E. R. GILL.
ELECTRIC BATTERY.
APPLICATION FILED NOV. 26, 1919.

1,381,298. **Patented June 14, 1921.**

5 SHEETS—SHEET 1.

Fig. 1.

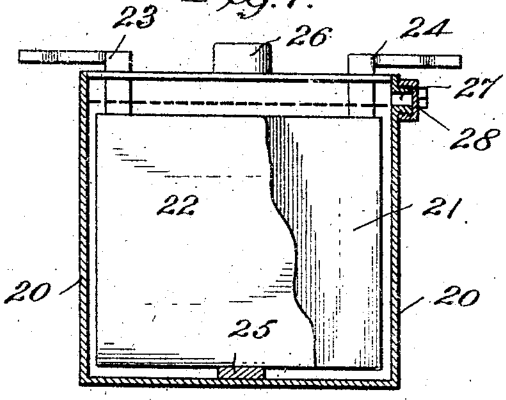


Fig. 2.

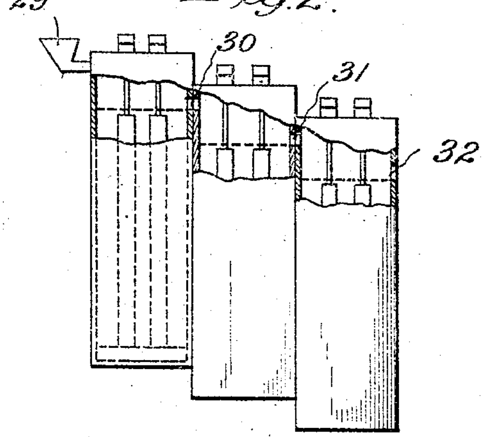
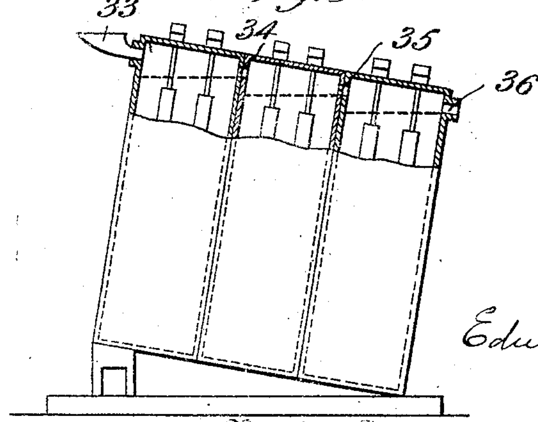


Fig. 3.



Edwin R. Gill
Inventor

By his Attorney [illegible]

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5 SHEETS—SHEET 2.

Fig. 4.

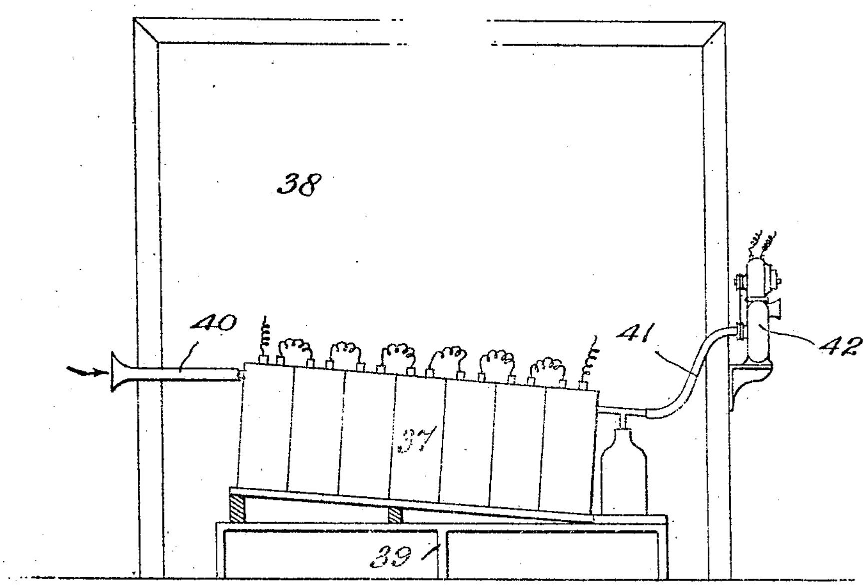
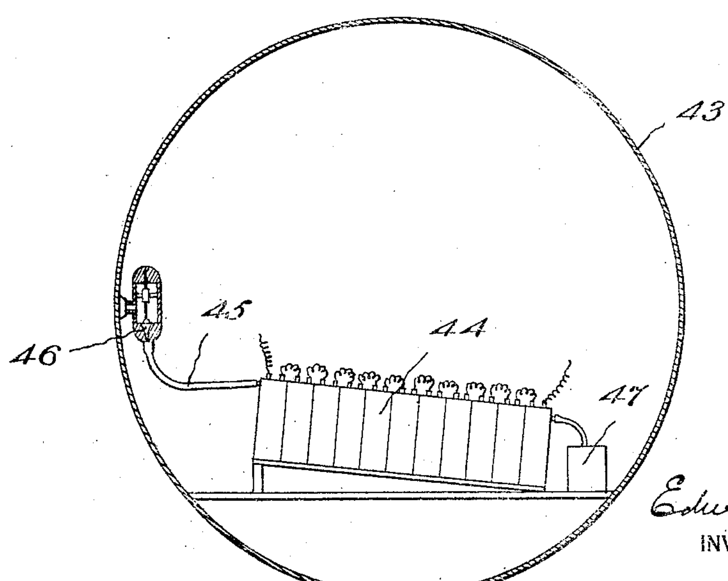


Fig. 5.



