FORM 1

COMMONWEALTH OF AUSTRALIA 614590

PATENTS ACT 1952

APPLICATION FOR A STANDARD PATENT

I\We,

TOHO TITANIUM CO., LTD.

of 2-13-31 KOUNAN
MINATO-KU
TOKYO
JAPAN

hereby apply for the grant of a standard patent for an invention entitled:

ELECTROLYTIC CELL FOR RECOVERY OF METAL

which is described in the accompanying complete specification

Details of basic application(s):

Number of basic application	Name of Convention country in which basic application was filed	Date of basic application
63-74598	JP	30 MAR 88
63-74597	JP	30 MAR 88
63-139440	JP	08 JUN 88

My/our address for service is care of GRIFFITH HACK & CO., Patent Attorneys, 601 St. Kilda Road, Melbourne 3004, Victoria, Australia.

DATED this 28th day of March 1989

TOHO TITANIUM CO., LTD.

GRIFFITH HACK & CO.

TO: The Commissioner of Patents.

Forms 7 and 8

AUSTRALIA

Patents Act 1952

DECLARATION IN SUPPORT OF A CONVENTION OR NON-CONVENTION APPLICATION FOR A PATENT OR PATENT OF ADDITION

Name(s) of Applicant(s)	In support of the application made by Toho Titanium Co., Ltd.
Title	for a patent for an invention entitled "ELECTROLYTIC CELL FOR RECOVERY OF METAL"
Name(s) and address(es) of person(s) making declaration	I/We, Shunichi Yashima, president of Toho Titanium Co., Ltd. 2-13-31 Kounan, Minato-ku, Tokyo, Japan

do solemnly and sincerely declare as follows:-

1. I am/we are the applicant(s) for the patent, or am/are authorised by the abovementioned applicant to make this declaration on its behalf.

2. The basic application(s) as defined by Section 141 of the Act was/were made in the following country or countries on the following date(s) by the following applicant(s) namely:-

Country, filing date and name of Applicant(s) for the or each basic application:

in Japan on March 30, 1988
by Toho Titanium Co., Ltd.
in Japan on March 30, 1988
by Toho Titanium Co., Ltd.
in Japan on June 8, 1988
by Toho Titanium Co., Ltd.

3. The said basic application(s) was/were the first application(s) made in a Convention country in respect of the invention the subject of the application.

Name(s) and address(es) of the or each actual inventor:

4. The actual inventor(s) of the said invention is/are (1) Hiroshi Matsunami, 2-10-8 Higashi Kaigan Minami, Chigasaki-shi, Kanagawa-ken, Japan (2) Kunio Maehara, 540-25 Kagawa, Chigasaki-shi, Kanagawa-ken, Japan (3) Susumu Kosemura, 511 3-204 Chigasaki, Chigasaki-shi, Kanagawa-ken, Japan

See reverse side of this form for guidance in completing this part

5. The facts upon which the applicant(s) is/are entitled to make this application are as follows:- the applicant would be entitled to have assigned to it a patent granted to the actual inventors in respect of the said invention.

DECLARED at Chigasaki, Japan this 13 th day of March, 1989

Shunichi Yashima

Shunichi Yashima, President

This form may be completed and filed after the filing of a patent application but the form must not be signed until after it has been completely filled in as indicated by the marginal notes. The place and date of signing must be filled in. Company stamps or seals should not be used.

No legalisation is necessary

PF/Mar/19/1981

Information for completing paragraph 5 -

A. If the application is by the actual inventor(s) it is not necessary to make any insertion in paragraph 5.

B. If the application is by a company or person to whom the invention has been assigned the appropriate insertion is "the applicant is the assignee of the actual inventor(s)"

C. If the application is by an employer entitled to the invention by service agreement(s) and a specific assignment has not been made the appropriate insertion is "the applicant would be entitled to have assigned to it (him, her) a patent granted to the actual inventor (any of the actual inventors) in respect of the said invention."

D. Where Convention priority is claimed and the applicant in Australia is not the applicant in the Convention country, paragraph must indicate how the Australian applicant obtained the right to claim priority. For this purpose appropriate additional wording may be "(and) the applicant is the assignee of the applicant(s) named in paragraph 2 above" or "(and) the applicant has the consent of the applicant(s) named in paragraph 2 above"

E. If the above information appears insufficient or inappropriate please defer completing the declaration form and discuss the matter with us. Remember that a declaration form may be completed and filed after lodgement of a patent application without any penalty or disadvantage. We do not need any signed form before filing an application.

CLEMENT HACK & CO.

(12) PATENT ABRIDGMENT (11) Document No. AU-B-31722/89
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(56) Prior Art Documents
US 4560449
US 4518475
US 4481085

(57) A bipolar type cell is described and claimed. The recovery of magnesium is described.

CLAIM

1. An electrolytic cell for recovery of metal comprising a first partition wall provided with partition openings situated beneath the level of an electrobath and disposed between a dissociated metal recovery chamber and an electrolytic chamber having an anode and a cathode and a second partition wall located on the side of a metal recovery chamber adapted to constitute an intermediate chamber between said first and second partition walls for recovery of dissociated Cl_2 gas.

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Form 10

COMPLETE SPECIFICATION

(ORIGINAL)

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Related Art:

TO BE COMPLETED BY APPLICANT

Name of Applicant: TOHO TITANIUM CO., LTD.

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601 St. Kilda Road,
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Complete Specification for the invention entitled:
ELECTROLYTIC CELL FOR RECOVERY OF METAL

The following statement is a full description of this invention including the best method of performing it known to me:-

SPECIFICATION

TITLE OF THE INVENTION

Electrolytic cell for recovery of metal

1. Field of the Invention

The present invention relates to an electolytic cell for electrolyzing a salt bath of metallic halide so as to effectively separate a metal substance from a halogen gas. The cell is advantageously used for an electrolysis of $MgCl_2$.

2. Prior Art

There has been provided an electrolytic cell for recovering Mg and Cl_2 substances by electrolyzing $MgCl_2$. Particularly, well known is a gas-lift type electrolytic cell arranged to separate and recover the Mg substance and the Cl_2 gas by generating a circulation of the salt electrobath bath utilizing a lifting force of the Cl_2 gas dissociated at the anode in electrolysis action (for example, as shown in the Japanese Unexamined Patent Publication No. 45-31529). The gas-lift type electrolytic cell is provided with a partition 7 which is arranged in a curtain-like form or has window-like openings 15 for separating the Mg metal recovery chamber 9 from the Cl_2 recovery chamber 5, as best shown in Fig. 2 of the Publication (and in Fig. 4 of this application). Such an arrangement allows the Cl2 gas produced at the anode to circulate an electrobath with difficulty. If the speed of the electrobath increases upto about 0.3 m/sec along the electrobath level in the Cl_2 gas recovery chamber 5 towards the partition 7, the separation of Cl_2 from the electrobath is hardly effected within the Cl_2 recovery chamber 5. Thus, a portion of the Cl_2 gas in unseparated state flows in a circulation and passes the single partition 7 to enter the Mg metal recovery chamber 9. The amount of an escaped gas may be about 15% of the Cl_2 gas using a single electrode type.

