(No Model.) 3 Sheets—Sheet 1.

L. MOND & C. LANGER.

GAS BATTERY.

No. 409,365. Patented Aug. 20, 1889.

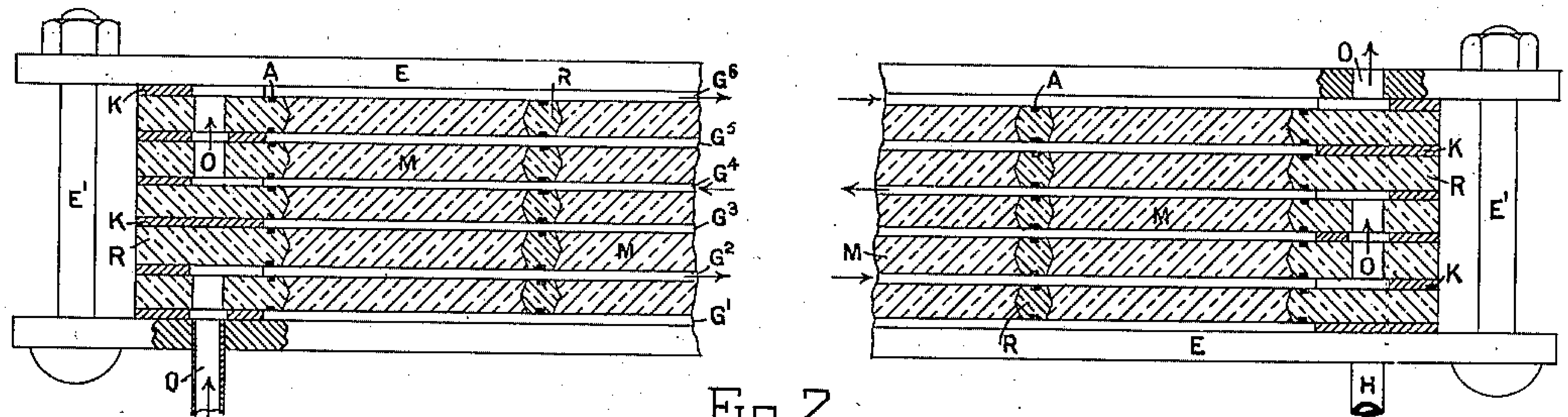

Fig. 2.

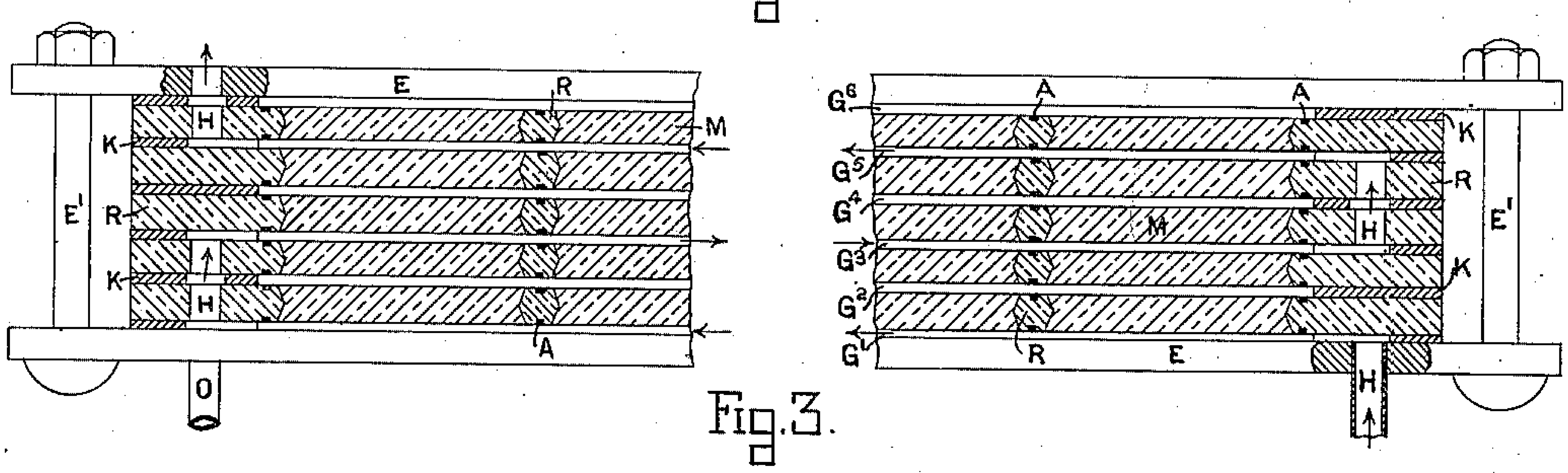

Fig. 3.

