J. WHITING.

ELECTROLYTIC CELL.

APPLICATION FILED DEC. 16, 1908.

951,229.

Patented Mar. 8, 1910.

3 SHEETS—SHEET 1.

Fig. 1.

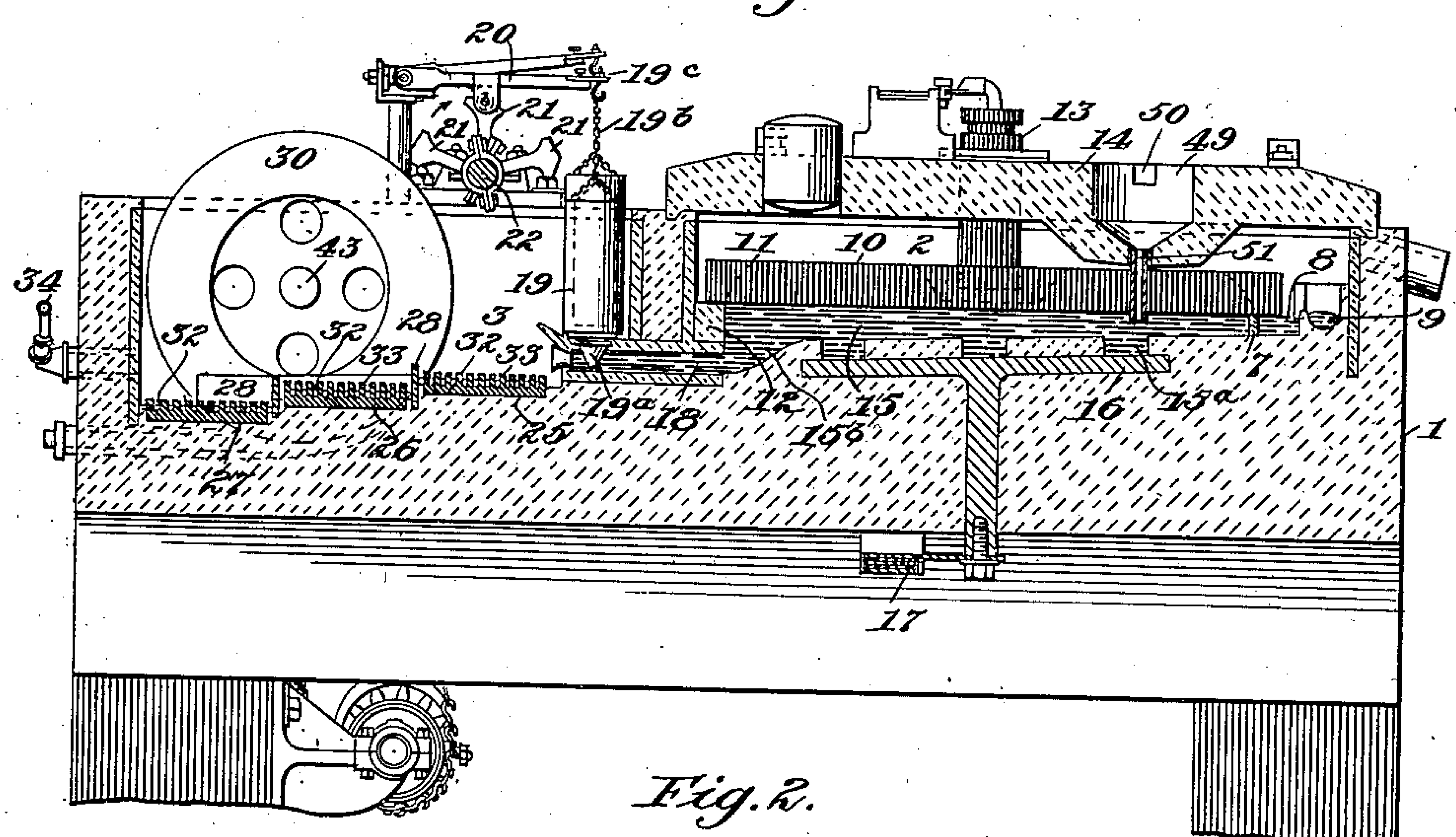


Fig. 2.

