims

ABSTRACT OF THE DISCLOSURE

An electroplating apparatus for a continuous wire comprising supply means, guide means, reagent tubes, electroless plating means and electrolytic plating means, said reagent tubes being orientated angularly in relationships to the horizontal wire, and said wire being treated in the reagent tubes and then electroless plated without contacting any surface.

This invention relates generally to plating methods and more specifically to methods of plating the outer conductor on a coaxial cable.

An object of the present invention is to provide an apparatus for continuously plating a substrate.

Another object of the present invention is to provide an apparatus for continuously plating a cylindrical substrate.

In the drawings:

FIG. 1*a* is a side elevation, partly in section, of the reduction module of the cable plating line;

FIG. 1*b* is a side elevation, partly in section, of the plating module;

FIG. 1*c* is a side elevation of the take-up module;

FIG. 2 is an enlarged view of the reagent tubes, partly in section;

FIG. 3 is an enlarged sectional view of the electroless copper plating station; and

FIG. 4 is a front elevation partially broken away and partially in section of a single drive roller, the frame supporting same and the main drive shaft.

Heretofore the preparation of core strands for electroplating in a continuous process was very difficult, particularly if long lengths of the core strand were required. As the core strands were transferred in coils from bath to bath, separate strands of the coil would either rub one another or contact the sides of the container producing bare spots. It was therefore highly desirable to develop a method of handling the core strands. The idea of dripping the solutions on the cable as it passed proved to be a spotty and highly inadequate approach. The use of water-wetted glass tubing to accomplish the required result was then thought of and has proved successful.

In the drawings there is shown an apparatus for plating a high frequency coaxial cable core **12**. The cable core **12** comprises an inner conductor coated with a jacket of dielectric such as polyethylene or "Teflon." The jacket may, if required, be externally grooved.

The apparatus comprises three modules, a reduction module, a plating module and a take-up module. Before the strand or strands of coaxial cable core enter the reduction module, it has already gone through certain preplating operations which would include a cleaning with alkaline or other types of cleaning solvents and also a pre-plate acid etch.

The strand of the coaxial cable core **12** is wound on a supply drum **14** which is immersed in a container **10** filled with a heated solution of clean, hot, deaerated water with a small amount of potassium dichromate. The strand of the coaxial cable core **12** is then brought into the plating line which includes the reduction module, the plating module, and a take-up module. The strand of

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coaxial cable core **12** is stretched from the supply drum **14** over a guide roller **16** through a series of reagent tubes **18** to the plating guide roller **20**. From the point where the strand **12** passes over the guide roller **16** until it reaches the plating guide roller **20**, it only passes through the necessary reagent solutions or through air without touching any other physical surfaces.

Each of the tubes **18** comprises a single treating station in the reduction module. The necessary reagents are fed into pipes down into the reagent tubes **18** from chemical dispensing tanks (not shown) by gravity feed or other feed means.

At the first station, the coaxial cable core strand **12** undergoes a second etching procedure to insure that the surface is hydrophilic. The flow rate is adjusted to provide a complete change of solution in the tube **18** approximately every 2.5 minutes. This adjustment is accomplished by using a clamping means or a metering device on the plastic hose leading from the dispensing tank to the supply nozzle of the tube **18**.

The next station is a rinse station which utilizes deionized water.

Station **3** provides a sensitizing treatment of a readily oxidized material, in this case stannous chloride, at room temperature, the flow rate being adjusted for complete changeover every four minutes.

Station **4** is another rinse adjusted to provide a flow rate providing a complete change every 2.5 minutes.

Station **5** deposits a catalytic film on the cable core. The catalyst in this case being palladium chloride. Silver compounds may also be used in place of the palladium.

Stations **6** and **7** are rinses.

Station **8** exposes the coaxial cable core to an electroless copper solution containing an A solution having a combination of copper sulfate and formaldehyde and a B solution of sodium carbonate, sodium hydroxide and Rochelle salt. The A and B solutions are stored in separate containers and are mixed just prior to use.

