Dec. 10, 1968 J. S. KOMJATHY 3,415,732

OPEN CHANNEL FLOW HIGH SPEED PLATING

Filed April 8, 1965

2 Sheets-Sheet 1

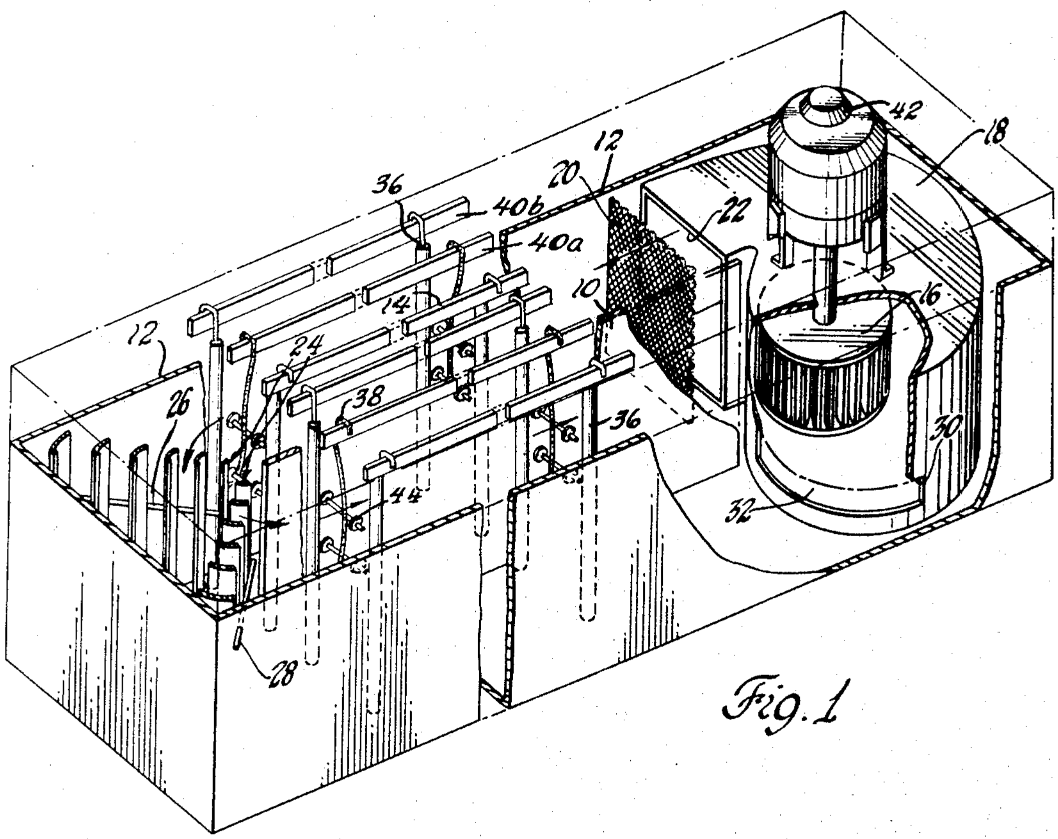

Fig. 1

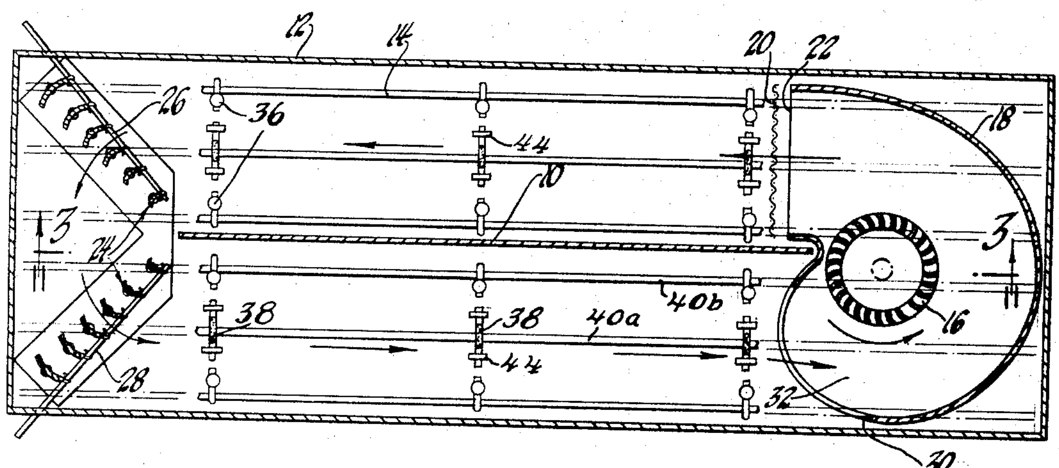

Fig. 2

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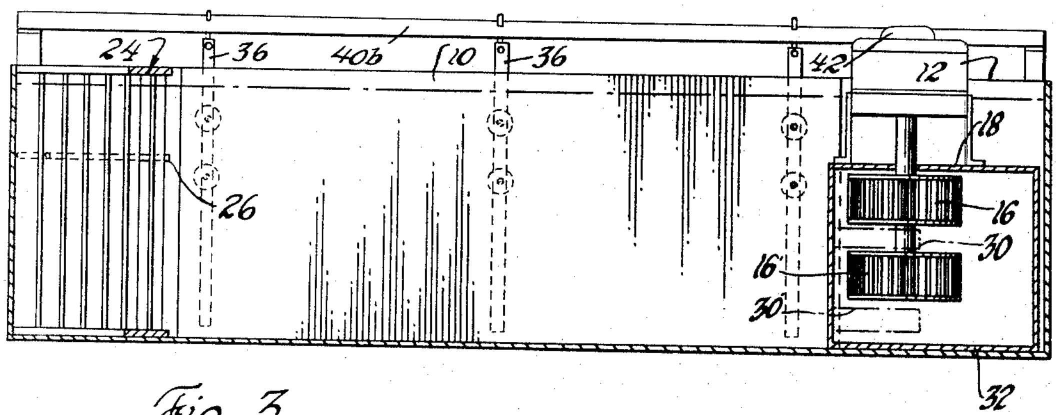

Fig. 3

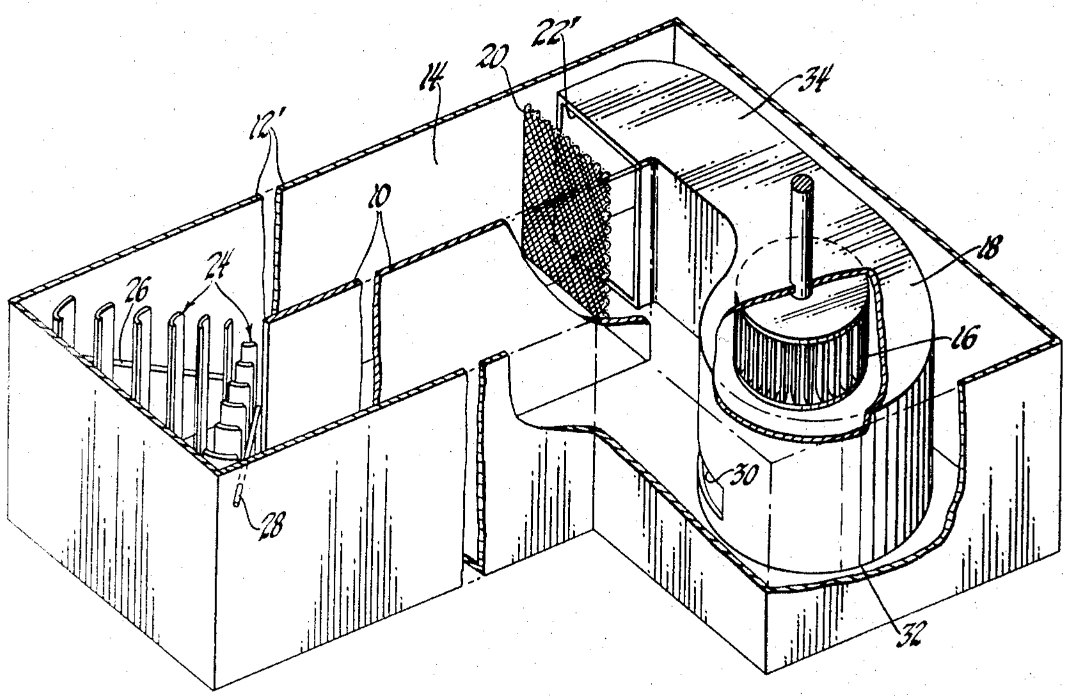

Fig. 4

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1

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OPEN CHANNEL FLOW HIGH SPEED PLATING

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ABSTRACT OF THE DISCLOSURE

An open channel flow electroplating apparatus including a flow channel and means for inducing highly uniform rapid flow of electrolyte through the channel, the means including a high volume-low pressure delivery centrifugal impeller in a log spiral enclosure for circulating electrolyte at a rate of about 0.5–4 feet per second.

