(No Model.) 2 Sheets—Sheet 1.

G. KERNER & J. MARX.

DIAPHRAGM FOR ELECTROLYTIC APPARATUS.

No. 410,976. Patented Sept. 10, 1889.

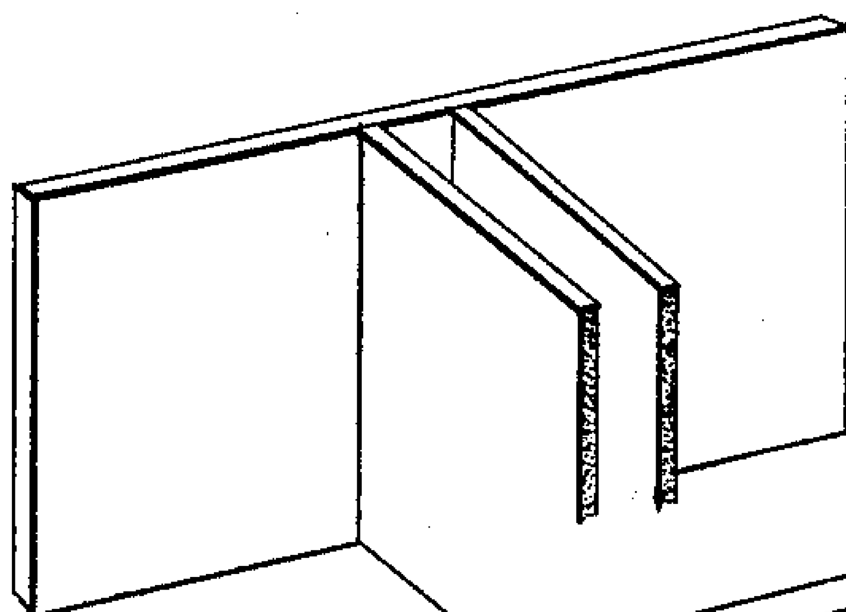

Fig. 1.

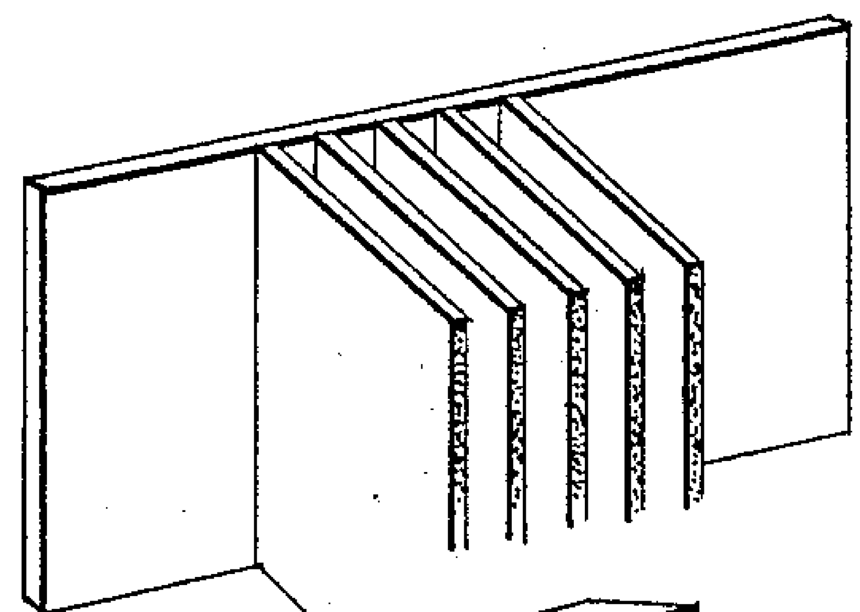

Fig. 2.

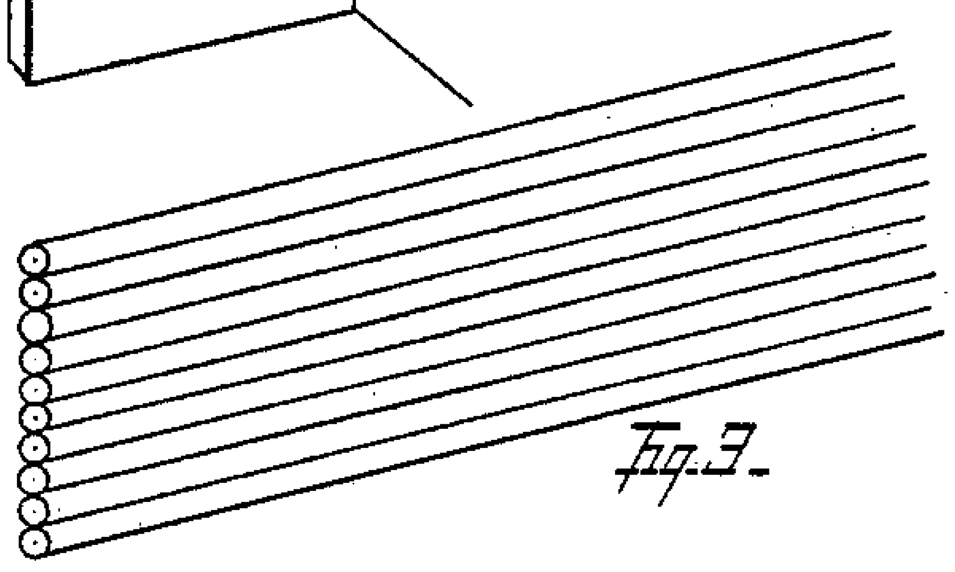

Fig. 3.

