

No. 617,911.

Patented Jan. 17, 1899.

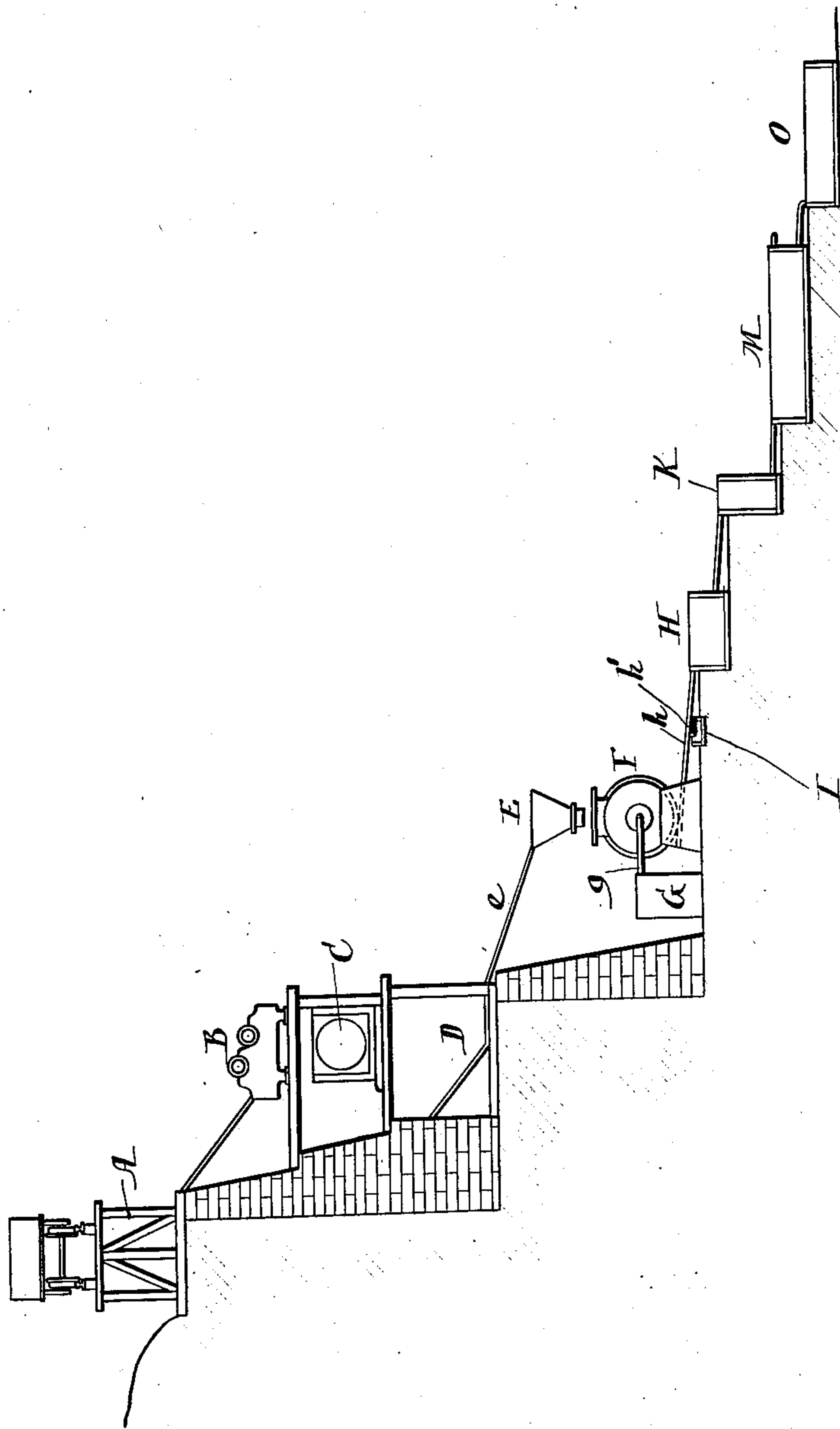
E. A. SMITH & M. H. LYG.  
METHOD OF EXTRACTING METALLIC ORES.

(Application filed Nov. 17, 1897.)

(No Model.)

4 Sheets—Sheet 1.

Fig. 1.



