(No Model.) 2 Sheets—Sheet 1.

A. ROVELLO.

PRODUCTION OF COPPER BY ELECTROLYSIS.

No. 405,604. Patented June 18, 1889.

Fig. 1

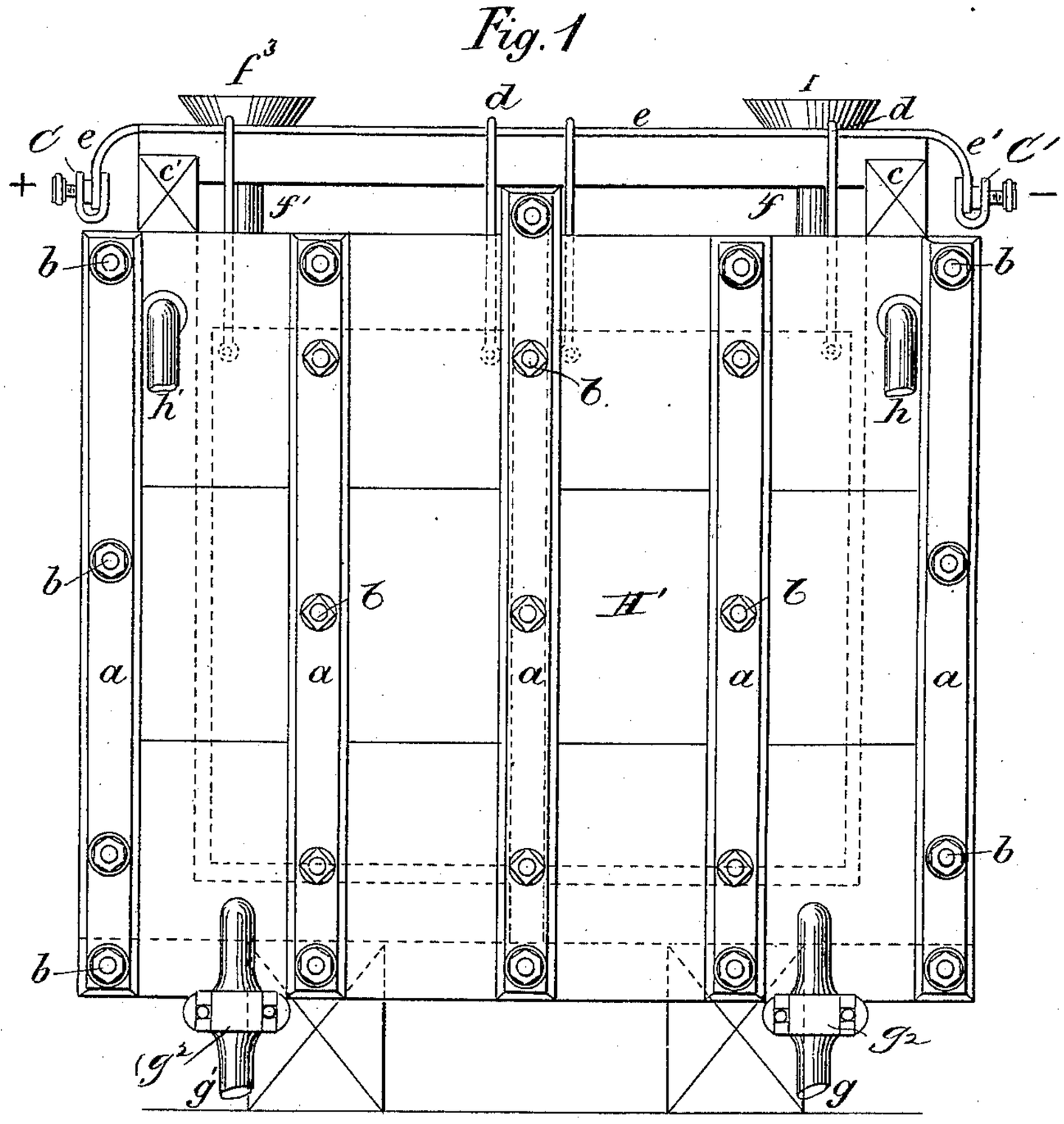