Edwin R. Gill
INVENTOR

BY H. M. MacKay
ATTORNEY

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5 SHEETS—SHEET 3.

Fig. 6.

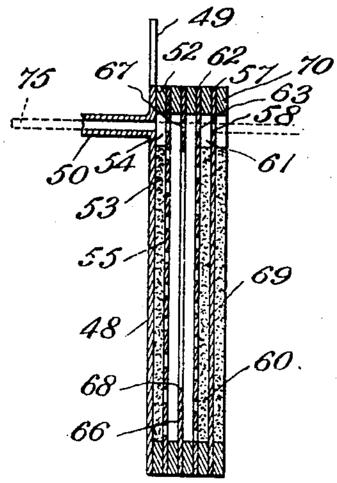


Fig. 7.

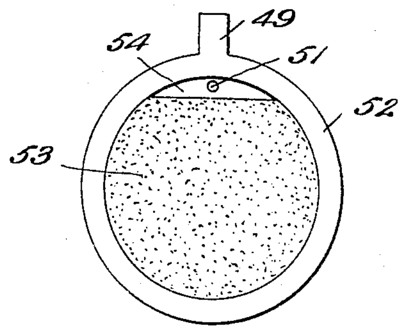


Fig. 8.

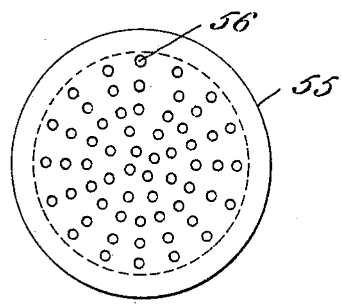


Fig. 10.

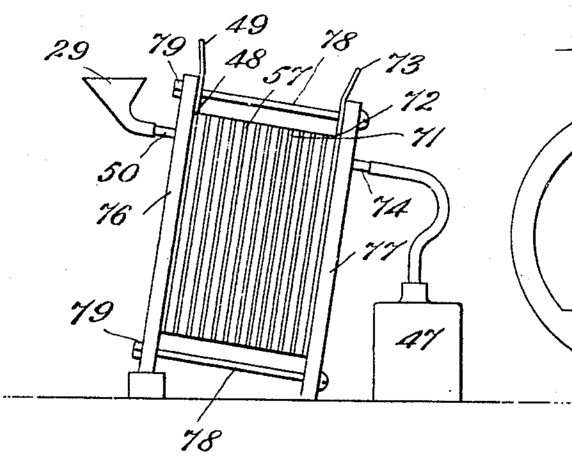
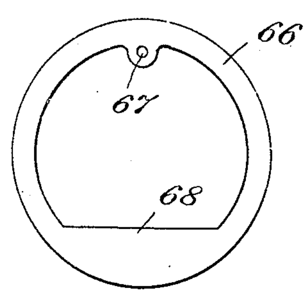


Fig. 9.



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5 SHEETS—SHEET 4.

Fig. 11.

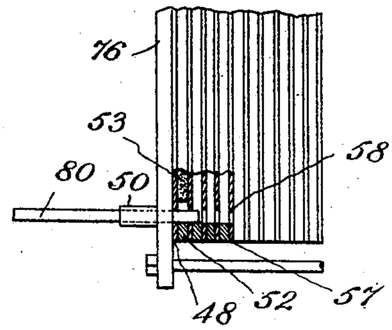


Fig. 12.

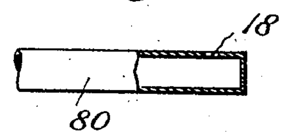


Fig. 13.

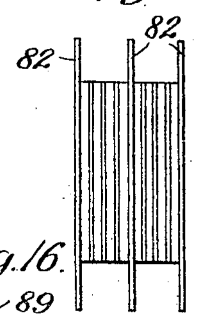


Fig. 14.

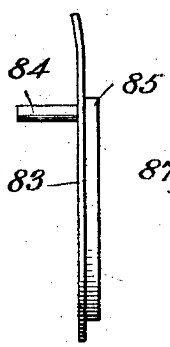


Fig. 15.

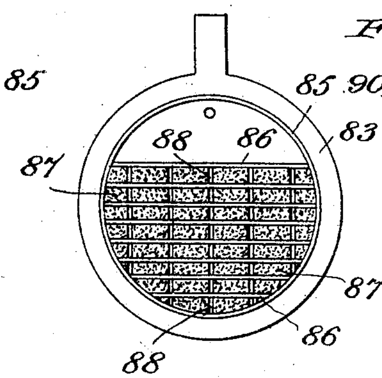


Fig. 16.

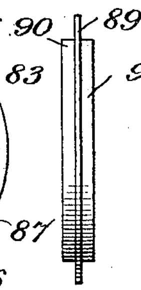


Fig. 19.

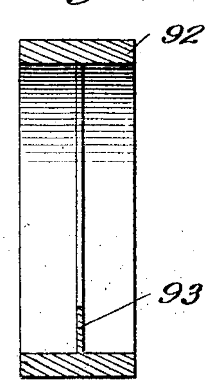


Fig. 17.