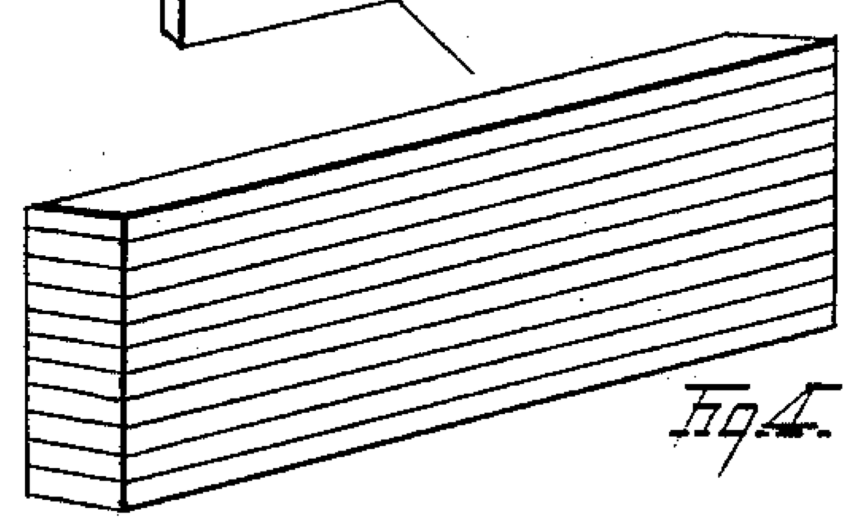

Fig. 4.

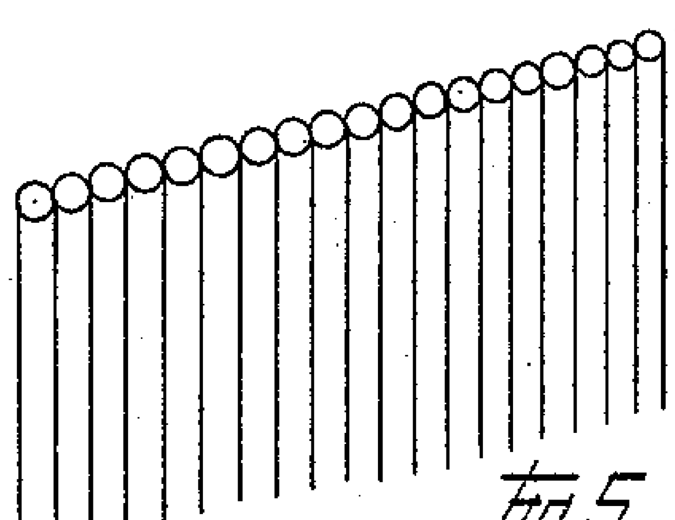

Fig. 5.

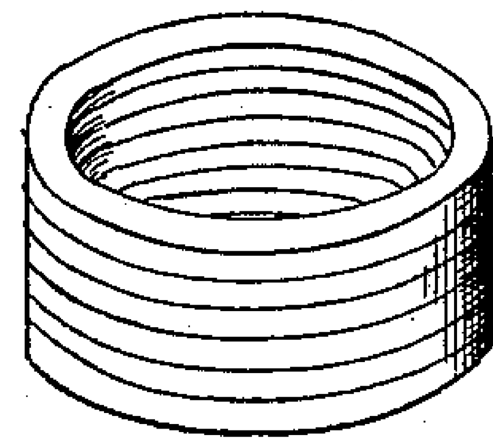

Fig. 7.

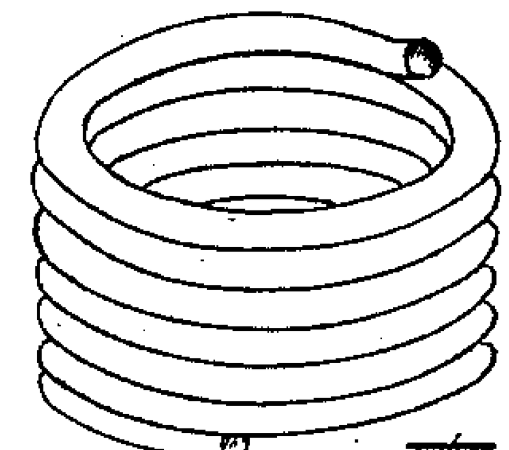

Fig. 8.