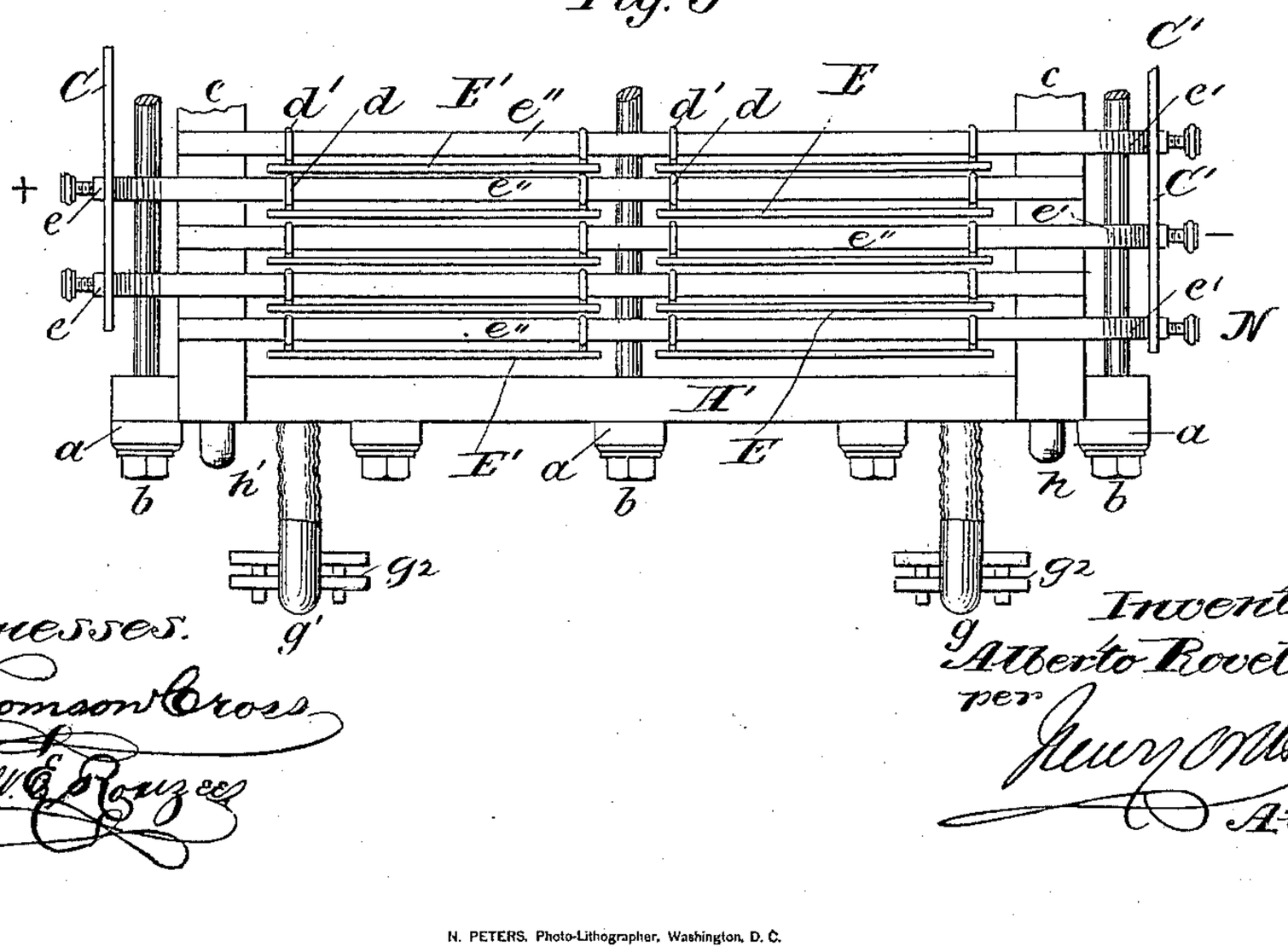


Fig. 3



Witnesses.
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(No Model.) 2 Sheets—Sheet 2.

