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Harke et al.

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[54] **CATHODE STRUCTURE FOR ELECTROLYTIC CELL**

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[51] **Int. Cl.** **B01k 3/04**

[58] **Field of Search** 204/256, 266, 278, 283, 204/284, 286

[56] **References Cited**

UNITED STATES PATENTS

2,987,463	6/1961	Baker et al.	204/283 X
3,342,717	9/1967	Leduc	204/266 X
3,493,487	2/1970	Ruthel et al.	204/284
3,498,903	3/1970	Kamarjan	204/283 X
3,755,108	8/1973	Raetzsch et al.	204/256 X

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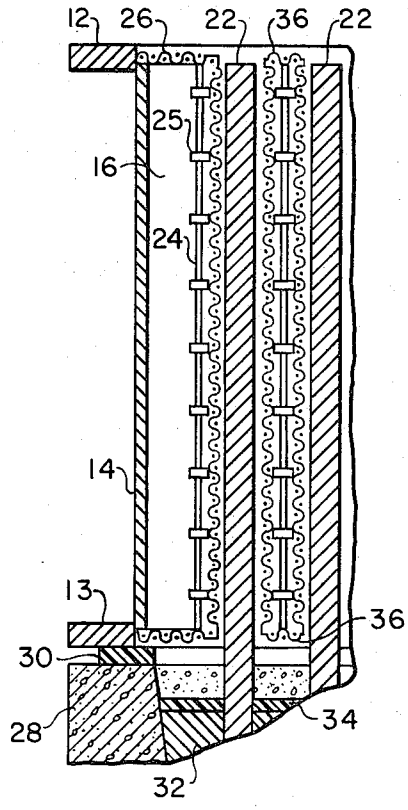
[57] **ABSTRACT**

A cathode structure for a chlor-alkali type diaphragm electrolytic cell presenting a conductive metal enclosure having positioned therein a peripheral, foraminous metal chamber, said chamber having in communication therewith plural foraminous metal projections, said foraminous metal projections being substantially rectangular in cross section, and including therein reinforcing means comprising a metal sheet extending substantially throughout the inner portion of said foraminous metal projections, said metal sheet having a plurality of projections extending from each side of said metal sheet to the inner surfaces of said foraminous projections. The thus described reinforcing means serves not only to maintain the foraminous metal projections in proper alignment with the anode members of the electrolytic cell across the entire height and width of the metal projections but also results in a decreased tendency of the hydrogen gas product to contaminate the anode product.