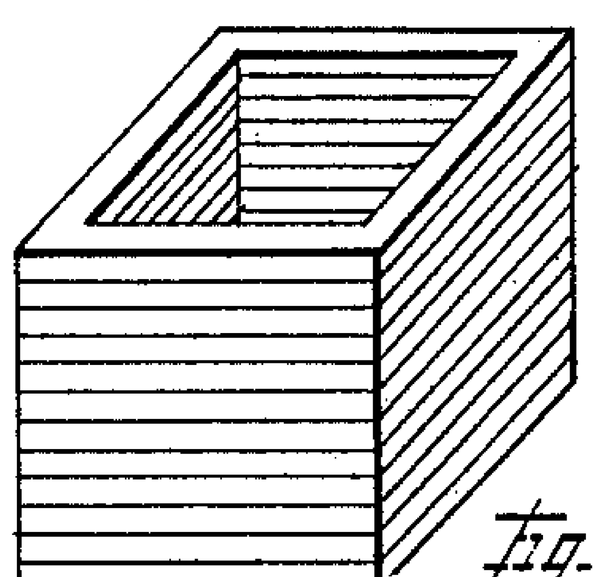

Fig. 9.

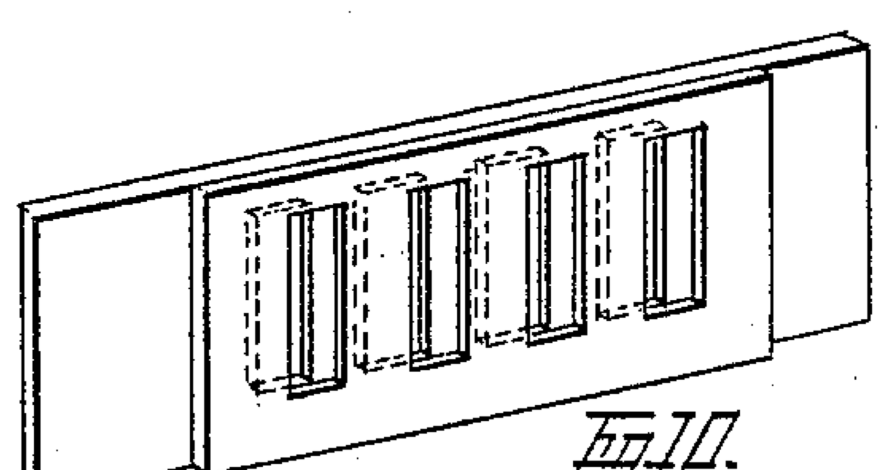

Fig. 10.

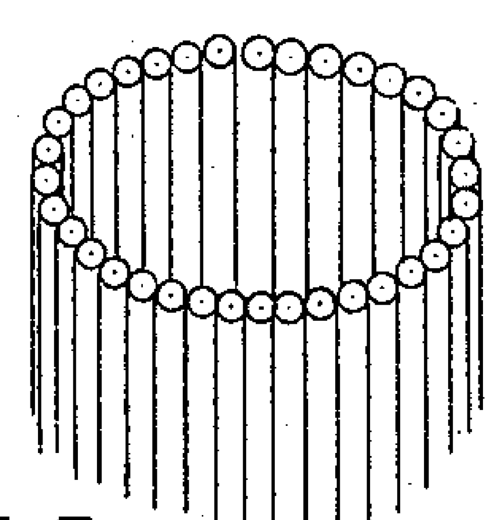

Fig. 6.

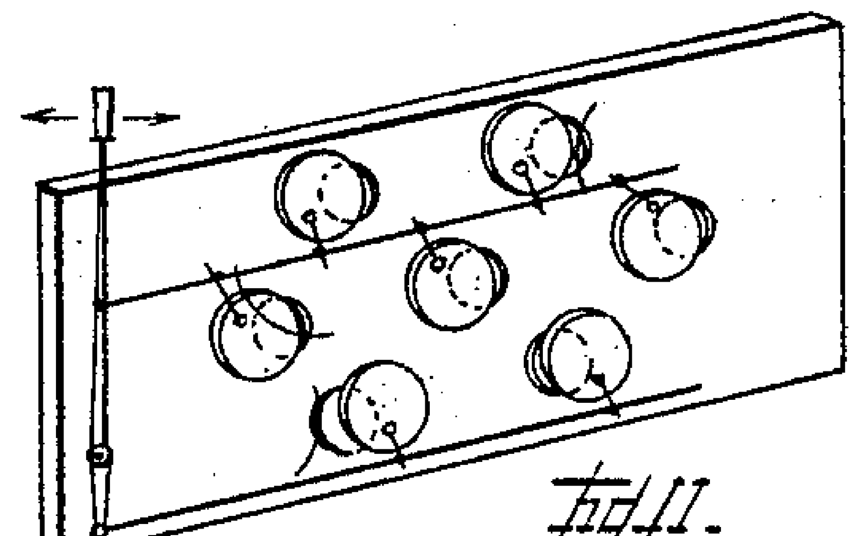

Fig. 11.