This invention relates to electroplating, and more particularly to an apparatus for high speed electroplating in an open, conventional electroplating tank.

The plater is confronted with a number of problems when he is required to plate a higher production volume than his equipment can produce. The plating rate of conventional electroplating machines is inherently limited. Increased current density deposition cannot be used to appreciably step up production. Moreover, increased thickness in deposits can only be attained at a loss in production rate. For these reasons, increased production or thickness has to be achieved by the purchase of additional new equipment or larger new equipment. The new equipment is costly enough, itself. However, it requires so much additional floor space that quite frequently plant expansion costs must also be incurred.

I have now found a way to perform high speed plating in an open channel. More specifically, I have found that this channel can be easily made in the tanks of conventional electroplating machines. Hence, conventional, known work transfer mechanisms can be used, or the maximum permissible electroplating current density for existing equipment can be at least doubled. Hence, existing equipment can be simply and economically modified to double its production capacity, without the significant capital investment costs of new equipment or plant expansion. Moreover, the cost of entirely new equipment using my principles is measurably reduced. The large increase in plating rate is achieved by modifying the open, rectangular tank of a conventional electroplating machine so that high speed plating can be performed in it.

It is, therefore, a principal object of my invention to provide an economical and practical means for high speed plating in an open, conventional plating tank, wherein one can use the conventional work transfer mechanisms of known and accepted conventional plating machines.

Other objects, features and advantages of my invention will become more apparent from the following description of preferred embodiments thereof and from the drawings, in which:

FIGURE 1 shows a perspective view of a conventional electroplating tank modified in accordance with the invention;

FIGURE 2 shows a diagrammatic, horizontal, sectional view of an apparatus of the type shown in FIGURE 1;

FIGURE 3 shows a diagrammatic, sectional view along the line 3—3 of FIGURE 2; and

FIGURE 4 shows a perspective view of another embodiment of the invention shown in FIGURE 1.

The invention comprehends an apparatus for rapidly but uniformly recirculating electroplating solution around a central baffle in an open, conventional, rectangular plating tank. The baffle provides an elongated, annular electroplating solution flow channel within the tank. A high volume-low pressure, centrifugal impeller housed in a log spiral enclosure at one end of the baffle produces rapid, uniform electroplating solution flow in the channel. Turning vanes at the opposite end of the baffle insure uniform solution flow throughout the length of the channel.

2

A clearer understanding of the critical features of the invention can be obtained by reference to FIGURE 1. A central baffle **10** is disposed within the rectangular tank **12**. The ends of the baffle **10** do not extend to the end walls of tank **12** thereby providing an annular electroplating solution flow channel **14** within the tank. A vertically mounted, centrifugal impeller **16**, enclosed within a log spiral housing **18**, provides uniform, rapid flow of electroplating solution within the open channel **14**. The impeller **16** is driven by a motor **42**. A wire screen **20** closely spaced from the outlet **22** of impeller housing **18** aids to stabilize the solution flow so that it is uniform even close to impeller housing outlet **22**. Turning vanes **24** at the opposite end of the central baffle insure uniform electroplating solution flow throughout the channel by stabilizing the flow around the adjacent end of the central baffle. The turning vanes **24** can be adjusted by rods **26** and **28** to accurately control solution flow. The inlet (not shown) for the vertically mounted, centrifugal impeller **16** is on the underside of the impeller. An impeller housing inlet **30** is located in the side of the impeller housing **18** below the plane of the impeller **16** for return flow of the electroplating solution. Inlet **30** can be in the lower wall **32** of the impeller housing **18**, should it be desired. An appropriate work conveyor system, not shown, is used to move work pieces **44** through the tank **12**. The work pieces **44** are suspended from racks **38** which are, in turn, suspended from the cathode bus bars **40*a***. Anodes **36** are suspended from anode bus bars **40*b***.