8 Claims, 3 Drawing Figures



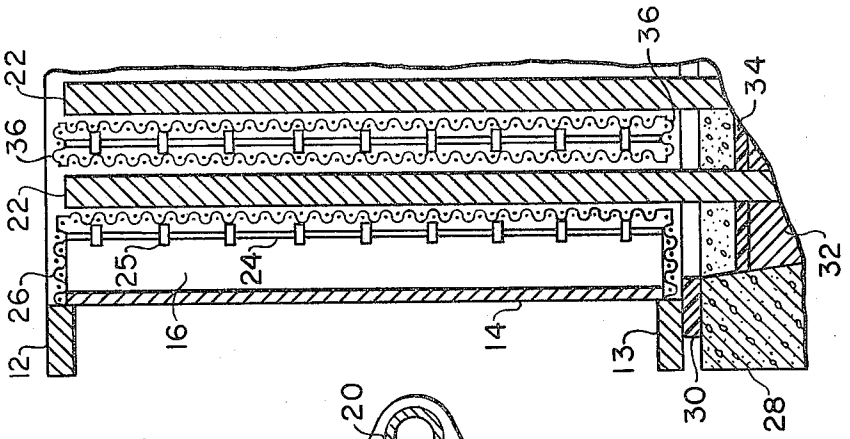


FIG. 2

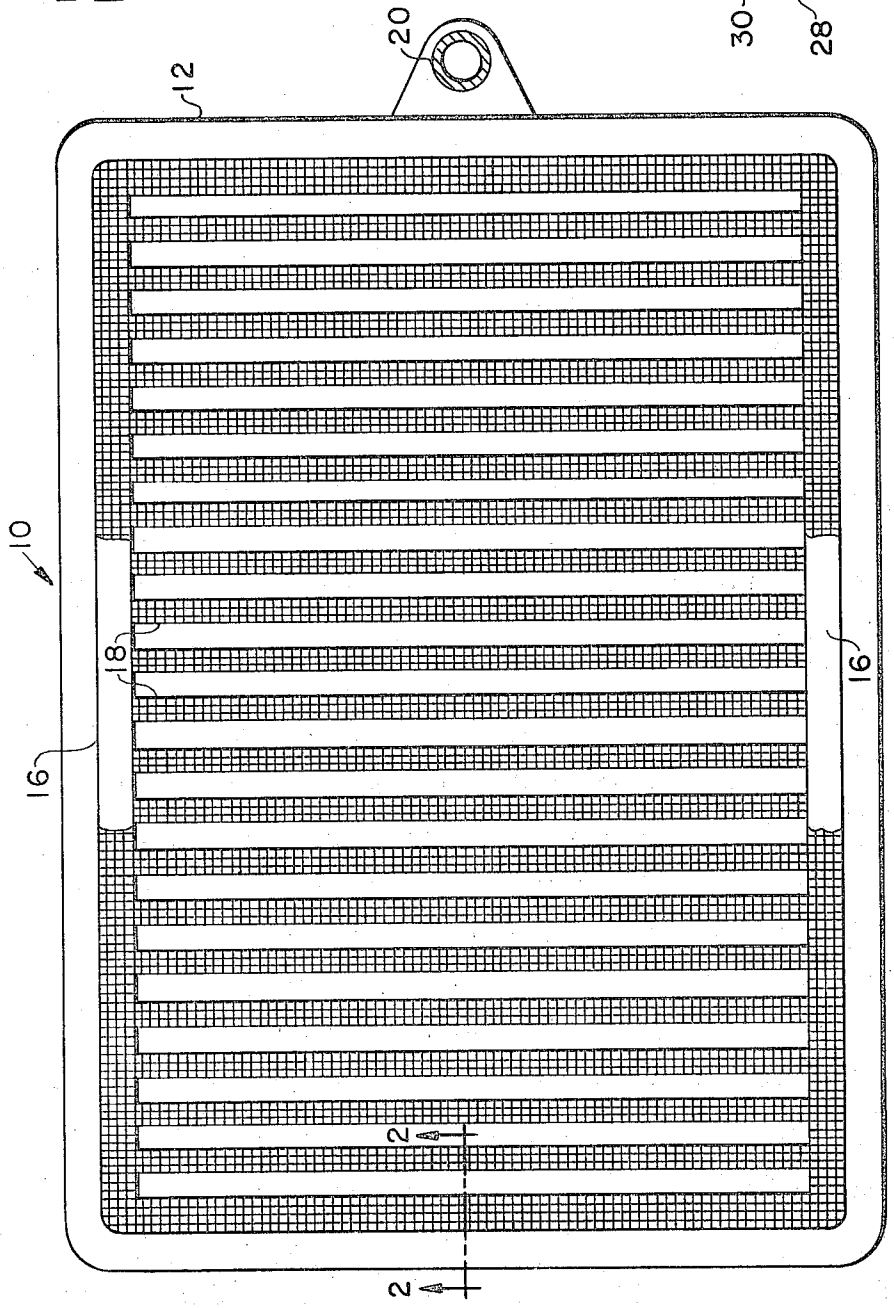


FIG. 1

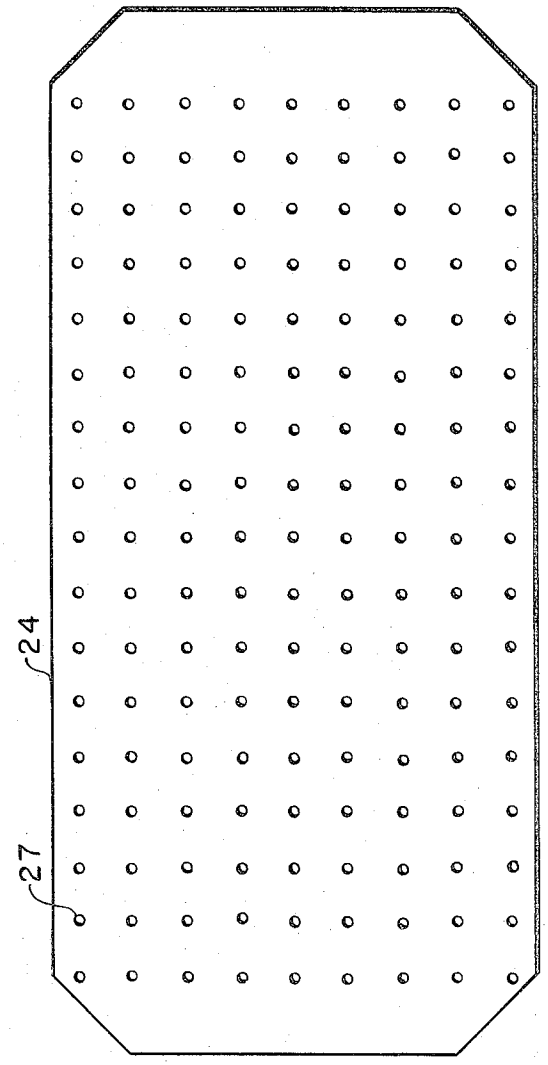


FIG. 3

CATHODE STRUCTURE FOR ELECTROLYTIC CELL

FIELD OF INVENTION

This invention relates to electrolytic cells for the electrolysis of aqueous solutions and more particularly to the cathode structure of a diaphragm type electrolytic cell particularly suited for the electrolysis of aqueous alkali metal chloride-containing solutions.

BACKGROUND OF THE INVENTION

Chlor-alkali diaphragm cells have been used extensively for many years for the production of chlorine, caustic and hydrogen. Over the years, such cells have been perfected to a degree whereby high operating efficiencies are obtained based on the electrical energy expended. Most recent developments in diaphragm chlor-alkali cells have been in improvements for increasing the production capacity of individual cells, thereby obtaining a higher production rate for a given cell room area. Chlor-alkali cells have been developed capable of utilizing over 55,000 amperes of current per cell. Currently cells operating at about 150,000 amperes are in use. In order to obtain high efficiencies in chlor-alkali diaphragm cells of such high current capacities, comparable to the more conventional lower amperage cells of about 30,000 amperes or less, various structural improvements are best incorporated into these high amperage cells to maintain or increase their current and power efficiencies. Mere enlargements of the component parts of such cells, while providing efficient cells, do not always provide the most favorable efficiencies, based on construction costs and operating performance.

With increasing sizes of electrolytic cells, difficulties are encountered in maintaining the relatively narrow tolerances in anode alignment with respect to the foraminous cathode structure. Higher capacity cells are substantially larger in size while the preferred spacing between the anode and cathode remains the same. If the distance between the anode and cathode is too little, electrical shorting will occur; the cell becomes electrically inefficient when the electrodes are too far apart. In order to obtain high efficiencies, the relatively narrow tolerances in anode alignment should be maintained for the entire expanse of anode and cathode surfaces.