Each of the reagent tubes **18** has an extension or supply nozzle **19** on its upper surface which engages with the hose from the chemical dispensing tanks and since each of the reagent tubes **18** is water wetted, surface tension will maintain a full tube of the reagent solution. Therefore, the strand of the coaxial cable **12** passes through what may be termed cylinders of reagent separated by air spaces. If no reagent is added to the reagent tube **18**, the reagent in the tube **18** will remain stationary. A runoff tank **24** surrounds the reduction module on three sides so that the dripping from the tubes **18** is caught in the runoff tank **24**. Each of the reagent tubes **18** is tilted slightly at the portion closest to the supply drum **14** and the reagents dripped into the tubes **18** are introduced in a counter current fashion so that the fresh portion of the solution is directly under the extension and by the time the reagent reaches the end of the tube for runoff, the useable chemicals have been exhausted for the purpose intended. The strand **12** moves in a direction counter to the flow of reagent in the reagent tube **18**. A set forth hereinbefore, the last station in the reduction module is the application of an electroless copper plate in preparation for the final electroplating. In this case the electroless plating tube **21** of the electroless plating station is split along its top surface to allow gases to escape. The plating solutions are fed through a nozzle having a T shape so that the A and B solutions are mixed just prior to entry into the main body of the tube **21**. The electroless plating tube **21** is also tilted in the same manner as the reagent tubes **18**. The electroless plating station is equipped with strip heaters and a thermistor temperature control the strand **12** then enters the electrolytic plating module.

The plating module starts with the plating guide roller **20** which guides the coaxial cable core **12** onto the first plating or drive roller **22**. The drive rollers **22** are twelve in number, are in spaced parallel relation to each other, and are placed transversely in relation to the strand **12**. Each of the drive rollers **22** has a series of guide grooves **25** formed around the periphery in sets of three, for a purpose to be described hereinafter, and a pair of drip grooves **26** spaced from each end of the plating rollers **22**. The drip grooves **26** are formed to prevent solutions from escaping along the shaft **28** of the drive roller **22** since these solutions may corrode the worm gears (not shown) which rotate the drive rollers **22**. Depending on the length of the drive rollers **22**, a number of parallel strands of coaxial cable core **12** may be simultaneously treated by adding the required number of sets of guide grooves **25**. The reason that three grooves are provided in each set of guide grooves **25** is that wear takes place at these grooves and, therefore, three potential areas of wear are provided to avoid the necessity of replacing a plating roller **22** when one area of wear has appeared.

As shown in FIG. 1*b* there are twelve plating or drive rollers **22** whose axes are in parallel relationship with each other; all of which are driven by a separate worm gear mechanism associated with each roller and all mounted on a frame **30** which is mounted outside and inside the plating tank **32** and moveable with the plating tank **32** set down below the surface of the drive rollers **22** and in which are set a series of subsidiary or idler rollers. The drive rollers **22** are all driven by a common drive shaft **36** (shown in FIG. 4) connected to the mentioned individual worm gears. The diameter of each of the drive rollers **22**, in sequence, is slightly larger than the one before, to slightly stretch the strand **12** and thereby keep the strand **12** from jumping from the guide groove **25**. For the sake of clarity the first of the idler rollers will be referred to as a primary idler roller **34*a*** and the second and third will be, hereinafter, referred to as secondary idler rollers **34*b*** with the remaining rollers being referred to as tertiary idler rollers **34**. The primary idler roller **34*a*** is set approximately ⅓ the way down from the top of the plating tank **32** and the secondary rollers **34*b*** are each set approximately ⅔ down from the top of the plating tank **32**. Tht tertiary idler rollers **34** are set approximately ⅞ down from the top of the plating tank **32** as shown in FIG. 1*b*. Each of the idler rollers **34** is similar to the drive rollers **22** except they do not have the drip grooves **26** and they are formed of a corrosive resistant material and need not be electrically conductive as are the drive rollers **22**.

Voltages are impressed on the drive rollers **22**, the first drive roller having a voltage of approximately 15 volts, the second drive roller having a voltage of 10 volts, the third drive roller having a voltage of 5 volts and the remaining drive rollers having a voltage of approximately 2 volts. This variation in voltage is provided to overcome the very high skin resistance of the plate on the strand **12** at the early stages of the electrolytic plating operation. As the plate is thickened, the necessity for the high potential is reduced and therefore, the voltage is reduced accordingly. The length of the strand being plated between the first drive roller **22** and the primary idler roller **34*a*** is of a predetermined length providing an efficient plating operation. The length of the strand **12** between the second drive roller **22** and the first secondary idler roller **34*b*** is of a greater length than that between the first drive roller **22** and the primary idler roller **34*a***, which length is maintained between the third drive roller **22** and the second secondary idler roller **34*b***. The length between the fourth drive roller **22** and the first idler roller **34** is greater than that between the second drive roller **22** and the first secondary idler roller **34*b***, which length is maintained for the remaining plating operation.

The impressed voltages are higher in the beginning of the plating operation because of the higher resistance of the thin skin of the plated metal and path lengths are reduced because the amount of current which can be carried by the developing outer conductor and the plating rate can be held constant by varying the strand length in the initial stages. By the time the fourth drive roller has been passed the electrical resistance of the plating solution controls the plating rate. These procedures provide that the deposition of the plate will be at a nearly constant rate.