A. ROVELLO.

PRODUCTION OF COPPER BY ELECTROLYSIS.

No. 405,604. Patented June 18, 1889.

Fig. 2

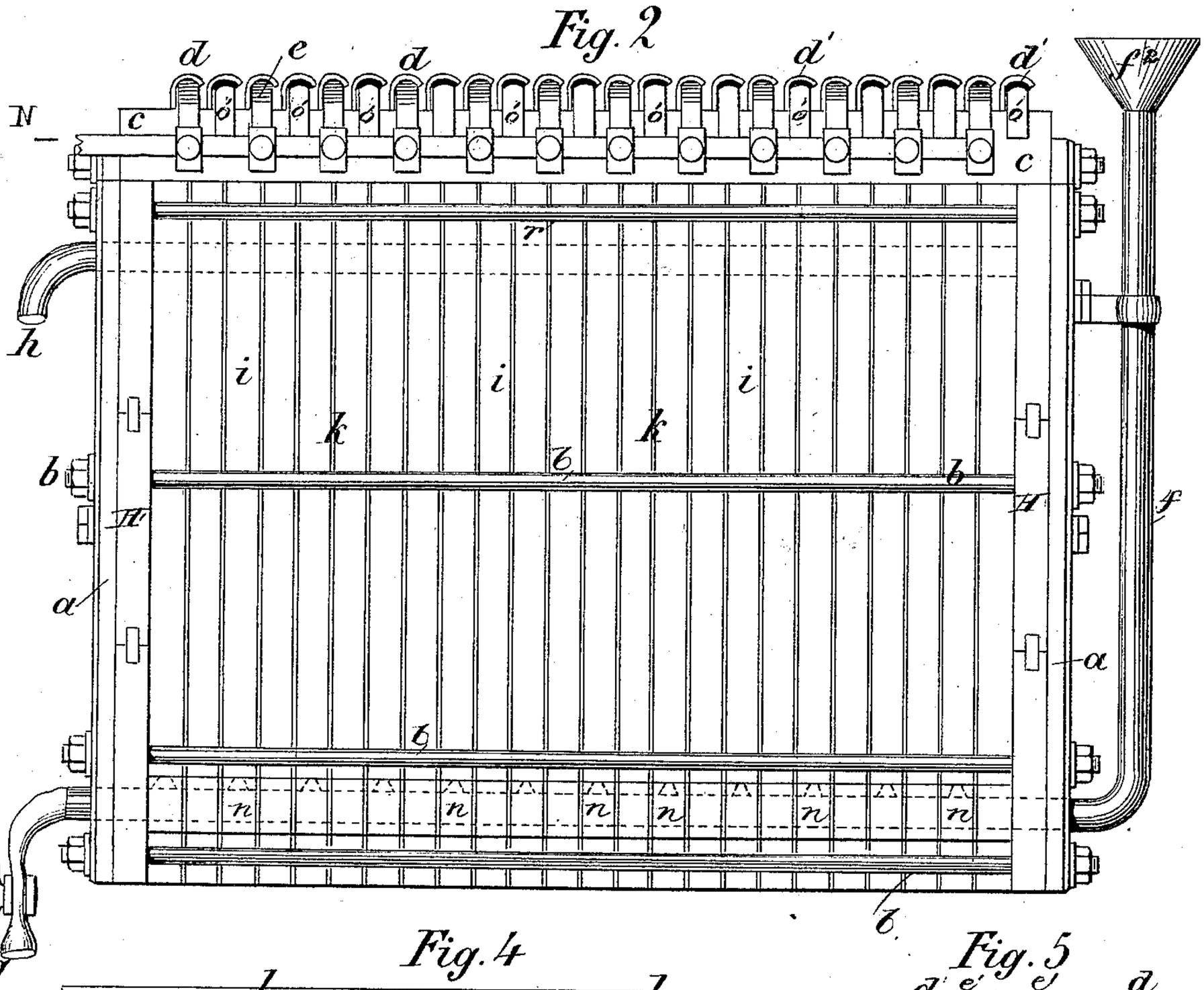


Fig. 4

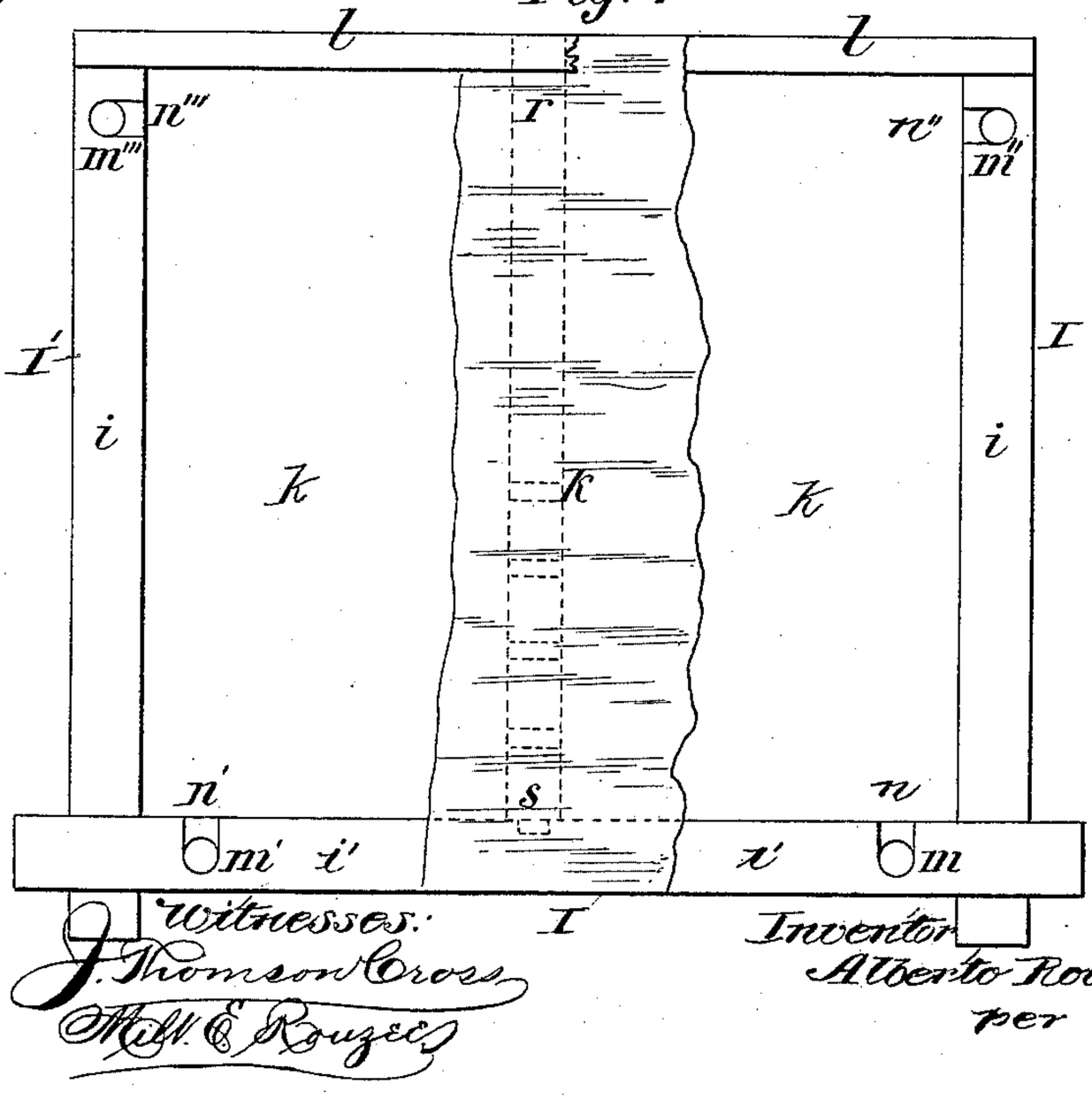
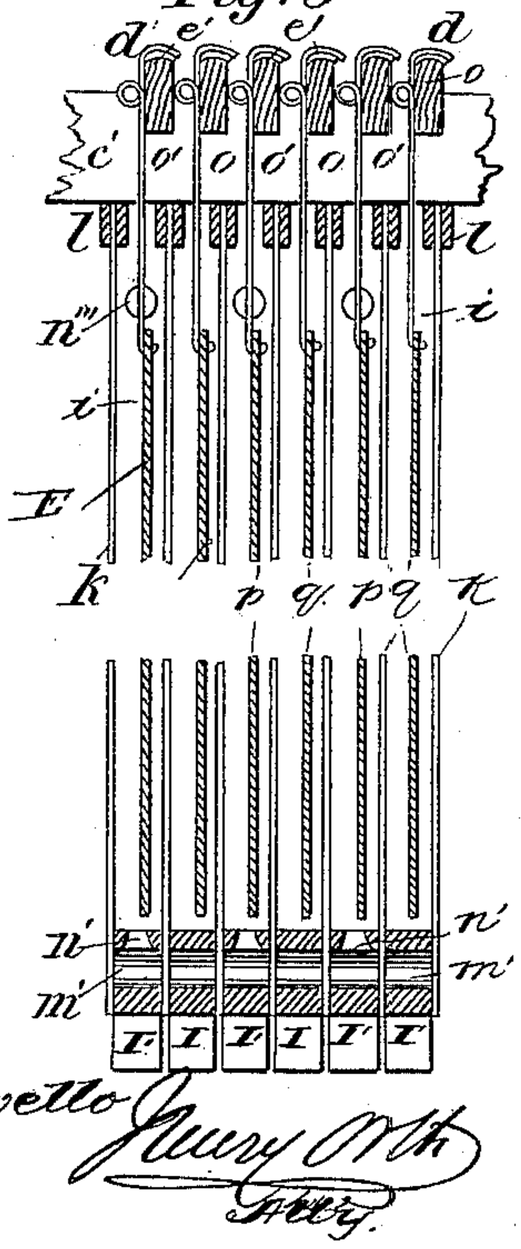


