(No Model.) 2 Sheets—Sheet 1.

# M. KILIANI, W. RATHENAU & C. SUTER.

## DIAPHRAGM FOR ELECTROLYTIC PURPOSES.

No. 562,304. Patented June 16, 1896.

*Fig. 1.*

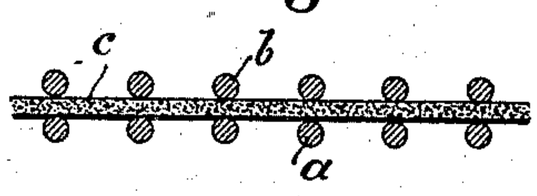



*Fig. 2.*

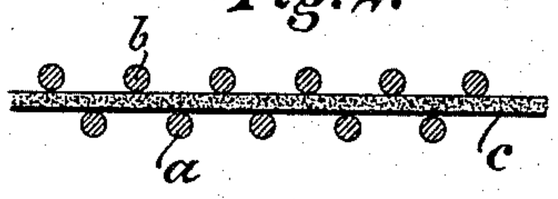



*Fig. 3.*


*Fig. 4.*

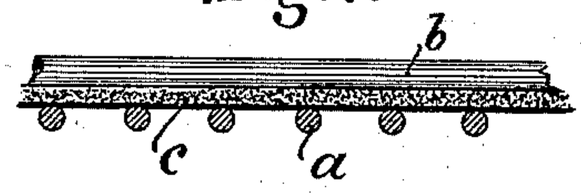



*Fig. 1a.*

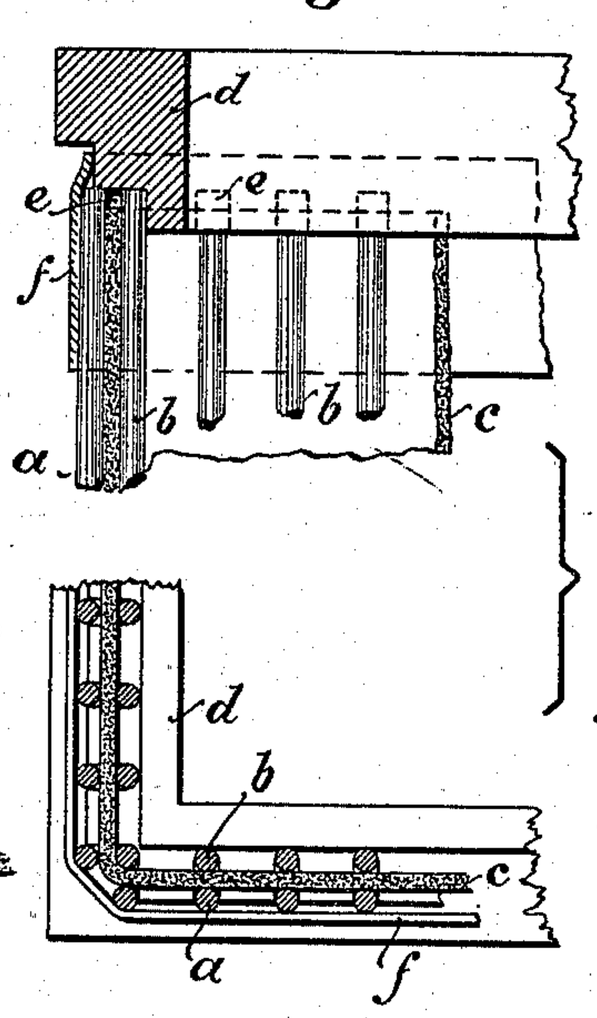



*Fig. 2a.*

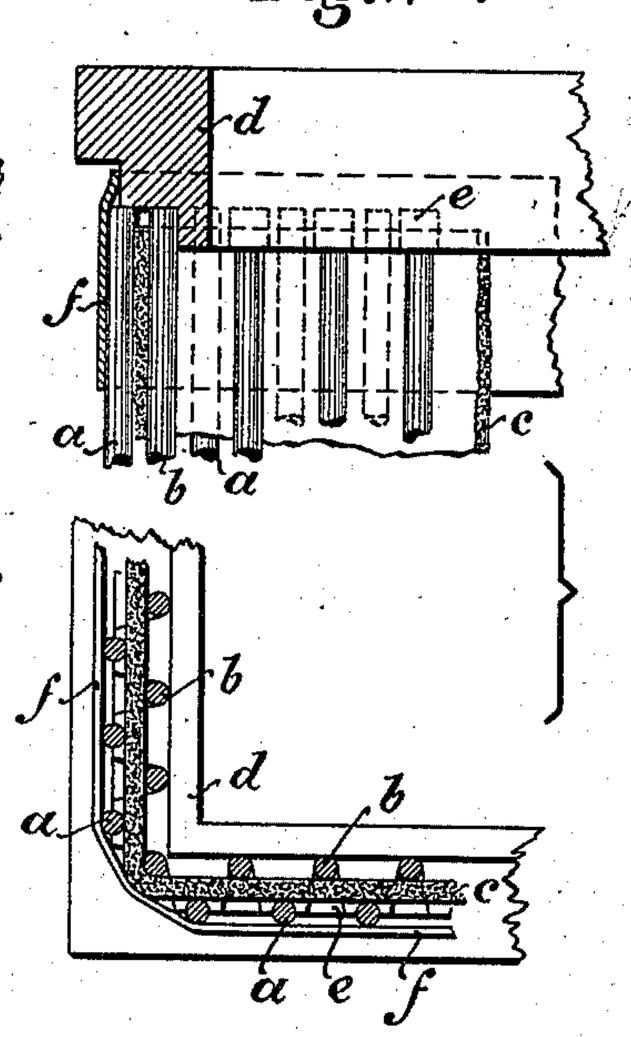



*Fig. 5.*

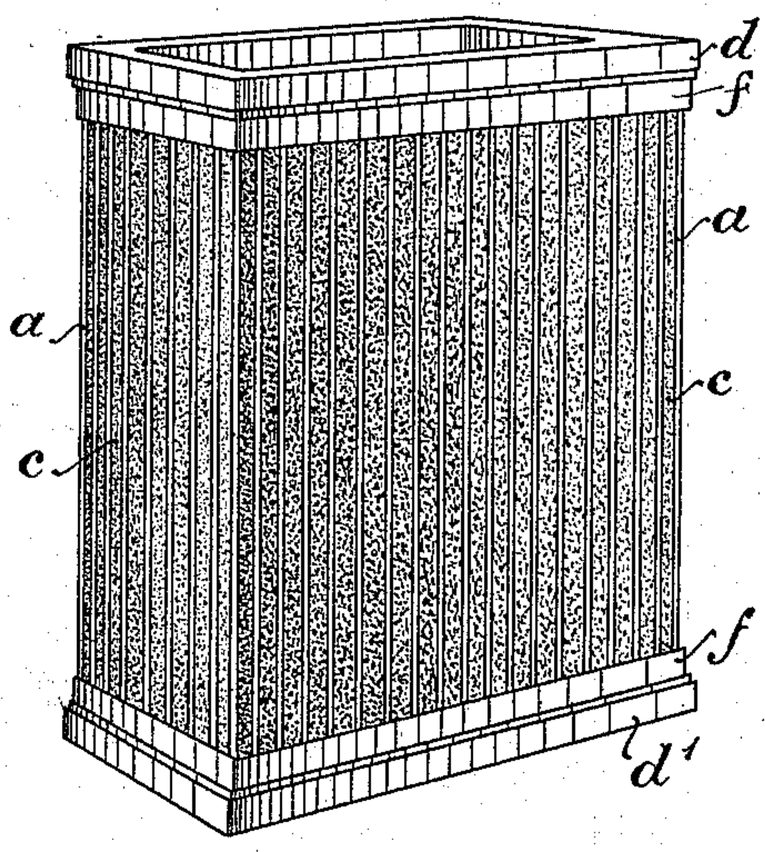
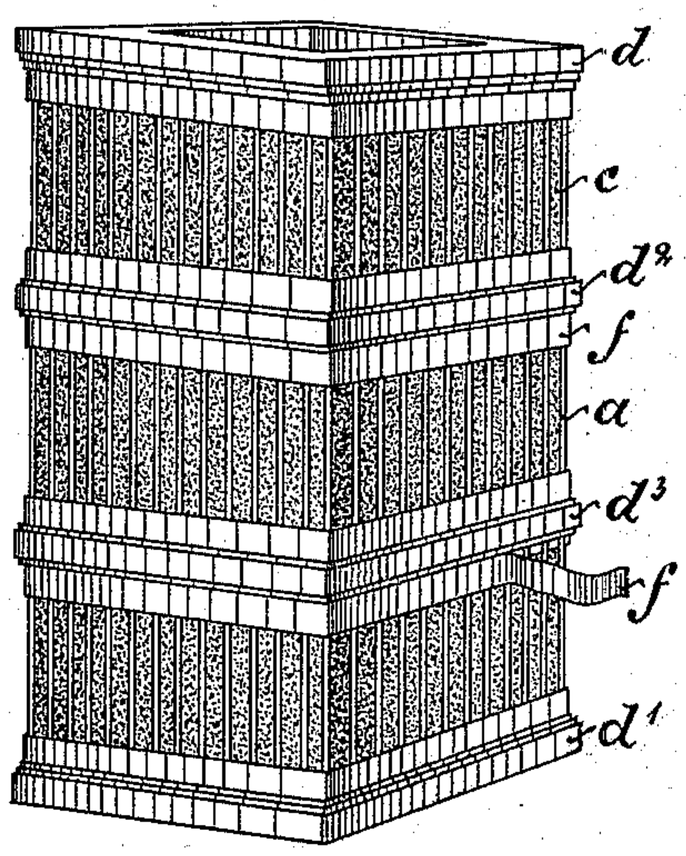