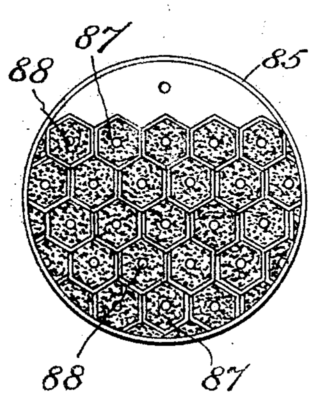
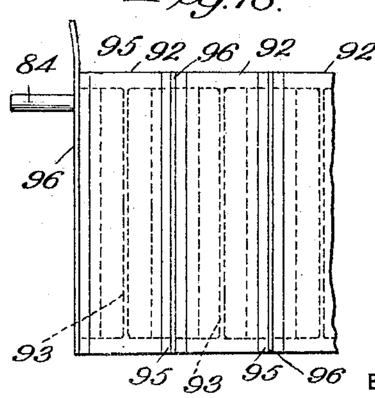


Fig. 18.



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INVENTOR

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E. R. GILL.
ELECTRIC BATTERY.
APPLICATION FILED NOV. 26, 1919.

1,381,298.

Patented June 14, 1921.
5 SHEETS—SHEET 5.

Fig. 20.

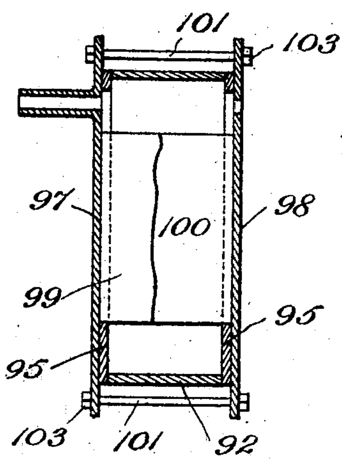


Fig. 21.

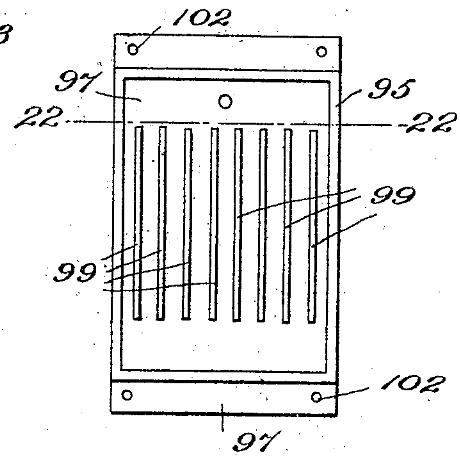


Fig. 22.

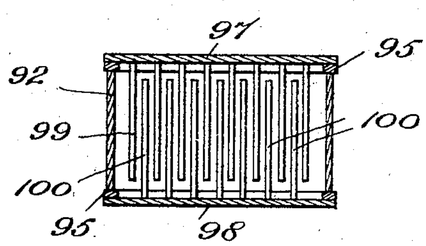
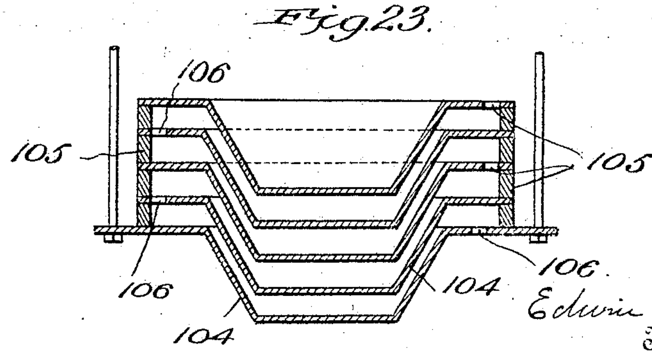


Fig. 23.



Edwin R. Gill
Inventor

By his Attorney H. S. MacKaye

UNITED STATES PATENT OFFICE.

EDWIN R. GILL, OF YONKERS, NEW YORK.

ELECTRIC BATTERY.

1,381,298. Specification of Letters Patent. Patented June 14, 1921.

Application filed November 26, 1919. Serial No. 340,960.

To all whom it may concern:

Be it known that I, Edwin R. Gill, a citizen of the United States, residing in Yonkers, Westchester county, the State of New York, have invented a certain Improvement in Electric Batteries, of which the following is a specification.

My present invention relates to certain new and useful improvements in electric batteries and in certain methods of using and managing the same. Some of the objects and advantages of the invention apply to single cells, whether of primary or secondary battery; while other features of the invention find their principal embodiment and application in batteries of connected cells, particularly (although not necessarily) of the secondary or storage type.

The significance and value of my invention will best appear from a statement of the difficulties which it overcomes in connection with secondary cells and batteries; since it is this branch of the art which is now of maximum importance commercially.

Secondary batteries are used very extensively (among other uses) in the art of wireless telegraphy and telephony, wherein small units are employed; and in automobiles, submarines, locomotives and power stations, which require much larger units. In any case a battery of this kind is composed of jars or cells, each containing one or more pairs of electrode plates of opposed polarities, immersed in a liquid electrolyte. Each jar is closed by an acid proof sealing compound and has a single filling opening at the top which is kept closed during use, a small opening or vent being left for escape of the gases generated by the activity of the cell. External terminals connected electrically with the different plates supply means whereby the cells are connected in battery formation for charging and discharging.