Fig. 5



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UNITED STATES PATENT OFFICE.

ALBERTO ROVELLO, OF TURIN, ITALY.

PRODUCTION OF COPPER BY ELECTROLYSIS.

SPECIFICATION forming part of Letters Patent No. 405,604, dated June 18, 1889.

Application filed April 2, 1889. Serial No. 305,681. (No model.) Patented in Italy September 30, 1885, XXXVII, 259, and March 31, 1887, XLI, 386; in France January 27, 1886, No. 173,753, and September 16, 1887, No. 185,873; in Belgium October 5, 1886, No. 74,738, and September 30, 1887, No. 78,910; in Spain December 20, 1887, No. 11,838; in England August 24, 1888, No. 12,208, and in Austria-Hungary September 15, 1888, No. 15,137.

To all whom it may concern:

Be it known that I, ALBERTO ROVELLO, a subject of the King of Italy, residing at Turin, Italy, have invented certain new and useful Improvements in Apparatus for the Production of Copper by Electrolysis; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to letters or figures of reference marked thereon, which form a part of this specification; and be it further known that I have obtained patents in the following countries: Italy, September 30, 1885, Vol. 37, No. 259, and March 31, 1887, Vol. 41, No. 386; France, January 27, 1886, No. 173,753, and September 16, 1887, No. 185,873; Belgium, October 5, 1886, No. 74,738, and September 30, 1887, No. 78,910; Spain, December 20, 1887, No. 11,838; Austria-Hungary, September 15, 1888, No. 15,137; England, August 24, 1888, No. 12,208.