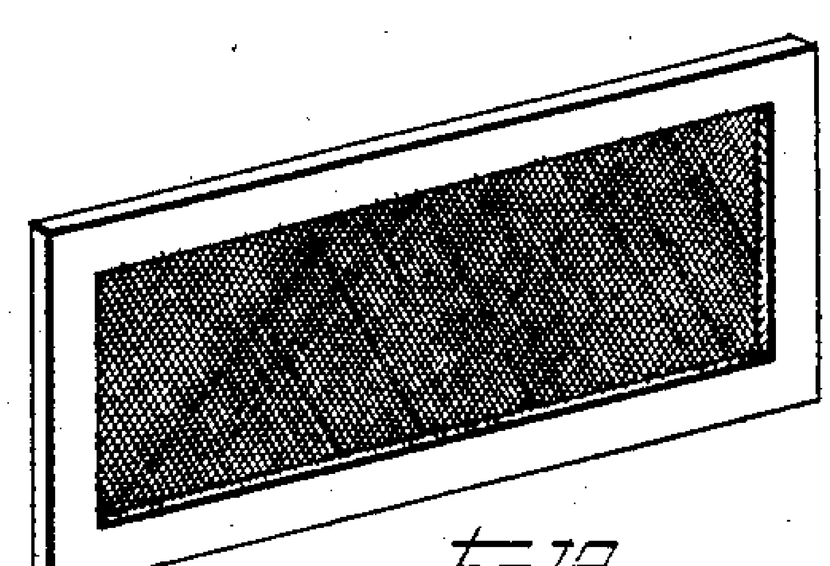

Fig. 12.

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(No Model.) 2 Sheets—Sheet 2.

G. KERNER & J. MARX.

DIAPHRAGM FOR ELECTROLYTIC APPARATUS.

No. 410,976. Patented Sept. 10, 1889.