OBJECTS OF THE INVENTION

It is an object of the present invention to provide a cathode structure particularly suited for high amperage chlor-alkali cells, whereby the relatively narrow tolerances of anode and cathode distances can be more readily obtained. Another object of the present invention is to provide an improved cathode structure of increased structural strength, whereby misalignment due to warpage and flexing of the cathode structure is greatly reduced. Another object is to provide an improved cathode structure which substantially decreases the tendency of hydrogen gas produced in the cathode section to permeate into the anode section, i.e., provides improved hydrogen gas release. A further object of the present invention is to provide an improved cathode structure which is more readily fabricated. These and other objects will become apparent to those skilled in the art from the following description of the invention.

BRIEF DESCRIPTION OF THE INVENTION

In accordance with the invention, a cathode structure is provided for an electrolytic chlor-alkali diaphragm type cell comprising a conductive metal enclosure having positioned therein a peripheral foraminous metal chamber, said chamber having in communication therewith a plurality of foraminous metal projections, said foraminous projections being substantially rectangular in shape and including therein reinforcing means comprising a metal sheet extending substantially throughout the inner portion of said foraminous metal projections, said metal sheet bearing a plurality of projections extending from each side of said metal sheet to the inner surfaces of said foraminous metal projections.

By "substantially rectangular" in cross section or shape is meant to include structures having parallel sides and either substantially 90° corners or substantially rounded corners.

The foraminous metal projections, commonly termed "cathode fingers" may traverse the width of the cathode structure or said fingers may comprise two sections, each extending from a side wall of the cathode structure to a mid-point thereof with an anolyte downcomer space in the center of the cell as disclosed in U.S. Pat. No. 3,492,422.