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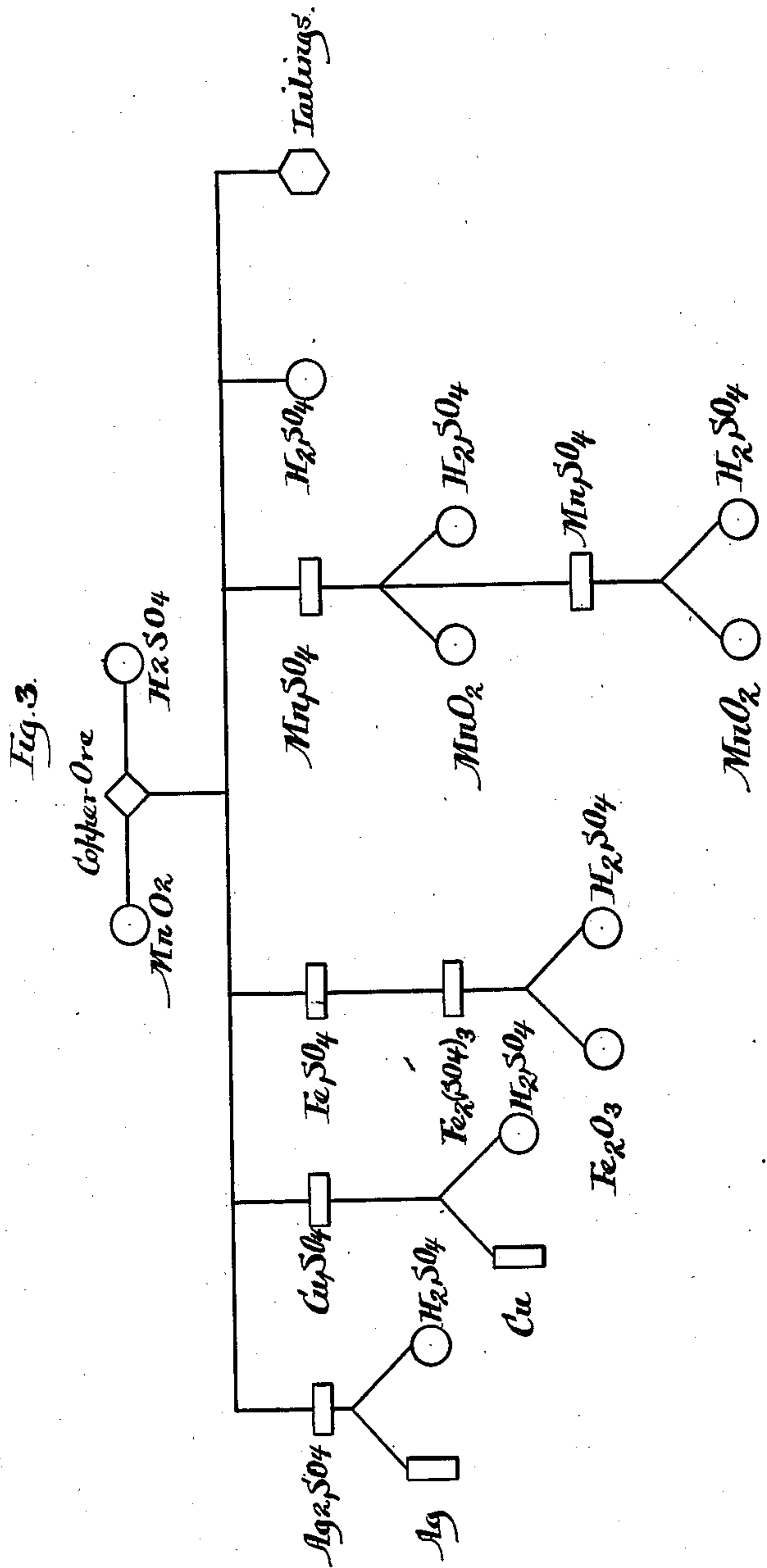
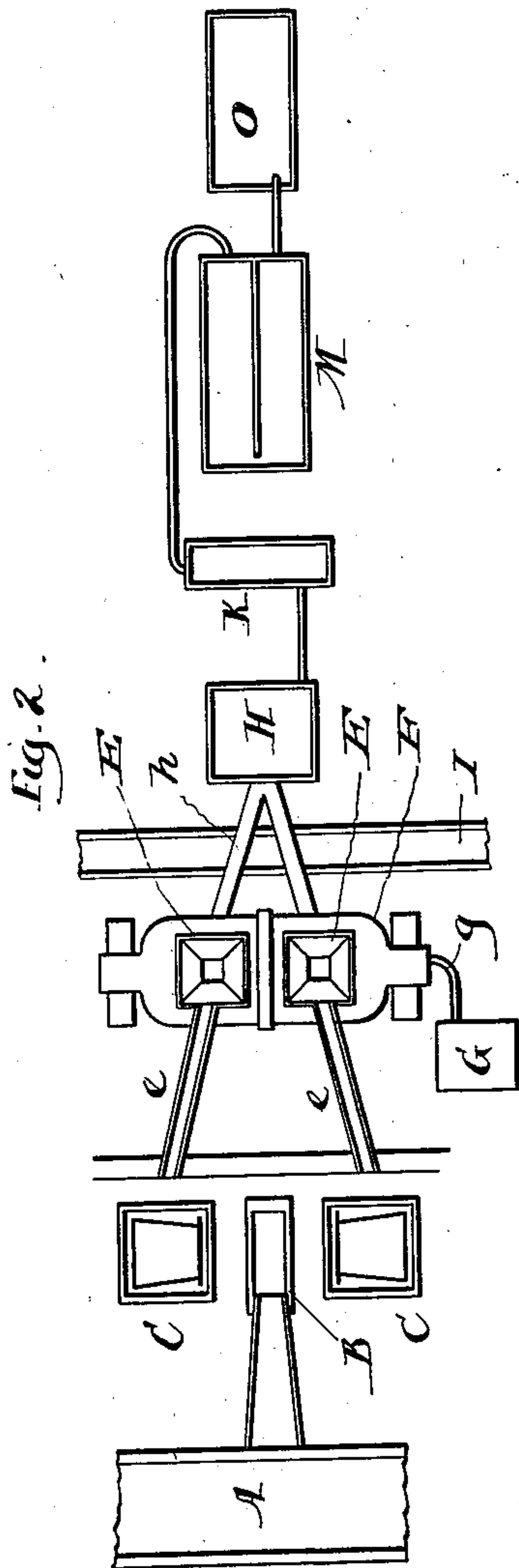