The care and management of these batteries, especially when they are subjected to high duty, or where subjected to vibration and jarring, as in automobiles, etc., is extremely arduous and expensive, and calls for a high degree of skill, care and vigilance. In some applications, as for instance, in submarine practice, these batteries become a source of actual danger; in some cases generating chlorin gas with fatal results, when accidentally wet with sea water; and in other cases causing disastrous explosions by generating a mixture of hydrogen and oxygen which explodes on occurrence of an accidental spark. It is indeed customary for manufacturers of secondary batteries to caution users against bringing a light near them.

But aside from actual danger of disaster, these batteries are a constant source of expense, trouble and loss. It is essential to proper operation that the electrolyte should be kept at just the right level; that is to say, high enough to submerge the plates but not so high as to spill under the jarring to which they are often subjected or to boil out through the vents. This last effect is caused by rapid disengagement of gas, and frequently causes a spraying of the external terminals and other metal parts, to the great detriment of the battery.

The inspection of each cell to ascertain the level of the electrolyte is a difficult and uncertain process, as each of a large number of jars must be separately opened and the operator must bring his face close to the opening, whence noxious gases are escaping, while trying to throw a light down into the opening to see where the level of the liquid is. Having done so, and finding it necessary to add liquid, he must guess when the right amount is added, and must continually check results to make sure that he does not overflow the jar. This happens frequently with the result of messing up the cells with strong sulfuric acid and ruining the metal parts. More or less complicated devices have been proposed for making the filling more speedy and certain but they all require expert attention in use and only partially solve the problem.

The trouble and loss of time involved in these operations is very great. In automobile practice for instance the constant evaporation requires refilling about once a week in summer and once a fortnight in winter. Moreover, since this constant evaporation is constantly causing the acid to become stronger and stronger, hydrometer tests are deemed necessary in many cases. The nature of the cells makes this tedious and difficult, and as the added water is apt to remain on top until time has caused proper mixture by diffusion, the test liquid withdrawn by the pipettes commonly used is frequently deceptive in character.

The spraying and disengagement of gases already mentioned is a source of loss and inconvenience if not of danger, necessitating in many cases the construction of a special room for accommodation of large batteries, entirely away from generators, motors, switches and other machinery. In some locations, too, as in stables where the air is tainted with ammonia, the external atmosphere, reaching the interior of cells when they are opened, or through the permanent vents, has a detrimental effect.

High duty batteries often give trouble owing to heating in use, and many cells of a given size and character would be capable of higher duty if they could be kept cool at all times.

Perhaps the greatest source of expense, loss of time and annoyance, however, is that incident to necessary repairs, renewals and cleaning. Secondary batteries, particularly under high duty, gradually disintegrate and the electrolyte becomes foul, a mud or sediment collecting at the bottom. It follows that such cells must be opened from time to time for cleaning out, as well as to replace worn out plates or grids. This involves much labor, as all the connections must be removed and the cells must be opened by breaking the sealing compound and pouring out the liquid. Every detail of disconnecting, emptying, washing, removing and replacing plates, resealing and refilling must be repeated for each of the many cells in a given battery.

By employing my present improvements some of the dangers and difficulties above pointed out are entirely obviated and the others are very greatly lessened.

My cells can be always kept filled to exactly the right height, which is self-determined, requiring no opening of the cell for inspection; and moreover, every cell in a given battery is kept filled to the same height as every other by a quasi-automatic effect. The importance of this feature from the point of view of uniform distribution of load and economy in use will be well understood.

No sealing compound is necessary in my preferred construction.

Any expansion of the volume of the electrolyte by gassing or "boiling" is taken care of and compensated for, the level being maintained automatically; besides which the degree of gassing, and the violence or quietude of any battery can be accurately gaged by the ear, and without opening the cell.

By the provision of an overflow container which is in constant operative relation with the battery, I am able to obtain accurate hydrometer tests with the greatest ease, and the violent changes in specific gravity resulting from additions of large quantities of distilled water to the electrolyte are avoided.

All gas liberation is controlled absolutely, making it possible to use batteries with perfect safety in all localities and preventing explosions, spraying, chlorin production, etc. For submarine work this result alone is invaluable.

In my preferred construction every cell is kept permanently cool, and can therefore be pushed, in case of need to higher activity than would otherwise be possible. The battery occupies a much smaller space, in its preferred form, than former batteries of the same capacity and duty, and it is so strongly made as to remove all danger of breakage from the jarring inseparable from use in automobiles and in like situations.

Perhaps the chief advantage and value of the invention is found in its superior cheapness of manufacture, ease and simplicity of assembling, and the extraordinary facility with which it can be washed without opening it, or can be taken apart, cleaned or repaired in any manner, and reassembled without any expert attention. In its prefered form, too, all connections by wires, screw terminals, etc. are made unnecessary except for connecting the battery as a whole to external apparatus.

