April 10, 1973 P. J. VERNEUIL 3,726,781

HIGHLY CONDUCTIVE ADJUSTABLE ELECTRODES

Filed March 4, 1971 2 Sheets-Sheet 1

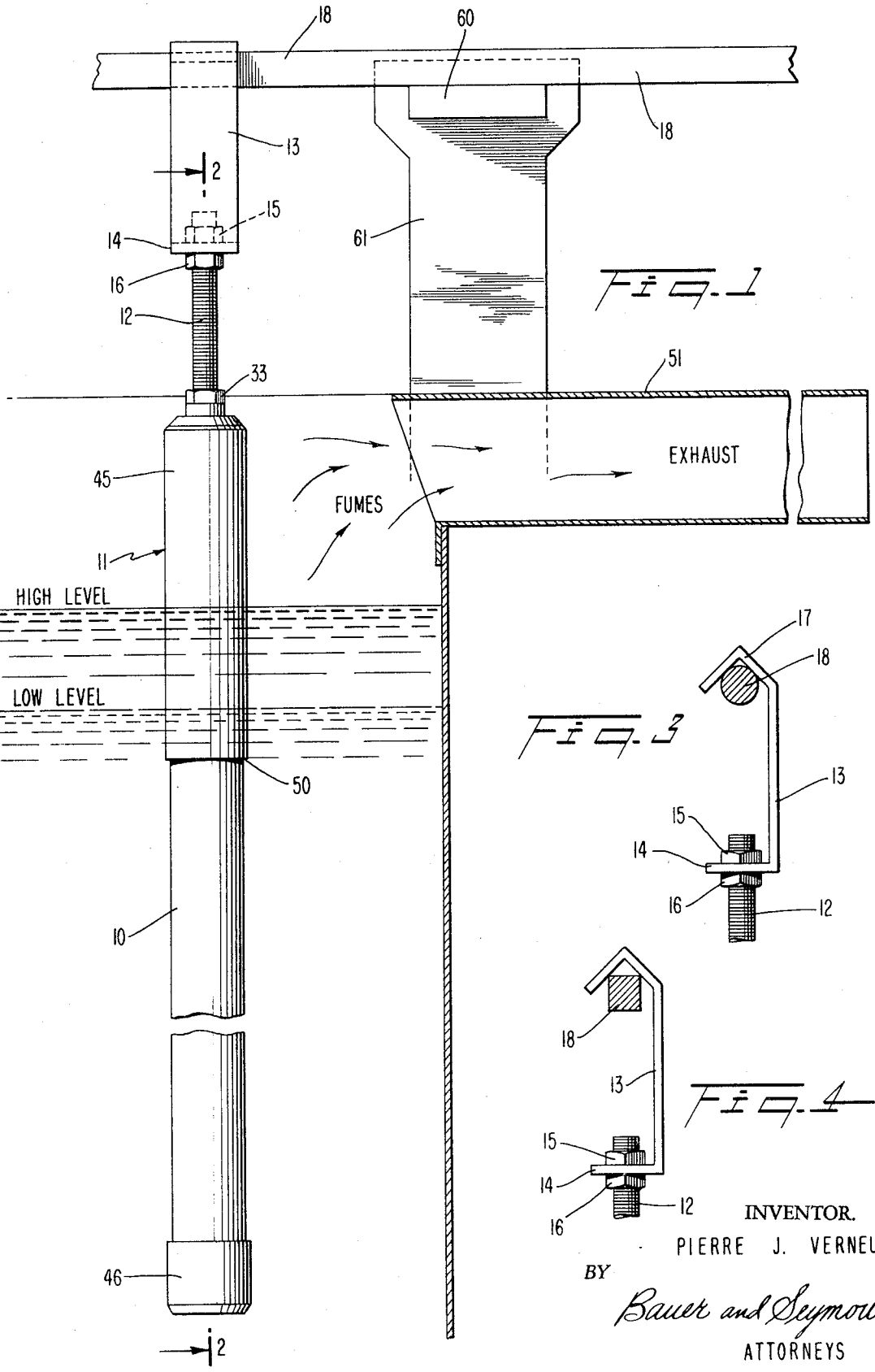