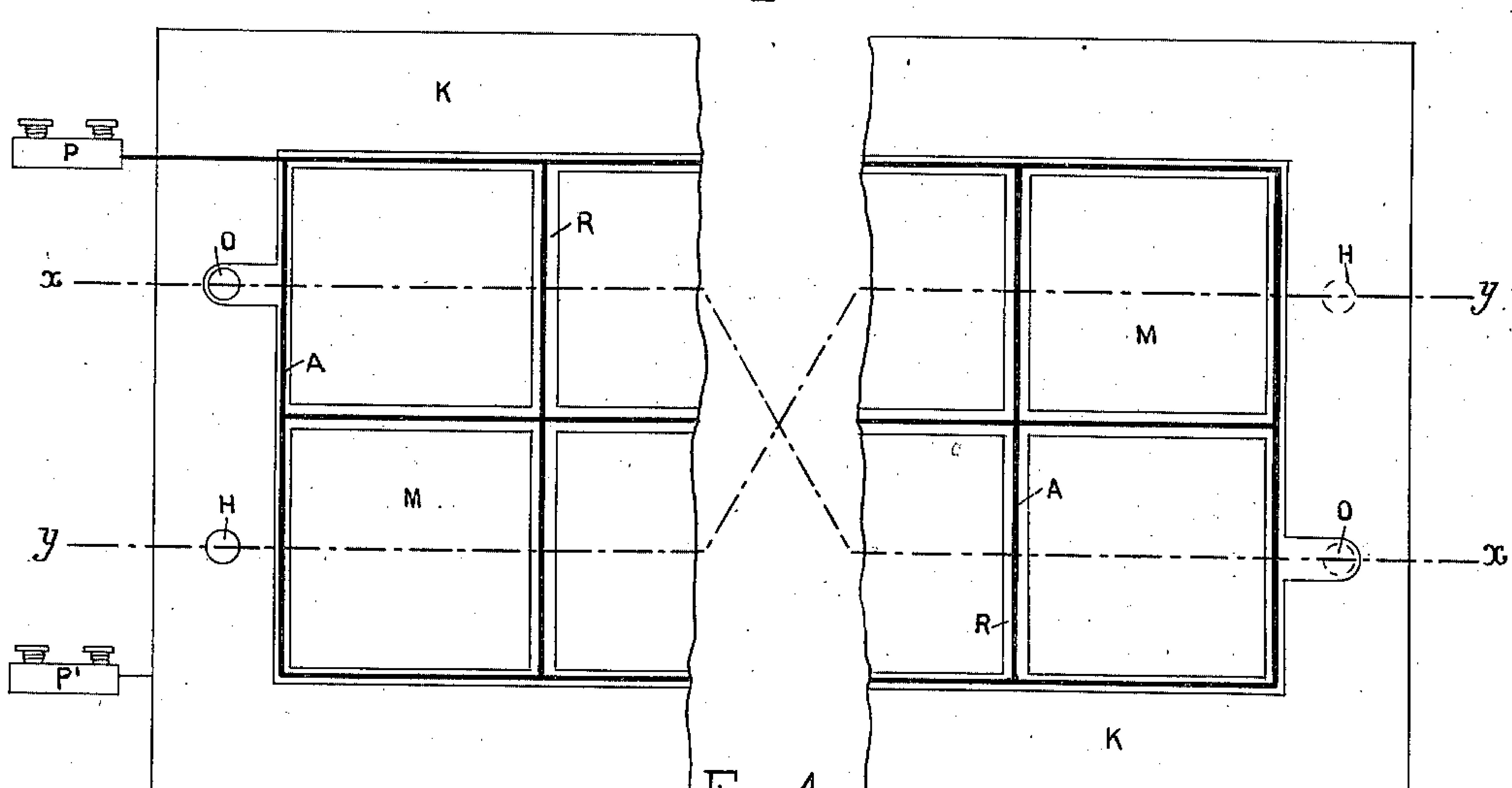

Fig. 4.

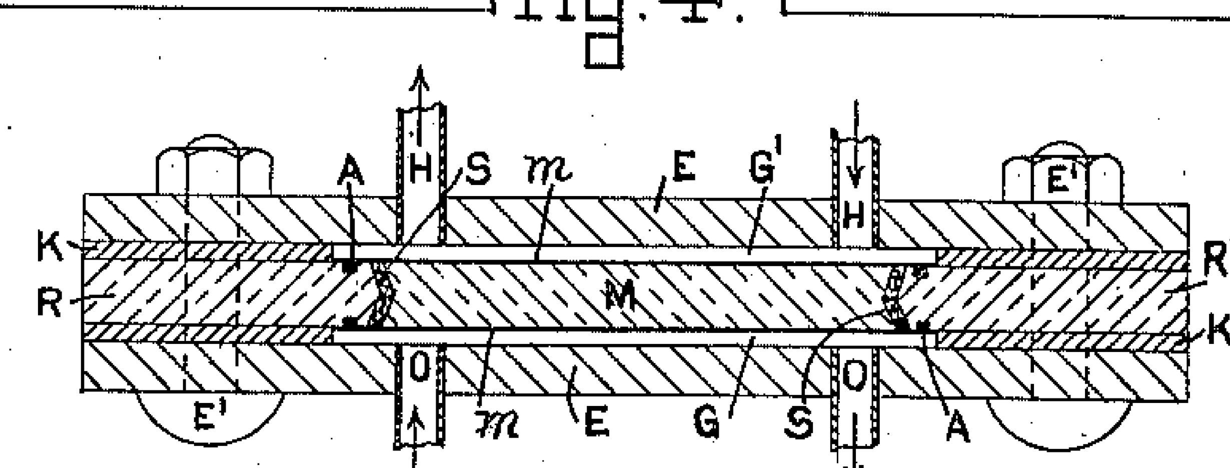

Fig. I.

Witnesses
James F. DuHamel
Horace A. Dodge

Inventors
Ludwig Mond, and
C. Langer,
by Dodger & Sons
Attys.

(No Model.) 3 Sheets—Sheet 2.

L. MOND & C. LANGER.

GAS BATTERY.

No. 409,365. Patented Aug. 20, 1889.

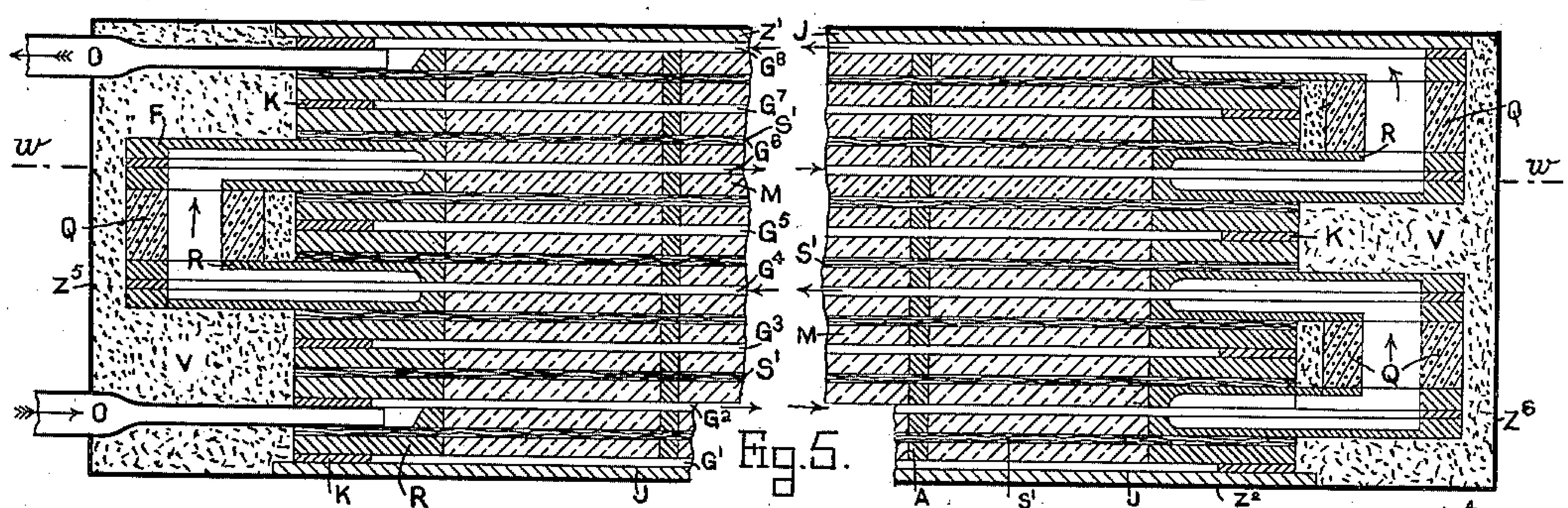

Fig. 5.