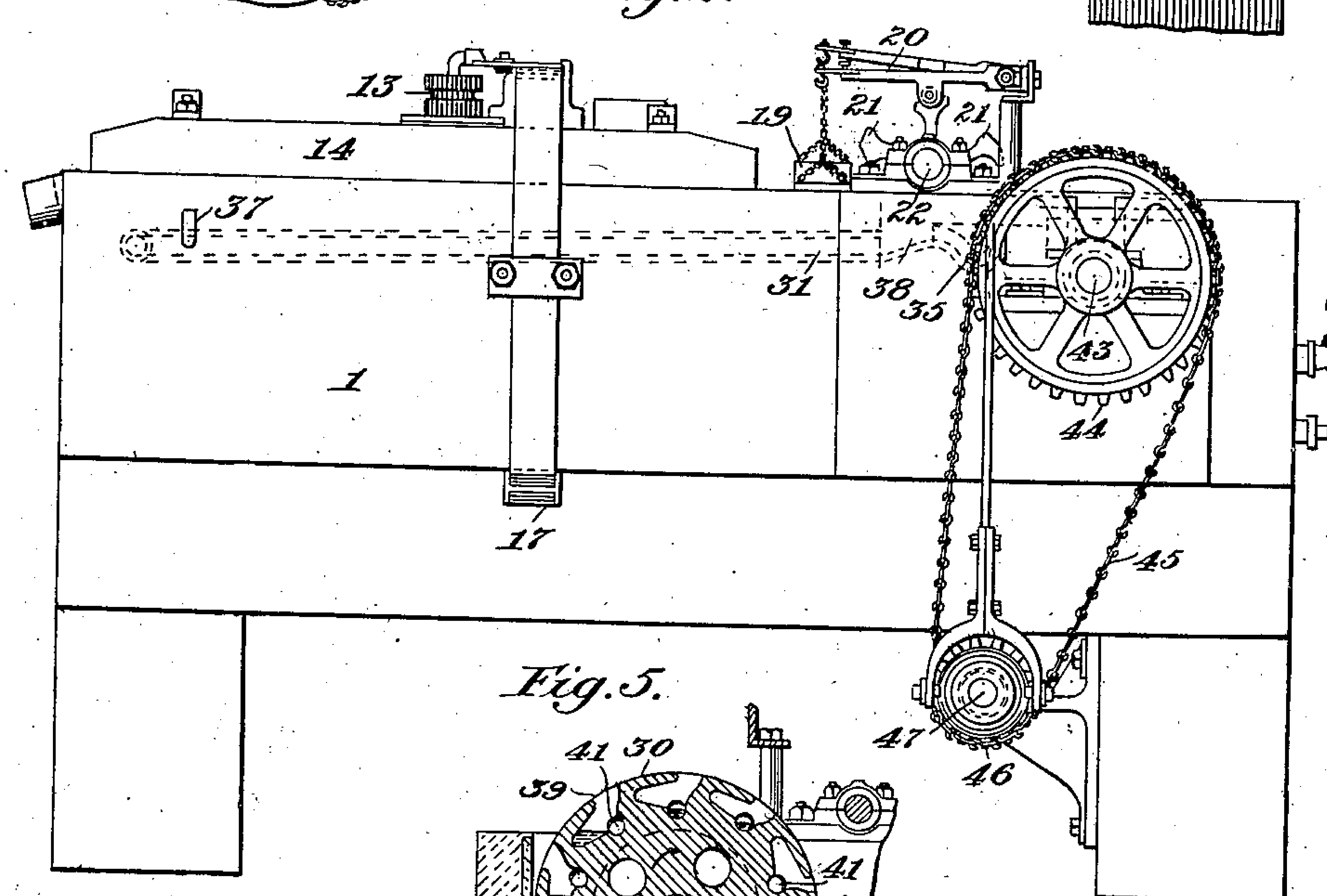
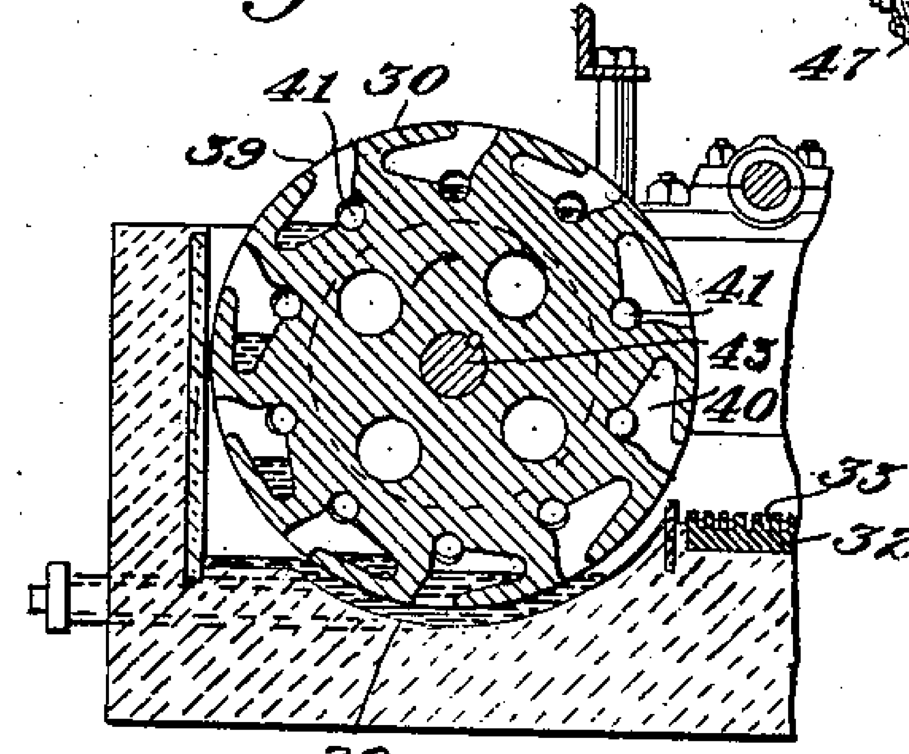


Fig. 5.