Although there has newly been developed a bipolar electrode type electrolytic cell having more than one bipolar electrode between the anode and the cathode for the purpose of reduction in electrical source or improvement in the facility productivity. However, a means for separating and recovering Mg and Cl_2 remains still unchanged in substantial function from those of a single cell arrangement.

The bipolar type electrolytic cell has a narrow distance between the electrodes, whereby the lifting effect of Cl_2 gas on the electrobath increases and the circulating speed of the electrobath becomes higher. As a result, the Cl_2 gas overflowing to the metal recovery chamber due to the circulation of electrobath will be increased in volume, thus causing environmental pollution or cost increase due to a decline in the Cl_2 gas recovery rate.

To solve the above problem, there is proposed such an arrangement as designated by the arrow in Fig.3 of Japanese Unexamined Patent Publication No.59-6389, having a barrage on the partition 7 so that an electrobath containing Mg and

Cl_2 gas can pass in a thin stream for promoting the separation of Cl_2 gas. However, this arrangement also requires the continuous supply of a predetermined amount of $MgCl_2$ or the use of an electrobath level control device for keeping the level of the electrobath, which varys as the $MgCl_2$ is consumed, at a particular elevation in order to permit the electrobath containing Mg and Cl_2 to pass the barrage in a thin stream.

Accordingly, the disadvantages of the prior art electrolytic cell are as follows:

i) The single partition allows a Cl_2 gas to overflow into the metal recovery chamber in a great amount, which affects the environment in a negative manner and reduces the rate of Cl_2 recovery as a resulting in cost-up;

ii) The electrobath level, particularly in such a bipolar type electrolytic cell as shown in the Publication 59-6389, needs to be uniform and thus, the control of electrolysis becomes troublesome;

iii) The single partition of a similar bipolar type electrolytic cell causes a short-current, which flows via ionized Mg substances floating in the metal recovery chamber, to become high and the cell effeciency declines;

iv) The single partition affects the flow of the electrolytic cell in a considerable scale and thus, the ionized Mg substances are activated in movement in the metal recovery chamber, which causes a newly developed Mg deposit to be exposed and burn for creating MgO.

v) For the purpose of continuous supply of a specified amount of $MgCl_2$ to keep the electrobath level uniform, there will disadvantageously be required various cooperative controls such as measurement of the electrobath level, operation of a related supply mechanism, composition adjustment of electrobath, or the like.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an electrolytic cell capable of effectively separating the Cl_2 gas from the Mg metal so as to substantially alleviate at least one of the above disadvantages.

According to the present invention there is provided an electrolytic cell for recovery of metal comprising a first partition wall provided with partition openings situated beneath the level of an electrobath and disposed between a dissociated metal recovery chamber and an electrolytic chamber having an anode and a cathode and a second partition wall located on the side of a metal recovery chamber adapted to constitute an intermediate chamber between said first and second partition walls for recovery of dissociated Cl_2 gas.

A preferred embodiment of the present invention in the form of a bipolar type electrolytic cell employs, in addition to such an arrangement as described, both an electrode arrangement (referred to as a first developed arrangement hereinafter) for minimizing the current short-circuit generated mostly under the bipolar electrodes and a control arrangement (referred to as a second developed arrangement hereinafter) for reducing a deposit of sludge carried by the circulating flow of electrobath.

Embodiments of the present invention will be described in more detail with reference to the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a longitudinally cross sectional view of an embodiment of the present invention showing the primary arrangement of an electrolytic cell; Fig. 2 is a cross sectional view taken along the line A-A of Fig. 1; and Figs. 3 and 4 are views of prior art electrolytic cells. Figs. 5 to 11 are explanatory views showing the first developed arrangement of the present invention in relation to the prior art, in which: Figs. 5a, 5b, and 5c are schematic cross sectional views showing a primary construction of the first developed arrangement; Figs. 6, 7a, 7b, 7c, and 7d are schematic cross sectional views showing another construction of the first developed arrangement; Fig. 8 is a curve diagram of voltage and current with respect to the electrolytic cell in action; Figs. 9 and 10 are views showing the lower structure of bipolar electrodes in a prior art electrolytic cell; and Fig. 11 is an explanatory view for calculation of the cell efficiency of the electrolytic cell. Figs. 12 to 15 are explanatory views showing the second developed arrangement of the present invention in relation to the prior art, in which: Fig. 12 is a cross sectional view taken (along the line B-B of Fig. 13) in parallel to the electrode of the second developed arrangement in the electrolytic cell; Fig. 13 is a cross sectional view taken along the line A-A of Fig. 1; Fig. 14 is an explanatory view showing a circulating flow of electrobath; and Fig. 15 is an explanatory view showing a deposit of sludge on the shelf of a prior art electrolytic cell.

DETAILED DESCRIPTION OF THE INVENTION

The primary arrangement of an electrolytic cell according to the present invention is characterized by a first partition wall having a plurality of partition openings formed therein beneath the level of electrobath and a second partition wall disposed to constitute an intermediate chamber situated between the first and second chambers for recovery of Cl_2 gas.

The primary arrangement will be described in more detail with reference to the drawings.

As shown in Figs. 1 and 2, there are provided a steel exterior plate 1, a thermally insulated brick wall 2, and a refractory brick wall 3. The numeral 4 is a cast cover covering the Cl_2 gas recovery chamber 5. The cover 4 is provided with the Cl_2 gas discharge conduit. The intermediate chamber 10 is interposed between the first partition wall 7 located on the Cl_2 gas recovery chamber 5 side and the second partition wall 8 located on the side of a metal recovery chamber 9. Represented by 11 is a steel cathode inserted from the outside while 12 is a graphite anode. There may be disposed bipolar electrodes between the cathode 11 and the anode 12. The level of electrobath is represented by 14. There are also designated a partition opening 15 interposed between the first partition wall 7 and its lower entension 17, a vent 16 formed in the first partition wall 7, and a through opening 16 provided beneath the first partition extension 17 while 19 is another partition wall and 191 is a barrage.

The operation of the electrolytic cell having the primary arrangement according to the present invention will be described.

The electrolytic cell is filled with electrobath containing 20% $MgCl_2$, 30% $CaCl_2$, 49% NaCl, and 1% MgF_2 in weight upto the liquid level 14 and then, operated by passing a direct current from the anode 12 to the cathode 11. As a result, there are produced the Cl_2 gas at the anode and the Mg deposit at the cathod. As the Cl_2 gas dissociated is much lighter in weight than the electrobath, it moves upward between the electrodes in the electrobath. This causes an upward flow of the electrobath for circulation. Thus, the Mg deposit on the cathode is also moved upward by the circulating flow of electrobath and enters the Cl_2 gas recovery chamber 5 along with the Cl_2 gas. When the electrolyte reaches the electrobath level 14 in the Cl_2 gas recovery chamber 5, most of the Cl_2 gas will escape from the electobath while the electrobath continues to circulate towards the the first partition wall 7. The electrobath on reaching the first partition wall 7 flows through the partition openings 15 provided in the first partition wall 7 into the intermediate chamber 10 where the remaining of the Cl_2 gas is completely separated from the electrobath. The Cl_2 gas recovered in the intermediate chamber 10 passes the vents 16 formed in the upper of the first partition wall 7 and enter the Cl_2 gas recovery chamber 5 before being discharged from the discharge conduit. After release of the Cl_2 gas in the intermediate chamber 10, the electrobath passes beneath the second partition 8 to the metal recovery chamber 9. The, the circulating speed of the electrobath slows down and Mg substances contained the electrobath will be liberated due to the specific gravity difference (1.75 for electrobath to 1.55 for Mg metal) and form layer of Mg deposit in the upper of the metal recovery chamber 9.