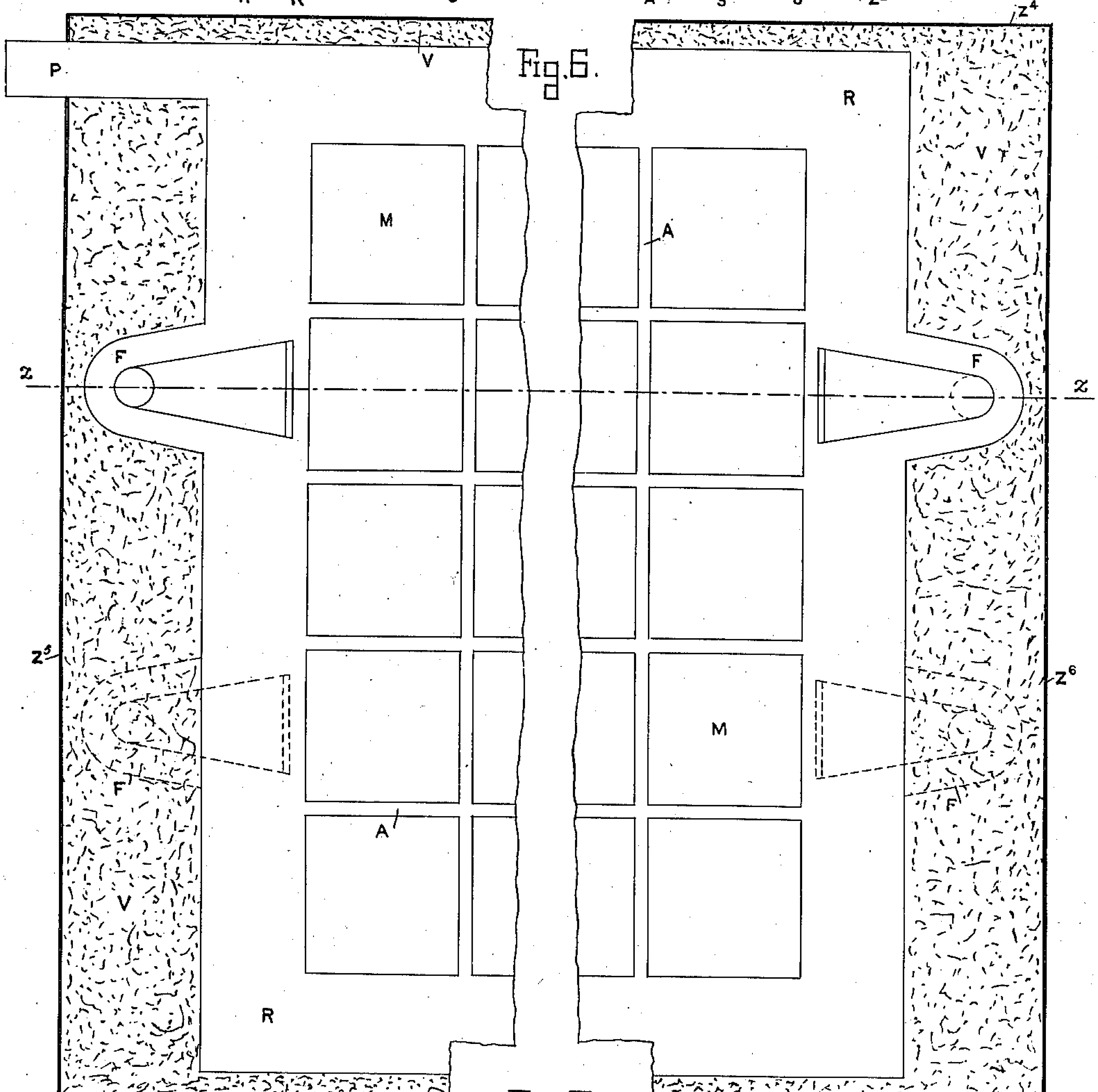

Fig. 6.

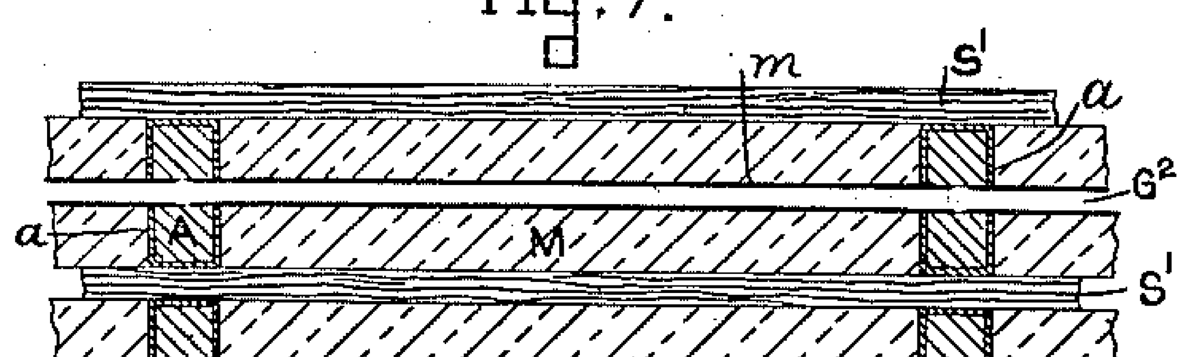

Fig. 7.

Witnesses
James F. DuHamel.
Horace A. Dodge.

Inventors
Ludwig Mond &
Carl Langer,
by Dodge & Sons, Attys.

(No Model.) 3 Sheets—Sheet 3.

L. MOND & C. LANGER.

GAS BATTERY.

