July 25, 1972 J. H. KING ET AL 3,679,570

BASEPLATE ASSEMBLY FOR MERCURY-CATHODE CELL

Filed July 7, 1970 5 Sheets-Sheet 1

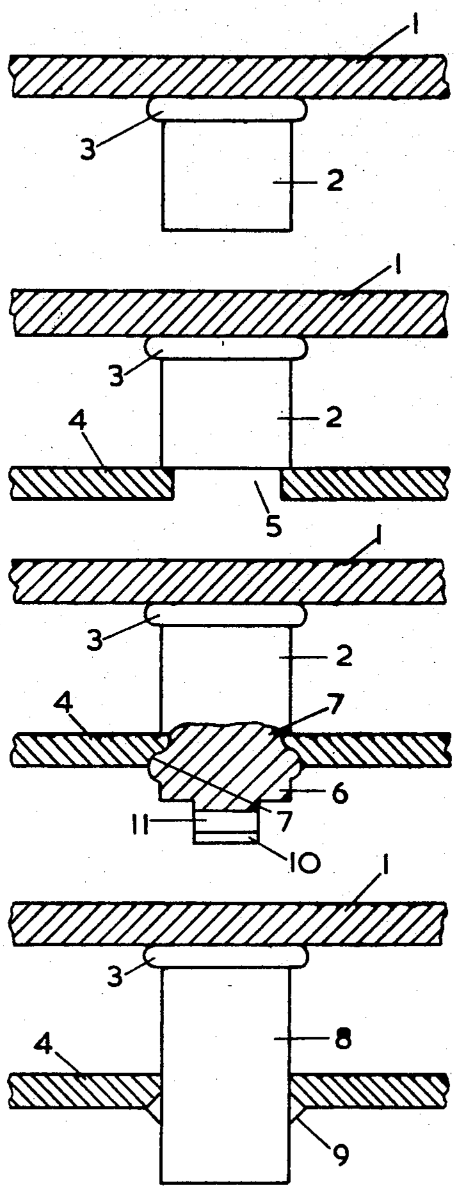

FIG. 1

FIG. 2

FIG. 3

FIG. 4

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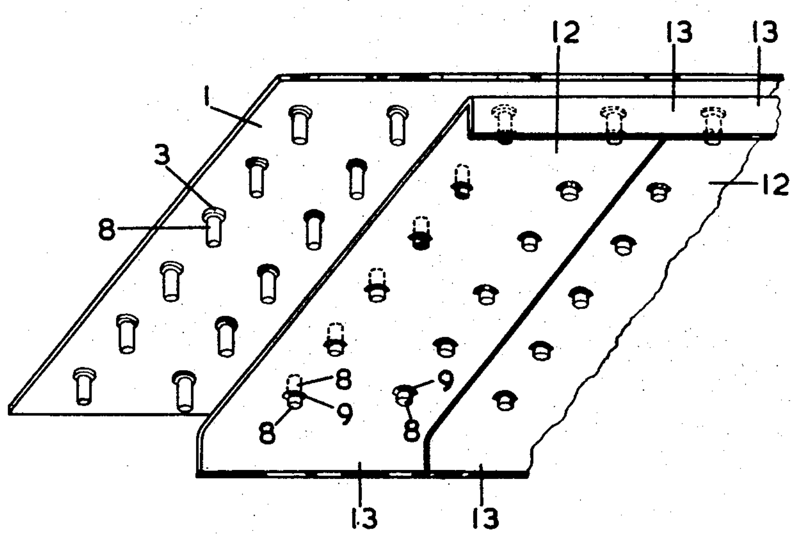