Fig. 1

Fig. 3

Fig. 4

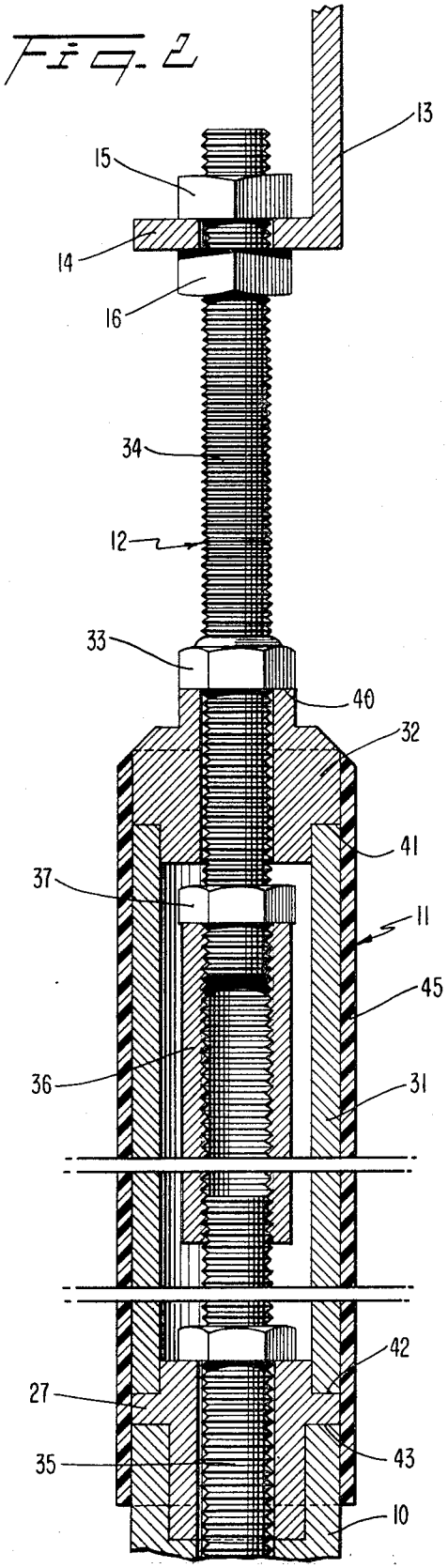
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Fig. 2