Certain preferred forms of my invention are illustrated in the accompanying drawings, wherein Figures 1, 2 and 3 are side elevations of my cells with certain parts broken away, Figs. 4 and 5 are elevations partly in section of my battery in relation to means for conveying away the gases generated therein, Fig. 6 is a vertical section of a terminal cell of one preferred form of battery. Figs. 7 to 9 are front elevations of the elements of said cell shown separately, Fig. 10 is a side elevation of my battery assembled and placed in filling position, Figs. 11 and 12 illustrate details used for washing out the separate cells, Fig. 13 is a side elevation of a special arrangement of cells to promote rapid cooling, Figs. 14 and 15 are a side view and a front view respectively of a modified form of terminal plate, Fig. 16 is a side view of a corresponding intermediate plate, Fig. 17 is a front view of a further modified form of battery, Fig. 18 is a side elevation of one end of a modified form of battery. Fig. 19 is a sectional view of the preferred separable cell body used in the same, Fig. 20 is a sectional view of another modified form of cell, Fig. 21 is a front view of the terminal plate of said cell, Fig. 22 is a horizontal sectional view of said cell on the line 22—22 of Fig. 21, and Fig. 23 is a vertical section of a further modification.

The basic principle which I employ in filling my cells is illustrated in connection with a single cell in Fig. 1, wherein is represented one cell of either a secondary or a primary battery. The outer jar 20 contains one or more pairs of electrode plates 21 and 22 (the latter being broken away to show the former behind it), which plates are permanently connected to external terminals 23 and 24. At 25 is shown a support under the plates. The electrolyte is poured into the jar 20 through a top opening normally covered by a cap 26. In order to determine automatically the level of the liquid when it is poured in, I provide an overflow opening 27 near the top of the jar in one of its walls, and this is normally covered by the cap 28. The position of this opening is such that, when liquid is poured into the jar, it will rise to the level indicated in dotted lines, just immersing the plates, after which it will overflow. All that is necessary, therefore, is to continue pouring in water or other liquid until there is an overflow at 27, after which the caps 26 and 28 can be put back and the battery is ready for use. It will be seen that this arrangement makes it unnecessary to inspect the liquid by attempting to look into the opening at the top.

In Figs. 2 and 3 I have shown two arrangements whereby this principle can be extended for batteries of an indefinite number of cells. In each figure I have shown the three cells next the filling end of the battery, the remainder of the cells being omitted. Here the first cell is filled to the level shown in dotted lines through the external filling tube 29 which enters quite close to the top of the cell. When the liquid reaches the desired level it finds the exit opening 30 which is lower than the tube 29 and opens into the second cell which is placed somewhat lower than the first cell. In the same way, the exit opening 31 determines the level of liquid in the second cell, and opens into the top of the third cell, placed a little lower than the second cell. This arrangement is continued throughout the series of cells in a given battery.

It will be seen that, by the use of this arrangement, the entire battery can be filled through a single entrance tube 29 at one end it only being necessary to keep on pouring the liquid in at 29 until it runs out of the lowermost exit opening at the opposite end of the battery. As soon as this occurs, the operator can be certain that every cell is properly filled to the level desired, and furthermore he cannot fill it any further by any carelessness.

As shown in Fig. 3, the successive cells may have the same heights and the entrance and exit openings may be placed at the same levels in all the cells, and yet my principle of operation can still be made available by simply supporting the entire battery in an inclined position, as shown. Upon pouring in the liquid at 33, it will pass through the openings 34, 35, 36 etc. until it overflows at the extreme end of the battery, when the level of the liquid in each battery will be above the tops of the electrode plates and will be inclined to the side walls so as just to reach the exit opening in each cell while being materially lower than the entrance opening to the same.

From what has been thus far shown, it is clear that an entire battery, whether primary or secondary, may be tightly closed except as to a single entrance or filling opening at one end and an overflow opening at the other. This makes it possible to absolutely control the disengagement of gases in such batteries, and by leading the same away through closed pipes, to permit the use of batteries of any kind or size in restricted spaces near other machinery and even in the presence of sparks, lights or fires.

In Fig. 4 I have shown one instance of this kind, wherein a battery 37 is located in a room 38, being supported in an inclined position on a bench 39. The entrance or filling tube is connected to a pipe or passage 40 of any appropriate kind which passes through one of the walls of the room 38. A similar pipe 41 is connected to the overflow tube and passes through another wall of the room. In order to expedite the flow of gases out of the battery, artificial draft may be employed if desired, as for instance by the use of a fan 42. Of course the pipes 40 and 41 can be disconnected from the battery at any time to permit of filling and replenishing in the manner above described.

In Fig. 5 is indicated the application of this principle to the use of batteries in submarines. Here the shell or wall of the submarine is indicated at 43, and the battery at 44, the latter being in the inclined position shown. The filling tube is connected by a removable pipe 45 to an automatic valve 46 which permits the gases to force their way out against external pressure while preventing entrance of water from without. The overflow, on the other hand, is connected to a tight vessel 47 which catches the superfluous liquid and confines the gases at that end. In case of rolling or pitching of the submarine while on the surface the liquid can be confined if desired by the closing tube hereinafter described in connection with my preferred form of battery.

The use of the overflow container 47 in the combination shown has important advantages. This container not only serves to catch the overflow when the battery is being filled, but, in case of expansion of the electrolyte through excessive gassing or overheating or both, as is frequent in secondary battery practice, this vessel is always ready to receive the surplus amount.