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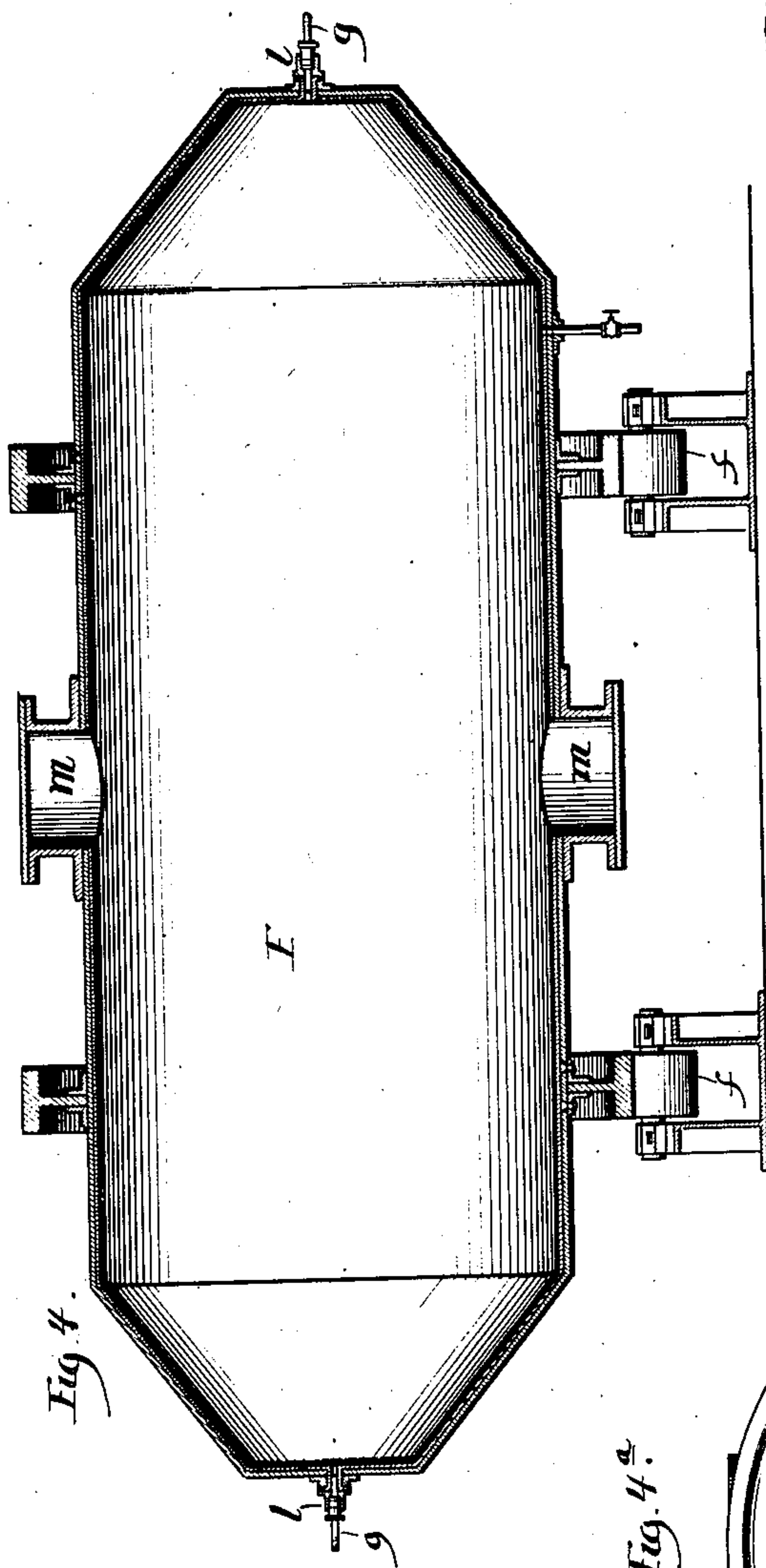