Witnesses:

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Inventor:

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3 SHEETS—SHEET 2.

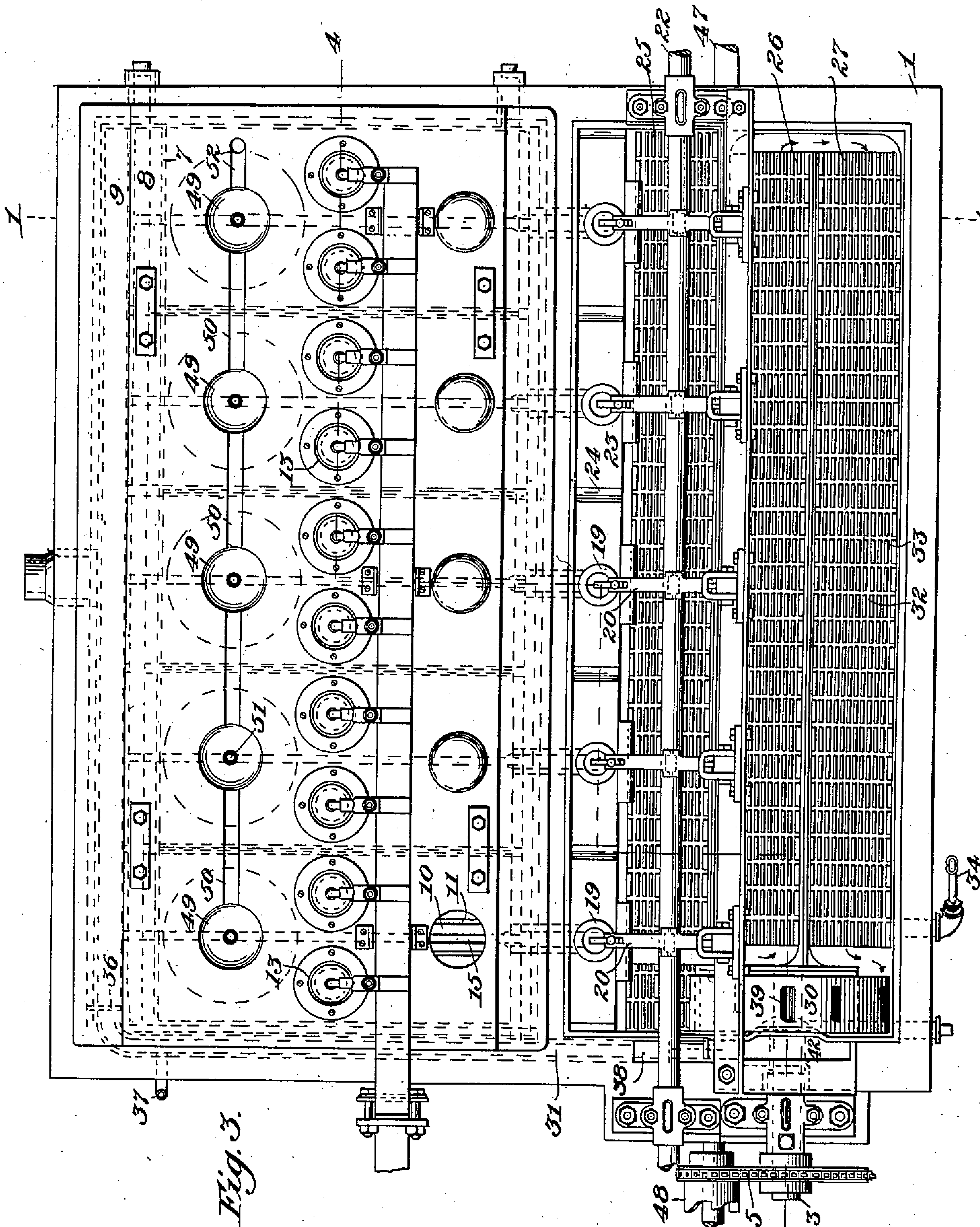

Fig. 3.