Again, when it becomes necessary to replenish the batteries to make up for evaporation or for the expansion and overflow above mentioned, the contents of this vessel 47 can be used instead of pure water, or may be mixed with water, as found necessary. Again, the ascertaining of the condition of the liquid within the battery by hydrometric tests is greatly facilitated by the use of the overflow container, since it affords a considerable body of liquid issuing from the battery, and in a condition permitting immediate use of the hydrometer. By mixing the water with the contents of this vessel before pouring it into the battery, the disadvantages arising from temporary lack of uniformity in the mixture within the battery are avoided.

It will be readily understood that, by simply connecting to either terminal opening of the battery a tube of any convenient length fitted with an ear piece, the person in charge of a battery can judge instantly of the degree of gassing going on within the same by merely listening at the end of such a tube. In this way a person in a central situation can readily listen in to any one of a number of batteries and thus keep a check upon the degree of activity of each. This is often useful in preventing overloading of a battery, as well as aiding in keeping a check upon the workmen in charge, by whose carelessness one or more cells might be allowed to get too low in its supply of electrolyte.

I have thus far described the application of the broader principles of my invention to batteries composed of cells of any well known construction. My invention includes, however, certain special features of preferred construction which I shall now describe in detail.

My preferred cell is composed of two opposed plates (preferably flat though not necessarily so) clamped in position on opposite sides of an open separating ring of any convenient shape, and generally circular, whereby a space is afforded between the plates for holding the electrolyte. The plates are provided each with a single aperture near its top for the admission and discharge of the electrolyte, and the plates are of such a nature as to serve as electrodes of opposite polarity, whether for a primary or a secondary battery. As the present invention finds its most valuable application in secondary batteries, I shall describe the same hereinafter in that connection, without any intention of limiting myself thereto.

It is to be understood that the drawings about to be described illustrate only a few of many different embodiments of the preferred invention, which are set forth by way of example, and to make the nature and advantages of the invention clear.

In Fig. 6 is shown in section the detail of one terminal cell and the beginning of the next cell in a secondary battery of indefinite length. In Figs. 7, 8 and 9 certain parts of the same are shown separately in plan view.

At 48 is shown a circular lead plate provided with an extension 49 to facilitate the exterior electrical connections. Near the top of this plate is a short filling tube 50 which projects from the back of the same and affords an opening into the top of the cell. This opening is shown at 51 in Fig. 7.

Upon the inner face of the plate 48 is placed, and preferably cemented on, a ring of suitable yielding and resilient material such as vulcanized rubber, shown at 52. The outer edge of this ring is of the same diameter as that of the circular lead plate 48, while the inner diameter of the ring is such as to leave ample room for the insertion and support of the active material. This active material is preferably not carried up to the top of the disk-shaped space within the ring 52, but is bounded at the top by a straight line, as shown in Fig. 7, leaving a cavity 54 adjacent to the opening 51. In order to hold the active material in place I may employ a retaining disk 55 of a well known nature for this purpose provided with many perforations, which is laid over the ring 52 and active material 53, as shown in Fig. 6. This ring is shown in front view in Fig. 8. It is provided with an opening 56 which is in alinement with the opening 51 in the lead plate 48, when the battery cell is assembled.

The electrode plate opposite in polarity to 48 is shown at 57. Since this is not a terminal plate of the battery it is not shown provided with an extension for making exterior connections, and it has no tube or pipe attached to it. It is provded with an opening 58, however, which is in alinement with the opening 51 on the terminal plate 48. The inner face of this plate is furnished with a ring 59 similar to the ring 52, which is preferably cemented to the plate 57 and confines a second body of active material 60, of polarity opposed to that shown at 53. Here also a space 61 is preferably left at the top of the active material adjacent to the exit opening 58. A second retaining disk 62 is placed over this second body of active material, the same being perforated like the disk 55, and having an opening 63 in alinement with the openings 51 and 58.

Between the two bodies of active material a space must be provided for the electrolyte, and for this purpose I prefer the construction shown wherein two rings 64 and 65, in all respects like the rings 52 and 59, are secured over the two retaining disks 55 and 62, and wherein these rings are separated by a guide disk 66 the preferred shape of which is shown in Fig. 9. This ring conforms to the shape of the rings 64 and 65 with which it is in contact save at the top, where it has a reëntrant portion provided with an opening 67 in alinement with the openings in the lead plates, and at the bottom, where it is provided with another reentrant portion whose top edge is preferably straight and horizontal as shown at 68.

The function of this guard disk is to

form a pocket at the bottom of the cell wherein is caught and retained any "mud" or sediment composed of particles which become detached from the active electrodes during use. This prevents short-circuiting by particles of this kind, and insures complete effective action of the cell. It will be understood, of course, that a guard disk made of appropriately porous material may be used which extends entirely across the cell.

While a cell composed as above described, and suitably held together, is complete in itself and could be connected in any desired manner with other similar cells, I prefer the construction shown in Fig. 10, and indicated at the right of Fig. 6, wherein all the lead plates except those at the extreme ends of a battery serve at once as the positive electrode of one cell and the negative electrode of the next. This feature is made clear at the right of Fig. 6 where the plate 57 is shown provided on one side with the active material 60 and on the opposite side with the active material 69, held in place by the ring 70. The remainder of the second cell is constructed as already described with respect to the first or terminal cell, and all the other cells in the battery are similarly made, there being only one lead plate between cells, which plate is arranged to serve as a positive electrode on one side and as a negative on the other side.