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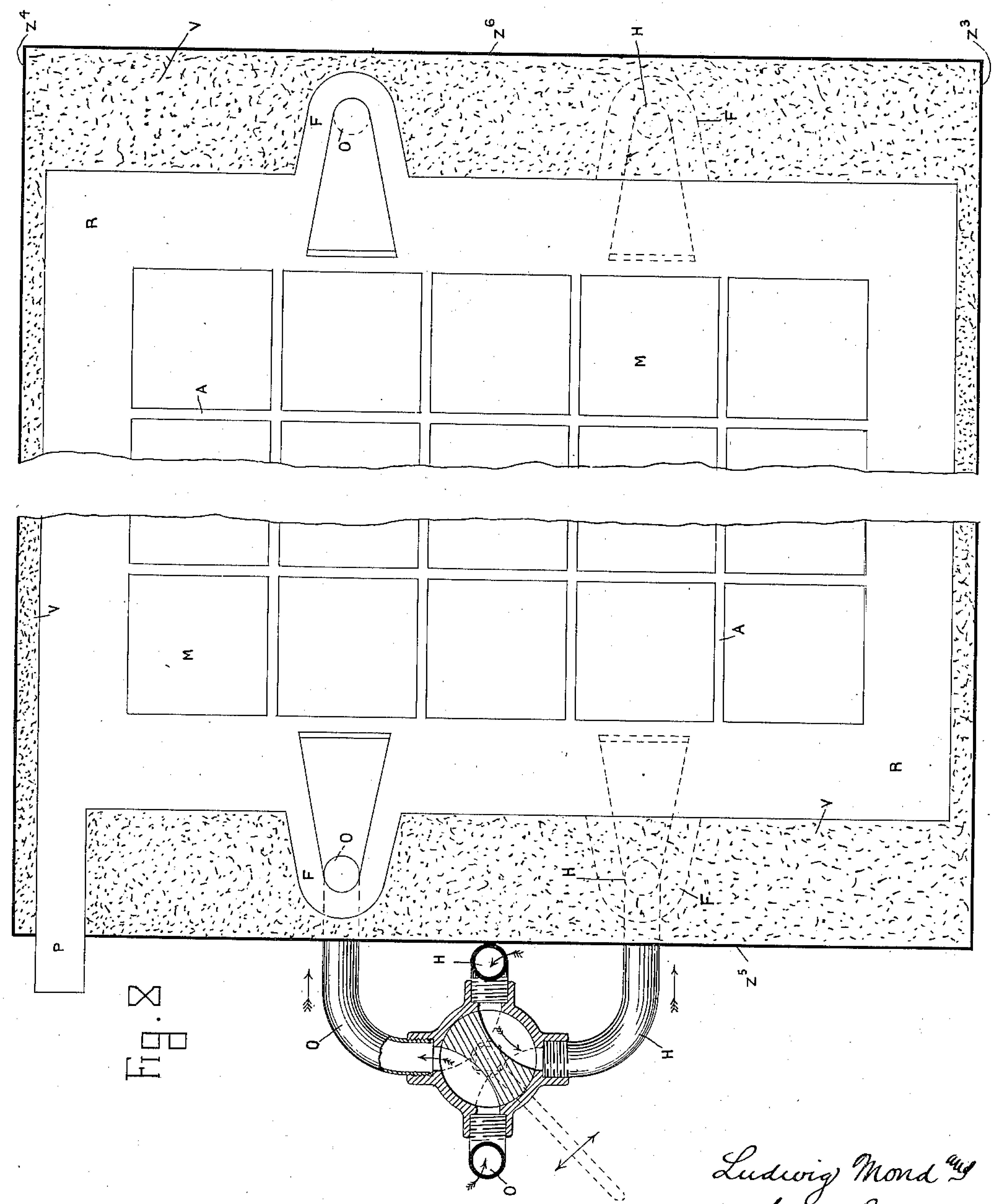


Fig. 8

Witnesses

James F. Duhamel

Horace A. Dodge.

Ludwig Mond and

Carl Langer,

Inventors

by Dodge & Sons,

Attys.

UNITED STATES PATENT OFFICE.

LUDWIG MOND, OF NORTHWICH, COUNTY OF CHESTER, AND CARL LANGER, OF LONDON, COUNTY OF MIDDLESEX, ENGLAND.

GAS-BATTERY.

SPECIFICATION forming part of Letters Patent No. 409,365, dated August 20, 1889.

Application filed November 28, 1888. Serial No. 292,116. (No model.) Patented in England February 17, 1888, No. 2,411; in France October 5, 1888, No. 192,342; in Italy October 13, 1888, XXII, 23,943, XLVII, 225; in Luxemburg November 28, 1888, No. 1,058; in Turkey November 28, 1888, No. 130; in Belgium December 15, 1888, No. 84,102; in New South Wales January 2, 1889, No. 1,152; in Brazil February 1, 1889, No. 665, and in Spain February 12, 1889, No. 8,955.

To all whom it may concern:

Be it known that we, LUDWIG MOND, manufacturing chemist, of Winnington Hall, Northwich, in the county of Chester, and CARL LANGER, Ph. D., of South Hampstead, London, in the county of Middlesex, England, have invented certain new and useful Improvements in an Apparatus for Obtaining Electricity from Gas, (for which we have received Letters Patent as follows, to wit: England, No. 2,411, dated February 17, 1888; France, No. 192,342, dated October 5, 1888; Italy, XXII, 23,943, XLVII, 225, dated October 13, 1888; Luxemburg, No. 1,058, dated November 28, 1888; Turkey, No. 130, dated November 28, 1888; Belgium, No. 84,102, dated December 15, 1888; New South Wales, No. 1,152, dated January 2, 1889; Brazil, No. 665, dated February 1, 1889, and Spain, No. 8,955, dated February 12, 1889,) of which the following is a specification.