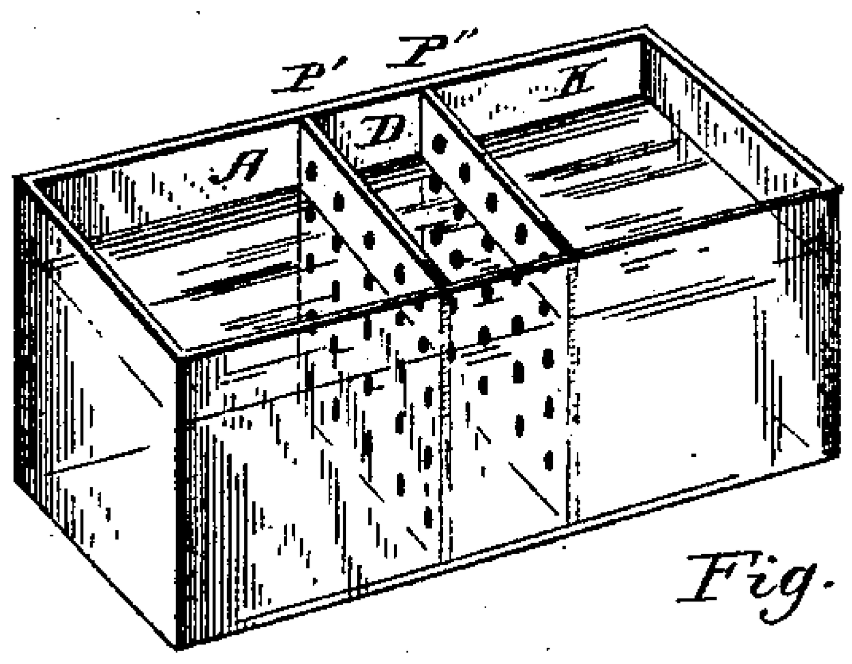


Fig. 1ª

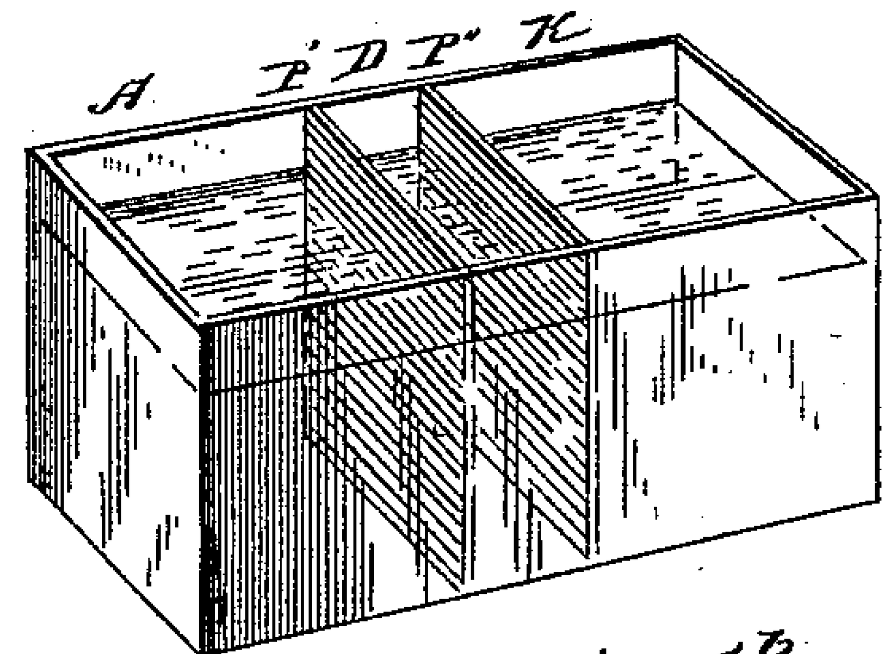


Fig. 1ᵇ

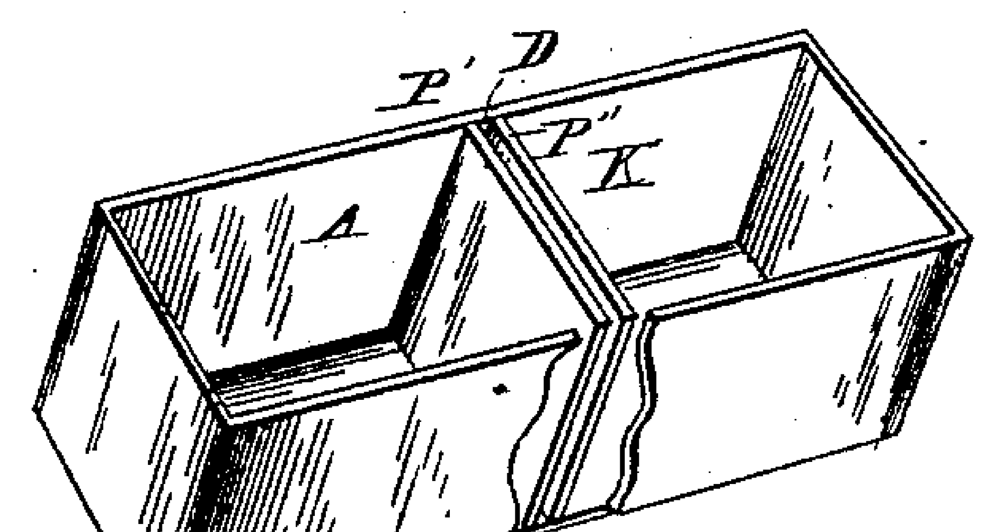


Fig. 14.