*Fig. 6.*

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(No Model.) 2 Sheets—Sheet 2.

# M. KILIANI, W. RATHENAU & C. SUTER.

## DIAPHRAGM FOR ELECTROLYTIC PURPOSES.

No. 562,304. Patented June 16, 1896.

*Fig. 3a.*

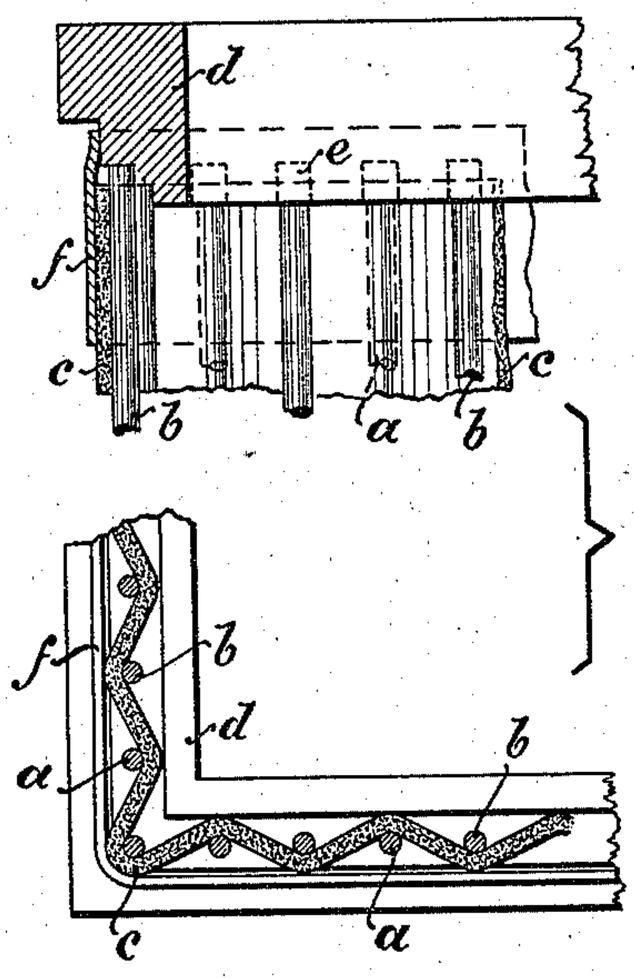



*Fig. 4a.*

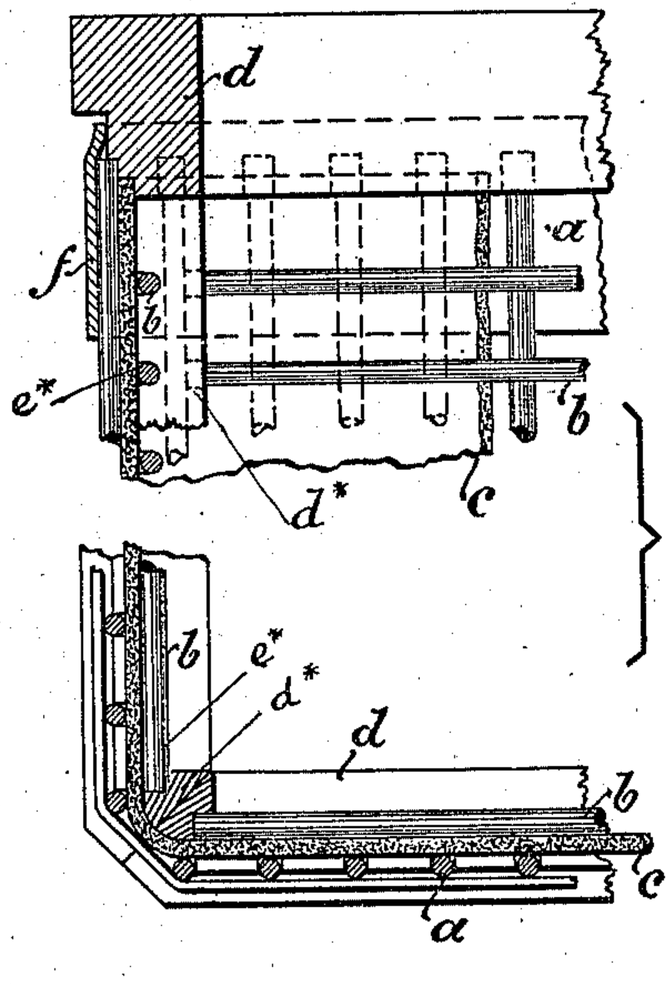
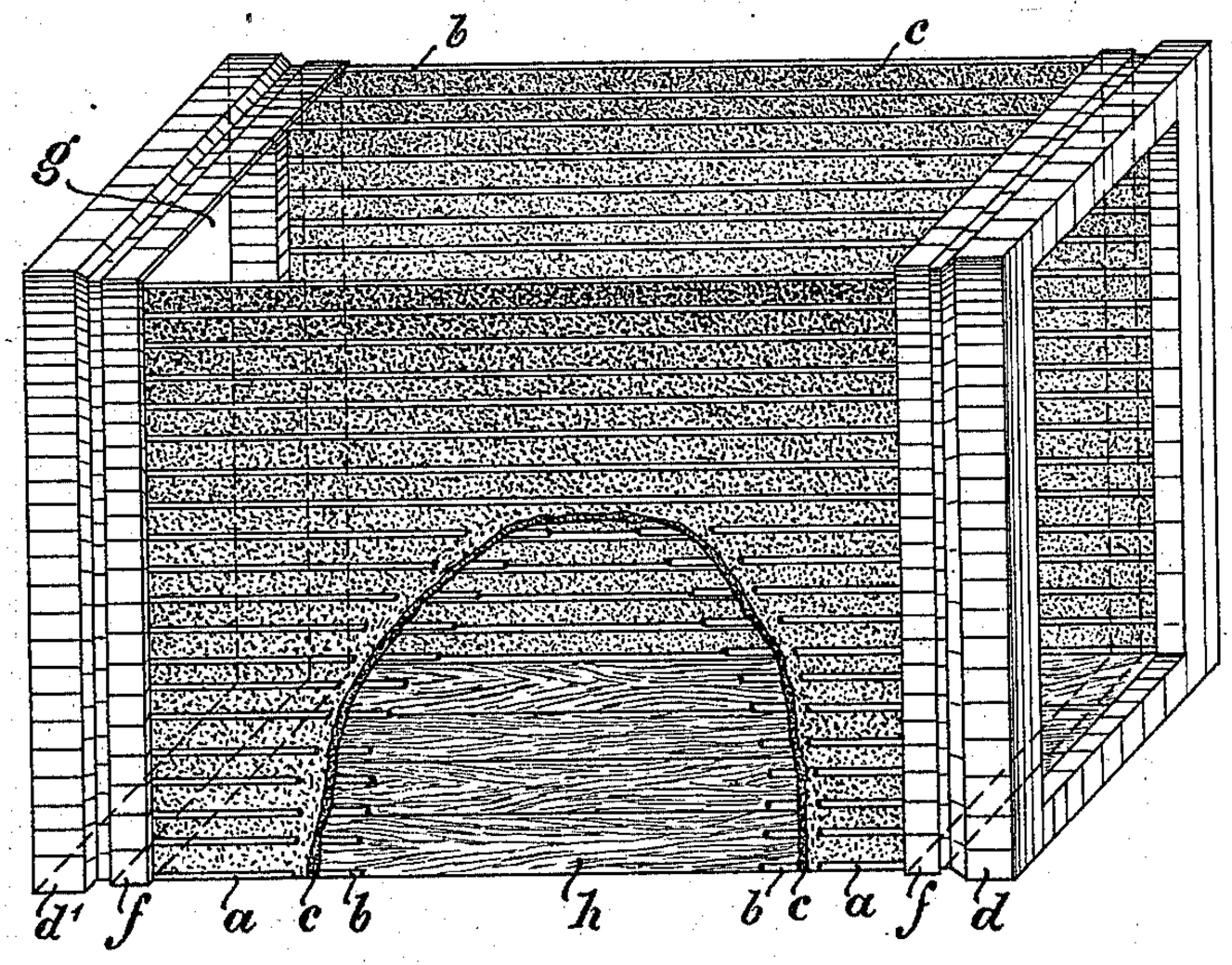