Fig. 4.

Fig. 4<sup>a</sup>.

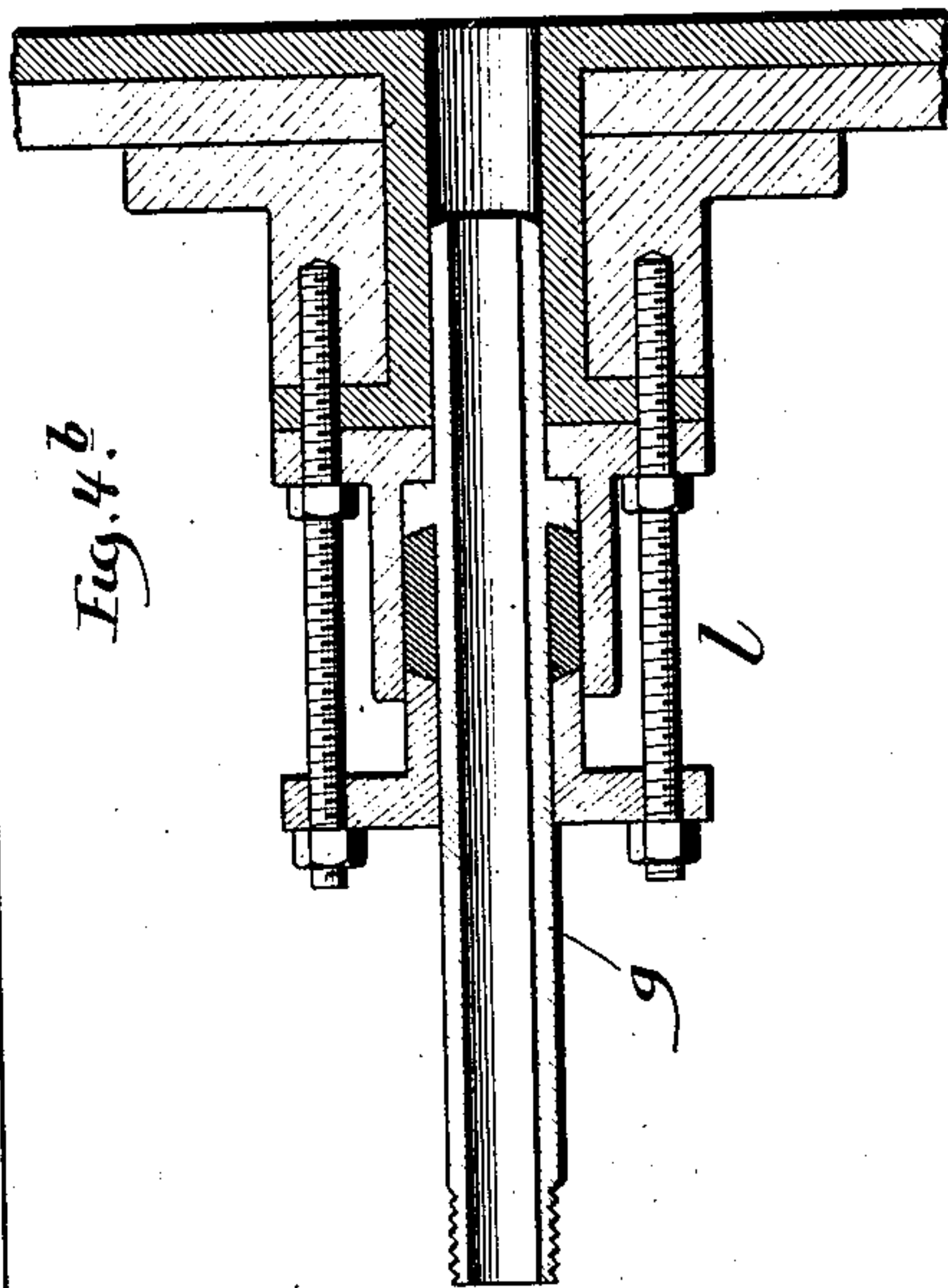