FIG. 5

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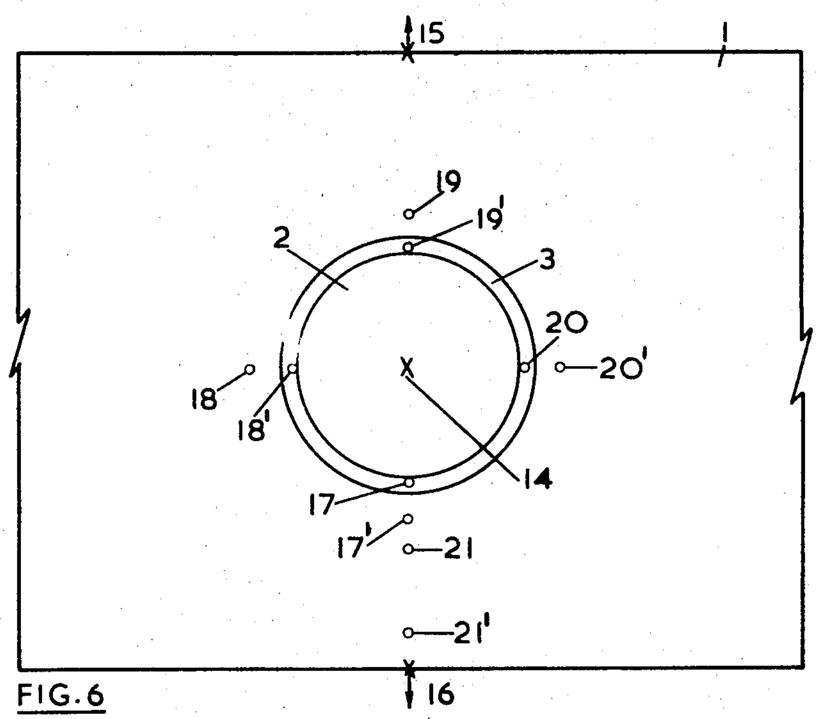

FIG.6

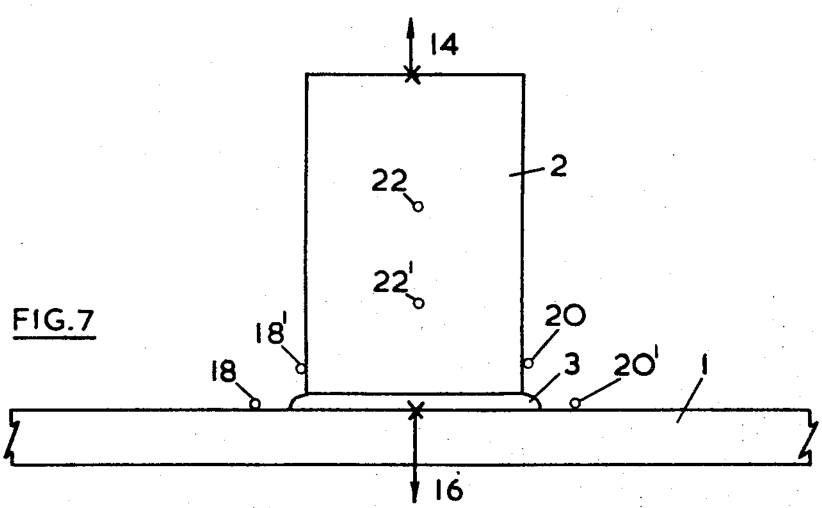

FIG.7

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BASEPLATE ASSEMBLY FOR MERCURY-CATHODE CELL

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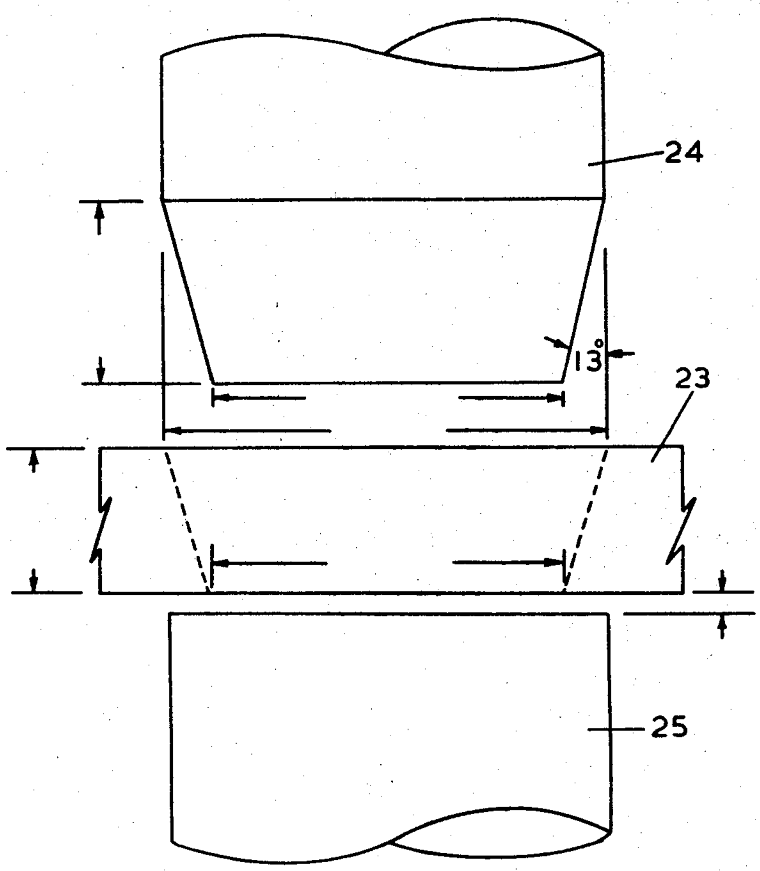