*Fig. 7.*

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# UNITED STATES PATENT OFFICE.

MARTIN KILIANI, OF NEUHAUSEN, SWITZERLAND, WALTHER RATHENAU, OF BERLIN, GERMANY, AND CARL SUTER, OF NEUHAUSEN, SWITZERLAND, ASSIGNORS TO THE ELEKTROCHEMISCHE WERKE, OF BERLIN, GERMANY.

## DIAPHRAGM FOR ELECTROLYTIC PURPOSES.

SPECIFICATION forming part of Letters Patent No. 562,304, dated June 16, 1896.

Application filed August 15, 1894. Serial No. 520,400. (No model.) Patented in Germany January 20, 1894, No. 78,732; in France July 13, 1894, No. 240,045; in England August 10, 1894, No. 15,276; in Hungary January 4, 1895, No. 1,861, and in Austria May 19, 1895, No. 1,755.

*To all whom it may concern:*

Be it known that we, MARTIN KILIANI, a subject of the King of Bavaria, residing at Neuhausen, Switzerland, WALTHER RATHENAU, a subject of the King of Prussia, Emperor of Germany, residing at Berlin, Prussia, German Empire, and CARL SUTER, a citizen of Switzerland, residing at Neuhausen, Switzerland, have invented certain new and useful Improvements in or Connected with Diaphragms for Electrolytic Purposes, (for which we have obtained Letters Patent in Germany, No. 78,732, bearing date January 20, 1894; in France, No. 240,045, bearing date July 13, 1894; in Great Britain, No. 15,276, bearing date August 10, 1894; in Hungary, No. 1,861, bearing date January 4, 1895, and in Austria, No. 1,755, bearing date May 19, 1895;) and we do hereby declare that the following is a full, clear, and exact description of the invention, which will enable others skilled in the art to which it appertains to make and use the same.

The present invention relates to diaphragms for use in electrolytic processes, and more especially to diaphragms which are to be constructed in the form of vessels or receptacles.

The construction of a serviceable diaphragm for electrolyzing salts, especially when the operation is to be carried out on a large scale, has hitherto been attended with many difficulties, the material used having proved either hard to work or being wanting in durability. Very frequently these diaphragms have to be constructed in the form of vessels surrounding one of the electrodes and containing the electrolyte surrounding the said electrode, the other electrode being arranged externally with respect to this closed system. Where firm and hard porous substances, such as clay, permeable porcelain, and the like are used for the construction of the diaphragms, such construction does not certainly involve any serious impediments or difficulties in itself; but it is generally found that, in addition to other drawbacks, the aforesaid substances have the objectionable feature of offering a very great resistance to the electrical current. Where, on the other hand, thin sheets of soft flexible material or membranes offering little or no resistance to mechanical strains and capable of being easily rent or torn, such as parchment, asbestos fabric, and the like are employed, special arrangements are requisite in order to impart sufficient firmness to the walls of the diaphragm to enable them to withstand safely any differences of pressure that may arise during the electrolytic process, while avoiding the necessity for unduly thick walls or immoderate overlapping of the membrane of porous material, both of which augment the resistance of the diaphragm and at the same time reduce its useful or available area.