Gas-batteries have hitherto been made by bringing two gases capable of chemical action upon each other—such as hydrogen and oxygen—into contact with solid substances which have the power of absorbing or condensing these gases—such as platinum and carbon—and immersing these absorbing substances partly into a liquid electrolyte, which keeps the two gases separated. All these batteries have proved very ineffective and of no practical utility. In the earlier ones, in which the absorbing substance remained stationary in the liquid electrolyte, the active surface was exceedingly small, and consequently the duty done by the battery was insignificant. In the later ones, in which the absorbing substance was alternately exposed to the gas and to the liquid electrolyte by moving either the former or the latter, the absorbing substances became covered by a film of liquid which almost destroyed their power of absorbing gases. In order to overcome both these difficulties, we abandon the use of a simple liquid electrolyte and substitute for it a solid porous substance, which we impregnate by a liquid electrolyte, so that the absorbing substance coming into contact with it remains dry enough to retain its absorbing power for the gases to a sufficient degree. The porous substances used for this purpose must be non-conductors of electricity. They must be unalterable by the other substances with which they come in contact in the battery, and must be impermeable to gases after they have been impregnated with the electrolyte. A great many substances can be used for this purpose, among which we may name paper, pasteboard, infusorial earth, sand, asbestus, clay, leather, linen, flannel, &c. If dry powders are used, we inclose these between diaphragms or in a bag of parchment, paper, or other suitable substance. We have, however, found plates of porous earthenware and plates of plaster-of-paris to be the most handy. These porous substances we bring in contact with a substance or a mixture of several substances which have the power of absorbing or condensing the gases to be employed. For this purpose the metals of the platinum group, (platinum, palladium, iridium, osmium, rhodium, ruthenium,) more particularly in the form of a fine powder—such as platinum-black—are pre-eminently suitable; but other substances may be used, among which we may name finely-divided carbon. These absorbing substances are relatively bad conductors of electricity, and, in order to reduce the internal resistance of the battery as far as possible, we bring them into frequent contact with a good conductor to carry away the electricity formed. This conductor must be in intimate contact with the absorbing substance; but it must neither prevent the free access of the gas to it nor the contact of the absorbing substance with the electrolyte, and it must also be unalterable by the substances used or produced in the battery. We find very thin platinum or gold foil or leaf perforated by very numerous and very small holes, or very fine platinum or gold wire-gauze most suitable for this purpose. This metallic foil leaf or gauze we apply over the whole surface of the absorbing substance, or we apply the foil leaf or gauze to the surface of the porous substance, and put the absorbing substance on the outside of it in such a way that it fills up the holes or open spaces in the foil or gauze, and thus comes in contact with the porous substance, or we may put the absorbing substance on both sides of the foil or gauze, or coat the foil or gauze with platinum-black or its equivalent electrolitically. The metallic foil or gauze is connected by convenient means to the poles of the battery. We thus obtain plates or vessels, which are fixed in gas-tight chambers provided with proper means of egress and ingress for the gases to be employed. If gases are used in such a battery—such as hydrogen or oxygen, which, by their chemical union, produce a liquid—the action of the battery would gradually decrease on account of the liquid formed soaking the absorbing substance employed. To avoid this, we employ one or both of the gases dry or hot, so that they are capable of evaporating and taking up the water or other liquid formed and pass the gases through the battery in sufficient quantity to carry off in this way in the form of vapor all the liquid produced in the battery. The gases, after having been deprived of the vapor so taken up by drying or cooling, may be returned to the battery. When we employ hydrogen and atmospheric air, we find that all the water formed can be removed by simply passing an excess of air through the battery without previously drying or heating it, the heat produced in the battery itself assisting in carrying the water from it.

We will now proceed to describe several ways for carrying out our invention, reference being had to the accompanying drawings, in which—

Figure 1 is a section of a very small battery consisting of a single plate, and illustrates the manner of constructing the plates. Figs. 2, 3, and 4 show a convenient form of construction for a battery of small or moderate size, Figs. 2 and 3 being respectively sections on lines *x x* and *y y*, Fig. 4, and Fig. 4 being a plan with the top covering-plate removed. Figs. 5, 6, and 7 illustrate a convenient form of construction for a large battery, Fig. 5 being a section on line *z z*, Fig. 6, Fig. 6 a sectional plan on line *w w*, Fig. 5, and Fig. 7 an enlarged section of a portion of the battery, illustrating the method of forming the plates thereof. Fig. 8 is the same battery shown in Figs. 5, 6, and 7, but with the addition to it of an appliance for use in changing the gas from time to time to counteract the polarization, as hereinafter described. Figs. 2 to 6, inclusive, and Fig. 8 are broken away in the center to avoid repetition in the drawings.

Referring to Figs. 1 to 4 for batteries of small or moderate size, we fix the porous plates M, mentioned above—say thin plates of earthenware or plaster-of-paris—in a frame R, composed of a material non-conducting and impermeable to the gases—such as ebonite—by means of a suitable cement S—such as sealing-wax. This frame is provided on both sides, all round the porous plates, with narrow metallic conducting-strips A, which are joined to the poles P P′ of the battery. We form these conducting-strips by providing the frame of ebonite all round porous plates at a distance of about two millimeters from these plates with grooves, which we fill with an easily-fusible alloy, with a hard-setting amalgam, or with metallic wires or strips fixed in these grooves. We employ the porous substance in small plates of square shape, of about three to five centimeters each side, and in case the surface of one porous plate is not sufficient to generate the required strength of current we cement several of them in the same frame of ebonite, as shown in Fig. 4. Then the porous plates are impregnated by a liquid electrolyte, (such as dilute sulphuric acid,) and afterward they are covered on both sides with platinum or gold-foil *m*, Fig 1, which projects beyond the plates in such a way that it is in metallic connection with the conducting-strips A—that is to say, that the foil covers the strips. To insure that the metallic contact between the foil and the conducting-strips does not suffer from the oxidation of these latter, we coat the foil in the places where it covers the strips with fused paraffine or a suitable varnish. The very fine metallic foil used contains already many small pores or holes, and can be applied as it is; but it is advantageous to perforate it with a very large number of very small holes, which can easily be done by mechanical means. The metallic foil is put upon the porous plates and made to adhere to them by gently rubbing over its surface, protected by a sheet of paper. Then the foil is covered with the absorbing substance, by preference with the platinum-black obtained by the reduction of chloride of platinum in dilute alkaline solution by means of formic acid. We find a quantity of two-tenths of a gram per square decimeter of surface to give a good result. This platinum-black we form into a paste with diluted sulphuric acid, and we apply this paste with a brush upon the metallic foil. Part of the platinum-black penetrates through the holes of the foil and is brought into contact with the porous plate, while part of it remains on the outside of the foil, where it is rapidly dried and kept dry by the gases passing through the battery, and consequently exerts upon the gases a very strong power of absorption. Between the plates thus prepared we place frames K, of india-rubber, or of another suitable substance, of the same dimensions in breadth and length as the frames R of the ebonite, so as to form narrow and gas-tight chambers G G′ G², &c., between the frames of ebonite, which may be arranged one above the other, as in Figs. 2

and 3, or side by side in such a way that after pressing them together with end plates E E of a stiff material and screws E′ we obtain between every two of the ebonite plates gas-tight chambers G′ G^2 G^3, &c. These chambers are put in communication with the gas-conducting tubes and with one another by connections O H, which allow of hydrogen or its equivalent to be passed through the chambers G′ G^3 G^5, &c., and air or its equivalent through the chambers G^2 G^4 G^6, &c. Each plate forms an element of the battery, which can be combined at will with the others.