FIG. 8

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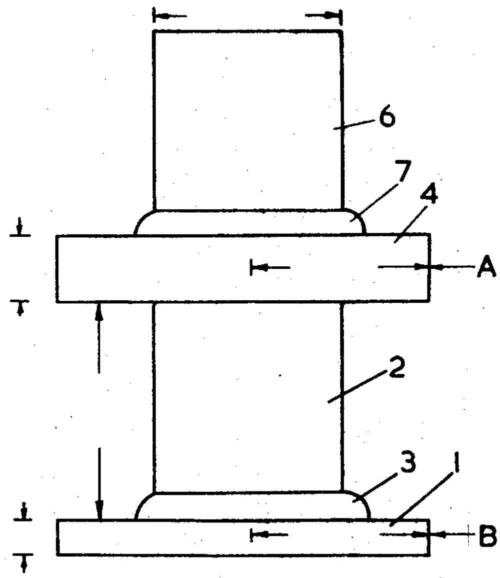

FIG.9

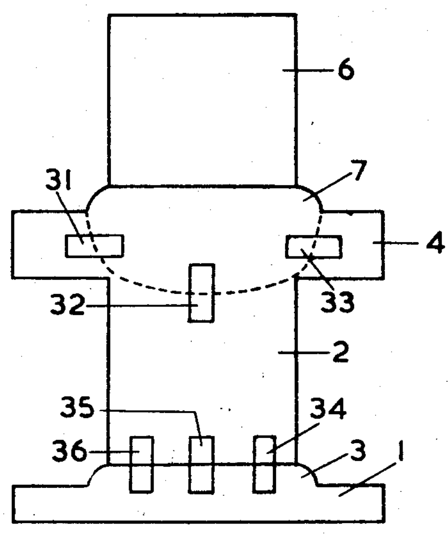

FIG.10

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BASEPLATE ASSEMBLY FOR MERCURY-CATHODE CELL

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U.S. Cl. 204—297 R 6 Claims

ABSTRACT OF THE DISCLOSURE

A baseplate assembly for an electrolytic cell having a flowing mercury cathode comprising a steel plate the upper surface of which in operation is wetted by and carries the flowing mercury cathode and a current extractor plate and made of a metal of higher electrical conductivity than steel, said plates being substantially parallel to each other and spaced apart by a plurality of aluminum studs distributed in a substantially uniform pattern over the common area of the two plates, one end of each stud being friction-welded to the steel plate and each stud being electrically-connected in rigid manner at or near its other end to the current extractor plate.

The present invention relates to a baseplate assembly for an electrolytic cell having a flowing mercury cathode. More particularly it relates to an assembly in which a steel baseplate is united with current collection means in novel manner so as to enable current to be withdrawn from the whole area of the baseplate in a substantially uniform pattern.

Cells for the electrolysis of alkali metal chloride solutions with a flowing mercury cathode are conventionally constructed with a baseplate of steel because steel is relatively cheap and is wettable by mercury and liquid alkali metal amalgam so that a thin layer of mercury or dilute amalgam can be caused to flow over the steel surface as a continuous film to form the working cathode of the cell when the baseplate is inclined at a suitable angle to the horizontal. The electrolysing current is removed from the cathode through the baseplate by attaching conductors, e.g. copper tapes, to one or more points along one edge or along opposite edges of the baseplate.

Since a modern multi-anode cell can obtain several hundred square feet of anode and cathode area, much of the electrolysing current, after entering the baseplate, has to travel an appreciable distance therein before it can be led away by the copper tapes attached to the edge of the baseplate. Since the electrical conductivity of steel is rather low the baseplate has to be made relatively thick and consequently very heavy, especially for working at the higher current densities visualised in recent times, in order to reduce the potential drop in the baseplate to acceptable proportions and to minimise the differences in total ohmic resistance that is presented to the currents flowing from individual anodes.