The present invention provides an improved cathode structure for diaphragm type electrolytic chlor-alkali cells by which accurate alignment of the cathode with the anode is more readily effected and maintained. Additionally, the cathode structure can be fabricated at a lower cost while resulting in increased structural strength.

A further asset or advantage over the older cathode finger structure reinforced by corrugated sheet material follows from the increased space within the improved reinforced cathode finger structure which offers less impedient to the flow of the hydrogen gas liberated at the cathode and thus decreases the tendency of the hydrogen gas to permeate the diaphragm and contaminate the anode product.

DESCRIPTION OF THE DRAWINGS

The invention will be more fully described by reference to the drawings in which

FIG. **1** is a plan view of the cathode structure in accordance with the present invention.

FIG. **2** is an enlarged partial sectional view of the cathode of FIG. **1** along the plane **2—2**, further illustrating the position of the anode and cell bottom in relation to the foraminous cathode projections, and

FIG. **3** is a plan view of an improved reinforcing means prior to emplacement within a foraminous cathode projection in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Because the present invention may be used in many different electrolytic processes of which chlor-alkali electrolysis is of primary importance, the invention will be described more particularly with respect to such chlor-alkali diaphragm cell operation. However, such description is not to be understood as limiting the usefulness of the present invention, particularly in view of the fact that the present cell can be operated without the use of a diaphragm as described hereinafter. Moreover, this description of the invention will be made with

specific reference to a cathode structure in which the cathode fingers traverse the width of the cathode structure, it being understood that said fingers may also comprise two sections each being attached to one side wall of the cathode structure and traverse about one half thereof with an anolyte downcomer space in the center of the cell separating the two sections of cathode fingers.

The cathode section **10** of the present invention is comprised of an enclosure having sidewalls **14** forming preferably a rectangular shaped structure of a suitable size corresponding to the particular cell and capacity thereof, with which cell it is to be used, and a plurality of foraminous projections **18.** Surrounding the enclosure at the top and bottom of sidewall **14** are flanges **12** and **13.** Flanges **12** and **13** are utilized to more conveniently seal the cathode section in a watertight relationship in the assembled electrolytic cell. Flange **13** rests on gasket **30** which is between the cathode **10** and cell bottom **28.** Flange **12** provides a contact plate on which the cell top (not shown) rests. Surrounding the internal portion of cathode **10** is peripheral chamber **16.** Gas being liberated in the cathode section during the electrolysis is channeled across the foraminous projections **18** to the peripheral chamber **16** from whence it proceeds to gas withdrawal means **20.**

Extending across cathode **10** are a plurality of foraminous projections **18.** These are commonly called cathode fingers. The number of foraminous projections may vary widely, depending on the particular cell size, but commonly about two to 100 or more, more preferably five to 50 and most preferably about 15 to 25 are present.

In the use of the present apparatus as a chlor-alkali diaphragm cell, an inert diaphragm is applied or deposited on the foraminous structure. The diaphragm which can be used to cover the screen of foraminous portion of the cathode is a fluid-permeable and halogen-resistant material. Preferably, the material is asbestos deposited in situ on the outer surfaces of the cathode or foraminous projections **18** and the peripheral chamber **16,** the diaphragm material facing the anode. However, other types of diaphragms can be used depending on the reaction and reaction conditions contemplated within the cell. Other diaphragm materials such as those comprised of synthetic organic materials, such as woven after-chlorinated polyvinyl chloride, polyvinylidene chloride, polypropylene, TEFLON, and the like, may be used. Particularly useful membrane materials are those fabricated from synthetic organic ionexchange resins such as sulfonated copolymers of styrene and divinyl benzene and the hydrolyzed copolymers of tetrafluoroethylene and a sulfonated perfluorovinyl ether. Electrolytic cells containing the latter membrane material are disclosed in copending application of E. H. Cook, Jr., et al., Ser. No. 212,171, filed Dec. 12, 1971. These and other suitable materials are known to those skilled in the art. The cathode structure is adapted to permit use of all types of diaphragms including sheet asbestos, deposited asbestos and synthetics which can be in the form of woven fabrics.