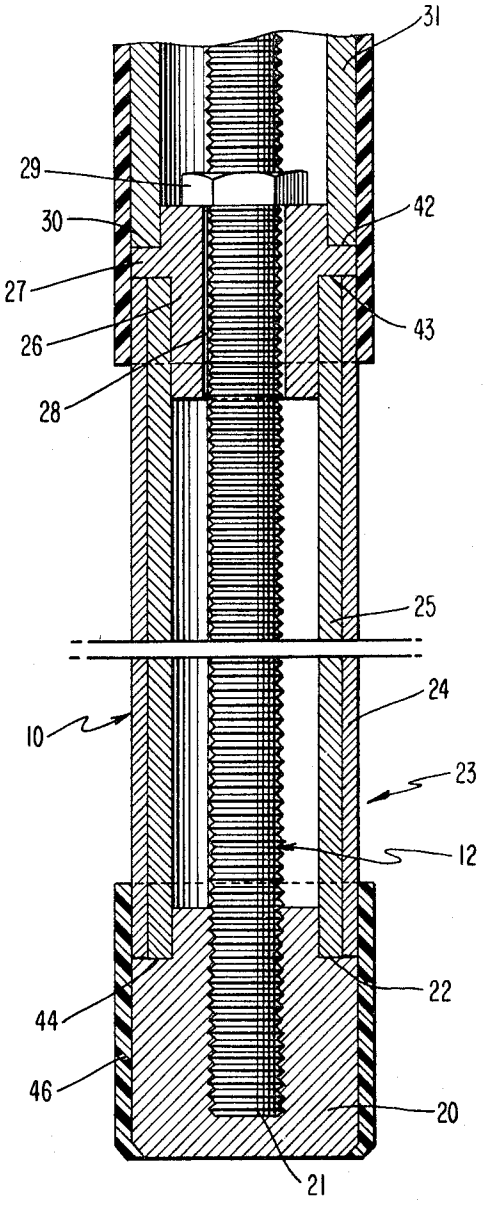


Fig. 2a

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HIGHLY CONDUCTIVE ADJUSTABLE ELECTRODES

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ABSTRACT OF THE DISCLOSURE

Electrodes, for instance those used in chromium plating, are lightened in weight, improved in efficiency and made of improved conductivity and high rigidity by a tubular sectional construction. Associated with these new electrodes is an advanced type of plating tank.

This invention relates to the construction of electrodes, and being particularly pertinent to the construction of the lead electrodes used in chromium plating, it will be described in its relation to that subject without detracting from the generality of its application. The invention also relates to the construction and operation of a novel plating tank, the novel features of which combine with those of the novel electrode to constitute a unit of superior efficiency.

Conventional insoluble anodes, such as the lead anodes generally used in chromium plating, work with a limited degree of efficiency, mainly because of unequal current density along the electrode, poor transmission of current from the anode bar, and, after a certain degree of evaporation of the solution, because the current is conducted below the surface of the electrolyte solely by the lead mass of the anode. In this case, the poor conductivity of lead (less than one twelfth that of copper) is detrimental.

This can be very readily verified in the case of hard chromium plating: For this particular application of chromium plating, high and accurately controlled current densities are required, as well as uniform distribution of current throughout the electrolytic circuit. These conditions can frequently be met only by using expensively engineered conforming anodes, but, quite often, as in the case of simple cylindrical parts, it is difficult to obtain uniform results, which has led to "boxing" straight anodes, and to various means of assuring contact between the anodes and the tank anode bar and of obtaining an acceptable degree of conductivity from said bar to the lead mass of the anode below the solution level.

Because of these and other deficiencies, these conditions are frequently not achieved, unsatisfactory results are obtained along the lines of undersize, out of round, or variable deposits on the parts which constitute the cathodic pole of the circuit. Similar variations also exist in the case of decorative plating, but are less noticeable than in the case of mechanical parts subject to measurement inspections. However, uniformity of deposit is always desirable.

It is an object of this invention to equalize the current density along the length of the electrode. In this description, we will assume that the electrode is the lead anode. Another object is to reduce the mass of the lead anode. Another object is to increase the rigidity of the lead anode. Another object is to make anodes of tubular section, of improved adjustability, which tend to eliminate concentration of current at the surface of the bath, which are of high conductivity, and which are not disturbed in function by the change in level of the plating bath. Another object is to construct a cooperating tank which combines with the new electrode to form a superior plating unit.

It is, therefore, proposed to correct the above-mentioned deficiencies, while meeting the individual requirements of

the user, such, for instance, as consideration of level variations due to long plating periods (plating overnight as an example in the case of hard chromium plating), by using an anode connector whose depth of immersion into the solution can be regulated, whose conductivity can be assured by a suitable section of a highly conductive metal, and whose main purpose will be to insure the proper flow of current to a point below the solution level, the lead mass of the anode being sufficient in itself for proper distribution of the electric current below that level. In order to meet these requirements two conditions are achieved by the invention, the novel use of highly conductive metals and superior rigidity of the connector assembly.

In the drawings, which include a preferred form of the invention,

FIG. 1 is an elevation diagrammatically illustrating the essential cooperative relation of the novel tank and electrode, the electrode being shown in the round;

FIG. 2 is a vertical section illustrating one form of the electrode, the electrode connector, and several novel features that provide rigidity and high conductivity to the electrode;

FIG. 2*a* is a vertical section of the preferred form of electrode as suspended from the electrode connector of FIG. 2;

FIGS. 3 and 4 illustrate a suspension hook for the electrode as applied to bus bars of different shapes.