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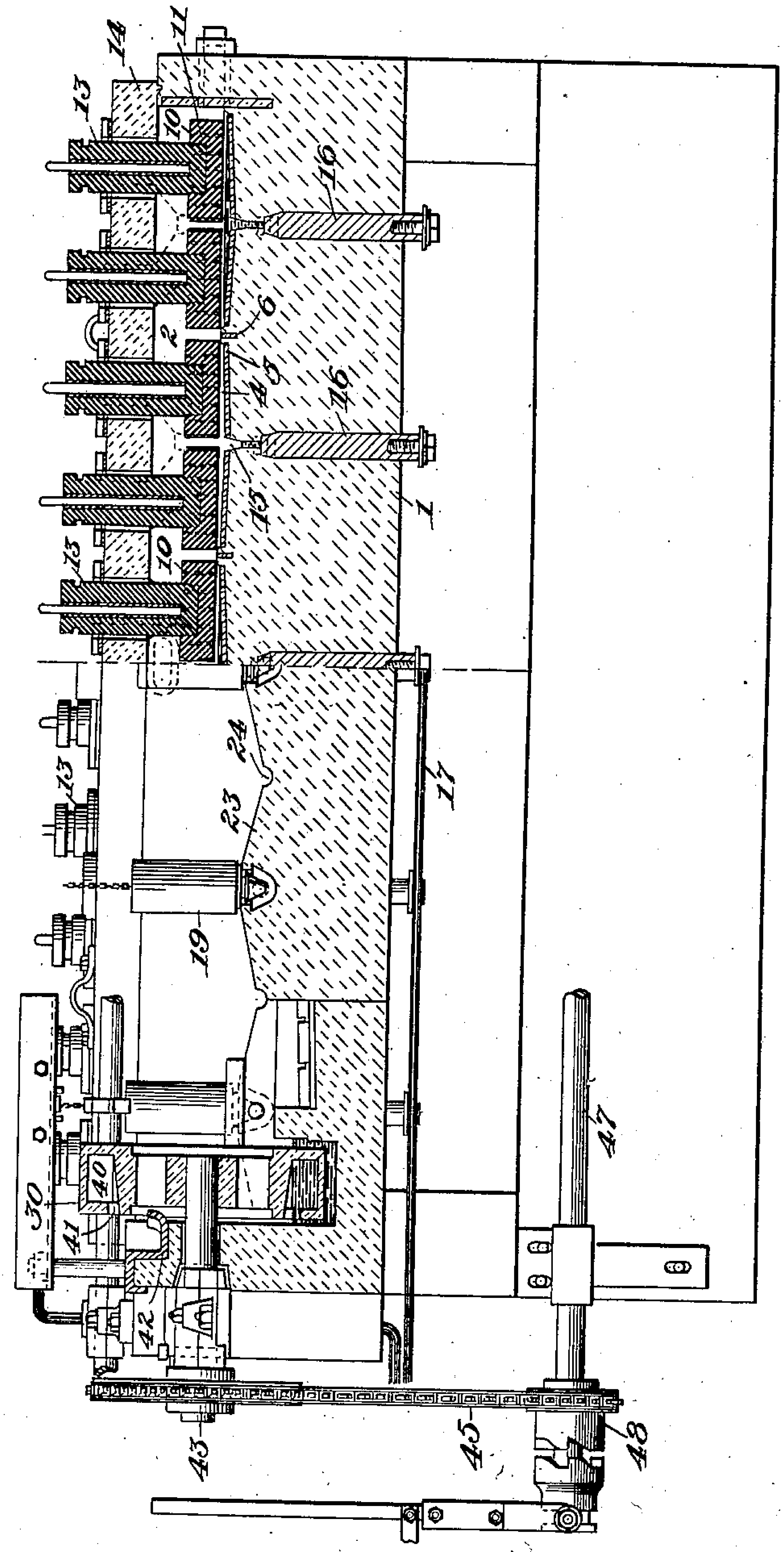
3 SHEETS—SHEET 3.

Fig. 4.



Witnesses:

Chas. H. Potter.

Inventor:

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UNITED STATES PATENT OFFICE.

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ELECTROLYTIC CELL.

951,229. Specification of Letters Patent. Patented Mar. 8, 1910.

Application filed December 16, 1908. Serial No. 467,847.

To all whom it may concern:

Be it known that I, JASPER WHITING, a citizen of the United States, residing at Boston, in the county of Suffolk and State of Massachusetts, have invented certain new and useful Improvements in Electrolytic Cells, of which the following is a specification.

This invention relates to the electrolytic decomposition of salts by means of apparatus employing as cathode a body of liquid metal or alloy. In operations of this character it has been usual heretofore to maintain a substantially continuous circulation of the cathode, but this practice has proven objectionable by reason of the tendency of the electrolytically separated metal, as sodium, to become oxidized and to reënter into solution in the decomposing compartment. For example, in the production of caustic soda by electrolysis of aqueous solutions of sodium chlorid in presence of a mercury cathode, the sodium amalgam tends to collect at the surface of the cathode and its removal to the oxidizing compartment is only incompletely effected by the flow of the underlying body of mercury; the sodium of the amalgam is therefore subject to oxidation by the electrolyte undergoing decomposition, resulting in a reduced efficiency of operation.