The foraminous projections **18** and peripheral chamber **16** are preferably constructed of metal screen mesh which can also be perforated metal plating or the like foraminous structures. The metal parts of the cathode are of a conductive metal and, preferably, are of relatively inexpensive low-carbon steel. However, various other metals can be used such as titanium, nickel, chromium, copper, iron, tantalum, and the like, and alloys thereof, especially stainless steel and other chromium steels, nickel steels and the like. Also, various parts of the cathode can be constructed of copper or other low resistance metals to increase electrical conductivity. When copper or other low resistance metals are used, it is preferred to construct the reinforcing means **24** of such metals because the reinforcing means serve the dual function of conducting the electrical energy to the foraminous screen surfaces and strengthening the projections. Thus, increased electrical efficiencies can be obtained in the use of the various more conductive metals and alloys.

The foraminous mesh screen **26** is reinforced with reinforcing means **24.** Reinforcing means **24** is preferably a sheet metal material which is preferably attached to the sidewall of the cathode on at least one side of the cathode. The foraminous mesh screen **26** is attached, as by welding, to the reinforcing means **24.** As stated above, reinforcing means **24,** serves the dual function of both supporting and reinforcing the foraminous screen and further in conducting the electrical energy to the extremities of the cathode fingers.

Reinforcing means, **24,** comprises a metal sheet extending throughout the inner portion of the foraminous metal projection, and preferably at substantially the middle thereof. The reinforcing means contains a plurality of projections, **25,** extending from the face of the metal sheet, on either side thereof to the inner surfaces of the foraminous metal projection. These extensions, which may be metal or plastic material, are located throughout the metal sheet, preferably equally spaced thereon (as shown on FIG. **3**). Most preferably, the reinforcing means is fabricated by boring or punching a series of holes **27** in a preformed metal sheet, **24** and metal pins **25,** inserted in the holes in such manner that the extremities of the pins when in place extend from one inner surface of the foraminous metal projection to the opposite inner surface. Alternatively the metal extensions, i.e., pins, can be placed in a random manner throughout the surface of the metal sheet. Another feasible structure, is that obtained by punching metal extensions in the metal sheet and bending the extensions to such length that they extend to and provide support for the foraminous metal screen. Other means of providing reinforcing extensions on the metal sheet will be obvious to those skilled in the art.

The reinforcing means serves to prevent the warping and flexing of the foraminous metal projection and thus to maintain the cathode and anode distances constant through the surface area of the electrodes.

In an especially preferred modification, the foraminous metal projection, i.e., the reinforced cathode finger, includes a plurality of fasteners, e.g., rivets, extending through the foraminous metal projection and the reinforcing means to secure the metal screen to the reinforcing means. In this manner additional rigidity is obtained and pressures developing in the cathode compartment (i.e., in the inner compartment of the metal projections) are prevented from causing the metal screen to warp or flex. Alternately, the foraminous metal screen **26** may be spot welded to the pins **25,** where the pins are metallic.

The foraminous projections **18,** may be fabricated from low-carbon steel mesh screen or the like as described, and may utilize sharp bends so as to provide

relatively sharp 90° corners, **36,** having a relatively small radius of curvature, or the bends may be more rounded, that is the radius of curvature may approximate a semi-circle. The radius of curvature is a means of measuring curves based on the radius of the arc formed by the bend. The measurements given are for the radius of an outside arc, the inside arc having a correspondingly smaller radius depending on the foraminous metal thickness. The foraminous projections **18** are conveniently attached, as by welding, to the foraminous section of the peripheral chamber while the reinforcing means **24** is preferably extended to, and attached to the sidewall of the cathode section.

In the assembled cell, cathode section **10** is positioned over cell bottom **28** in a manner whereby anodes **22** project from cell bottom, **28,** upwards between foraminous projections **18.** The alignment distance between the anode and the foraminous fingers is normally between about ⅛ and ⅜ of an inch. Therefore, as the height and width of the cathode structure increases, the criticality of having the anode and cathode functions in proper alignment with each other across the entire height and width of the electrode surfaces becomes increasingly difficult as the size thereof is increased. In the present invention these difficulties are substantially reduced or eliminated and the desired cathode alignment with respect to the anode is more readily obtained. Thus, slight warpages, flexing and the like in the foraminous projections previously resulted in extreme difficulties in maintaining proper distances between the anode and cathode over wide expanses, whereas the present invention overcomes these difficulties and provides the means for retaining the desired anode-cathode distance for the entire opposing anode and cathode surfaces by providing a more rigid cathode structure which is resistant to permanent structural deflections.