My invention primarily contemplates modifying existing open plating tanks of conventional electroplating machines so that high speed plating can be accomplished in them without further extensive machine modification. Consequently, the invention is primarily intended for use with a rectangular tank from a conventional electroplating machine. However, the invention can be used with open electroplating tanks of generally any shape, including square, L-shaped, ovulate, circular and the like.

The central baffle **10** preferably extends directly from the bottom of the tank to above the level of the electroplating solution in the tank. If it did not substantially so extend, losses in recirculation efficiency and effectiveness in the solution flow uniformity would result. The baffle is appropriately shorter in length than the tank, of course, to provide adequate circulation around the end of the baffle.

The most important aspect in obtaining high velocity, uniform flow substantially throughout the channel lies in the nature of the impeller **16** and its enclosing log spiral housing **18**. It is extremely important, especially with short tanks, that the flow be uniform even close to the impeller housing outlet **22**. Otherwise, considerable channel length is required to obtain uniform flow throughout the cross section of the channel. High speed electroplating cannot be satisfactorily accomplished in the region of non-uniform flow. Hence, this region represents an effective loss in tank space, or more specifically a loss in channel length. Such a loss actually is a loss in the production volume capability for the apparatus. This loss can easily be so large as to preclude any production gain at all from the high current density deposition. Thus, not only rapid but extremely uniform solution flow substantially throughout the baffle area in the tank is extremely important, even quite close to the impeller housing outlet **22**.

Impeller **16** must be a vertically mounted, high volume-low pressure impeller capable of producing uniform flow substantially throughout the channel **14** at a velocity of about 0.5–4 feet per second. However, a velocity of 1–3 feet per second is preferred. I have found that to get maximum utilization of channel length one must use an impeller delivering at least 90% of the volume recirculated in the tank at a pressure below about 20 inches of water and preferably below about 6–12 inches of water.

The impeller **16** not only must have a high delivery-low pressure characteristic but also must deliver electrolyte to the channel in a uniform distribution. To achieve this, the height-to-diameter ratio of the impeller must be about 0.4. Moreover, the impeller diameter must be within about 10% of the channel width. If the channel depth-to-width ratio exceeds about 1.5, more than one impeller is necessary to get uniform distribution. For each whole number added to this ratio, a corresponding number of additional impellers should be used. Each of the impellers can be housed in separate log spiral enclosures, or all of them housed in one enclosure, as one chooses. The impellers are vertically spaced from one another, of course, to permit electroplating solution to enter each impeller inlet. As previously indicated, the impeller inlet is located on the lower side of each impeller to prevent impeller starvation, and thereby insure uniform circulation in the system.

Also as previously indicated, the log spiral housing **18** for the impeller **16** is necessary to obtain uniform delivery. Moreover, it is also of importance in obtaining efficient impeller delivery. As can be seen in connection with FIGURES 2 and 3, the housing **18** is preferably positioned within the tank **12** in such a manner as to generally prevent recirculation of the electrolyte in the channel **14** without going through the housing. Best control of uniformity in solution flow is thereby achieved. However, in some embodiments of the invention one may prefer not to recirculate all, only substantially all, of the electroplating solution in the channel through the impeller, as hereinbefore explained. In such instance, space can be allowed for partial solution flow under, around and/or over the impeller housing **18**. This latter embodiment is probably most suitable for commercial applications. If the impeller housing assembly is not extremely closely fitted, or sealed in place, it can be much more easily installed, adjusted and replaced. Moreover, such a construction offers an ancillary advantage in that it facilitates use of commercially available impeller housing assemblies from a variety of sources.

The impeller housing inlet **30** for return flow of electroplating solution to the impeller **16** can be of any configuration but preferably short and wide. However, inlet **30** should be located below the plane of impeller **16**, since the impeller inlet (not shown) is on the lower side of the impeller. The housing inlet **30** should have an area which is sufficient to prevent starvation of the impeller. Generally, a housing inlet area about equal to the impeller inlet area can be used. If more than one impeller is used, as in FIGURES 2 and 3, the two impellers should be vertically spaced from one another so that the upper impeller **16** is not starved. The housing inlet **30** for the upper impeller **16** should be located between the two impellers **16** and **16′** on the housing wall. The housing inlet **30′** for the lower impeller **16′**, or when only one impeller is used, can be either in the housing side wall or in the bottom **32** of the housing. If in the bottom, the housing should, of course, be spaced somewhat from the bottom of the tank.