In my prior patent No. 877,537, granted January 28, 1908, I have described a method of electrolyzing salts wherein a cathode of liquid metal or alloy is maintained in a quiescent state during the period of electrodeposition therein of an alkali or other metal, the cathode being periodically conveyed from the decomposing compartment to a suitable oxidizing compartment, and returned to said decomposing compartment, the flow of the electric current being preferably maintained without interruption by the provision of a plurality of bodies of the cathode metal adapted to be conveyed in succession to the oxidizing compartment or compartments. As described in said patent, the contents of the decomposing and oxidizing compartments are in balanced relation, and the metal or alloy which is discharged periodically from the decomposing compartment is conveyed to a pump or equivalent device by means of which it is elevated and discharged into the oxidizing compartment, the denuded metal flowing thence by gravity to the decomposing compartment where its contents of alkali metal is restored.

The present invention is an electrolytic cell having decomposing and oxidizing compartments adapted to contain liquid metal, and provided with means operating at predetermined intervals for transferring said metal from the decomposing to the oxidizing compartment. This cell may be of the character described in my prior patent above referred to, wherein the contents of the decomposing and oxidizing compartments are in balanced relation and the amalgam is elevated to the oxidizing compartment and permitted to return thence by gravity to the decomposing compartment. I prefer however to provide a modified form of apparatus wherein the liquid metal is during the charging period mechanically separated from the contents of the oxidizing compartment, and is permited to flow thereinto by gravity at the close of such period, this construction securing several important advantages as hereinafter set forth.

For a full understanding of the invention the same will be described by reference to the production of caustic soda by the electrolytic decomposition of an aqueous solution of sodium chlorid in the presence of a cathode of mercury.

A preferred form of apparatus is illustrated in the accompanying drawings wherein,—

Figure 1 is a longitudinal section on line 1—1 of Fig. 3; Fig. 2 is a side elevation of the apparatus; Fig. 3 is a plan view of the same; Fig. 4 is a transverse vertical section on the broken line 4—4 of Fig. 3; and Fig. 5 is a fragmentary vertical sectional view showing a preferred form of elevating device or pump for the mercury.

Referring to the drawings 1 represents a body of cement, concrete or other suitable material, in which are formed one or more decomposing compartments 2 and an oxidizing compartment 3. As illustrated, I preferably provide a plurality of mechanically separated bodies of mercury contained in shallow basins 4, shown as five in number, formed in the bottom of the decomposing compartment 2: it will be understood however that a single body of mercury or any desired number of bodies may be provided in the decomposing compartment. These basins may be lined with glass, slate or earthenware

5 and are separated from each other by low partitions 6 set in the cement base and extending above the normal surface of the mercury cathode, the arrangement providing a common body of electrolyte above the several separated bodies of mercury. 7 is a similar partition disposed transversely of the basins 4 and near one end thereof in such manner as to provide an equalizing channel 8 from which the mercury may flow to the several basins, this equalizing channel being supplied with mercury from a distributing conduit 9 which receives the denuded metal from the oxidizing compartment. Above each basin is disposed an anode or anodes 10, which may be vertically slotted as indicated at 11 to permit the escape of chlorin. These anodes are usually of graphite and are carried at one end by a ledge 12 integral with the cell body, and at the other by the partition 7. The anodes preferably extend over the mercury in the equalizing channel as shown in such manner as to constitute the mercury therein a part of the active cathode, whereby the capacity of the cell is increased to a corresponding extent. The several anodes are electrically connected in circuit through graphite leads 13 extending upwardly through the cover 14 of the decomposing compartment. The cover 14 is removable together with the anodes, this arrangement permitting the ready opening of the cell for inspection, cleaning or the repair or replacement of parts.

Centrally disposed in the bottom of each basin 4 is a longitudinal slot or channel 15, the mercury in which is in electrical contact with suitable conductors 16 which are embedded in the body 1 and are connected to the cathode bus bars 17. The slots 15 incline downwardly to the discharge end of the cell, and communicate at their lower ends with conduits 18 through which the amalgam may be discharged into the oxidizing compartment 3. At the bottom of each slot are shown a plurality of wells 15^a adapted to retain small volumes of mercury which serve to protect the metallic conducting plates 16 and to establish electrical contact between them and the overlying amalgam. Each slot terminates at its lower end in a pocket 15^b, the construction being such as to permit the mercury to be discharged from the cell or compartment with substantial completeness. Each conduit 18 is provided at its discharge end with a weighted valve 19 normally closing the same but adapted to be opened at desired intervals by the movement of levers 20, actuated by cams 21, carried by a rotary shaft 22. The valves 19 are guided to their seats by downward projections 19^a. As illustrated, they are suspended by chains 19^b, and an adjusting screw 19^c is provided by means of which the lift of the valve may be varied as desired. It will be understood however that the invention is not restricted to the particular means illustrated for operating the valves at the desired or predetermined intervals. When the valves 19 are opened the mercury or amalgam in the respective basins of the decomposing compartment flows by gravity upon the inclined surfaces 23 (Figs. 3 and 4) and thence through channels 24 to the oxidizing compartment 3. In the particular form of apparatus illustrated, the oxidizing compartment comprises a series of wide shallow channels 25, 26, 27 disposed at successively lower levels and separated by partitions 28 so arranged that the amalgam is directed in a tortuous path as indicated by the arrows through the several channels, the denuded mercury flowing finally to the sump 29 (Fig. 5). It is then elevated by a rotary disk pump 30 and returned by conduit 31 (Figs. 2, 3) to the distributing conduit 9, passing thence to the equalizing channel 8 and the proper basin of the decomposing compartment. As indicated in Figs. 1 and 3 the bottom of each of the channels 25, 26, 27 of the oxidizing compartment is constituted by a carbon or graphite slab 32, having integral members 33 projecting upwardly into contact with the water or oxidizing electrolyte, the members 33 being disposed to permit a ready flow of the amalgam while providing a maximum contact therewith. The oxidizing compartment is supplied with water, the caustic soda solution escaping through an outflow 34.