The present invention provides a baseplate assembly which approaches more closely to the ideal of collecting the current individually from each anode into a low-resistance path and also allows operation of the cell at higher current densities without increasing the thickness of the conventional steel baseplate.

According to the present invention we provide a baseplate assembly for an electrolytic cell having a flowing mercury cathode, which comprises a steel plate for carrying the flowing mercury cathode and a current extractor plate made of metal of higher electrical conductivity than steel, said plates being substantially parallel to each other and spaced apart by a plurality of aluminium studs distributed in a substantially uniform pattern over the common area of the two plates, one end of each stud being friction-welded to the steel plate and each stud being electrically connected in rigid manner at or near its other end to the current extractor plate.

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Preferably the current extractor plate is made of aluminium. Other materials of high electrical conductivity may alternatively be employed, for instance copper or an aluminium alloy containing a major amount of aluminium. The extractor plate may itself be a composite of narrower plates placed with their edges parallel to each other and running substantially the length or the breadth of the steel plate. For minimum overall electrical resistance such narrower plates will be placed substantially edge-to-edge, but if the thickness of the plates in relation to current density allows it they may be spaced apart with any convenient gap. Furthermore the current extractor plate may extend along at least one edge beyond the area of the steel plate for the extensions to act as bus-bar and/or switching connections leading to the electrolysing current source or to neighbouring cells in a series of cells.

In one embodiment of the invention each aluminium stud friction-welded at one end to the steel plate is electrically connected in rigid manner to the current extractor plate by providing a corresponding opening in the extractor plate of approximately the same diameter as the stud, passing the other end of the stud into the opening or passing it through the opening so that it protrudes therefrom and making a fusion weld in an inert-gas-shielded protective atmosphere, e.g. by argon arc-welding, around the circumference of the stud at or near its free end so as to unite the stud with the extractor plate.

In another embodiment of the invention each aluminium stud fixed by friction-welding at one end to the steel plate is electrically connected in rigid manner to the current extractor plate by another friction weld, which is made with the aid of a second aluminium stud. One method of producing an assembly according to this embodiment comprises providing an opening in the current extractor plate corresponding with the free end of each fixed stud and of smaller diameter than the fixed stud, abutting the free end of the fixed stud against the etxractor plate to cover the said opening and friction-welding to the fixed stud through the corresponding opening in the extractor plate and to the adjoining area of the extractor plate a second aluminium stud of substantially the same diameter as the said fixed stud. The openings provided in the extractor plate before assembly may most suitably have a diameter about 0.8 times the diameter of the aluminium studs.

An alternative method of producing an assembly according to the second-mentioned embodiment is to taper the free end of each fixed stud over a length about ⅛ inch greater than the thickness of the current extractor plate (a suitable taper is one of about 13° half-angle) and to provide a tapered hole in the extractor plate to fit the end taper of the stud so that when the parts are mated together the end of the stud protrudes about ⅛ inch from the hole in the plate. The friction weld is then made by spinning a second aluminium stud of substantially the same diameter as the overall diameter of the fixed stud in end-to-end contact with the end of the fixed stud until it is forged into the current extractor plate as well as the end of the fixed stud.

The invention is further illustrated by reference to the accompanying drawings 1–10, which are not to scale. FIGS. 1–3 show vertical sections through a single pair of co-operating studs at three stages during the first-described procedure for producing an assembly according to the second-described embodiment on the invention.

FIG. 4 shows a vertical section through one of a plurality of studs in an assembly produced according to the first-described embodiment of the invention and FIG. 5 is a view from underneath in isometric projection of part of a baseplate assembly in accordance with this embodiment showing suitable positioning of a plurality of studs at a stage during construction when two rows of studs still remain to be attached to the current extractor plate.

FIGS. 6 and 7 show the test positions used for measuring the electrical potential drop across a friction weld between an aluminium stud and part of a mild steel baseplate.

FIG. 8 shows a suitable arrangement of the parts ready for making an aluminium/aluminium friction weld by the second-described procedure for producing an assembly according to the second-described embodiment of the invention. FIG. 9 (elevation) shows the arrangement used for measuring the electrical resistance between the aluminium plate and the steel plate across both the friction welds of a part assembly made by this procedure, after the plates have been trimmed to the sizes shown, and FIG. 10 (section along the axis of the studs) shows the positions of pieces cut for electrical testing from the aluminium/aluminium and the aluminium/mild steel friction welds respectively of the same assembly.