Referring to the numerals of the drawing wherein like numbers refer to like parts,

The electrode **10**, in this instance lead, is connected to and forms a unit with the electrode connector **11** and the rigid screw threaded shaft **12** which forms the core of the unit. The core is adjustably connected to a bracket **13** which has an apertured foot **14** of which the aperture receives the end of the core, which is made adjustable in height by the nuts **15**, **16** which rigidly clamp the electrode in place. The upper end **17** of the bracket is angle shaped to accommodate the current carrying bus bars **18** of different shape. The angle **17** is aligned with the axis of the core **12** to avoid a bending moment.

In the preferred form of the invention, FIG. 2*a*, a solid block or plug of suitable, relatively inert metal, e.g. lead, **20** receives the lower end of the core **12** in a screw threaded hole **21**, being thus adjustably mounted on the end of the core and adapted to accommodate electrodes of different size. A circular ledge or shoulder **22** is provided in the upper circumference of the circular block **20** to receive the end of a composite tube **23** which is composed of an outer shell **24** of lead and an inner lining **25** of copper. The lead and the copper may have a force fit to assure tight contact throughout their length. Mounted on the upper end of the tube **23** is a second copper block or plug **26** which is provided with a circular flange **27** equal in width to the thickness of the tube **23**. The flange **27** can be screw threaded on the core **12** but need not be, being shown in the figure as having a smooth central hole **28** through which the core passes. Firm contact is made between block **26** and the tube **23** by means of a nut **29** which is threaded on the core. Above the flange **27** is a circular shoulder **30** which receives a copper tube **31**. Mounted on the tube **31** is a circular copper block or plug **32** which is held in firm conductive contact with the tube **31** by means of a plastic lock nut **33**, or a copper nut sealed by a plastic washer.

The central core **12** is made adjustable in length and its rigidity is assured by making it of an upper adjustable screw **34**, a lower adjustable screw **35** and an internally screw threaded sleeve **36** which joins the ends of the two screws by assuring a sufficient penetration of the screws **34**, **35** into the sleeve **36**, and by tightening the lock nut

37 the rigidity of the core is assured and even increased above what it would be were it a single piece.

The tubular construction of the electrode **10** and the electrode connector **11** combine with the rigid core to make a unit of exceptional lightness and great strength.

There are joints **40**, **41**, **42**, **43** and **44** along the length of the unit which, although tightly fitting, might slowly admit plating solution or fumes. The uppermost of these joints is sealed by plastic lock nut **33** and the others are sealed by sleeves **45**, **46** of plastic tubing inert to the fumes and the bath. Polyvinyl chloride tubing is illustrative of a number of plastic materials which are satisfactory in this use. Some of such tubes are known to shrink on drying or curing, forming a tight seal, and others can be shrunk into position by exposure to ionizing radiation. Such proposals have been made heretofore in the packaging industry and need no detailed description. It is also possible to seal these joints by the application of a coating composition with suitable resistance to the fumes from and contents of the bath.

This construction is also readily adapted to an electrode constituting a single lead mass as illustrated in the bottom of FIG. 2. A screw thread is provided in the interior of the electrode into which the adjustable screw **35** fits, the assembling of the electrode being otherwise as described hereinabove. In both cases the electrode and electrode connector are assembled from the bottom up.

The assembling of the apparatus in the plating tank is illustrated in FIG. 1 wherein the bracket **13** is hung over the anode cross bar **18** which supplies the current. The plastic core **45** extends below both the high level and the low level of the plating solution and to a point **50** well below the surface of the low level so that the lead tube of the anode is prevented from delivering a concentration of current at the liquid level. The lead tube of the anode is of the length chosen for its intended work and is related to the size of the cathode and the depth of the bath, conditions which will be understood by platers. Just above the high liquid level is an exhaust hood **51** which draws off the fumes from the bath and protects those parts of the apparatus which may be affected by the fumes and delivers the fumes to a scrubbing station which protects the environment. The current from the anode bar **18** passes through the bracket **13** to the adjustable screw **12**, the copper block **32**, the copper sleeve **31**, the second copper block **26**, and the copper sleeve **25** into the lead tube **24**. Because of the high conductivity of the chain of copper connections the current density along the length of the lead anode is more uniform than has heretofore been achieved. This uniformity is increased by the fact that the iron core transmits some current to the lead block **20** thereby supplying the lower end of the copper tube **25** and the lower end of the lead tube.