The outlet **22** for the log spiral impeller housing **18** should have a width which is substantially the same as, within about 10% of, the channel width in order to obtain maximum utilization of the channel for plating. However, in some limited circumstances one may prefer to use an outlet width within only about 25% of the channel width. The height of the housing outlet is principally dictated by the impeller height, inlet opening height, plus nominal clearances for the components involved, since the upper and lower walls of the impeller housing are generally parallel. The housing is positioned so that the electroplating solution exiting the housing outlet is directed parallel to the channel wall, to stabilize solution flow in the shortest channel distance.

Particularly when only one impeller is employed, it may be desirable to accelerate flow stabilization. If so, flow stabilizing means, such as one or more metal screens, sets of vanes, louvers, or the like, can be used. The screens should be at least 70% open. The stabilizing means effectively extends the length of the plating area in the channel by permitting satisfactory plating closer to the housing outlet.

The turning vanes **24** at the end of the baffle opposite to the impeller housing can be of any type which will facilitate uniform flow of the solution around the end of the baffle, for return back to the impeller. These vanes can be fixed or movable. They can be flat, arcuate or of any other configuration which would facilitate uniform solution flow.

The foregoing discussion is specifically directed to application of the invention to the well-known, typical, rectangular electroplating tanks. It is with such tanks that the invention would most generally be useful. However, some conventional electroplating machines have work transfer mechanisms that preclude use of the invention with a regular rectangular tank. The impeller motor and support (not shown) may be an obstruction to the work transfer mechanism. In such case, the impeller can be appropriately offset somewhat from the main body of the tank, as shown in FIGURE 4. The resulting tank **12′** is still generally rectangular in configuration, and the invention would be practiced in it identically as previously described. However, since the impeller and log spiral enclosure are at least partially outside the main body of the tank, a duct extension **34** is used. The outlet **22′** of the duct extension **34** is located as is the outlet **22** of the impeller housing shown in FIGURES 1 and 2.

The duct extension **34** is an extension of the impeller housing outlet **22** shown in FIGURE 1. The duct cross-sectional dimensions should, therefore, be dictated by the preferred housing outlet **22** dimensions explained in connection with FIGURE 1. Of course, turning vanes (not shown) can also be used in the duct extension **34** if it is desired, especially if the offset is so large so to form an L-shaped tank. Otherwise, the apparatus shown in FIGURE 4 is the same as described in connection with FIGURES 1–3. With the impeller housing assembly being offset, plating racks can be lifted from the tank and moved out of the tank area over the duct **34** without encountering any obstruction.

It is to be understood that although this invention has been described in connection with certain specific examples thereof, no limitation is intended thereby except as defined in the appended claims.

I claim:

1. An apparatus for open channel flow electroplating which comprises a generally annular electroplating solution flow channel adapted to contain electrodes and means in said channel to induce highly uniform rapid flow of electroplating solution around said channel, said uniform flow-inducing means including at least one vertically mounted centrifugal impeller which provides relatively high volume-low pressure delivery, the impeller diameter being within about 25% of the width of said channel and its height-to-diameter ratio being about 0.4, the impeller inlet being on the impeller's lower side, and a log spiral enclosure for said impeller having an outlet which is of a dimension substantially the same as the channel width directing fluid flow along the length of the channel.

2. An apparatus for open channel flow electroplating which comprises a tank, a central baffle in said tank forming a generally annular electroplating solution flow channel adapted to contain electrodes, means in said channel at one end of said baffle to induce highly uniform rapid flow of electroplating solution around said channel, and turning vanes in said channel to maintain uniform solution flow, said uniform flow-inducing means including at least one vertically mounted centrifugal impeller which provides relatively high volume-low pressure delivery, the impeller diameter being wtihin about 25% of the width of said channel and its height-to-diameter ratio being about 0.4, the impeller inlet being on the impeller's lower side, and a log spiral enclosure for said impeller having an outlet which is of a dimension substantially the same as the channel width directing solution flow along the length of the channel.