In FIG. 1 is shown part of the steel plate **1** (suitably 0.5–1.0 inch thick) which will carry on its upper surface the flowing mercury cathode when the baseplate assembly is installed in the electrolytic cell. **2** is an aluminium stud, suitably about 3-inch diameter, which has been fixed to the steel plate by a friction weld shown at **3**. FIG. 2 shows the next stage in making the assembly, where the free end of the aluminium stud **2** is abutted against a current extractor plate **4** (suitably an aluminium plate about 0.75 inch thick) which has been provided with an opening **5** in register with the stud **2** but of smaller diameter (suitably about 2.5-inch diameter for a 3-inch diameter stud). FIG. 3 shows the final stage, in which a second aluminium stud **6** of approximately the same diameter as the stud **2** has been applied to the opposite side of plate **4** and has been spun under increasing pressure so as to be forged through the opening in plate **4** to make a friction weld as indicated at **7** with the end of stud **2** and the surrounding area of plate **4**. In the whole baseplate assembly a plurality (not shown) of studs **2** and **6** are similarly fixed in place to unite the plates **1** and **4**. Suitably the studs are fixed in parallel rows over the common area of the two plates with their centres between about 10 inches and 25 inches apart. It will, however, be understood that the diameter of the studs may be varied and their relative spacing may be also varied both inside and outside the above-stated range according to the current density at which the cell is intended to operate.

In the embodiment illustrated by FIG. 4 the steel plate which is to carry the flowing mercury cathode in the working cell is again shown as **1**. Each aluminium stud, now shown as **8**, is again fixed to plate **1** by a friction weld **3** but is of sufficient length to pass through an opening of the same diameter in the current collector plate **4**, suitably an aluminium plate as before, and the stud has been fixed into the plate **4** by a peripheral fusion weld **9**, made for instance by argon arc welding. In the whole baseplate assembly there is a plurality of studs **8** suitably distributed over the common area of plates **1** and **4**, for instance in parallel rows as shown in FIG. 5. The left-hand side of this isometric view shows two rows of six studs **8** that have been friction-welded as indicated at **3** to the steel plate **1** and are ready for welding to the current extractor plate. The right-hand side of the figure shows a current extractor plate formed as a composite of narrower plates **12** which run approximately edge-to-edge of each other across the breadth of the steel plate. The studs **8** pass through openings in the plates **12** and are secured thereto by welds **9**. In the embodiment shown in FIG. 5 the opposite edges of the plates **12** which extend beyond the area of the steel plate **1** have been bent over at **13** to provide a vertical surface for bolting on of switchgear or other electrical connections.

A further advantage of the baseplate assemblies of the invention is that the points beneath the assembly where the studs are fixed provide suitable positions for inserting a jack to raise or lower local areas of the assembly so as to obtain a level upper surface of the steel plate **1** on which the mercury cathode is to flow and thus avoid or reduce the need for grinding this surface to a true plane when installed in the cell. If desired the pendent end of each stud may be provided with a spigot of smaller diameter to fit the jack as shown at **10** in FIG. 3. In FIG. 3 this spigot is also shown with a transverse bore **11** for attachment of the jack when a downward pull is needed for levelling the baseplate.

The following examples illustrate the use of the friction-welding technique in the manufacture of part-assemblies according to the invention, the testing of the welds and the low distortion produced by welding.

Three 3-inch diameter aluminium studs were fixed in line to a plate of mild steel 0.5 inch thick at intervals of 14 inches by friction-welding one end of each stud to the plate under a maximum load of 40 tons. No special preparation of the aluminum studs was carried out; they were welded in the as-sawn condition. The mild steel plate was faced up at the welding positions to remove mill-scale and rust locally from the weld areas. Measurement of distortion of the mild steel plate after welding showed that there was localised dimpling in the plate at the weld locations to a maximum of 0.010 inch. No progressive bending of the plate was found.