The strand **12** is passed over the first plating guide roller **20** down under the primary idler roller **34** and this sequence is continued throughout the length of the plating line. A series of anodes **38** are suspended below each drive roller **22** and fixed in position by passing each anode **38** between a pair of parallel bars **40** connected to the frame **30** in spaced parallel relation to the drive rollers **22**, as shown in FIG. 1*b*. The solution in the plating tank **32** is $CuSO_4$ and H_2SO_4. The deposition of the copper plate on the strand **12** is brought about by processes well known in the art.

At the completion of the plating operation the strand **12** is passed through a treatment station which includes a water rinse station **42** and an anti-tarnish station **44** which uses an amine rinse as a reagent and thence onto a take-up reel **46**.

While there has been illustrated and described a preferred embodiment of the invention, it should be understood that the invention is best described by the following claims.

What is claimed:

1. An apparatus for plating a strand, said apparatus comprising a supply means, a guide means, a series of sloping reagent tubes, an electroless plating means, and an electrolytic plating means, said reagent tubes being in an in-line relationship longitudinally, and each of said reagent tubes having a forward terminal end and a rear terminal end, said forward terminal end being on a plane above the plane of said rear terminal end, and each of said reagent tubes having a means of receiving reagents proximate said forward end, whereby the strand passes from said supply means over said guide means horizontally through said reagent tubes and said electorless plating means to said electrolytic plating means and from said guide means to said electrolytic plating means, the strand touching only reagents and air.

2. An apparatus for plating a strand as set forth in claim **1** wherein each of said reagent tubes has a supply nozzle extending therefrom to engage a reagent supply hose.

3. An apparatus for plating a strand as set forth in claim **2** wherein said guide means comprises a roller and said electrolytic plating means has a plating guide roller and the strand touches only reagents and air from said guide roller to said plating guide roller.

4. An apparatus for plating a strand, said apparatus comprising a supply means, a guide means, a series of sloping reagent tubes, a strand to be plated, an electroless plating means and an electrolytic plating means, said reagent tubes being in an in-line relationship longitudinally, and each of said reagent tubes having a forward terminal end and a rear terminal end, said forward terminal end being on a plane above the plane of said rear terminal end, and each of said reagent tubes having a means of receiving reagents proximate said forward end, and reagents added at each reagent tube, sand strand moving horizontally through said reagent tubes in one direction and the reagents flowing through said reagent tubes in the opposite direction toward said rear terminal ends whereby the strand passes from said supply means over said guide means through said reagent tubes and said electroless plating means to said electrolytic plating means and from said guide means to said electrolytic plating means, the strand touching only reagents and air.

5. An apparatus for plating a strand of material, said apparatus comprising a reduction module, an electroplating module, and a take-up module, said reduction module including a supply means, an apparatus for plating a strand, said apparatus comprising a supply means, a guide means, a series of sloping reagent tubes, an electroless plating means, and an electrolytic plating means, said reagent tubes being in an in-line relationship longitudinally, and each of said reagent tubes having a forward terminal end and a rear terminal end, said forward terminal end being on a plane above the plane of said rear terminal end, and each of said reagent tubes having a means of receiving reagents proximate said forward end, whereby the strand passes from said supply means over said guide means horizontally through said reagent tubes and said electroless plating means to said electrolytic plating means and from said guide means to said electrolytic plating means, the strand touching only reagents and air and said electroplating module comprising an electroplating apparatus comprising at least two drive rollers, an idler roller, and anode means, a frame and a tank means, said idler roller set below the axis of said drive rollers in said tank means, the first of said drive rollers having an electrical potential greater than the other of said drive rollers when said apparatus is in operation, said drive means engaged to said frame above said tank means and said anode means mounted on said frame within said tank means spaced from said drive rollers and said idler roller.

6. An apparatus for plating a strand, said apparatus comprising a supply means, a guide means, a series of reagent tubes, an electroless plating means, and an electrolytic plating means, said reagent tubes being in an in-line spaced relationship longitudinally, and each of said

reagent tubes having a forward terminal end and a rear terminal end, each of said reagent tubes having a means of receiving different reagents and said reagent tubes being spaced from each other and the path of said strand being horizontal and in angular relation to the horizontal axis of said reagent tubes, whereby the strand passes from said supply means over said guide means through said reagent tubes and said electroless plating means to said electrolytic plating means and from said guide means to said electrolytic plating means, the strand touching only reagents and air.

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204—28; 118—429; 134—122