After release of the Mg substances, the electrobath flows downward in the metal recovery chamber 9 and passes through the opening 18 formed beneath the first partition extension 17 for returning to between the anode 12 and the cathode 11. The electrobath continues a circulation.

The first partition extension 17 is arranged to restrict the flow of electrobath between the electrolytic chamber and the intermediate chamber and allow a circulating flow of electrobath from the partition openings to the lower through opening. Accordingly, the extension 17 will give the equal effect even if the electrobath is separated by an array of cathodes. The Cl_2 gas recovered in the upper of the intermediate chamber 10 may be collected through separate discharge conduits while the first partition wall 7 is provided with no vent in the uppermost of the cell. This arrangement will give increased strength for mounting of the first partition wall 7.

(Example 1)

The electrobath containing 20% $MgCl_2$, 30% $CaCl_2$, 49% NaCl, and 1% MgF_2 was dissociated by an electric current of 100,000A in the electrolytic cell of Fig. 1 kept the temperature at 660°C to 680°C. Consequently, the electrobath flowed at a great speed from the back to the front of the electrodes in the electrolytic cell and particularly, passed the first partition openings 15 in fast and strong streams while there was no escaping flow of Cl_2 gas into the metal recovery chamber 9. This condition remained unchanged during the time when the electrobath level 14 shifted from the lower end 16_1 of the vent 16 to the lower end 15_1 of the partition opening 15.

With the use of the primary arrangement of the present invention as above described, the following results are obtained. An escaping flow of Cl2 gas to the metal recovery chamber 9 is prevented and thus, environmental pollution and a decline in the recovery rate due to rebonding of Cl_2 with Mg, can be avoidable. Additionally, the electrolysis operation is extensively effected during the time when the electrobath level 14 shifts from the lower end 16_1 of the vent 16 to the lower end 15_1 of the first partition opening 15. This eliminates the difficulty of electrobath level control which cannot be overcome in the prior art. The advantageous effects are given with equal success with the use of a bipolar type electrolytic cell having a plurality of bipolar electrodes between the anode and the cathode.

Although this example requires non of electrobath level control and continuous supply of electrobath which are problems to be solved in the prior art, it may be possible to join the present invention with the prior art in practice.

Then, the necessity of electrobath level control and continuous supply of electrobath is lessened and the electrolysis operation can assuredly be carried out.

The first developped arrangement of the present invention comprises such an electrode arrangement as a short-circuit current generated mostly under the bipolar electrodes is reduced with the use of a bipolar type electrolytic cell. More specifically, there are produced short-circuit current flows between the anode and the cathod inserted from the outside into the electrolytic cell, which run without passing the bipolar electrodes and will cause a decline in the cell efficiency of the bipolar type electrolytic cell. Assuming that an electrolytic cell 28 has a plurality of bipolar electrodes 23_1, 23_2, ... and 23_n which are disposed between an anode 21 and a cathode 22 to separate into n sections, as shown in Fig. 11, where the current applied between the anode and the cathode is I_T; the short-circuit current between the same I_S; and the current passing bipolar electrodes I_E, the cell efficiency is determined by:

$$n = \frac{n\ I_E + I_S}{n\ I_T} \times 100\%$$

To reduce the short-circuit current, a particular arrangement for cavity spaces around the electrodes or an improved lower construction of the bipolar electrodes in the electrolytic cell is needed.

Such a lower arrangement of the bipolar electrodes in a prior art electrolytic cell includes an array of electric insulation blocks disposed beneath the anode and the cathode inserted from the outside and the bipolar electrodes for control of the short-circuit current, as shown in Fig. 3 of Japanese Unexamined Patent Publication 59-6389 (Fig. 10 attached to this specification) or in Fig. 1 of No. 59-107090 (Fig. 9 attached to this application).

However, this lower arrangement of the bipolar elecrodes for use with a prior art bipolar type electrolytic cell has the following disadvantages.

i) The distance between the two adjoined insulation blocks is about 1 to 5 cm and it will be difficult to install the electric insulation blocks in the electrolytic cell for a proper arrangement.

ii) Each electric insulation block beneath the bipolar electrode is thin and breakable.

iii) The distance between the two insulation blocks of 1 to 5 cm is so narrow that electrolytic sludge in paste state which results from oxidization of $MgCl_2$ or Mg, can easily accumulate. As the result, there are caused a short-circuit between the electrodes and a slowdown in the flow of electrobath and thus, the cell efficiency and the current efficiency will be reduced.

The first developed arrangement of the present invention is then adapted to overcome the above disadvantages and provide high efficiency in a bipolar type electrolytic cell, in which no electric insulation block is provided beneath the bipolar electrodes by extending downward the bipolar electrodes 23, 23_1, ... so as to be longer than the anode 21 and the cathode 22 or extending the same to the lowermost end of the electric insulation blocks 24 and 25 which are joined to the bottom ends of the anode 21 and the cathode 22 respectively, as shown in Figs.5a to 5c. More specifically, the electrolytic cell having the first developed arrangement is characterized by bipolar electrodes which are extended downward instead of having at low end the electric insulation blocks 26, 26_1, ...employed for control of the short-circuit current in the prior art. The extension of the bipolar electrode may be determined to a proper length, e.g. preferably 5 to 40 times the distance between the two electrodes. Although the electrolytic cell according to the present invention provides remarkably high effectiveness with the use of not more than two bipolar electrodes, it will work with equal success with more than two bipolar electrodes. However, in the latter case, a short-circuit current flows between the bipolar electrodes and a decline in the cell efficiency will be inevitable.

During the operation of the bipolar type electrolytic cell having the first developed arrangement, advantageous effects are given by the following two functions.

I. As the distance between the electric insulation block situated beneath the anode or cathode and the lower extention of the bipolar electrode acts as a narrow and long electrical passage in the electrobath, an electrical resistance in the distance becomes great. Thus, the current causing a short-circuit between the anode and the cathode (or between the bipolar electrode and the anode or cathode) will considerably be reduced.

II. In the narrow spaces between the electric insulation blocks 26, 26_1, ... provided in the prior art bipolar type electrolytic cell shown in Fig.6c, 7c, 9, or 10, deposition of electrolytic sludge occurs due to no electrochemical action on the surfaces of the insulation blocks. On the other hand, the first developed arrangement has the bipolar electrodes extending downwardly of the anode and the cathode so that electrochemical action can occur on the surfaces of the electrodes. Accordingly, the electrode surfaces are cleaned and the flow of electrobath is activated by production of Mg and Cl_2, which will minimize the deposition of electrolytic sludge.