Electrical measurements were carried out on each of these welds as shown for one weld in FIG. 6 (plan view) and FIG. 7 (elevation), in which parts **1**, **2** and **3** are as described for FIG. 1. A current of 50 amp was passed into the free end of the aluminium stud as indicated at **14** and out at opposite edges of the mild steel plate as indicated at **15** and **16**. Potential difference measurements were made using probes with a constant straight-line spacing 5.45 cm. between positions **17–17′**, **18–18′**, **19–19′** and **20–20′** across the aluminium/mild steel interface (the actual distance between the probes in the metal round the right angle bend being 7.72 cm.) and between positions **21–21′** in the mild steel plate and positions **22–22′** in the aluminium stud. The results are shown in Table 1.

A 3-inch diameter aluminium stud was friction-welded at one end to a mild steel plate 0.5 inch thick as described in he penultimate paragraph. The other end of the stud was then joined to an aluminium plate 1.125 inches thick by a friction weld made with the aid of a second aluminium stud. The preparation of the parts before making this second weld is illustrated in FIG. 8, wherein **23** is the aluminium plate, **24** is the free end of the aluminium stud which has its opposite end already fixed to the steel plate (not shown) and **25** is the second aluminium stud. The free end of the stud **24** has been tapered at an angle of 13° and an opening has been made in the aluminium plate **23** to fit this taper. The friction weld was made by spinning the end of the stud **25** against the end of the stud **24** projecting through the opening in the plate **23** and against the adjacent area of the plate under a maximum load of 40 tons with the aluminium plate supported annularly at 12 inches from the centre line of the studs. FIG. 9 shows the finished part assembly after cutting the plates to the sizes shown for electrical testing. The electrical resistance measured between points A and B was found to be only 1.40 microhms. Six test pieces, each 2.54 cm. (1 inch) long and 0.9 cm. (⅜ inch) diameter, were turned from the finished part-assembly in the areas of the two welds at the positions indicated by the numerals **31–36** in FIG. 10. A current of 50 amp was passed through each test piece and the potential difference was measured with probes over a distance of 1.45 cm. across the weld interface.

TABLE 1

Weld No.	Potential difference, millivolt						
	Solid aluminium, 22-22′	Solid mild steel, 21-21′	Across aluminum/mild steel interface				
			17-17′	18-18′	19-19′	20-20′	Average
1	0.015	0.082	0.100	0.117	0.103	0.083	0.101
2	0.015	0.079	0.104	0.092	0.102	0.135	0.103
3	0.018	0.096	0.104	0.074	0.080	0.112	0.098

The specific resistances of the mild steel and the aluminum were calculated from measurements on test pieces of the solid metal of the same size; these values were used to calculate the resistance of the weld interface in the six test pieces **31–36** over their cross-sectional area of 0.7 cm.². The results are shown in Table 2.

TABLE 2

Test piece: Type	Test piece: No.	Measured resistance, μΩ	Specific resistance, μΩ cm.	Interface resistance, μΩ
Al/Al	31	5.6		Zero
Al/Al	32	5.6		Zero
Al/Al	33	5.8		Zero
Solid Al		5.8	2.84	
Al/steel	34	21.0		1.20
Do	35	22.0		1.94
Do	36	25.0		2.30
Solid steel		33.8	16.5	

We claim:

1. A baseplate assembly for an electrolytic cell having a flowing mercury cathode, comprising a steel plate the upper surface of which in operation is wetted by and carries the flowing mercury cathode and a current extractor plate disposed below the steel plate and made of a metal of higher electrical conductivity than steel, said plates being substantially parallel to each other and spaced apart by a plurality of aluminium studs distributed in a substantially uniform pattern over the common area of the two plates, one end of each stud being friction-welded to the steel plate and each stud being electrically-connected in rigid manner at or near its other end to the current extractor plate.

2. A baseplate assembly according to claim **1**, wherein the current extractor plate is made of aluminium.

3. A baseplate assembly according to claim **1**, wherein the current extractor plate is a composite of narrower plates placed with their edges parallel to each other and running substantially the length or the breadth of the steel plate.

4. A baseplate assembly according to claim **1**, wherein the current extractor plate extends along at least one edge beyond the area of the steel plate for the extensions to act as bus-bar or switching connections.

5. A baseplate assembly according to claim **1**, wherein each of the said aluminium studs is connected to the current extractor plate by a fusion weld around the circumference of the stud.

6. A base plate assembly according to claim **1**, wherein each of the said aluminium studs is connected to the current extractor plate by way of a friction weld made through an opening in the extractor plate between the end of the said stud which is remote from the steel plate and one end of a second aluminium stud which second stud is also friction-welded to the adjoining area of the extractor plate.

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204—219, 250, 286