The invention relates to the extraction of copper from the cupreous lyes obtained either in the treatment of copper ores by what is called the "wet process" or in the lixiviation of the ashes obtained in the burning or roasting of cupreous pyrites in the manufacture of sulphuric acid.

The object of my invention is to recover the copper from such lyes by electrolysis; and it consists, essentially, in the construction of the apparatus employed, substantially as hereinafter fully described, and set forth in the claims.

The recovery of the copper from the lyes referred to has heretofore been effected by treatment with scrap-iron or cast-iron to precipitate the copper in an impure form called "cement-copper," containing at most seventy-five per cent. of copper. This cement-copper has to undergo various treatments—such as compression, desiccation, smelting, and refining—in order to obtain a commercial product. In this process the proportion of iron should theoretically be in proportion to the copper—that is to say, in the ratio of the chemical equivalents or less than one of iron to one of copper precipitated—yet in practice the proportion of iron is usually double or nearly double that quantity.

By my improved process pure copper is obtained directly from the solution or lye, thus dispensing with the expensive processes referred to, the proportion of iron used being but slightly greater than the theoretical proportion, while no external electric current is required.

In carrying out my invention I employ an apparatus in which the electro-negative or cathode consists of wrought-iron, though cast-iron may be used instead, or zinc, the electro-positive or anode consisting of course of copper, and when the two are included in a short circuit the resistance is so slight that practically the whole of the electrical energy is utilized in the electrolytical treatment of the lyes. The electro-motive force of the elements, consisting of copper and iron with an interposed porous diaphragm and two liquids—namely, a cupreous solution and a ferrous solution—is at least 0.60 volt; but if zinc is substituted for the iron the electro-motive force increases to one volt. If, therefore, the apparatus has an internal resistance of, say, 0.003 ohm, the current given by the formula $I=\frac{E}{R}$ will amount to two hundred ampères with an iron cathode and three hundred and thirty ampères with a zinc cathode. Consequently at the rate of 1.19 gram of copper deposited per ampère and per hour such an apparatus will yield every twenty-four hours a product in the first case of more than five kilograms of copper and of more than nine kilograms in the second case. In order to reduce the internal resistance to a minimum—say less than 0.003 ohm—it is necessary to employ large electrode-surfaces as well as diaphragms of very small specific resistance, and to arrive at these desired results I have devised the apparatus which I will now describe, reference being had to the annexed drawings, in which—

Figure 1 is an end elevation. Fig. 2 is a side elevation. Fig. 3 is a partial top plan

view. Fig. 4 is an elevation of one of the cell-frames, and Fig. 5 is a transverse vertical section of a few of the cells.

The apparatus consists of a series of cells of even number, formed in an inclosing-case by diaphragms *k*, of a porous material, preferably artificial parchment or parchment-paper, though parchment diaphragms may be employed.

With a view to economy in construction and to facilitate the dismantling of the apparatus when this becomes necessary from any cause, I have devised the following construction:

The inclosing-frame consists simply of two heads or ends H H′, which, like all the wooden parts of the apparatus, are preferably made of pine. These heads are formed of cross-boards joined together fluid-tight—as, for instance, by a feather-joint, as shown—and between which heads the frames I I′ are clamped or tied by means of tie-rods *b* that extend through the heads and through vertical brace-bars *a*.

At one end of the apparatus the head H′ has four ports, to which are connected overflow-pipes *h h′* and exhaust-pipes *g g′*, said pipes being preferably of a flexible material, the pipes *g g′* being simply provided with a clamp g^2 for compressing and closing the same, though they may be provided with other suitable means of closure—such as a valve or stop-cock. I prefer the clamps, as a metallic contact with the lyes is thereby avoided, said clamps acting from the outside of the pipes, and form a very simple and effective means of closure. In the opposite head H of the apparatus are formed two ports, to which are connected two feed-pipes *f f′*, surmounted by funnels f^3 f^3, respectively.