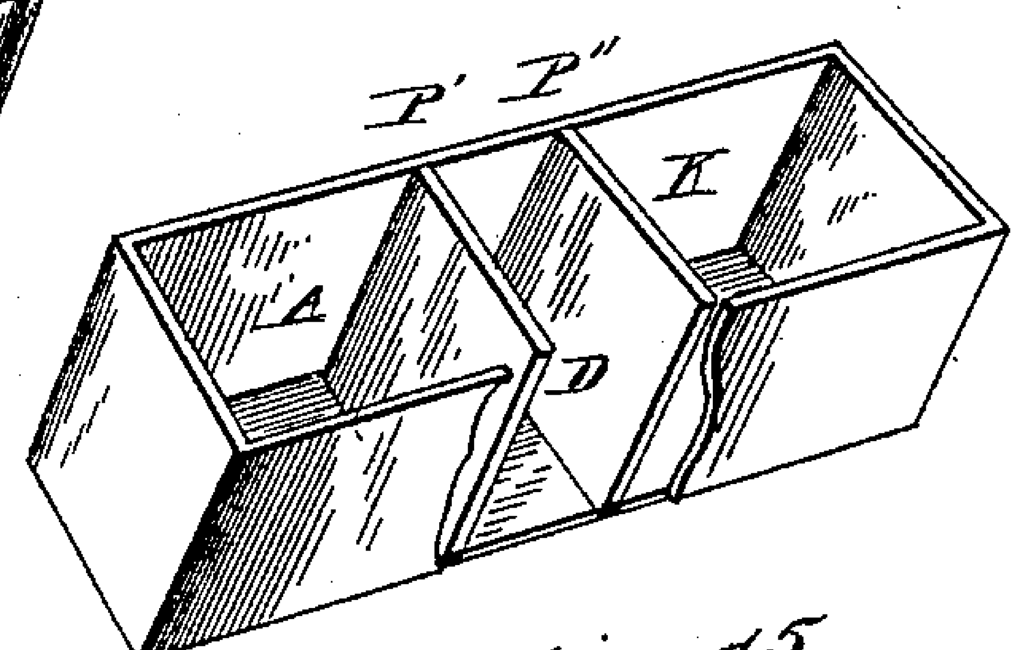


Fig. 15

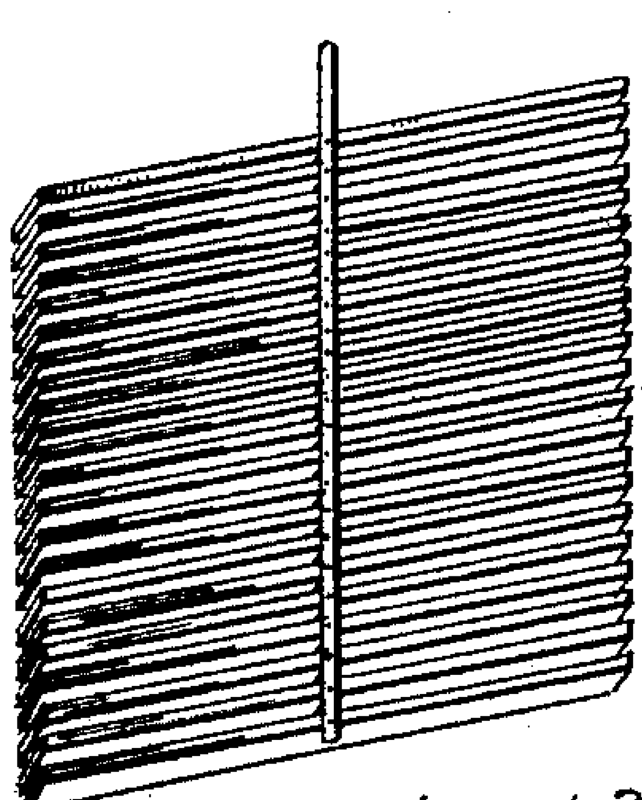


Fig. 13.

Fig. 16

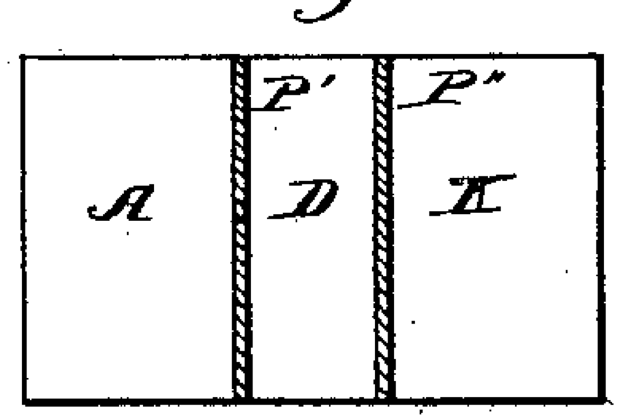
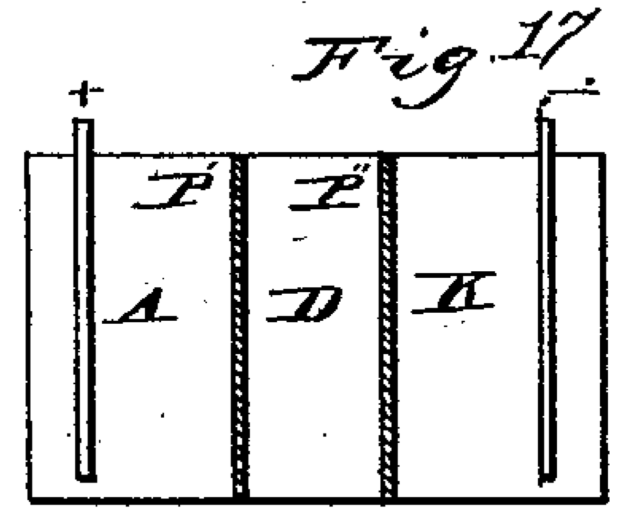


Fig. 17.



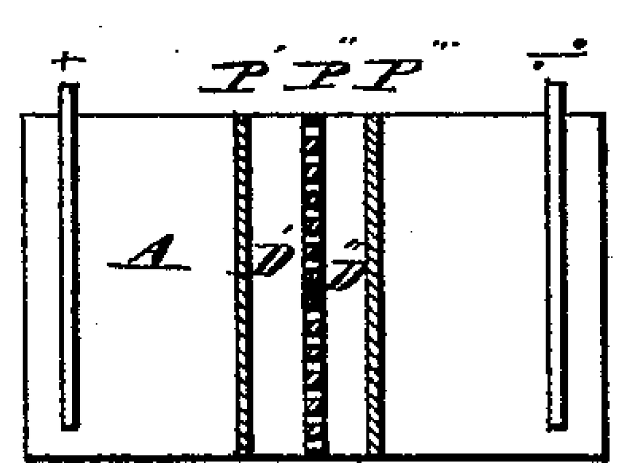


Fig. 18.

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George Kerner & Julius Marx,
Inventors

By their Attorney
Robert B. Brown

UNITED STATES PATENT OFFICE.

GEORG KERNER, OF FRANKFORT-ON-THE-MAIN, PRUSSIA, AND JULIUS MARX, OF ULM-ON-THE-DANUBE, WÜRTEMBERG, GERMANY.