(Example 2)

Assuming that each of the electrode arrangements schematically shown in Figs.6a, 6b, 6c, 6d, 7a, 7b, 7c, and 7d was used in the electrolytic cell, the cell efficiency was calculated separately. The cell efficiency was about 95 % for the arrangement of Fig.6a or 7a in which the bipolar electrode is equal in length to the anode and the cathode while no electric insulation block was employed. The cell efficiency was about 98% for the arrangement of Fig. 6b or 7b in which the bipolar electrode was downwardly extended. Both show improvement in the efficiency. The cell efficiency was about 99.5% for the arrangement of Figs. 6c or 7c similar to that in a prior art electrolytic cell, which is very satisfactory. The cell efficiency was about 99.3 to 99.4% for the improved arrangement of Fig. 6d or 7d, which almost equaled that of the prior art electrolytic cell.

A bipolar type electrolytic cell of 100,000A capacity in which the bipolar electrode was downwardly extended 20 times the distance between the two bipolar electrodes as shown in Fig. 5c, was filled with an electrobath containing 20% $MgCl_2$, 30% $CaCl_2$, 49% NaCl, and 1% Mg_2 and operated at a temperature ranging from 660 to 680°C for 12 months. A change in the cell efficiency is obtained from the curve diagram of current and voltage in Fig. 8 given by measuring changes in voltage with the current reduced periodically during the operation. The cell efficiency of the bipolar type electrolytic cell was given through measuring the relation between a current I and a cell voltage E and examining the relative points and the inclination of two given lines. The resultant values were within an allowance range of each measuring device and equal to the calculated value with an equivalent circuit. Also, no time-relating change was detected. The arrangement according to the present invention was checked after the electrolytic cell stopped and no blockage with electrolytic sludge was found. It is thus determined that the electrolytic cell has been operated in a normal condition throughout the period of practice time.

Although the embodiment is described with respect to electrolysis of $MgCl_2$ solution, it is not limited to that. The bipolar electrode electrolytic cell having the improve arrangement will be utilized with equal success for electrolysis of alkaline metal, alkaline earth metal, etc under their respective conditions.

The second developed arrangement according to the present invention is adapted for use with a bipolar type electrolytic cell, having such a control plate arrangement that the sludge carried by a circulating flow in an electrobath can be prevented from accumulating on a particular place in the cell. More specifically, the bipolar type electrolytic cell has insulation blocks arranged beneath the anode and cathode inserted from the outside or the bipolar electrodes for the purpose of preventing a by-pass current which flows without passing the bipolar electrodes. The insulation block is made of refractory almina material. To support the insulation blocks, there is provided a shelf formed on the inner wall of an electrolysis chamber. As a result, the flow of the electrobath moving towards the upper of the electrolysis chamber has a stagnant portion on the shelf 32 as shown in Fig.15, and allows sludge 38 of mostly MgO to accumulate on the same. The sludge 38 also contains Mg metal substances thus having a conductive nature. Consequently, the sludge 38 short-circuits between the electrodes and electrosis between the same will be prevented. Also, above the shelf 32 there are caused turbulent flows in the electrolyte bath and the bonding reaction of Mg metal and Cl_2 gas dissociated by electrolysis will be increased.

To solve the above problem, there has been proposed a prior art in which the shelf is arranged to have a sloping top and incorporated with the inner wall of an electrolysis chamber so as to prevent an electrobath circulating flow from stagnating.

Accordingly, a prior art bipolar type electrolyte cell has a sloping top shelf incorporated with the inner wall of the electrolysis chamber to prevent the electrobath circulating flow from stagnating in the electrolysis chamber. The disadvantages are:

i) It will be difficult in process and installation due to an integrated arrangement of the sloping top of the shelf to the inner wall of the electrolysis chamber;

ii) It will be breakable due to an integrated arrangement of the sloping top of the shelf to the inner wall of the electrolysis chamber; and

iii) It will be less flexible and thus, may give damage to electrodes due to an integrated arrangement of the sloping top of the shelf to the inner wall of the electrolysis chamber.

The second developed arrangement of the present invention is then adapted to overcome the above disadvantages and provide high effectiveness in a bipolar type electrolytic cell.

For the purpose, the bipolar type electrolytic cell having the second developed arrangement has control plates 33 disposed on the shelves 32 in the electrolysis chamber separately from the inner wall of the electrolysis chamber for slow dispersion of the circulating flow in an electrobath, as shown in Figs.12 and 13. Designated in Fig.31 are a bipolar electrode 34, an insulation block 35, an electrobath 36, an electrolysis chamber inner wall 37, a sludge deposit on the shelf 38, a cathode 30, and an anode 39. The arrows in Figs.14 and 15 represent flows in the electrobath.

The control plate 38 used in the embodiment is so shaped as to disperse the circulating flow in the electrobath generally as shown in Fig.14 and prevent the deposition of sludge 38 shown in Fig.15 in which no control plate is employed. Preferably, the control palte 38 is of a right-angled triangle having the bottom equal in length to the shelf and arranged at an angle of 30° to 80° to the sloping side. The sloping side may moderately be curved in either convex or concave form other than straight configulation.

During the operation of the bipolar type electrolytic cell having the second developed arrangement, advantageous effects are given by the following functions. The control plates provided on the shelf of the electrolysis chamber separately from the inner wall of the electrolysis chamber, which are unbreakble and will give no damage to the electrodes, prevent sludge from accumulating on the shelf during the passing of a circulating flow in the electrobath and also, allow no stagnation nor excessive turbulance in the circulating flow.

(Example 3)

A bipolar electrolytic cell having the control plates of alumina material, each of which has a bottom of 100 mm length and a sloping side arranged at an angle of 60^{o} to the bottom, and is 10 mm in thickness, disposed between the electrodes (i.e. between the anode and a bipolar electrode, between the bipolar electrodes, and between a bipolar electrode and the cathode), was filled with an electrobath containing 20% $MgCl_2$, 54% NaCl, 25% $CaCl_2$, and 1% MgF_2. Then, an electrolysis operation has been carried out at a bath temperature of 660^{o} to 670^{o} under a condition of applying an electrolytic current of 100,000A for 12 months.

The electrolytic cell had been running well during the operation and thereafter, was disassembled for inspection of the shelf 32 and controlplates 33. As a result, the predicted effects were obtained with no damage to the plates nor the electrodes and no deposition of sludge generated.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. An electrolytic cell for recovery of metal comprising a first partition wall provided with partition openings situated beneath the level of an electrobath and disposed between a dissociated metal recovery chamber and an electrolytic chamber having an anode and a cathode and a second partition wall located on the side of a metal recovery chamber adapted to constitute an intermediate chamber between said first and second partition walls for recovery of dissociated Cl_2 gas.

2. An electrolytic cell for recovery of metal as defined in claim 1 wherein said first partition wall is spaced from the ceiling of the cell so that said intermediate chamber can communicate with the upper of the electrolytic chamber.

3. An electrolytic cell for recovery of metal as defined in claim 1 wherein said first partition wall is closely fitted to the ceiling of the cell so that said intermediate chamber can be separated from the upper of the electrolytic chamber.

4. An electrolytic cell for recovery of metal as defined in claim 1, 2 or 3 wherein the partition openings in the first partition wall is incorporated at lower end with the cathode in the electrolytic chamber.

5. A bipolar type electrolytic cell for recovery of metal as defined in claim 1 further comprising bipolar electrodes, the lower end of which is extended downwardly from the lower end of the anode and cathode inserted from the outside.

6. A bipolar type electrolytic cell for recovery of metal as defined in claim 5 further comprising electric insulation blocks respective ones of which are mounted to the lower ends of the anode and the cathode inserted from the outside.