The intermediate frames I that serve to form the cells are constructed of a lower cross-bar *i′*, vertical bars *i*, at the upper end of which is formed a rabbet on opposite sides for the reception of the lighter cross bars or strips *l*, each vertical bar having two such strips, as shown in Fig. 5, to which the upper edge of the diaphragms *k* are secured or between which such diaphragms are clamped.

In the lower cross-bars *i′* of all the frames I I′ are formed two ports *m* and *m′*, located near the opposite ends of said bar inside the vertical or side bars I, in each of which is also formed a port *m″* and *m‴* respectively.

The ports *m m″* in one set of frames I communicate with vertical and horizontal passages *n* and *n″*, respectively, and the ports *m′ m‴* in the other set of frames I′ communicate, respectively, with like vertical and horizonal passages *n′ n‴*, as shown in Figs. 4 and 5, the diaphragms secured to or clamped between the frames being provided with holes registering with the ports *m* and *m′* and *m″ m‴*, respectively.

The frames may be further strengthened by intermediate vertical stays *r s*, as shown in dotted lines in Fig. 4, through which the tie-rods pass, a fluid-tight joint being formed in any desirable manner by suitable packing. The number of these vertical intermediate braces will necessarily depend upon the dimensions or capacity of the apparatus, and such braces are dispensed with when the apparatus is of small capacity, as will be readily understood. It will be seen that when these frames I and I′ are assembled in alternate order there will be formed four continuous passages *m m′ m″ m‴*, and that the said passages will be in communication with the inner spaces or cells through the passages *n n′ n″ n‴*. The feed-pipes *f* and *f′* and the exhaust-pipes *g* and *g′* are connected to the opposite ends of the passages *m* and *m′*, respectively, while the passages *m″* and *m‴* are connected with the two overflow-pipes *h* and *h′*, respectively. The exhaust-pipes *g* and *g′* being closed, a liquid fed through pipe *f* will pass into passage *m*, and thence through passages *n* into every alternate cell formed by the diaphragms *k*, which, when full, will overflow through the horizontal passages *n″* into passage *m″*, and thence to and through overflow-pipe *h*. A liquid fed through pipe *f′* will pass into passage *m′*, thence through passages *n′* into every alternate cell, the overflow from said cells passing out of the apparatus through passages *n‴ m‴* to and through overflow-pipe *h′*.

The diaphragm *k* may be secured to the frames in any usual or preferred manner, or they may simply be clamped between the frames, a tight joint being practicable through the medium of the rods *b*, thereby simplifying and cheapening the construction of the apparatus very materially.

On the top of the apparatus are laid cross beams or bars *c*, to which are secured the wooden supports *o* and *o′* for the electrodes E and E′, respectively, said supports being made conductive through the medium of a strip of sheet-copper, (indicated by e^2,) one end of which strip projects beyond the support and is connected by a suitable clamp to a conductor. These supports *o* and *o′* are also arranged alternately, the ends *e* of the strips e^2 of sheet-copper for the supports *o* being connected to a conductor C at one end of the apparatus, while the ends *e′* of the strips e^2 for the supports *o′* are connected to a conductor C′ at the opposite end of the apparatus.

The negative or copper electrodes E′ are supported from the supports *o′* by means of copper hooks *d′*, and are connected through the ends *e′* of the copper strips e^2 with the conductor C′, and the positive or iron or zinc electrodes E are suspended from like hooks *d* from the supports *o*, the ends *e* of whose copper strips e^2 are connected with the conductor C.

The negative electrodes E′ are suspended in those cells which are in communication

with the feed-pipe f', and the positive electrodes E in those cells which are in communication with the feed-pipe f.

Instead of connecting the ends e and e' of the conducting-strips e^2 according to their polarity with separate conductors, all the strip ends e and e' may be electrically connected at either end of the apparatus without regard to their polarity, so that there will be no distinct poles, while the short external circuit thus established will present the least possible resistance to the passage of the current, thus materially increasing the efficiency of the apparatus.