In the electrical supply system the anode bar **60** is supported rigidly by a non-conductive plastic support **61** and the anode cross bar **18** rests upon the main anode **60**. Both anode bars are copper, producing high conductivity above the solution level between the main anode bar and the core of the connector. The core of the connector may be malleable iron which is rigid and has fair conductivity. The anode connectors may be supplied with couplings having angular hook connections of various sizes which permit the use of bars of any selected section. The available adjustments secure proper immersion of the anode connector and of the anode. Such adjustments permit the maintenance of the connectors between the core and the main anode bar, above fume level. This construction, wherein the hood is well below such connections greatly reduces corrosion due to fumes and reduces the weight of the anode for the same total depth of immersion.

The use of liquid tight and plastic bonded coverings of metals and joints permits the use of high conductivity metals, of which copper is chief but not exclusive, which would otherwise be affected by the fumes in the bath.

The weight of the anode is materially reduced, especially in the case of medium size anodes, currently used in the industry which facilitates handling, replacement and cleaning.

The core of the anode connector can be made solid metal but adjustability is preferred as rigidity can be maintained along with the necessary conductivity by using tubular sections to reduce the cost and the weight. Empty space in the tubular assembly can be filled with some inert material to prevent condensation which might arise from temperature changes. The chemically inert plastic coating just below solution level eliminates the formation of lead chromate which occurs on lead anodes at solution level. The lock nut construction of the unit maintains high conductivity throughout the length of the electrode. The use of malleable iron for the core improves the conductivity of the unit for its conductivity is twice that of lead. Lead burning in assembling the components is eliminated.

Round anodes are illustrated but anodes of any shape can be constructed on the principles of the invention.

For the construction of the novel unit in various applications reference can be had to metals which may suitably replace lead, copper and maleable iron for particular uses.

PROPERTIES OF USEFUL METALS, APPROXIMATE VALUES

Material	Weight, lb./cu. ft.	Modulus of elasticity, lb./sq. in.	Electrical conductivity
Aluminum	169	10,000,000	58
Magnesium	109	6,500,000	39
Yellow brass	529	15,000,000	27
Copper	560	16,000,000	103
Malleable iron	456	25,000,000	16
Lead	708	2,600,000	8
Plain carbon steel	490	29,000,000	13

These values are based on properties of pure or commercially pure metals.

For reference, see "Alcoa Aluminum Bus Conductor Handbook."

As a modification, hose clamps of chemically inert metal (e.g. tantalum or titanium) of construction such as those used on automobile radiator hose connections can be used as a safety factor at the top and bottom of the plastic covering. The plastic covering can be bonded in place thermally, when a thermoplastic tube is used, or by an inert adhesive. Such clamps are isolated from the lead mass of the anode by the plastic covering and do not suffer from anodic action. The anode support **61** may be a simple crutch mounted on a flange provided on the upper end of the tank. If greater surface area of contact is desired between the bracket **13** and an anode cross bar having a flat upper surface the bracket can be made of block C-shape, the straight upper limb of the C being clamped to the anode bar by a C clamp.

As many apparently widely different embodiments of the present invention may be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited to the specific embodiments.

What is claimed is:

1. An electrode assembly comprising, a rigid metallic core, a tubular electrode surrounding said core in radially-spaced relation therewith and comprising imperforate outer and inner, self-sustaining, interfitting tubes, respectively of lead and a metal of higher conductivity than lead, conductive first and second, lower and upper plugs closing the respective ends of said tubular electrode having means cooperating with means on the core to force said plugs together into liquid-tight contact with the respective ends of said tubular electrode, means to electrify the tubular electrode, and support means attached to the upper end of said core.