7. A bipolar type electrolytic cell for recovery of metal

as defined in claim 5 or 6 wherein the bipolar electrode is extended 5 to 40 times the distance between the two bipolar electrodes downwardly from the lower end of the anode and cathode inserted from the outside.

8. A bipolar type electrolytic cell for recovery of metal as defined in claim 5 wherein blocks are provided beneath the anode and cathode or the bipolar electrodes and are supported by shelves formed on the inner wall of the electrolytic chamber and wherein control plates for preventing the stagnation of an electrobath flow are further provided and alternately disposed between said insulation blocks.

9. A bipolar type electrolytic cell for recovery of metal as defined in claim 8 wherein the control plates are separated from the inner wall of the electrolytic chamber and substantially formed of a triangle shape, more particularly a right-angled triangle shape having a bottom side arranged at 30° to 80° to a sloping side.

10. An electrolytic cell substantially as herein described with reference to and as illustrated in figures 1, 2, 5, 6a, 6b, 7a, 7b, 8, and 11 to 14 of the accompanying drawings.

Dated this 20th day of June, 1991.

<u>TOHO TITANIUM CO., LTD</u>.
By It's Patent Attorneys:

<u>GRIFFITH HACK & CO</u>.
Fellows Institute of Patent
Attorneys of Australia.

31 722/89

FIG. 1

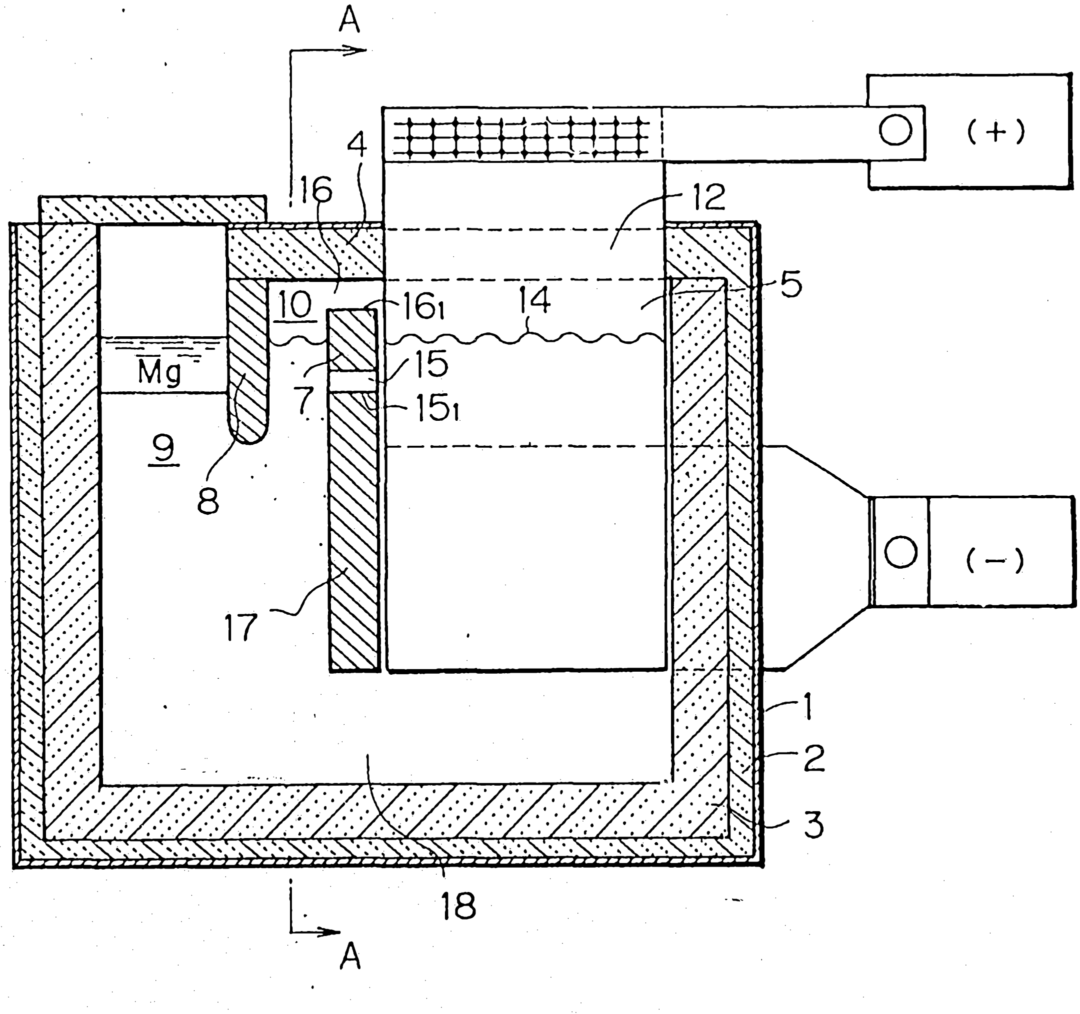

FIG. 2

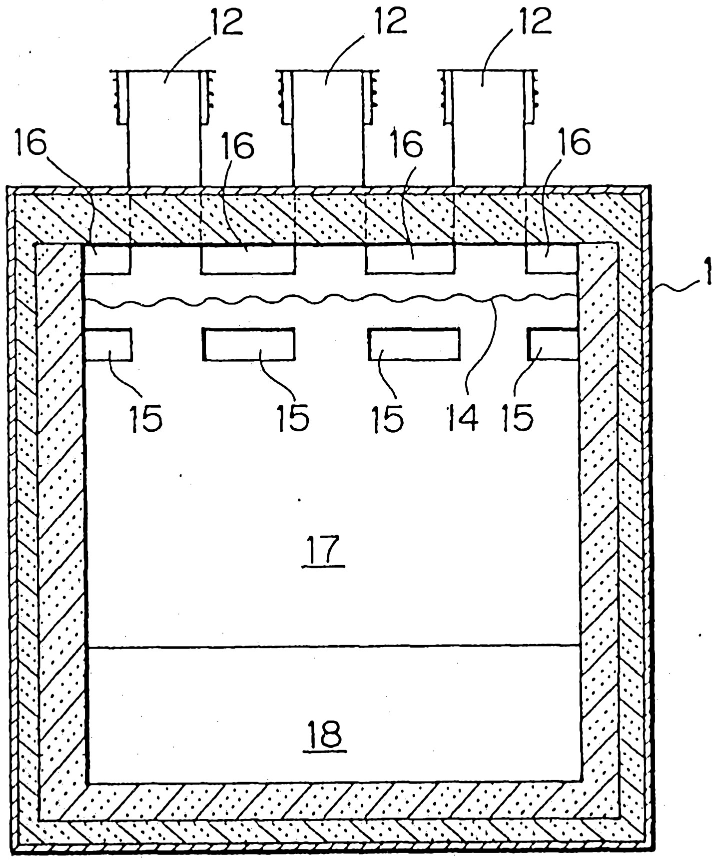

FIG. 3 (Prior Art)