It is important that the denuded mercury should be freed from adhering or mechanically conveyed caustic soda solution before reëntering the decomposing compartment. In the present construction this may be accomplished by the provision of traps or seals of any ordinary type in the conduits 31 and 9. Thus I have illustrated in Fig. 2 a trap or seal 35 arranged in connection with the discharge line of the pump 30 and serving to retain the supernatant liquid while permitting the flow of the mercury. A similar arrangement comprising a partition extending below the surface of the mercury in distributing conduit 9 is indicated at 36 in Fig. 3. If desired the mercury may readily be washed and thereby thoroughly freed from alkaline constituents by the introduction of water into the conduit 31 at a point intermediate these seals, as at 37, (Figs. 2, 3), this water overflowing at 38 into the oxidizing compartment 3 and serving as a source of supply therefor.

For elevating the denuded mercury from the sump 29 to the conduit 31 leading to the decomposing compartment, I have illustrated a rotary disk pump 30 provided with peripheral inlet apertures 39 leading to internal pockets 40 (Fig. 5), from which the mercury is discharged laterally through conduits 41 as the pockets are brought successively into proper relation to a trough 42, leading to the conduit 31. As shown, the pump 30 is mounted on a shaft 43 carrying a sprocket 44, driven by a chain 45 from a sprocket 46 on a shaft 47 having a clutch connection 48 with a power shaft. This apparatus for elevating the mercury is found to operate without such agitation of the metal as would result in its subdivision into globules with consequent danger of loss, and is claimed in my co-pending application, Ser. No. 467,848, filed December 16, 1908.

I prefer to provide in connection with the cell an intermittently operating device for supplying the electrolyte to the decomposing compartment, this device being automatic in character and permitting the electrolyte to flow into the several basins of the decomposing compartment only while the mercury or amalgam is absent therefrom or substantially so. As herein illustrated this feed device comprises a plurality of receptacles 49 disposed in the cover of the cell above the respective basins 4, and interconnected by open channels 50. From the bottom of each receptacle 49 a tube 51 extends downwardly below the normal surface of the mercury in the basins 4 in such manner as to be sealed thereby. Electrolyte is supplied to one of the receptacles 49 and conveyed by the equalizing channels 50 to each of the others, any excess being permitted to return to the circulating system, or if desired to flow continuously into the decomposing compartment as through conduit 52. So long as the several basins 4 contain sufficient mercury to seal the lower ends of the discharge tubes 51, the electrolyte is prevented from flowing therethrough, but when the mercury is discharged from any basin into the oxidizing compartment this seal is broken and a quantity of electrolyte corresponding approximately to the capacity of the receptacle 49 flows into the decomposing compartment. By this arrangement the fresh electrolyte is introduced at the bottom of the cell beneath the body of partially spent and consequently lighter electrolyte therein, and distributes itself beneath the latter, thereby providing a body of substantially saturated electrolyte at the precise point where the electrolytic decomposition is most active. Furthermore by the arrangement described this introduction of electrolyte occurs while there is no amalgam in the cell, and is therefore without tendency to agitate the amalgam or to re-dissolve the alkali metal.