DIAPHRAGM FOR ELECTROLYTIC APPARATUS.

SPECIFICATION forming part of Letters Patent No. 410,976, dated September 10, 1889.

Application filed January 9, 1889. Serial No. 295,903. (No model.) Patented in France December 14, 1887, No. 187,606; in Italy June 19, 1888, XXII, 23,169, XLVI, 191, and in Belgium July 4, 1888.

To all whom it may concern:

Be it known that we, GEORG KERNER, a subject of the King of Prussia, and JULIUS MARX, a subject of the King of Würtemberg, the first residing at Frankfort-on-the-Main, Prussia, and the second at Ulm-on-the-Danube, Würtemburg, Germany, have invented new and useful Improvements in Diaphragms for Electrolytic Apparatus, (for which we have obtained patents in France December 14, 1887, No. 187,606; in Italy June 19, 1888, XXII, 23,169, XLVI, 191, and in Belgium July 4, 1888,) of which the following is a specification.

The present invention relates to the employment of new or improved diaphragms or septa, hereinafter described, to be employed in substitution for the diaphragms or septa heretofore used for the osmotical separation of liquids or solutions.

We are well aware of the fact that usually porous plates or vessels are used for the purpose, which are made out of different materials with pores or spiracles of a more or less microscopical character and being imperfectly permeable.

Figures 1ᵃ and 1ᵇ indicate different forms of diaphragms in place in a tank. Figs. 1 to 13 indicate various forms of partitions which serve to inclose the liquid forming the diaphragm. Figs. 14 and 15 are isometric views of the vessel and partitions. Fig. 16 shows the vessel 15 in section. Figs. 17 and 18 show the vessel provided with electrodes.

In opposition to the present theory that the osmotical action was dependent upon the porosity of these organic or inorganic membranes or septa, we found that liquid bodies replace advantageously in many cases the solid bodies hitherto used, especially in electrolytic work, where the resistance of the cell may thereby be very greatly reduced, and, furthermore, in osmotic work, when the diaphragm itself may be used for chemical reactions. We found that theoretically the only condition to be attended to when employing liquids as diaphragms is to maintain that part of the liquid which it is intended to use for the osmotic separation in the same position. If it were practically possible to keep the different parts of the liquid perfectly immovable, they would only intermingle slowly. It is well known that this is not possible, and that on the contrary the unavoidable mechanical shocks and the molecular and chemical actions always bring about movement to effect a rather rapid intermixture. It is only to prevent this kind of intermixture and not to cause osmosis that a certain kind of partition is to be provided for; but this partition should not cause such a real interruption as the usual porous solid diaphragms with their more or less microscopical spiracles would do, or else all the advantages of our new liquid diaphragms would be lost. It is evident that the usual diaphragms must cause a real interruption. For these the osmose must be effected by the diaphragm itself. On the contrary, with ours the osmose is transmitted by the liquid inclosed between these partitions, of which at least two must be provided for; but, if necessary, as many may be applied as desired. Therefore practically we get four conditions of our new liquid diaphragms, viz: First, two partitions at least must be applied to keep the part or parts of liquid serving as diaphragms in their position; second, the partition used to keep the part or parts of liquid serving as diaphragm in their position must not be of such a small permeability as usual solid diaphragms are; third, the part or parts of liquid serving as diaphragm must not be in the same state as the endosmotical and exosmotical liquids; fourth, the part or parts of the liquid serving as diaphragm must not partake of the electrolytical action.