The cupreous lye is fed through pipe f' to the cells in which are suspended the negative electrodes E', and a weak solution of the salt of the same metal of which the positive electrode is formed is fed through pipe f to those cells in which the positive electrodes E are suspended. Thus, if the cupreous solution is one of sulphate of copper, the other solution should be one of a sulphate of iron or zinc, according as the positive electrode is of iron or zinc. These solutions are fed simultaneously and in such manner as to cause them to rise together and slowly in their respective cells, the overflow passing out through the overflow-pipes h and h', respectively, as hereinbefore described, the electrolytical process being a continuous one.

The conductors C and C', connecting the copper strips e e', being short-circuited, the resistance to the passage of the current is reduced to the minimum, while the electrolytical action takes place at once, and the elimination of the copper will proceed, so that the cupreous solution fed to the negative-electrode cells at the bottom thereof will be deprived of nearly all of its copper as it passes out of the cells at their upper end through the passage m''' and overflow h'.

The overflow may be collected and again passed through the same apparatus; or a number of such apparatus may be arranged and connected in series, the overflow of cupreous solution being conducted from one into the other until deprived of its copper; or such impoverished cupreous solution may be enriched by using it as a lixiviating agent either in the treatment of copper ores by the wet process or for lixiviating the ashes resulting from the manufacture of sulphuric acid.

The apparatus may also be employed in the recovery of zinc from solutions of such, the negative electrode being of course of zinc and the positive of iron, the liquids used being a solution of a sulphate of zinc which may be obtained in the lixiviation of sulphate ores and a weak solution of sulphuric acid or of a sulphate of iron.

In the production of zinc I preferably connect the conductors with a dynamo-electric machine, and so arrange the connections that each apparatus or group of such is made to work in series or parallel arcs, and are supplied with a current, giving at the pole-connections a difference of potential not less than 0.34 volt, and not exceeding 1.40 volt, so as not to decompose the water of the solutions.

Having described my invention, what I claim, and desire to secure by Letters Patent, is—

1. The herein-described electrolytical apparatus, consisting of a tank or casing formed of two heads and a series of intermediate frames detachably connected together, said frames being provided with porous diaphragms dividing the tank into an equal number of cells, a feed and exhaust duct for each alternate series of cells having its inlet and discharge, respectively, near the bottom of the tank at opposite ends thereof, and an overflow for each of said alternate series of cells, in combination with electrodes for the cells and an electrical circuit including said electrodes.

2. The herein-described electrolytical apparatus, consisting of a tank or casing composed of two heads, whereof one is provided with two feed-ports and the other with two exhaust and two overflow ports, arranged as set forth, a series of intermediate frames, each provided with diaphragms that divide the tank into a plurality of cells, each of said frames having four ports m m' m'' m''', whereof ports m'' and m''' register with said overflow-ports and communicate by ports n'' n''' with the interior of the cells, the two other ports m m' in the bottom of said frames registering with the feed and exhaust ports in the heads and communicating by ports n n' with the interior of said cells, said parts being detachably connected together, for the purpose set forth.

3. The herein-described electrolytical apparatus, consisting of a casing or tank composed of two heads whereof one is provided with two feed-ports and the other with two exhaust and two overflow ports, arranged as described, a series of intermediate frames provided with porous diaphragms that divide the tank into a plurality of cells, a feed and exhaust duct for each alternate series of cells, in communication therewith and with the corresponding ports in the heads of the tank, and an overflow-duct for each of said alternate series of cells communicating with the overflow-ports in one of the heads, in combination with electrodes, supporting-rods for the same, provided with conducting-strips e^2, electrical conductors, to which the alternate ends of the strips are connected, and an electric circuit including said electrical conductors, for the purpose specified.

In testimony whereof I affix my signature in presence of two witnesses.

ALBERTO ROVELLO.

Witnesses:

ENRICO ENGEL,

FRANCESCO DEL BIANCO.