Referring to Figs. 5, 6, and 7, for the construction of large batteries, we cast frames of a suitable metal, (for example, an alloy of lead and antimony,) consisting of a broad edge R R, conducting-strips A, and flaps F, with the holes and channels O H, which form the inlets and outlets for the gases to the gas-chambers G′ G^2 G^3, &c., or we cut such frames from a metallic plate of a suitable metal. The places which later will be in contact with the electrolyte are covered with an insulating-layer *a*, Fig. 7, impermeable to and unattackable by the electrolyte, (for example, a mixture of beeswax and resin or gutta-percha.) Between two such frames we insert a thin sheet S′, of porous material, prepared by coating a piece of canvas or paper, or other suitable substance, of the full size of the frames, with plaster-of-paris or its substitute on both sides and made impervious round the edges by impregnating it with a mixture of beeswax and resin, or other suitable insulating substance. We then fill the free spaces M in the squares formed by the conducting-strips with a porous substance—say plaster-of-paris—in such a way as to obtain a plate even on the outside. These plates are then covered with the conducting and absorbing substances *m*, Fig. 7, in the same way as before described, and are united in a battery with the interposition of frames K, of india-rubber, pasteboard, or other suitable substance, so as to form the gas-chambers G.

Fig. 5 shows a transverse section (on line *z z*, Fig. 6) of a battery of seven plates, and also the method of connecting the gas-chambers with each other. The communications between these chambers are made by cork or rubber washers or hollow cylinders Q. The first and last gas-chambers are formed by placing a plate J, of pasteboard or other non-conducting material, at each side of the battery. The whole battery is now placed between two metallic plates L′ L^2, Fig. 5—say of zinc—which project a certain distance beyond the plates forming the battery. All the visible parts of the frames not covered by these two zinc plates L′ L^2 are now well coated with a mixture of beeswax and resin or other suitable varnish, and the space V left between the two zinc plates is then filled up with plaster-of-paris, so as to obtain a solid block with even surfaces. After the plaster-of-paris has been allowed to set and dry, we cover it with the zinc plates L^3 L^4 L^5 L^6, and solder all the zinc plates together, so as to obtain one solid compact block, with no opening into it, except the exits and entrances O H for the two gases.

The chemical action in the battery consists of the decomposition and new formation of the electrolyte. If we employ, for instance, dilute sulphuric acid, this will be decomposed into H_2 and SO_4. The hydrogen is carried by the current to the oxygen side and there combines with it by the aid of the platinum-black under the formation of water. The SO_4 is carried toward the hydrogen side and combines with this again, forming sulphuric acid. By this action an increasing accumulation of the sulphuric acid on the hydrogen side takes place, and an accumulation of water on the oxygen side, which produces a polarization, causing a diminution of the electro-motive force of the battery. To counteract this polarization, we change the gases from time to time—for instance, say once an hour—so that the hydrogen is passed through the chambers previously filled with oxygen, and vice versa. By this means the sulphuric acid accumulated on one side of the element is gradually taken back and then accumulated on the other side, and so on. The changing of the gases can be carried out by any suitable means, either in one chamber at a time or through the whole battery at once; or the appliance shown in Fig. 8 may be employed, which, as will be seen, is simply a four-way cock. By moving the handle shown in dotted lines so that the plug of the cock takes a position at right angles to that shown in the drawings the oxygen will then pass through the chambers through which the hydrogen is passing, while the hydrogen will pass through those through which the oxygen has been passing.

These gas-batteries enable us to produce electricity at a very low cost, by using on the one side atmospheric air, on the other side the hydrogenic gases produced by the action of steam upon incandescent coke, anthracite, iron, &c., and by the imperfect combustion of coal, coke, or other carbonaceous substance by a mixture of air and steam. These gases, however, must be very carefully purified and freed as much as possible from the carbon monoxide which they may contain.

Even in using the hydrogen produced by the action of sulphuric acid upon zinc, our batteries offer special advantages over the hydro-electric batteries. We use atmospheric air as a depolarizer, and our battery is very compact, very clean, does not give out any smell, and is easily and quickly set in and out of action.

We do not limit ourselves to the details of the form and construction of the batteries which we have described, nor to the use of the gases and substances mentioned in this specification as being used in the construction and working of the batteries. It is evident that the form and construction of the batteries can be varied in a great many ways, and that a very large number of different substances can be employed to attain our end.

No claim is made herein to the method of obtaining electricity from gas, as that forms the subject-matter of an application filed by us March 18, 1889, Serial No. 303,742.

We claim as our invention—

1. In a gas-battery, a solid porous non-conducting substance impregnated with an electrolyte liquid at or near ordinary temperatures, and covered on each side with one or more substances capable of absorbing the gases employed and exposed on the one side to the one gas and on the other to the other gas used.

2. In a gas-battery, a solid porous non-conducting material impregnated with an electrolyte liquid at or near ordinary temperatures, and coated on each side by a conducting material capable of absorbing gases in its pores, such as described.

3. In a gas-battery, the combination of a solid porous non-conducting material impregnated with an electrolyte liquid at or near ordinary temperatures, with a porous conducting material covering the same, and a gas-absorbing material covering or impregnating the said porous conducting material, substantially as described.

4. In a gas-battery, in combination with a solid porous non-conducting substance impregnated with an electrolyte liquid at or near ordinary temperatures, and covered on each side with gas-absorbing material, a porous metallic conducting material in contact with or permeating the gas-absorbing material on each side and connected with the poles of the battery.

5. In a gas-battery, the combination of a porous non-conducting substance, a liquid electrolyte impregnating the same, a gas-absorbing coating on each side of said porous substance, with a good conductor of electricity on each side in the form of thin metallic foil, gauze or perforated plates permeable to the gases employed and in frequent contact with the absorbent coating over its whole surface, whereby the electricity is taken and conducted away from numerous points at small distance from each other, and thus the internal resistance is reduced and the work done by the battery is increased.

6. In a gas-battery, the combination of a non-conducting porous plate impregnated with an electrolyte, with a coating on each side of it of conducting and gas-absorbing material, such coatings being insulated from each other but connected with opposite poles of the battery, and an electro-negative gas bathing one side of the coating and an electro-positive gas the other side of the coating.