In Fig. 10 is shown a side elevation of a complete battery of three cells, wherein the respective lead plates are shown at 48, 57, 71 and 72, the last being a terminal plate and being provided with an extension 73 for making connections, and with a pipe 74 through which the electrolyte overflows into the container 47 as heretofore explained. In building up such a battery, the various elements described are superposed in their proper order, by slipping the successive openings 51, 56, 57, etc., upon a suitable rod or spindle, such as is indicated in dotted lines at 75 in Fig. 6. This is continued until the desired number of cells has been assembled to constitute the battery, after which the whole can be secured together in any convenient manner.

Many different plans are available for securing the parts together, all of which would come within my invention. I prefer, however, for the type of battery shown, the arrangement shown in Fig. 10, wherein clamping plates or boards 76 and 77 are applied to the ends of the battery, being drawn down tightly upon it, so as to make all the cells thoroughly water and gas-tight, by means of the bolts 78 at the four corners, and the nuts 79 engaging their threaded ends. The filling and overflow pipes 50 and 74 pass through openings in the clamping plates, and the battery is preferably used in the inclined position, for the reasons already described in connection with Fig. 3. It is of course to be understood that such a battery can be used in the upright position if desired, but the inclined position makes it possible to keep the level of the liquid in each cell right up to the exit or overflow opening, while leaving a material space above the liquid between it and the filling opening of each cell, with the advantages heretofore set forth.

While, for the reasons above given, it is preferred to operate such a battery with the various openings unobstructed, and to lead off the disengaged gases at one end, my improved battery lends itself to easy closure, not only at the extreme ends, but also between cells. For this purpose a long stopper rod can be strung through the entire battery through the successive alined openings, in the position shown by the dotted lines 75 in Fig. 6, this rod being of just the proper size to close all the openings between cells. By running this rod more or less far into the battery, more or less of the cells can be closed, leaving the remainder open if desired. Such a rod would preferably take the form of a tube of resilient material such as vulcanized rubber, so that, in the event of gas forming in any cell beyond a certain pressure, it would automatically be relieved and discharged from one cell to another by squeezing past the tube.

It will be seen that a battery made in this manner can be emptied and flushed out with fresh water with the greatest ease. It is only necessary to disconnect the same from exterior connections and then turn the battery upside down, when all the acid can be poured out through one of the pipes 50 or 74, after which a stream of water can be passed through the battery while in this inverted position.

In case a more thorough local washing is desired, it can be accomplished by the means indicated in Figs. 11 and 12, in the former of which is shown a portion of the inverted battery with a part broken away to show the mode of use of the washing tube, the exit end of which is shown on an enlarged scale in Fig. 12. This washing tube 80 is made of proper diameter to be passed through the various openings 51, 56, 67, etc., and is closed at its end, save for a small opening 81 in its side. By thrusting this tube into either end of the battery until it reaches the particular space desired to be washed out, the opening 81 is brought into position so that a stream of water can be forced through the tube 80, issuing in an effective jet which thoroughly washes and cleanses the space opposite to which the opening has been brought. The dirty water with the material to be washed out passes out through the opposite end of the battery.

On the other hand, if it is found desirable to repair or replace any parts, or to cut out and replace any active material on any plate, the whole battery can be taken apart in a few minutes, by simply freeing the clamping plates. When the desired operation is completed, the reassembling is just as easy, the method of alining all parts being above described.

It will be understood, of course, that it is not necessary that all the spacing rings, 52, 64, 65 and 59 should be of resilient material. It will suffice if enough elastic rings are used to insure tight packing of all joints when the whole is clamped together. The middle rings 74, 65, for instance may be of glass or celluloid, in which case it will be possible to inspect the interior through the transparent sides.

My improved batteries will always be cooler than those heretofore used, because the lead plates between cells tend to conduct any heat rapidly to the surface. This effect can be accentuated by using the construction indicated in Fig. 13, wherein the lead plates 82, have a materially greater diameter than the other members between them, thus affording fins which radiate heat very efficiently. Such batteries may be immersed in a current of cooling fluid (air, water or oil) whereby a very rapid cooling is effected.

The form of the lead plates and the disposition of the active material are susceptible of all sorts of variations. In Figs. 14 and 15, for instance, I have shown a modified form of terminal plate, and the same type of plate for intermediate position in the battery is shown in Fig. 16. The terminal plate 83 is provided on the outside with the filling pipe 84, and on the inner side with a flange 85 forming a cylinder to carry the active material. This cylinder may be subdivided by partitions arranged in a great variety of ways. As shown in Fig. 15 these may be horizontal shelves or ridges 86; or they may form a honeycomb as in Fig. 17.

In any event I prefer to pack the active material between the partitions in sections 87 provided with small openings or empty spaces 88 which afford room for the expansion of the active material during use. This prevents to a great extent the crowding out of particles of active material, which otherwise occurs through expansive action, and lengthens the life of the cell.

As shown in Fig. 16, the intermediate plates 89 have flanges 90, 91, on both sides, for carrying positive and negative active material, respectively.

Plates of the kind just described may, of course, be assembled substantially in the manner above described in connection with Figs. 6 to 10, but I prefer in some cases the form of cell shown in Figs. 18 and 19.