3. An apparatus for open channel flow electroplating which comprises an elongated tank, a central baffle in said tank producing an elongated annular electroplating solution flow channel adapted to contain electrodes, means in said channel at one end of said baffle to induce rapid flow of electroplating solution around said channel and highly uniform flow along the length of said tank, and means at the other end of said tank to facilitate uniform solution flow around the other end of said baffle, said uniform flow-inducing means including at least one vertically mounted centrifugal impeller which provides relatively high volume-low pressure delivery, the impeller diameter being within about 10% of the width of said channel and its height-to-diameter ratio being about 0.4, the impeller inlet being on the impeller's lower side, and a log spiral enclosure for said impeller having an outlet which is of a dimension substantially the same as the channel width.

4. The electroplating apparatus defined in claim 3 in which the impeller and enclosure are at least partially offset from the main body of the tank.

5. An apparatus for open channel flow electroplating which comprises a generally rectangular tank, a central baffle in said tank extending along the length thereof producing an elongated annular electroplating solution flow channel adapted to contain electrodes, means in said channel at one end of said tank to induce flow of electroplating solution around said channel at a rate of about 0.5–4 feet per second and highly uniform flow along substantially the whole length of the elongated portions of said channel, and turning vanes in said channel at the other end of said baffle to facilitate uniform solution flow around the end of said baffle, said uniform flow-inducing means consisting of at least one vertically mounted impeller which provides a relatively high volume-low pressure delivery, the impeller diameter being within 10% of the width of said channel, the impeller height-to-diameter ratio being about 0.4, the impeller inlet being located on its lower side, one such impeller for a channel depth-to-width ratio up to about 1.5 and for each whole number added to this ratio a corresponding number of additional such impellers added, and a log spiral impeller enclosure having an outlet width which is of a dimension substantially the same as the channel width.

6. The electroplating apparatus defined in claim 5 in which the impeller and impeller enclosure are at least partially offset from the main body of the tank.

7. An apparatus for open channel flow electroplating which comprises a generally rectangular tank, a central baffle in said tank extending along the length thereof producing an elongated annular electroplating solution flow channel adapted to contain electrodes, an impeller assembly in said channel at one end of said tank for recirculating electroplating solution around said channel at a rate of about 0.5–4 feet per second with highly uniform flow along substantially the whole length of the elongated portions of said channel, and turning vanes in the channel at the other end of said tank to facilitate uniform solution flow around the end of said baffle, said impeller assembly consisting of at least one vertically mounted, high volume-low pressure impeller, the impeller diameter being within 10% of the width of said channel, the impeller height-to-diameter ratio being about 0.4, the impeller inlet being located on its lower side, one such impeller for channel depth-to-width ratios up to about 1.5 and for each whole number added to this ratio a corresponding number of additional such impellers, the total number of impellers used being capable of recirculating at least about 90% of the volume circulated in the channel at a pressure of less than about 20 inches of water, a long spiral impeller enclosure restricting recirculation of channel solution without passing through said impeller, and said impeller having an outlet which is of a dimension substantially the same as the channel width.

8. An apparatus for open channel flow electroplating which comprises an elongated tank, a central baffle in said tank extending along the length thereof producing an elongated annular electroplating solution flow channel adapted to contain electrodes, an impeller assembly in said channel, means at one end of said tank for recirculating electroplating solution around said channel at a rate of about 1–3 feet per second with highly uniform flow along substantially the whole length of the elongated portions of said channel, said assembly delivering at least 90% of the volume recirculated in said channel at a pressure less than about 12 inches of water, said impeller assembly consisting of at least one high volume-low pressure vertically mounted impeller, the impeller diameter being within 10% of the width of said channel, the impeller height-to-diameter ratio being about 0.4, the impeller inlet being located on its lower side, one such impeller for channel depth-to-width ratios up to about 1.5 and for each whole number added to this ratio a corresponding number of additional such impellers, a log spiral impeller enclosure having an outlet which is of a dimension substantially the same as the channel width, channel flow stabilizing means closely adjacent said enclosure outlet, and means in said channel to facilitate uniform solution flow.

9. The electroplating apparatus as defined in claim 8 in which the impeller assembly is offset from the main body of the tank.

10. The apparatus as defined in claim 8 wherein the impeller enclosure is disposed in the channel so as to substantially restrict recirculation without passage through the impeller assembly.

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