When it is desired to construct large diaphragms in the form of vessels of such non-resistant diaphragm material, it is necessary to impart sufficient firmness to the walls of the same. Now it has to be taken into account that, on the one hand, the structural parts employed for this purpose have to be made of substances which are proof against the action of acids and alkalies and are therefore, for the most part, rather difficult to work into shape, and that, on the other hand, it is desirable to avoid, so far as practicable, the subdivision of such structural parts into sections, and the necessity, consequent thereon, of providing packing or means for tightly closing the joints.

The improved construction of a diaphragm according to this invention, as hereinafter described and illustrated by the accompanying drawings, affords a practical and convenient means for meeting the requirements hereinbefore stated.

According to this invention the diaphragm material is inclosed within two frames combined therewith in a peculiar manner, which, in addition to rendering the whole arrangement extremely simple and easily controllable, has the advantage of facilitating the firm and reliable locking or securing in position of the walls of the diaphragm.

Another advantage of the improved construction is that it requires but few simple molded pieces and consequently presents but few joints requiring to be packed, the said

pieces permitting of being readily manufactured in great quantities.

On the annexed sheet of drawings, Figures 1 to 4 show several modes of supporting the diaphragm. Fig. 1[a] is a section through and a view from below of a portion of a diaphragm vessel, the diaphragm being supported as indicated in Fig. 1. Fig. 2[a] is a similar section and view of a portion of a diaphragm vessel, the diaphragm being held and steadied as shown in Fig. 2. Fig. 3[a] is a similar section and view of a portion of a diaphragm vessel, the diaphragm being maintained as represented in Fig. 3. Fig. 4[a] is a similar section and view of a portion of a diaphragm vessel, the diaphragm being steadied as indicated in Fig. 4. Fig. 5 is an isometric view of a complete diaphragm vessel placed vertically. Fig. 6 is a similar view of a compound diaphragm vessel. Fig. 7 is a similar view of a diaphragm vessel placed horizontally and open at the top, while the side with which it is placed is made solid.

The diaphragm *c*, consisting of a permeable membrane, (parchment, glass-wool, asbestos card or the like,) is steadied by being compressed between two series of parallel laths, bars or rods *a b* of acid-proof material, such as glass, porcelain or the like, which laths, bars or rods may be arranged opposite each other in such a manner as to either coincide on the same lines, respectively, as shown in Fig. 1, or so as to break joint with each other, each lath, bar or rod on one side being placed about half-way between a pair of laths, bars or rods on the other side, as illustrated in Fig. 2; or they may be arranged all in the same plane, in which case the material of the diaphragm will have, as it were, to undulate through them, as shown in Fig. 3, or, again, the laths, bars or rods may be at right angles to each other, as shown in Fig. 4.

By combining a number of sheets of diaphragm material thus inclosed between laths, bars or rods a box or receptacle may be constructed, the shape or disposition of the parts of which will of course depend on requirements and the material used in its construction. Considering the little power of resistance of such diaphragms, the safety and reliability of the operation almost entirely depend upon the secure position of the lattice-work or framework, which, once put in place and properly adjusted, should remain firmly in position. To attain this result, the laths, bars or rods are all jointly secured to two end or edge frames *d d'*, Fig. 5, one of which is to form the upper edge of the diaphragm or receptacle, while the other surrounds its bottom, or itself constitutes the bottom plate. The upper edge frame may be constructed so as to constitute a lid or cover, if desired.