In the operation of the apparatus described the mercury in the several basins 4 beneath a common body of electrolyte in the decomposing compartment 2 remains in a quiescent state during the charging period, that is to say the period during which the sodium is being electrically deposited, and is therefore under the most favorable conditions as regards efficiency of operation. At the conclusion of the electrodepositing or charging period, when the mercury has received the desired quantity of sodium, the valve 19 controlling the outflow of one of the basins is raised by the corresponding cam 21, and the entire body of amalgam in this basin, with the exception of such small quantity as is required to maintain a seal in the conduit 18 between the decomposing and oxidizing compartments, flows rapidly by gravity but without serious agitation to the oxidizing compartment 3, traverses the same and is thereby denuded of its alkali metal. The pure mercury is then conveyed by pump 30 to the conduit 31 and thence through conduit 9 and equalizing channel 8 to the decomposing compartment, flowing as will be understood into an empty or discharged basin, in preference to one containing mercury. By the slow rotation of the shaft 22 the next cam 21 will after an appropriate interval be brought into position to raise the valve 19 of the basin next in series, the operation continuing in such manner that the mercury in the several basins 4 is discharged in rotation and at proper intervals, denuded of its alkali metal, and returned to the decomposing compartment. As the amalgam is discharged from each basin a body of fresh electrolyte is introduced through the tube 51 beneath the body of partially spent electrolyte therein, thereby maintaining the required degree of saturation of the electrolyte. While the liquid cathode is maintained during the charging period in a state of rest, it will be observed that during the oxidizing period it is caused to flow in contact with carbon surfaces and an oxidizing electrolyte, thereby providing the most effective conditions for completely denuding it of its content of alkali metal.

The herein described apparatus possesses several important advantages over that described in my prior patent, No. 877,537, above referred to, these advantages following chiefly from the construction which permits the amalgam to flow by gravity from the decomposing to the oxidizing compartment instead of being elevated to the oxidizing compartment and being permitted to flow by gravity therefrom to the decomposing compartment. Among such advantages are the following:—(1) During the charging period the mercury and superposed electrolyte in the decomposing compartment is mechanically separated from that in the oxidizing compartment instead of being in balanced relation therewith, whereby it is not subject to fluctuation in level or variation in quantity due to the changes in the relative density of the electrolytes or in the pressure of the evolved gases: therefore more nearly constant current conditions may be maintained and the general operation of the cell improved. (2) There is less liability to the conveyance of caustic soda or other alkaline constituents from the oxidizing to the decomposing compartment, the flow of the denuded mercury to the decomposing compartment being tortuous, involving passage through a pump or elevating device and providing opportunities for further purifying operations to be performed upon it. (3) The arrangement permits the equalizing channel for the mercury to be placed within the decomposing compartment, thereby rendering the mercury in this channel available for use as a part of the cathode and correspondingly increasing the cell capacity. (4) The method provides for the pumping of pure mercury instead of amalgam, this being advantageous as avoiding all tendency to the formation of incrustations outside of the oxidizing chamber. (5) The construction is such as to permit the mercury to be discharged with substantial completeness from the decomposing cell or compartment. (6) The cell is more compact, more economical as regards the use of mercury, and of simpler and less expensive construction.

I claim:—

1. A decomposing cell having a liquid metal cathode, an outlet for said cathode, controlling means for said outlet, and means operating at predetermined intervals for actuating said controlling means.

2. A decomposing cell having a liquid metal cathode, an oxidizing cell, a conduit for liquid metal extending between said cells, controlling means in said conduit, and means operating at predetermined intervals for actuating said controlling means.

3. A decomposing cell having a liquid metal cathode, an oxidizing cell, a conduit for conveying liquid metal from the decomposing to the oxidizing cell, controlling means in said conduit, means operating at predetermined intervals for actuating said controlling means, and means for returning the liquid metal to the decomposing cell.

4. An electrolytic cell having decomposing and oxidizing compartments, a conduit for mercury extending between said compartments, controlling means in said conduit, and means operating at predetermined intervals for actuating said controlling means.

5. A decomposing cell having a plurality of bodies of liquid metal constituting the cathode, and means operating in conjunction with each of said bodies for withdrawing the same from the cell at predetermined intervals.

6. In an electrolytic cell, a decomposing compartment containing a plurality of bodies of liquid metal constituting the cathode, an oxidizing compartment, means operating in conjunction with each of said bodies for transferring the same at predetermined intervals to the oxidizing compartment, and means for returning the liquid metal from the oxidizing to the decomposing compartment.

7. In an electrolytic cell, a decomposing compartment containing a quiescent body of liquid metal constituting the cathode, an oxidizing compartment, means for establishing a flow of liquid alloy therethrough, and means for transferring liquid metal between said compartments.

8. In an electrolytic cell, a decomposing compartment containing a plurality of quiescent bodies of liquid metal constituting the cathode, an oxidizing compartment, means for establishing a flow of liquid alloy therethrough, and means for transferring liquid metal between said compartments.

9. In an electrolytic cell, a decomposing compartment containing a quiescent body of liquid metal constituting the cathode, an oxidizing compartment, means for transferring said body to the oxidizing compartment at predetermined intervals, and means for returning the denuded metal to the decomposing compartment.

10. In an electrolytic cell, a decomposing compartment containing a plurality of quiescent bodies of liquid metal constituting the cathode, an oxidizing compartment, means for transferring said bodies successively to the oxidizing compartment at predetermined intervals, and means for returning the denuded metal to the decomposing compartment.

11. In an electrolytic cell, a decomposing compartment containing a plurality of quiescent bodies of liquid metal constituting the cathode, an oxidizing compartment, means for transferring said bodies successively to the oxidizing compartment, and means for returning the denuded metal to the decomposing compartment.