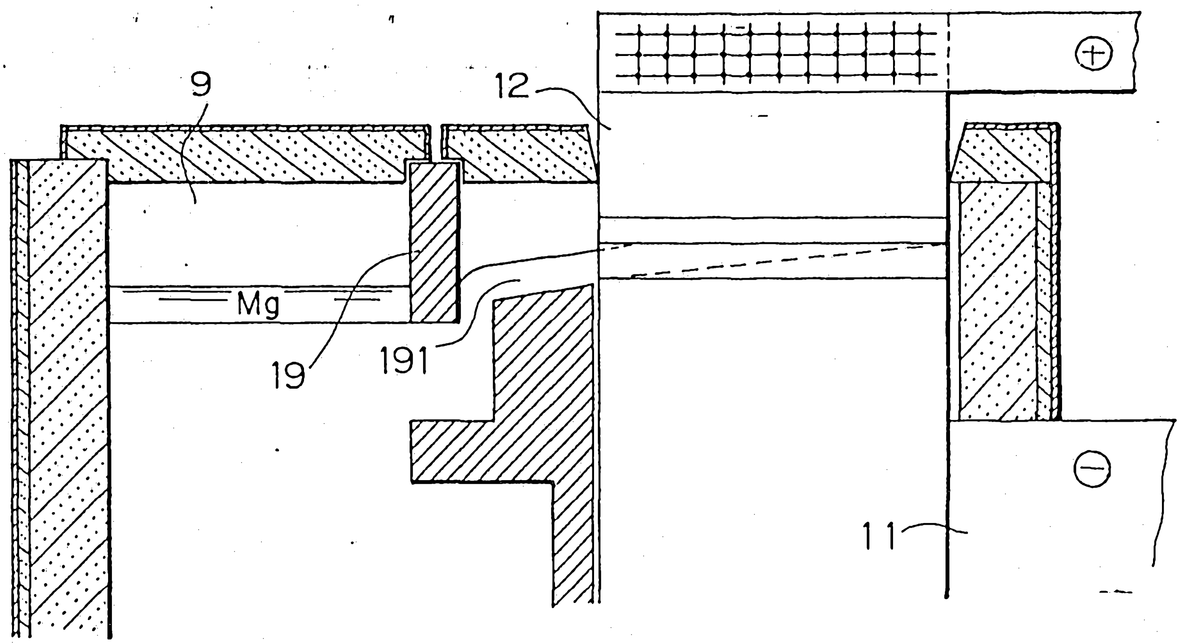

FIG. 4 (Prior Art)