One of the main peculiarities of this improved arrangement is that it does not require a special frame for each side of the vessel, the said frame lying in the plane of the side, but that the whole of the laths, bars or rods being retained in position by one pair of frames *d d'*, which, for this purpose, are arranged at right angles to the said laths, bars or rods. These frames therefore do not, properly speaking, inclose the lattices, but rather constitute a directrix for the arrangement of the said laths, bars or rods. With this mode of construction, the shape of the diaphragm or receptacle is determined by the form of the frames *d d'*, or, in other words, the frames *d d'* have to conform to the shape to be given to the diaphragm or receptacle. For instance, for diaphragms in the form of rectangular vessels, rectangular frames *d d'*, and for diaphragms in the form of oval or round vessels, oval or round frames *d d'* are to be used.

For the purpose of enabling the laths, bars or rods to be properly secured to the frames *d d'*, the said frames are provided at their edges with series of indentations or notches *e*, Figs. 1[a], 2[a], 3[a], and 4[a]. Into these indentations or notches the inner laths, bars or rods *b* (see same figures) are fitted, so that a species of cage is formed. The permeable or porous material *c* is tightly stretched around this cage and then is surrounded by another outer casing of similar lattice-work, formed of laths, bars or rods *a*, retained in position by india-rubber rings *f*, or by wire wound round them, or by any other suitable means to tightly press the said laths, bars or rods *a* against the diaphragm *c*, as shown in Figs. 1[a], 2[a], 3[a], 4[a], and 5. In the case of the inner rods *b* being placed horizontally, corner-posts *d** are to be arranged reaching from one end frame to the other and having notches or indentations *e** for the ends of said bars to be placed in.

In order to still further increase the stability of the structure, the upper frame *d* may be connected by a number of supports with the lower frame *d'* or the bottom plate.

For extensive plants diaphragm vessels are frequently required of such a size that one single membrane or diaphragm is not sufficient to form the walls, or that the exceptional length of the laths, bars or rods forming the supports or lattice-work would not be sufficiently secure. In these cases the novel structural arrangement offers the additional advantage of enabling a number or series of systems of frames to be combined together by means of an intermediate frame or intermediate frames, such as $d^2$ $d^3$, of a similar nature to those above and below, Fig. 6.

The diaphragms or receptacles may be arranged either vertically or horizontally, as desired. Moreover, according to the purpose for which they are intended one side or more sides may be left open, *i. e.*, have no diaphragm-wall in them, or such side or sides may be closed by a wall of solid material.

Fig. 7 represents a diaphragm of this description arranged for use in the horizontal position. One side thereof (the top side) is open, as shown at *g*, and serves the same purpose as the upper opening or orifice of the

vertical arrangement, while the side opposite to this opening, having to bear the pressure of the liquid which the diaphragm contains, is made solid and forms the bottom or base-plate *h*. In cases where a number of such diaphragms are to be arranged in juxtaposition the adjacent sides may be left open or they may be closed either by a solid wall or by a pervious wall.

What we claim as our invention is—

1. An electrolytic diaphragm in the form of a vessel constructed with a series of inner steadying laths bars or rods *b*, a permeable membrane *c* placed against said inner series, a series of outer steadying laths, bars or rods *a* placed against said membrane, and two parallel end frames *d d'* for supporting the inner system of laths, bars or rods, substantially as described.

2. A diaphragm in the form of a vessel such having the laths, bars or rods constituting the inner frame or lattice, fitted in indentations or notches provided for their reception in the frames *d d'*, while the laths, bars or rods constituting the outer frame or lattice are securely fastened to, and pressed against end frames and the membrane interposed between them, by means of devices such as india-rubber rings, bands or wires such as *f* substantially as described.

3. An electrolytic diaphragm in the form of a vessel constructed with a series of inner steadying laths, bars or rods *b*, a permeable membrane *c* placed against said inner series, a series of outer steadying laths bars or rods *a* placed against said membrane, two parallel end frames *d d'*, and intermediate frames such as $d^2$ for the purpose of increasing the stability of the diaphragm, substantially as described.

In testimony whereof we have hereunto set our hands in the presence of two subscribing witnesses.

MARTIN KILIANI.
WALTHER RATHENAU.
CARL SUTER.

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F. GIRARD.
Witnesses as to Walther Rathenau:
MAX ROSENKRANS,
A. HERRMAN.
Witnesses as to Carl Suter:
CHAS. H. DAY,
W. HAUPT.