7. A gas-battery formed of porous non-conducting plates impregnated with an electrolyte coated on each side with conducting and gas-absorbing matter, the sides being insulated from each other and connected with opposite poles, and of chambers between the plates, each alternate chamber being filled with an electro-negative gas and the others with an electro-positive one.

8. In a gas-battery, in combination with a porous non-conducting plate impregnated with liquid electrolyte having two gas-absorbing electrically-conducting layers, one on each side of the porous plate, a conductor connected with one of the poles of the battery fixed on each side of the porous plate and electrically connected with the absorbing conducting layer nearly or quite all round.

9. In a battery having as its electrolyte a liquid permeating and absorbed by a porous non-conducting solid material, the combination of the said electrolyte with a coating on each side of gas-absorbing materials, a gas-chamber on each side of the said electrolyte supplied, respectively, each with one of the gases used.

10. The combination of the insulating-plates R, conductors A, embedded therein, and non-conducting panels M, impregnated with an electrolytic liquid and covered on each side with gas-absorbing and conducting material, said material on each side being in electrical contact with the conductor A on that side.

11. As an element of a gas-battery, the combination of a non-conducting frame R, porous non-conducting plates M, permeated by a liquid electrolyte and coated on each side by a gas-absorbing and conducting layer insulated from the layer on the other side, conductors A, respectively, all round the plates on each side and each connected with one pole, each in electrical contact with the conducting-layers on its own side, and said layers being exposed one to an electro-negative and the other to an electro-positive gas.

12. In a battery, a series of non-conducting frames R, non-conducting plates M, impregnated with an electrolytic liquid, and having a conducting gas-absorbing layer on each side, conductors A on each side, each connected with its respective pole and with the absorbing conducting-layer on its own side, poles P P′, positive gas-passages O and positive gas-spaces G^2 G^4 G^6, negative gas-passages H and negative gas-spaces G′ G^3 G^5, outside inclosing-case E, and distance-pieces K, forming with frames R said gas-chambers G′ G^2, all combined substantially as described.

13. A battery composed of a series of porous plates M, permeated with an electrolyte liquid at or near ordinary temperatures and coated on each side with a gas-absorbing and conducting layer, the layers facing one way being insulated from the layers facing the other way, and a series of spaces between the plates, one alternate set of which is exposed to an electro-negative gas and the other to an electro-positive one.

14. In a gas-battery, the combination of a

(No Model.) 3 Sheets—Sheet 1.

L. MOND & C. LANGER.

PROCESS OF OBTAINING ELECTRICITY FROM GAS BATTERIES.

No. 409,366. Patented Aug. 20, 1889.