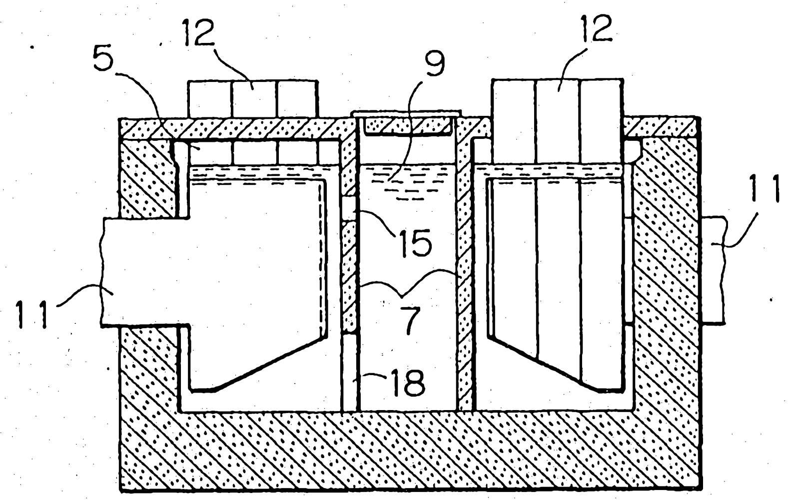

FIG.5

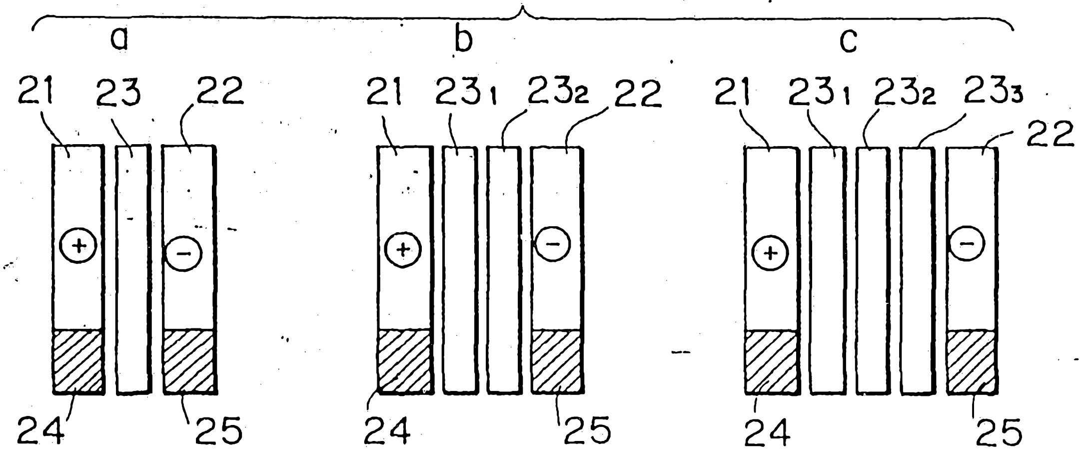

FIG.6

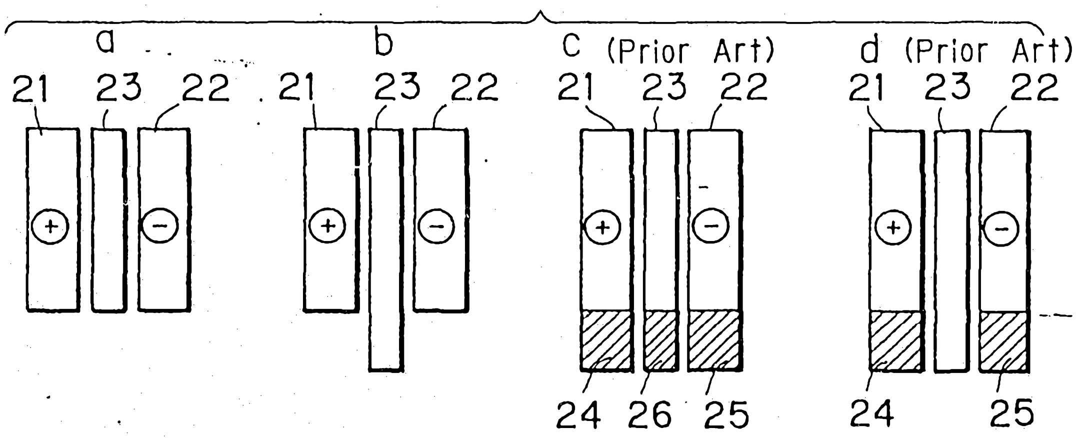

FIG.7

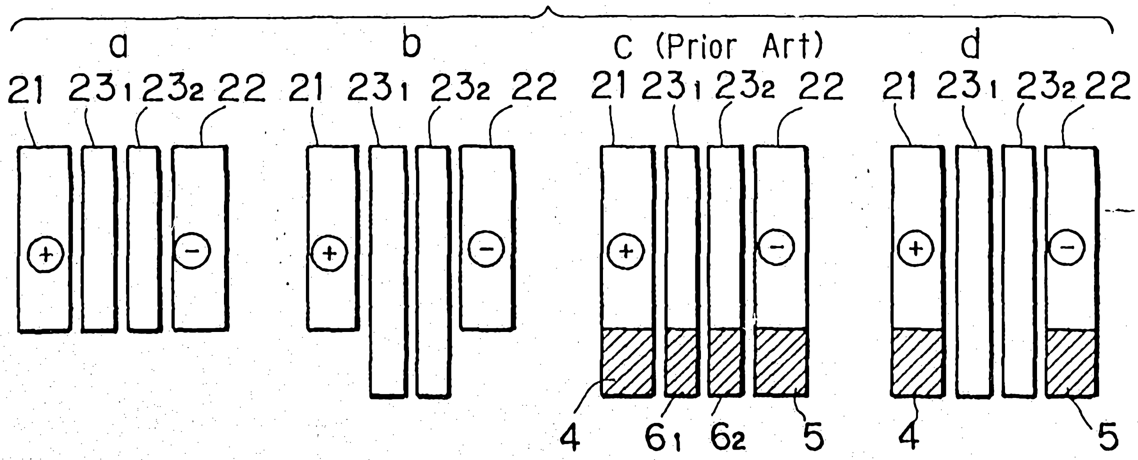

FIG.8

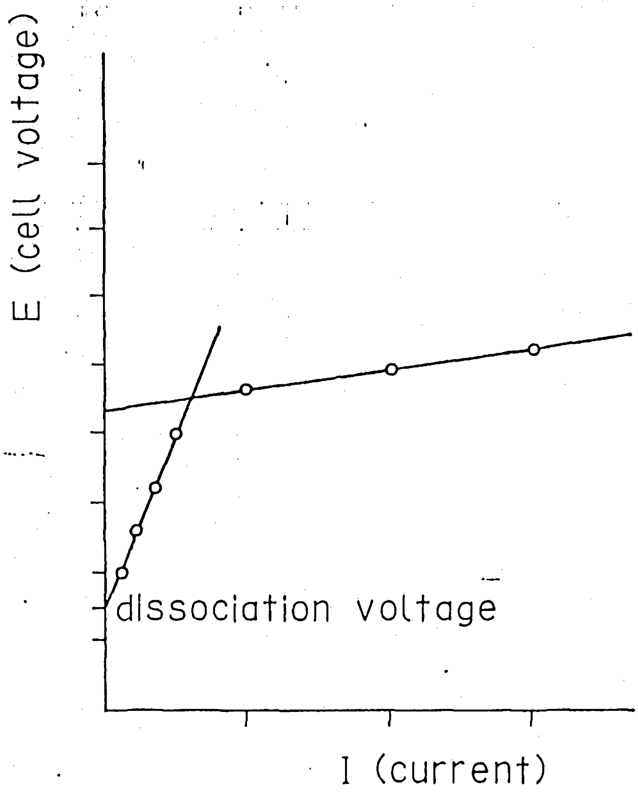

FIG.9 (Prior Art)

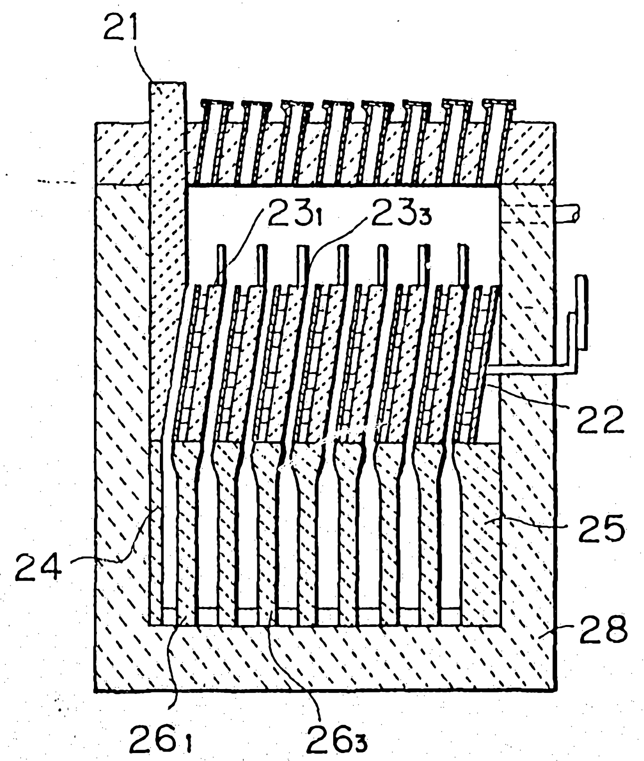

FIG. 10 (Prior Art)

