CLAIMS

1. An electroplating system, comprising:

a vessel assembly for holding an electrolyte;

a weir thief electrode assembly in the vessel assembly, the weir thief electrode assembly including a plenum inside of a weir frame, the weir thief electrode assembly having at least first, second, third and fourth virtual thief electrode segments, the first, the second and the third virtual thief electrode segments subtending an angle greater than the fourth virtual thief electrode segment;

a plurality of spaced apart openings through the weir frame into the plenum;

a weir ring attached to the weir frame; and

at least first, second, third and fourth physical thief electrodes electrically connected to first, second, third and fourth independently controllable power supply sources, respectively.

2. The electroplating system of claim 1 with the weir frame further including an angle section extending from the weir ring towards a plane section, and the plurality of spaced apart openings in the plane section.

3. The electroplating system of claim 2 further including a cylindrical weir lip on the weir frame, the plane section perpendicular to the weir ring and the plurality of openings centered on a diameter greater than an inner diameter of the weir ring.

4. The electroplating system of claim 1 wherein the vessel assembly includes a vessel frame, and the first, the second, the third and the fourth physical thief electrodes are supported on the vessel frame at a vertical position below the weir ring.

5. The electroplating system of claim 1 further including a first thief channel, a second thief channel, a third thief channel and a fourth thief channel in the vessel assembly

extending respectively from first, second, third and fourth chambers containing the first, the second, the third and the fourth physical thief electrodes to the plenum.

6. The electroplating system of claim 5 further including a thief channel membrane in each thief channel, a chamber containing a second electrolyte below each thief channel membrane, the second electrolyte in each chamber in contact with one of the physical thief electrodes.

7. The electroplating system of claim 1 wherein the vessel assembly includes an electrolyte vessel below the weir thief electrode assembly and a paddle in the vessel, the paddle attached to a paddle actuator, for agitating the electrolyte.

8. The electroplating system of claim 1 wherein the first and the third virtual thief electrode segments subtend an angle of 130 to 150 degrees and the second virtual thief electrode segment subtends an angle of 70 to 90 degrees.

9. An electroplating system, comprising:

a vessel assembly including a lower cup and an upper cup on top of the lower cup;

a vessel membrane between the lower cup and the upper cup;

a paddle above the upper cup connected to a paddle actuator for moving the paddle;

a weir thief electrode assembly in the vessel assembly above the paddle, the weir thief electrode assembly including a weir frame having a plenum divided into first, second, third and fourth virtual thief electrode segments, the first, the second and the third virtual thief electrode segments subtending an angle greater than the fourth virtual thief electrode segment;

a plurality of spaced apart openings in the weir frame to allow electrolyte to flow out of the plenum; and

first, second, third and fourth physical thief electrodes electrically connected to first, second, third and fourth independently controllable power supply sources, respectively.

10. The electroplating system of claim 9 wherein the first, the second, the third physical thief electrodes are at a vertical position below the paddle and are electrically continuous with the first, the second, and the third virtual thief electrode segments via a first, a second, and a third thief channel in the vessel assembly extending respectively from the first, the second, and the third physical thief electrodes to the plenum, at least part of the first, the second, and the third thief channels filled with electrolyte.

11. The electroplating system of claim 9 wherein the paddle comprises a plurality of parallel spaced apart blades and a first slot and a second slot between adjacent blades.

12. The electroplating system of claim 9 with the paddle further including chord shaped openings at opposite sides of the paddle.

13. The electroplating system of claim 10 wherein the first and the third virtual thief electrode segments subtend an angle of 130 to 150 degrees, the second virtual thief electrode segment subtends an angle of 70 to 90 degrees.

14. The electroplating system of claim 9 further including a flat weir ring attached to the weir frame and a cylindrical weir lip on the weir frame perpendicular to the weir ring.

15. The electroplating system of claim 14 wherein the paddle moves within a travel dimension and the weir ring has an inside diameter greater than travel dimension.

16. The electroplating system of claim 14 wherein one or more of the virtual thief electrode segments has a radial portion extending inwardly through or under the weir ring.

17. An electroplating system, comprising:

a vessel assembly including a lower cup in an anode assembly and an upper cup on top of the lower cup;

a vessel membrane between the lower cup and the upper cup;

a paddle above the upper cup connected to a paddle actuator for moving the paddle;

a weir thief electrode assembly in the vessel assembly above the paddle, the weir thief electrode assembly including a weir frame having a plenum divided into a first virtual thief electrode segment, a second virtual thief electrode segment, a third virtual thief electrode segment and a fourth virtual thief electrode segment, the first, second, third and fourth virtual thief electrode segments comprising first, second, third and fourth electrolyte containing chambers separated by interior walls;

the first, the second and the third virtual thief electrode segments subtending an angle greater than the fourth virtual thief electrode segment;

a plurality of spaced apart openings in the weir frame leading into the plenum;

a first physical thief electrode, a second physical thief electrode, a third physical thief electrode and a fourth physical thief electrode in electrical continuity with the first, the second, third and fourth virtual thief electrode segments, respectively, the first, the second, the third and the fourth physical thief electrodes electrically connected to a first separately controllable power supply source, a second separately controllable power supply source, a third separately controllable power supply source and a fourth separately controllable power supply source, respectively;

wherein the first, the second, the third and the fourth physical thief electrodes are below the paddle and are electrically continuous with the first, the second, the third and the fourth thief electrode segments via thief channels in the vessel assembly extending respectively from the first, the second, the third and the fourth physical thief electrodes to the plenum, and at least part of each thief channel is filled with the electrolyte; and

a thief channel membrane in each thief channel, each thief channel membrane separating the electrolyte from a second electrolyte below the membrane, and the first, the second, the third and the fourth physical thief electrodes in contact with the second electrolyte.