Having thus laid down the principle of our invention, we now describe some of the easiest means to execute it for practical purposes. These means naturally must correspond to the four conditions just mentioned, and the liquid which serves as diaphragm must keep a certain degree of chemical and osmotical neutrality, (or, in other words, must not be in the same state as the osmotical and endosmotical liquids;) otherwise, as will be clear, it would be deteriorated by the diffusion which must take place. It is constantly or at intervals renewed, which is best effected either by passing a fresh solution of its original contents slowly through it, or water or other suitable liquid which is mixable with the solution on both sides. In electrolysis, instead of water, the saline solution to be electrolyzed is preferably passed slowly through the diaphragm. The passage of water, or other liquid which serves to restore the diaphragm or to maintain it in its original condition, is regulated in such a way as to compensate the deterioration of the liquid diaphragm, which would otherwise occur, because of the slow diffusion from the liquids on both sides. For example, a simple square vessel is to be divided by a liquid diaphragm. In order to do this, a part of the liquid is to be separated from the rest by partitions where the division is to take place. Figs. 1^a and 1^b (see diagram) show such a vessel. In A is the endosmotical liquid, in K is the exosmotical liquid, and in D is the diaphragmatical liquid. The partitions p' and p'' are but accessories, (in Fig. 1^a perforated plates, and in Fig. 1^b superjoined rods or tubes.) The main part of the whole is liquid D, which forms the liquid part or liquid body which transmits the osmotical action from A to K. If it is intended to employ electrolysis, A is to be fitted with the anode, K with the cathode, and D is only the diaphragm which permits of the passage of the current. Now the only object of the partitions p' and p'' is to keep the part of the liquid or liquid body D in place and to prevent it from a too rapid intermingling with A and D, and to prevent it from partaking of the electrolytical action. Therefore these partitions may have comparatively large openings, and thus may be made from a foraminous substance or any foraminous system of substances, provided they are not attacked by the chemical actions going on. The form, shape and material of partitions are thus quite indifferent; but there must be two of them at least. The main condition is that the liquid layer D remains in its proper state, as is described. Thus the accessory partitions, which at least must be two, may have the form of plates with holes or slits, as in Figs. 1 and 2, or may be built up by rods or tubes, as in Fig. 3, or straps or shelves, as in Fig. 4, which are superposed on each other; or the rods or the like may be placed side by side, as in Fig. 5, or in a circular form, as in Fig. 6. Then it is easy to make the vessels of any form—round ones, Fig. 6, elliptical ones, or multiangular ones; also, by superposing rings or frames, Fig. 7 or 9, or by winding a coil or helix round a model of the form which it is desired to obtain. Fig. 8 shows a round form. These superposed or juxtaposed rods and the like offer the advantage that the openings may be increased or reduced at will, which also may be done by mechanical devices such as are shown in Figs. 10, 11, and 13. The partitions may also be made by network, knitting-work, or brush-like arrangements, as in Fig. 12. As we have already mentioned, the manufacture or shape of these solid partitions is dependent upon no condition except that the openings are not such minute ones as those of the usual porous membranes or septa and that there be at least two of them. The salient point is only the liquid body or liquid layer or layers which have been formed by separating a part or parts of the liquid and which are inclosed in a definite space. A very important advantage of these new diaphragms is that their permeability, and thereby their resistance, may be altered and regulated at will. For instance, if the partitions retaining the liquid body which constitutes the diaphragm are put closely together, the resistance is diminished, Fig. 14; if they are put farther asunder, the resistance is increased, Fig. 15, for in the first instance the liquid body—*i. e.*, the active part—becomes thinner, and in the second instance it becomes thicker. We prefer to make these partitions out of many single parts, Figs. 3 and 9. In this case the partitions may be increased or reduced in size at will to adjust them to suit circumstances, and if parts are injured or broken these parts can be replaced, and it will not be necessary to make new partitions. Lastly, such partitions offer the convenience of increasing or decreasing the openings, thereby increasing or decreasing the resistance too, and thus thoroughly adapting the diaphragm for every special purpose. By mechanical devices the above adjustment of any broken or injured part may be done, even during the process. In many cases strips or shelves are well adapted, for they can be placed so as to hinder or accelerate the diffusion. In electrolysis—*e. g.*, in electrolyzing an alkaline chloride—the arrangement may be as in Fig. 17, for then the solution in A becomes lighter and the one in K heavier. Thus the first, against its tendency, has to descend, and the second, against its tendency, has to rise into the liquid diaphragm. Thereby the resistance to diffusion, but not the resistance to the electric current, is increased. This property of our liquid diaphragm is very important, as it enables us at once to have with the same surface small resistance, as the smaller resistance permits the greater amount of work being done by the same current. Of course, instead of one liquid body, two or more, or, in fact, as many as desired, may be employed. Fig. 2 shows an arrangement of four liquid diaphragms. It is obvious that by arranging such series of liquid diaphragms the resistance is increased for each one added; but, on the other hand, some remarkable facilities and advantages are offered thereby. When it is intended to employ the diaphragm for chemical reaction, a different reaction may be caused in each one, and in electrolyzing a series of liquid diaphragms may serve as a regulator. For instance, Fig. 18 shows an electrolytical vessel containing two liquid diaphragms d' and d'', inclosed by the partitions p' p'' p'''. By altering the size and position of the openings of each one it is very easy to either increase or decrease the diffusion, the chemical action, or the electric processes. By means of the preceding examples, we think it clear that the liquid parts inclosed between the partitions, which must be at least two, are the acting parts, and that by altering these the resistance of the diaphragms is regulated, as we have shown, but that these partitions have no action in themselves, but only in the liquid part between, for in themselves they have no osmotical power.

We repeat that we do not claim a new, more suitable solid material, nor do we claim a new, more suitable form or shape to be employed for making the diaphragms hitherto used more effective, as our diaphragms are of quite a new and different kind.

Therefore what we claim, and desire to secure by Letters Patent, is—

In electrolytic apparatus, a diaphragm consisting of a liquid inclosed between two or more partitions having perforations therethrough of considerable size, which are too large to act osmotically by themselves, in contradistinction to diaphragms of porous clay or animal membrane, or similar partitions, as fully set forth and described.

In testimony whereof we have signed our names to this specification in the presence of two subscribing witnesses.

GEORG KERNER.
JULIUS MARX.

Witnesses:
C. W. SCHWARZ,
JACOB MUELLER.