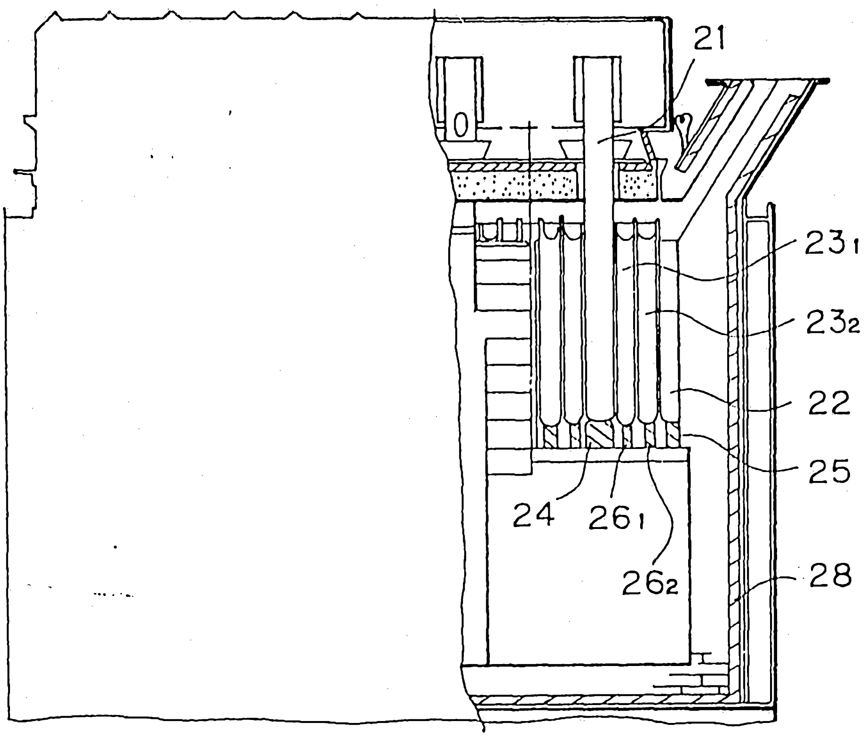

FIG. 11

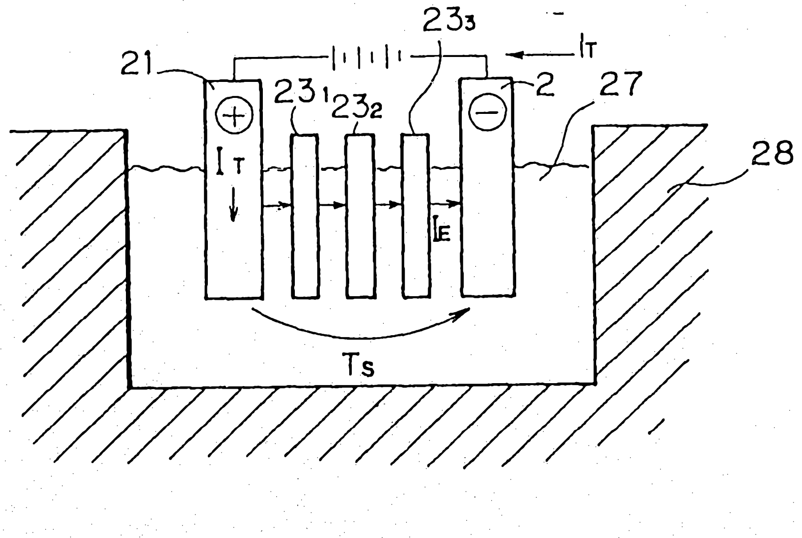

FIG. 12

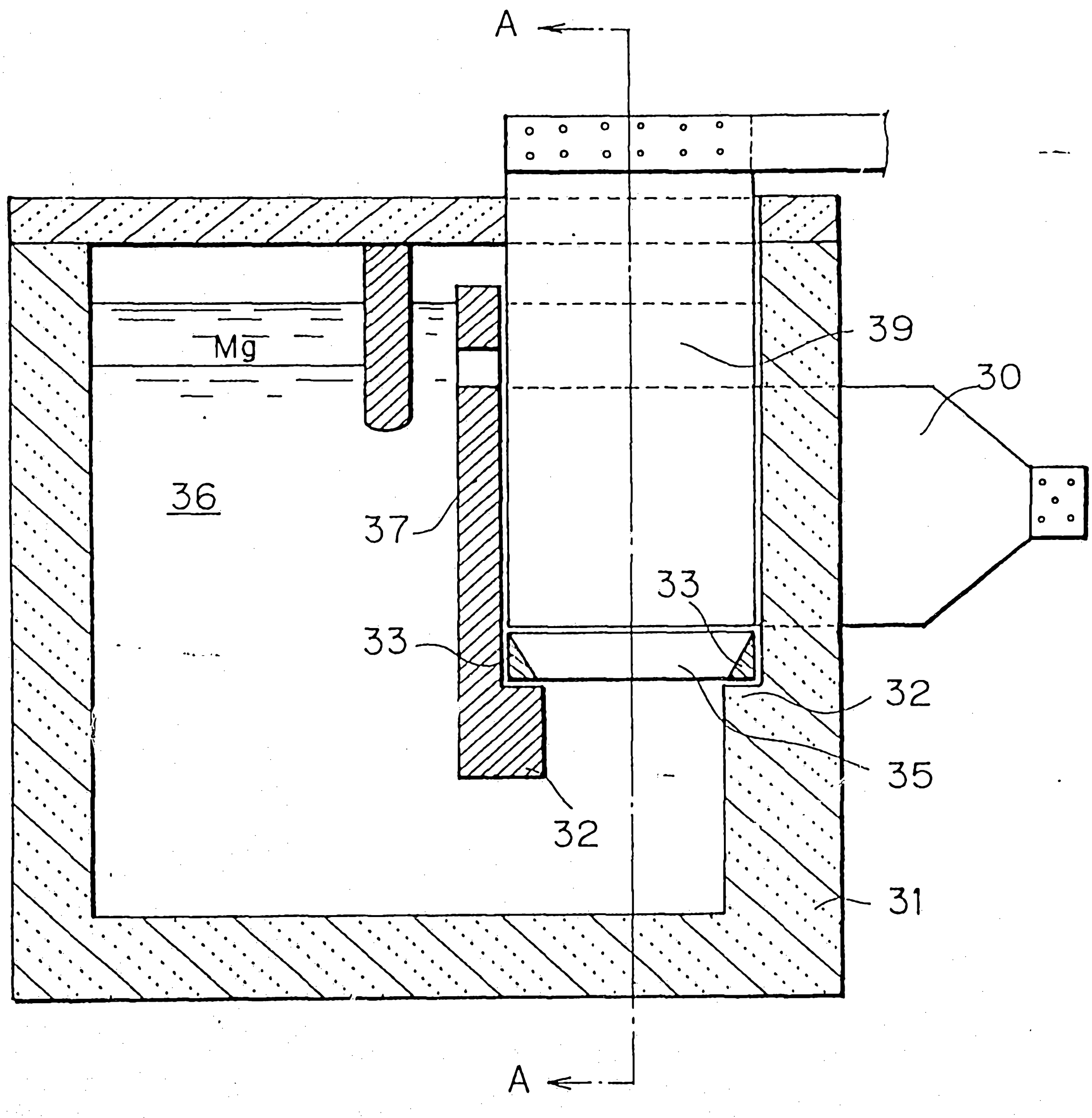

FIG. 13

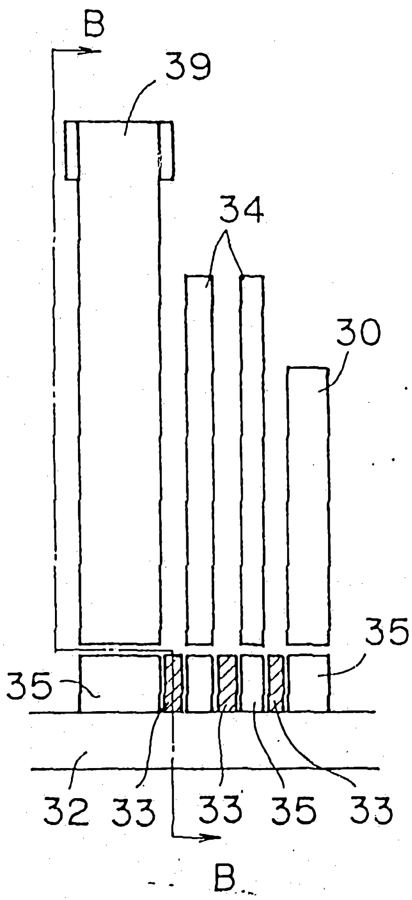

FIG. 14

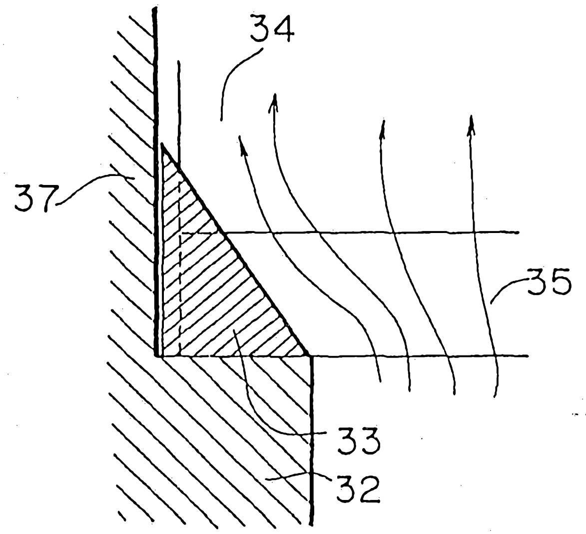

FIG. 15 (Prior Art)