Fig 2

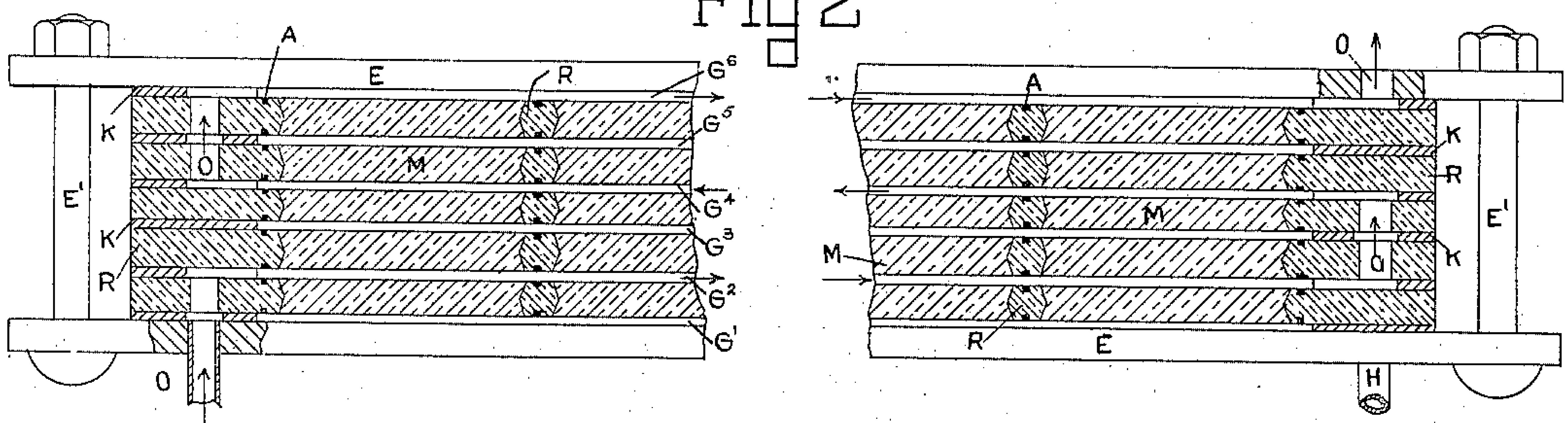


Fig 3

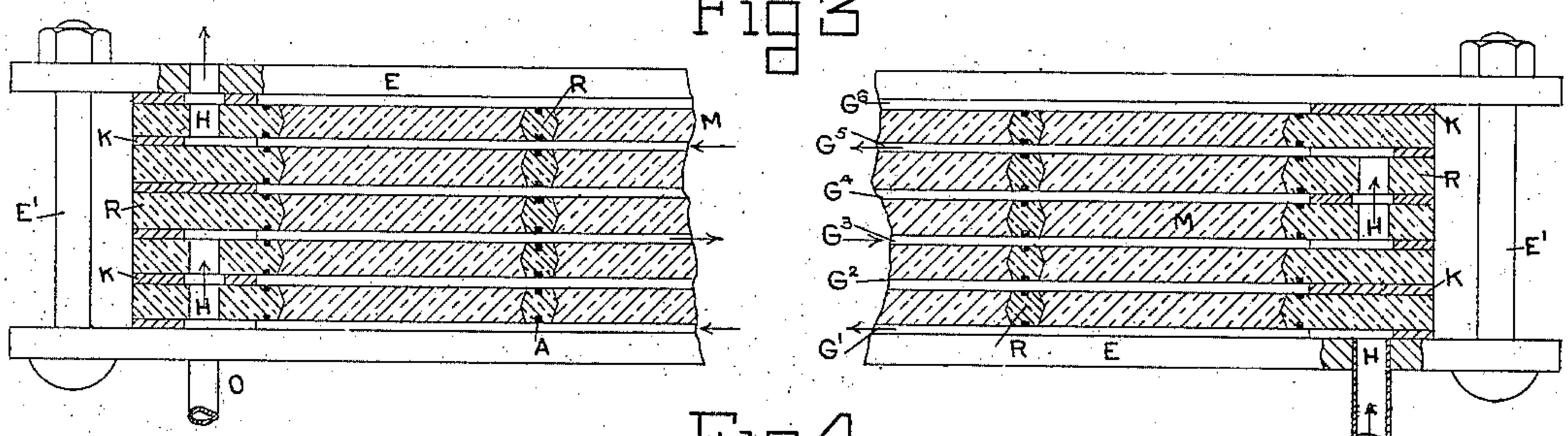
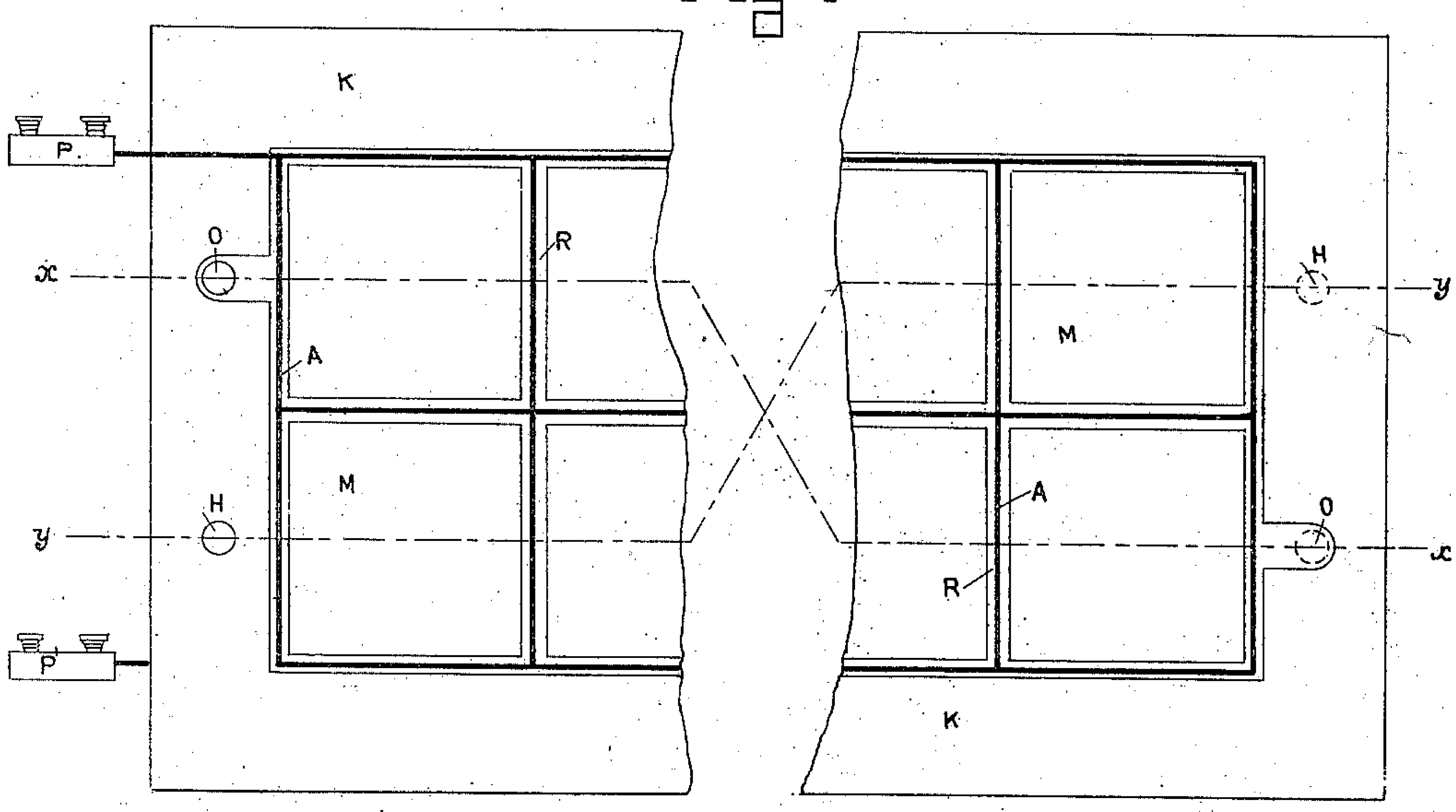


Fig 4



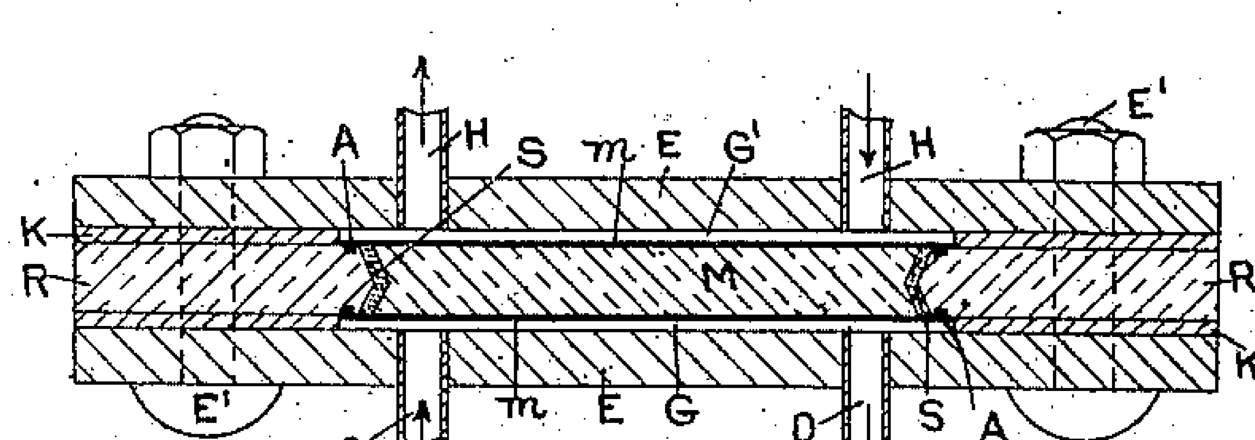


Fig I

Witnesses

H. Hollingsworth

Horace A. Dodge

Inventors

Ludwig Mond and

Carl Langer,

by Dodge & Sons, Attys.