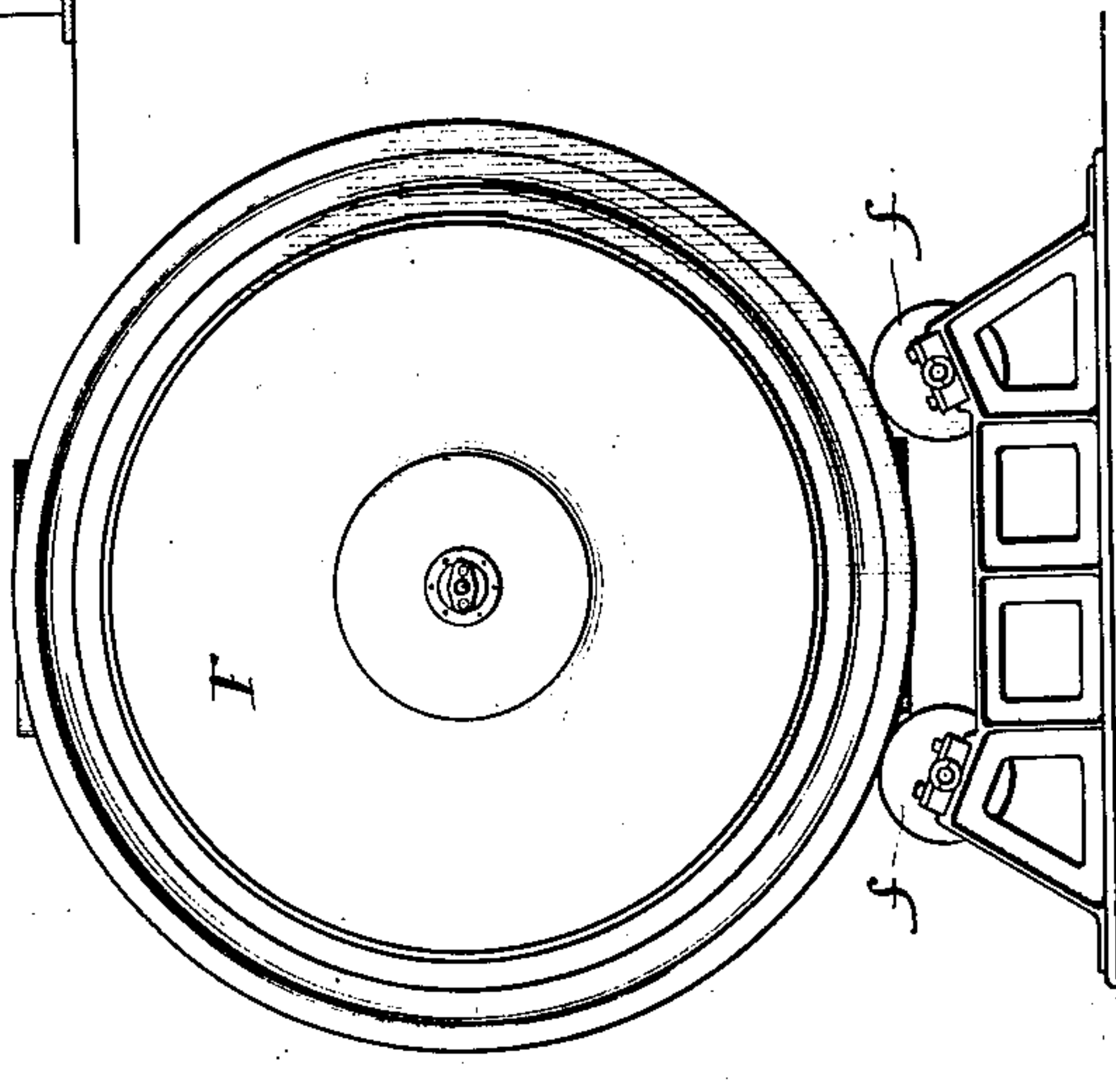