The anode **22,** which may be fabricated from graphite or metal such as a valve metal, e.g. titanium, coated with a noble metal or oxide thereof, are secured to cell bottom **28** by means of conductive metal **32.** Conductive metal **32** is normally lead or other relatively low melting conductive metal material which can be readily molded about the anode. The particular metal utilized is one which will melt at a temperature below that at which anodes are degraded. The anode **22,** may also be mechanically fastened to the bottom **28,** by bolt or other means. A sealing material **34,** such as an inert organic polymer or resinous material, is applied over the conductive metal **32** to eliminate electrolytic attack by the electrolyte on the conductive metal during cell operation.

In the operation of an electrolytic cell using the present cathode structure as a chlor-alkali cell, an alkali metal chloride, for example, sodium chloride, is introduced into the cell as a brine stream of desired concentration. The brine level within the cell is brought to a point above the anodes within the cell. By adjusting the level within the cell, the hydrostatic head or pressure exerted upon the diaphragm covering the foraminous cathode fingers is varied, thereby varying the flow of electrolyte through the diaphragm into the cathode compartment. Under normal operating conditions, the height of the brine above the anodes is about 1 to 15 or more inches.

As previously stated, the cathode section of the present invention can be used in a cell used for the electrolysis of alkali metal chloride solutions, including not only sodium chloride but also potassium chloride, lithium chloride, rubidium chloride and cesium chloride. In the electrolysis using a diaphragm covering the foraminous cathode, caustic, chlorine and hydrogen are produced. Using certain modifications and changes in the method of reacting, such as by removing the diaphragm or further reacting the produced caustic and chlorine, alkali metal chlorates can also be produced by the present cell. Thus, in some instances, when used for the production of alkali metal chlorates, solutions containing both alkali metal chlorate and alkali metal chloride are recirculated to the cell for further electrolysis. In yet another modification, the present cathode structure can be utilized in a cell for the electrolysis of hydrogen chloride by electrolyzing hydrogen chloride in combination with an alkali metal chloride. Thus, the present cathode structure and cell is highly useful in these and many other aqueous electrolytic processes.

The above-described cathode section offers significant advantages when utilized as a cathode section of an electrolytic cell. A most important consideration is the extremely high electrical efficiency in operation at unusually high current capacities of the order of 100,000 amperes and higher. Such high amperages provide for considerably greater productivity for a given cell room area. The novel structure of the cathode of the present invention provides improved control of structural tolerances, thereby permitting the practical operation of large electrolytic cells. In addition to being capable of operating at extremely high amperage capacities, the present cell can also be effectively operated at lower amperages, such as about 30,000 amperes or less, and higher amperages upward to 150,000 amperes.

While there have been described various embodiments of the present invention, the apparatus described is not intended to be understood as limiting the scope of the invention. It is realized that changes therein are possible. It is further intended that each element recited in any of the following claims is to be understood as referring to all equivalent elements for accomplishing substantially the same results in substantially the same or equivalent manner. It is intended to cover the invention broadly in whatever form its principles may be utilized.

What is claimed is:

1. A cathode structure for a diaphragm type electrolytic cell comprising a conductive metal enclosure having positioned therein a foraminous metal chamber, said chamber having in communication therewith a plurality of foraminous metal projections, said foraminous metal projections being substantially rectangular in cross section and including therein reinforcing means which comprise a substantially planar metal sheet extending substantially throughout the inner portion of said foraminous metal projections, said metal sheet having a plurality of projections extending from each side thereof to the inner surfaces of said foraminous metal projection.

2. The apparatus of claim **1** wherein the foraminous metal projections are of steel screen mesh.

3. The apparatus of claim **1** wherein the foraminous metal projections traverse the width of said cathode structure.

4. The apparatus of claim **1** wherein the projections extending from the metal sheet are metal projections.

5. The apparatus of claim 1 wherein the metal sheet comprises a plurality of holes through which have been inserted plugs extending from one inner surface to the opposite inner surface of said foraminous metal projection.

6. The apparatus of claim 5 wherein said holes are equally spaced in the metal sheet.

7. The apparatus of claim 5 wherein said foraminous metal projection includes also a plurality of fasteners extending through said foraminous metal projection and reinforcing means thereby securing said projection to said reinforcing means.

8. The apparatus of claim 7 wherein said fasteners are rivet members.

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