2. An electrode assembly according to claim **1**, said core comprising upper and lower axially aligned rod sections, and means within said inner tube and radially spaced therefrom, connecting the contiguous ends of said rod sections for adjustment toward and from each other.

3. An electrode assembly according to claim 1, and resinous pellicle tube means surrounding and enclosing said second plug in liquid tight sealing relation therewith.

4. An assembly according to claim 1, said conductive support including a conductive bracket, and means connecting said bracket to the upper end of said core, and operable to effect relative axial adjustment therebetween.

5. The electrode assembly of claim 2, said upper plug being mounted on said core for sliding therealong and having an integral flange extending over and closing the contiguous end of said electrode, a third tube surrounding the core and having its lower end in contact with said flange, conductive closure means surrounding said core in electrically conductive contact therewith, and in contact with the upper end of said third tube, to thereby force the same against said second plug.

6. The electrode assembly of claim 5, and a sleeve of plastic material inert to electrolyte, surrounding and fitting said third tube and the flange of said upper plug, and forming a liquid-tight protection therefor and for the upper end of said tubular electrode.

7. The electrode assembly of claim 5, said conductive closure means comprising a third plug slidable on said core and having a downwardly-facing shoulder in contact with the upper end of said third tube, and means interengaging with said core and operable to engage said third plug and force the shoulder thereof into engagement with the contiguous end of said third tube.

8. The electrode assembly of claim 7, and a sleeve of plastic material inert to electrolyte, surrounding and fitting said third tube, said third plug and the flange of said second plug.

9. The electrode assembly of claim 1, said core being a threaded rod, said lower plug having an upwardly-facing shoulder and a central aperture threaded onto the contiguous end of said core to thereby force the lower end of said electrode onto the shoulder of said lower plug, and a sleeve of material inert to electrolyte, surrounding said lower plug and the lower end of said electrode, and forming a liquid-tight seal therefor.

10. In an electrode assembly, a metallic core, a tubular electrode comprising outer and inner, first and second interfitting tubes of lead and copper, respectively, said electrode surrounding a first end portion of said core, in radially-spaced relation therewith, first and second plugs of conductive material cooperating with said core to close the ends of said electrode, means attached to the second end portion of said core to support the electrode in a cell, and a non-conductive sleeve of material inert to electrolyte, and enclosing the end of said electrode contiguous to said second plug and sealing the joint between said electrode and said second plug.

11. The electrode assembly according to claim 10, said core being a ferrous rod, said support means being a conductive hanger adapted to embrace a bus bar, said first and second plugs being of lead and copper, respectively.

12. The electrode according to claim 10 in which said plugs are held by said core in tight, conductive engagement with the ends of the electrode, and an impervious plastic coating covering and sealing the joint between said first plug and said electrode.

13. An electrode assembly comprising aligned upper and lower tubes of which the lower has a lead surface in contact with the electrolyte and the upper is highly conductive, a rigid metal core within the tubes and spaced therefrom, conductive first and second, lower and upper plugs closing the lower end of the lower tube and the upper end of the upper tube, a conductive block having a flange engaging the lower end of the upper tube and the upper end of the lower tube, means on the rigid metallic core cooperating with the plugs and the block to force the tubes, the plugs, and the block into tightly fitting contact, and sleeve means inert to the bath and to fumes generated therein sealing the upper tube, the block, and the joints of the block from contact with electrolyte.

14. An electrode assembly according to claim 13 in which the metallic core is screw threaded into the lower plug, a nut screw threaded on the core bears on the lower sleeve through the flanged block and forces it into tightly fitting contact with the lower plug and with the flange of the block, and a nut screw threaded on the core bears on the upper sleeve through the upper block, and forces the upper plug, the upper sleeve, and the block into tightly fitting contact.

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