Fig. 4<sup>b</sup>.



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4 Sheets—Sheet 4.

(No Model.)

Fig. 5<sup>a</sup>.

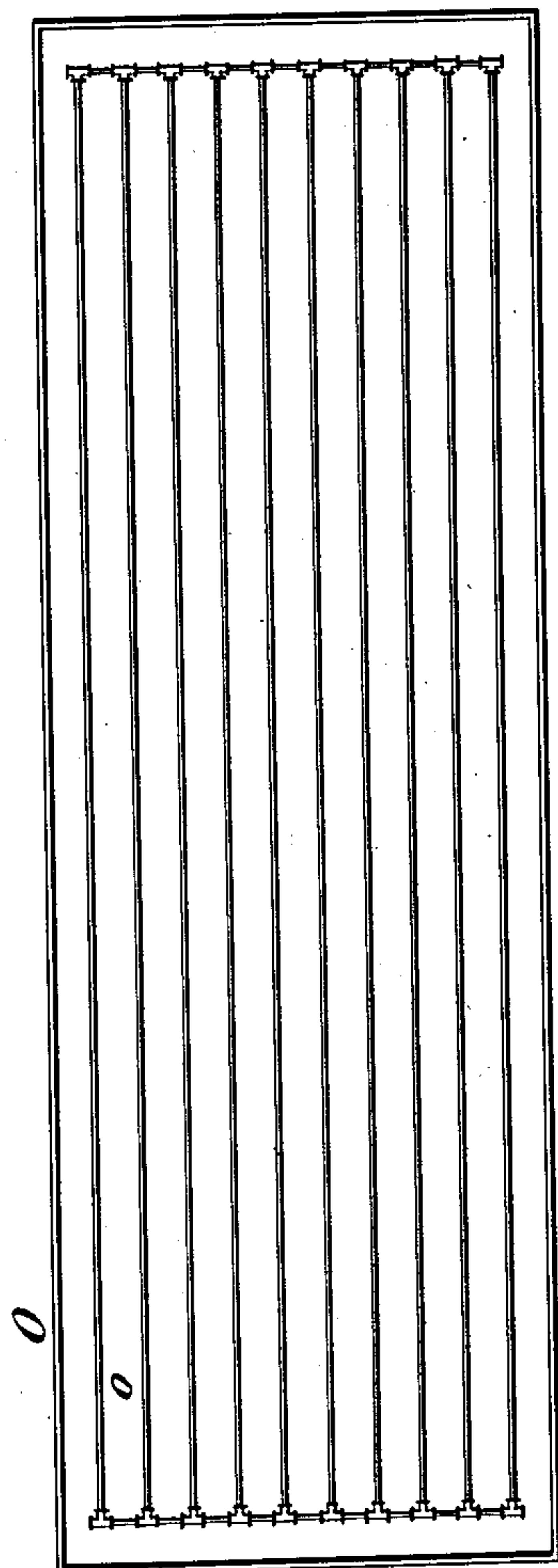
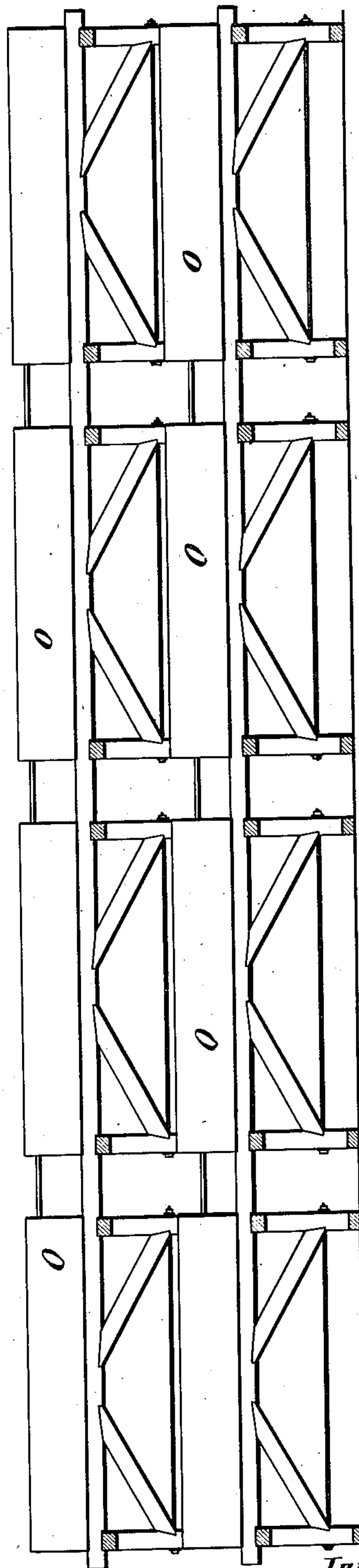


Fig. 5.



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# UNITED STATES PATENT OFFICE.

ELIAS ANTHON SMITH AND MARKUS HARTMANN LYG, OF ANACONDA, MONTANA.

## METHOD OF EXTRACTING METALLIC ORES.

SPECIFICATION forming part of Letters Patent No. 617,911, dated January 17, 1899.

Application filed November 17, 1897. Serial No. 658,881. (No specimens.)

*To all whom it may concern:*

Be it known that we, ELIAS ANTHON SMITH and MARKUS HARTMANN LYG, residents of Anaconda, Deer Lodge county, Montana, have invented certain new and useful Improvements in Methods of Extracting Metallic Ores, of which we do declare the following to be a full, clear, and exact description.