12. In an electrolytic cell, a decomposing compartment containing a plurality of shallow receptacles for liquid metal under a common body of electrolyte, an outlet for each receptacle, and controlling means for each outlet.

13. In an electrolytic cell, a decomposing compartment containing a plurality of shallow receptacles for liquid metal, an outlet for each receptacle, controlling means for each outlet, and mechanism operating in conjunction with said controlling means for discharging the liquid metal from said receptacles in succession.

14. In an electrolytic cell, a decomposing compartment containing a quiescent body of liquid metal constituting the cathode, an oxidizing compartment at a lower level than said decomposing compartment, means op-

erating at predetermined intervals for permitting said body to flow from the decomposing to the oxidizing compartment, and means for returning the denuded metal to the decomposing compartment.

15. In an electrolytic cell, a decomposing compartment containing a body of liquid metal constituting the cathode, an oxidizing compartment at a lower level than said decomposing compartment, means operating at predetermined intervals for permitting said body to flow from the decomposing to the oxidizing compartment, and means operating continuously for returning the denuded metal to the decomposing compartment.

16. In an electrolytic cell, a decomposing compartment containing a body of liquid metal constituting the cathode, an oxidizing compartment at a lower level than said decomposing compartment, means between said compartments for controlling the flow of liquid metal, means operating at predetermined intervals for actuating said controlling means, and means for returning the denuded metal to the decomposing compartment.

17. In an electrolytic cell, a decomposing compartment containing a body of liquid metal constituting the cathode, an oxidizing compartment at a lower level than said decomposing compartment, a valve between said compartments for controlling the flow of liquid metal, means operating at predetermined intervals for actuating said controlling means, and means for returning the denuded metal to the decomposing compartment.

18. In an electrolytic cell, a decomposing compartment containing a body of liquid metal constituting the cathode, an oxidizing compartment at a lower level than said decomposing compartment, a valve between said compartments for controlling the flow of liquid metal, means operating at predetermined intervals for actuating said valve, and means for returning the denuded metal to the decomposing compartment.

19. In an electrolytic cell, a decomposing compartment containing a plurality of bodies of liquid metal constituting the cathode, an oxidizing compartment at a lower level than said decomposing compartment, means operating at predetermined intervals for permitting said bodies to flow successively from the decomposing to the oxidizing compartment, and means for returning the denuded metal to the decomposing compartment.

20. In an electrolytic cell, a decomposing compartment containing a plurality of bodies of liquid metal constituting the cathode, an oxidizing compartment at a lower level than said decomposing compartment, means operating at predetermined intervals for permitting said bodies to flow successively from the decomposing to the oxidizing compartment, and means operating continuously for returning the denuded metal to the decomposing compartment.

21. In an electrolytic cell, a decomposing compartment containing a plurality of independent bodies of liquid metal constituting the cathode and underlying a common body of electrolyte, an oxidizing compartment at a lower level than said decomposing compartment, means for controlling the flow of liquid metal between said compartments, and means for returning the denuded metal to the decomposing compartment.

22. In an electrolytic cell, a decomposing compartment containing a plurality of shallow receptacles for liquid metal under a common body of electrolyte, an outlet for each receptacle, controlling means for each outlet, and an oxidizing compartment below said receptacles and in position to receive the metal therefrom.

23. In an electrolytic cell, a decomposing compartment containing a plurality of shallow receptacle for liquid metal, an outlet for each receptacle, controlling means for each outlet, mechanism operating in conjunction with said controlling means for discharging the liquid metal from said receptacles in succession, and an oxidizing compartment below said receptacles and in position to receive the metal therefrom.

24. In an electrolytic cell, a decomposing compartment comprising a plurality of bodies of liquid metal constituting a cathode, an equalizing channel containing liquid metal in electrical connection with said bodies, and an anode above said bodies and equalizing channel.

25. In an electrolytic cell the combination of a liquid metal cathode, and an intermittently operating feed device for admitting electrolyte to said cell, said feed device controlled by said cathode.

26. In an electrolytic cell, the combination of a liquid metal cathode, and a feed device for electrolyte having a discharge opening below the normal surface of said cathode.

27. In an electrolytic cell the combination of a liquid metal cathode, means operating at predetermined intervals for discharging the same from the cell, and a feed device for electrolyte having a discharge opening below the normal surface of said cathode.

28. In an electrolytic cell the combination of a liquid metal cathode, means operating at predetermined intervals for discharging the same from the cell, and an intermittently operating feed device for supplying electrolyte to said cell, said feed device controlled by said cathode.

29. In an electrolytic cell the combination of a liquid metal cathode, means for periodically removing said cathode from the cell and returning it thereto, and a feed device constructed and arranged to admit electrolyte to the cell while the cathode is removed therefrom.

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

JASPER WHITING.

Witnesses:
JOHN L. PALFREY,
BERTHA S. CHASE.