The invention is directed more particularly to the treatment of copper ores, and is equally applicable whether a minor percentage of silver be present in the ore or not. In preferred form the improvement designs to convert the metals into sulfates by digesting the ores under heat and pressure with a suitable oxidizing agent in presence of free sulfuric acid and after precipitating the silver, if any, by means of copper filings subjecting the solution to electrolysis. Under such action the copper and the oxidizing agent are for the most part recovered. The copper depositing on the cathodes, while the oxidizing agent is regenerated at the insoluble anodes and in proper state for reuse precipitates from the electrolyte. The residue of the metallic salts, with free sulfuric acid, constituting the bulk of the spent electrolyte, is later evaporated, the salts crystallized out and calcined or otherwise treated to restore the contained oxidizing agent to active condition for reuse, while the sulfuric acid after crystallization of the salts remains as a mother-liquor in readiness to be employed anew at the digester. The method proceeds in cycle—that is, the oxidizing agent and sulfuric acid, which effect the solution of the metallic elements of the ore at the leaching stage, are both ultimately recovered at marked saving, to be employed over again in digesting fresh batches of ore. The nature of the invention will appear in detail from the description following and be more distinctly pointed out by claims at the conclusion thereof.

In the drawings which accompany, Figure 1 is a diagrammatic elevation view of various sorts of apparatus employed for practice of the invention. Fig. 2 is a like view of the same in plan; Fig. 3, a graphic table of the chemical changes which ensue during progress of the treatment; Fig. 4, a view of the

rotary digester in longitudinal section; Fig. 4<sup>a</sup>, an end view thereof; Fig. 4<sup>b</sup>, a detail section view of one of the stuffing-boxes for the digester; Fig. 5, an elevation view of a series of evaporating vats or tanks; Fig. 5<sup>a</sup>, a plan view of one of said vats with pipe-coil therein.

As shown by the drawings, the ore will be delivered in the usual manner to the bins A, from which it passes into a suitable crusher B and thence through the screens C into storage-bin D. From bin D the classified ore discharges by chute *e* and hopper E into digester F. Digester F consists of a revoluble cylinder made of boiler-plate or the like having an acid-proof lining of lead, brick, or similar material. Digester F is mounted upon supporting-rolls *f* and at its opposite ends carries the stuffing-boxes *l*, fitted with lead pipes *g* for entry of air or steam. Manholes *m* afford access to the interior of the vessel. In practice the digester may contain from ten to twenty tons of ore when half-full in readiness for action. Within the closed cylinder F the ore charge is treated with manganese oxid or similar oxidizing agent, to which some free sulfuric acid preferably is added. While the digester revolves slowly, hot air at forty to eighty pounds pressure is injected through the hollow trunnions. The proportions of oxidizing agent and acid used will depend upon the percentage of metallic elements present in the ore under treatment. Ordinarily from ten to fifteen per cent. of manganese oxid will suffice for each one hundred percent. of ore. The sulfuric acid should be in quantity slightly in excess of what is necessary to convert the metals into sulfates. The digester being properly charged is caused to revolve slowly while hot air forces itself into the interior through pipes *g*, leading from furnace G or other convenient source. The batch of material within the digester is subjected simultaneously to the action of the oxidizing agent and of the heated air, and in presence of the free acid the copper and part of the silver are taken up in solution. The duration of the treatment at the digester must depend upon the character of the ore and in measure upon the size to which it has been previously ground. The time varies ordina-



rily from four to sixteen hours per charge. At the end it will be found that the digester contains copper, (perhaps silver,) manganese and iron sulfates, sulfuric acid, and insoluble tailings. This condition of the charge is indicated by the graphic table at Fig. 3. The iron sulfate is to be traced in large measure to the manganese oxid, with which the iron is generally associated. At the close of the digester treatment the solution is drained off from the tailings and discharges from the extractor by suitable troughs *h* into a settling-tank H. Only one settling-tank is shown, although any number may be used, if requisite to obtain a perfectly-clear solution. After the tailings are washed and the liquor added to the main solution the solid residues find exit through trap-door *h'* into the tailing-flume I. The solution remains in the settling tank or tanks until it is thoroughly clarified, which must depend in measure upon the character of the ores taken and the tendency to form slime. When sedimentation is effected, the clear solution is drawn off, and if silver be present it may be run over copper or other metallic filings within a suitable precipitating-tank K. The filings serve to throw down the silver in metallic form, to be subsequently cast into bars, while the copper takes its place in solution. Thus prepared the finished bath or solution serves as an electrolyte and can at once be admitted from tank K into the refinery-vats M. Said refinery-vats contain insoluble anodes either of carbon or lead. By action of the electric current the copper in solution is deposited on the cathodes, as usual, while the manganese oxid, constituting the oxidizing agent at the digester, is for the most part regenerated at the anodes and separates from the solution. When the spent electrolyte is drawn off from the vats, the regenerated oxidizing agent remains and can be cleaned out and taken back for reuse at the digester. The electrolyte solution is kept flowing from vat to vat of the refinery M. Eventually all of the copper present is deposited from solution. Aside from the free acid the spent or lean electrolyte contains a minor part of the oxidizing agent and as well the associated iron in form of sulfates. The spent bath is run into a tank or tanks O, where it may be repeatedly evaporated and then cooled to crystallize out the salts of iron and manganese. The free sulfuric acid left as the "mother-liquor" remains in proper state for reuse at the digester. To effect evaporation, the tanks O may be arranged in series, one tier above another, as seen at Fig. 5. The tanks at one part of the plant can be out of action to allow for crystallization and removal, while at another part evaporation proceeds. The tanks should be lined with lead or like resistance and, as shown at Fig. 5<sup>a</sup>, may be heated by submerged lead-pipe coils *o*, through which live steam can pass. On removal from the tanks O the sulfate crystals may be decom-

posed in an ordinary calciner to form resultant oxids, in which condition the manganese stands regenerated and in readiness to be used again at the digester. The fumes of sulfuric acid evolved during calcination may be condensed by water and saved.

Instead of calcining the sulfate crystals derived from evaporating-tanks O said crystals can be dissolved in water and then treated hot with slaked lime sufficient to unite with the free and combined acids, hot air being blown in during the treatment. The manganese of lime thence resulting can be used as an oxidizing agent at the digester.

Having removed the copper and also the silver, if present, by primary digestion or leaching in manner already detailed, it becomes feasible to re-treat the tailings for recovery of the gold should the ore values justify. To such end the refuse tailings are to be restored to the digester. Leaching proceeds anew, hydrochloric in lieu of sulfuric acid being now employed along with the oxidizing agent—*e. g.*, manganese oxid. The soluble salts of gold thence derived on removal from the digester may be treated with ferrous sulfate or metallic zinc for precipitation of the gold, as well understood. The chlorids of iron and manganese yet held in solution would thereupon be evaporated, crystallized out, and calcined for regeneration of the oxidizing agent in manner already detailed. Should zinc or nickel be present in paying quantities, these can be leached out as soluble salts by the digester treatment and be ultimately recovered under suitable conditions, although the acid electrolyte already detailed could only serve at the refinery for the separation of the copper alone.

Manifestly the details can be varied according to the mechanic's skill without departure from the essentials of the invention.

Having thus described our invention, what we claim as new, and desire to secure by Letters Patent, is—

1. The method of leaching metallic ores which consists in digesting the wet pulverized ore, under heat and pressure, by means of a suitable oxidizing agent in presence of a free acid and thereafter separating the soluble salts from the refuse gangue, substantially as described.

2. In extracting copper from its ores, the method of preparing the electrolyte which consists in digesting the wet pulverized ore, under heat and pressure, with manganese oxid in presence of free sulfuric acid, substantially as described.

3. In extracting copper from its ores, the method of preparing the electrolyte which consists in injecting hot air into the wet pulverized ore while digesting the same with a suitable oxidizing agent in presence of a free acid, substantially as described.

4. In extracting copper from its ores, the method of preparing the electrolyte which consists in injecting hot air into the wet pul-



verized ore while digesting the same with manganese oxid in presence of free sulfuric acid, substantially as described.

5 5. In extracting copper from its ores, the method of preparing the electrolyte which consists in injecting hot air into the wet pulverized ore while digesting the same with a suitable oxidizing agent, such as manganese oxid, in presence of a free acid *e. g.*, sulfuric  
10 acid, and separately precipitating the silver from solution by metallic copper or the like, preliminary to electrodeposition of the copper salts, substantially as described.

15 6. The electrolytic method of extracting copper ores which consists in digesting the wet pulverized ore under heat and pressure, with aid of a suitable oxidizing agent *e. g.*, manganese oxid, in presence of free acid (*e. g.*, sulfuric acid), eliminating the silver if any  
20 be in solution, by metallic precipitation, and then electrolyzing—with help of insoluble anode—the bath thus prepared, to effect deposition of the copper at the cathode and simultaneously to eliminate in regenerated  
25 state, the oxidizing agent from the electrolyte solution, substantially as described.

30 7. The method of extracting copper ores which consists in digesting the wet pulverized ore under heat and pressure by means of a suitable oxidizing agent *e. g.*, manganese

oxid, in presence of free acid *e. g.*, sulfuric acid, electrolyzing the dissolved sulfates thence derived to deposit the copper and precipitate a part of the oxidizing agent in regenerated state, then evaporating the spent  
35 electrolyte, crystallizing out the metallic sulfates for subsequent regeneration of the oxidizing agent *e. g.*, by calcination, and saving the mother-liquor *i. e.*, the concentrated free acid, for digesting fresh charges of ore, substantially as described. 40

8. The wet process of extracting copper from its ores having precious metal therein, which consists in digesting the pulverized ore under action of heat and an oxidizing agent, 45 in presence of sulfuric acid, exposing the dissolved sulfates to metallic copper for precipitation of the silver, treating the filtrate electrolytically to deposit the copper, evaporating the lean electrolyte to concentrate the  
50 free acid, and crystallize the metallic sulfates, and finally calcining such crystallized sulfates to properly regenerate them as oxidizing agents for reuse, substantially as described.

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