Here the middle portion of each cell comprises a cylinder 92, which may be of glass, of celluloid or other suitable acid-resisting material which is preferably transparent to facilitate visual inspection. The guard disk 93, in this case can be made integral with the cylinder, being molded in one piece with it as shown in Fig. 19 on an enlarged scale. It then has substantially the form of the disk shown in Fig. 9 and has the same function. The guiding opening 67 will not be necessary in this case, as the transparent wall makes it possible to assemble in the proper position by sight.

In assembling this form of cell, resilient rings 95 fit over the flanges on the lead plates 96, and the ends of the cylinders 92 abut upon these rings, so that tight joints are everywhere formed, when the battery is clamped together. It is one of the advantages of the form of lead plates shown in Figs. 14 to 18 that their flanges serve to adjust the resilient rings, making it unnecessary to cement these rings in place.

The circular form of plate and cell so far described is not essential to my invention, as any convenient shape may be used. Rectangular plates are illustrated in Figs. 20 to 22, wherein are also shown a form and arrangement of plates affording a very large active surface within a small space. These figures also illustrate the fact that the terminal clamping plates are not essential.

In these figures, each rectangular plate 97, 98 is provided with active wings 99, 100, respectively, which stand at right angles to the plates carrying them. When the cell is assembled, the wings 99 overlap the wings 100, as shown in Fig. 22, and, by the breaking away of a part of the plate 99 in Fig. 20. The cell wall 92 is substantially square in cross section, and its ends abut upon a substantially square resilient ring 95 (see Fig. 21).

The cell (or cells) are clamped together by bolts 101 passing through holes 102 in the plates themselves, and secured by nuts 103. These bolts should be made of insulating material, or other provision for avoiding short-circuit between terminal plates should be provided.

The vertical position of the plates, although affording many advantages which makes it preferable, is not essential to my broad invention. In Fig. 23 I have shown a battery in which the plates 104 are made in conical cup shape, one fitting within the other below it, and wherein these plates are spaced apart by resilient rings 105. The openings 106 may be placed at opposite sides alternately, or in any desired relative angular position. It is clear that the electrolyte may be poured into an opening 106 at the top of such a battery until it overflows at the bottom, when the liquid will just fill each cup, as indicated by the horizontal dotted lines in Fig. 23.

No active material is shown upon the plates 104, although this may be provided in any well known manner. In the specific form shown in Fig. 23, however, the plates are supposed to be rendered active by the charging current in the manner employed with the earliest secondary batteries. It is, of course, within my invention to employ plates rendered active in this manner, in connection with any form of battery containing my improvements.

While I have referred to lead plates in the preferred cells described, it is to be understood that plates of any material found suitable in the different forms of cell described will come within my invention.

Many changes in material, form and arrangement may be made without departing from my invention, and I do not limit myself to the details herein shown and described.

What I claim is:—

1. In an electric battery cell, a pair of active electrodes and a closed container therefor having a filling opening in one side thereof and an overflow opening near the top of another side thereof.

2. In an electric battery, a succession of cells having containers provided with communicating openings at progressively lower levels in successive cells.

3. An electric battery cell having a filling opening and an overflow opening in mutual alinement on opposite sides of the cell.

4. In an electric battery, a succession of cells, each having a filling opening and an overflow opening, wherein the filling opening in one cell is the continuation of the overflow opening of the preceding cell.

5. An electric battery having the characteristics set forth in claim 4 hereof, wherein the successive filling and overflow openings are all in mutual alinement.

6. An electric battery cell comprising two electrodes of opposite polarity, each of which constitutes one wall of the cell.

7. In an electric battery, a series of contiguous cells separated by electrode-plates forming separating walls between the cells.

8. An electric battery having the characteristics set forth in claim 7 hereof, and wherein each electrode plate has an opening affording an overflow passage from one cell to the next.

9. In an electric battery cell, two electrode plates having active portions of opposed polarities, means for inclosing the electrolyte placed between said plates, and means adapted to hold said parts together so as to produce tight joints between them.

10. Apparatus of the character set forth generally in claim 9 hereof, wherein the sides of the cells are constituted by the electrode plates and wherein said plates have openings in their upper portions for filling and overflow purposes respectively.

11. Apparatus of the character set forth generally in claim 9 hereof, wherein the sides of the cells are constituted by metal plates partly covered with electro-active material, and wherein said plates have openings set above their electro-active portions for filling and overflow purposes respectively.

12. Apparatus of the character set forth generally in claim 9 hereof, wherein resilient rings are used as elements between the electrode plates.

13. Apparatus of the character set forth generally in claim 9 hereof, wherein a guard plate is employed between the electrode plates, and wherein alined openings are provided in said guard plate and said electrode plates.

14. Apparatus of the character set forth generally in claim 9 hereof, wherein perforated cover plates are placed over the active parts of the electrode plates and wherein alined openings are provided in said cover plates and electrode plates.

15. Apparatus of the character set forth generally in claim 9 hereof, wherein the cell is constructed of flat parallel elements clamped together, said elements comprising two outer metal plates having resilient rings on their inner faces, cover plates next to said rings, rings within said cover plates for inclosing the electrolyte, and a middle guard plate between said last named rings.

16. Apparatus of the character set forth generally in claim 9 hereof, wherein each electrode plate has an internal annular flange for inclosing electro-active material, within which flange, and near the top thereof, the opening is placed.

17. Apparatus of the character set forth generally in claim 9 hereof, wherein the portion for inclosing the electrolyte is a transparent cylinder of acid-resisting material.

18. Apparatus of the character set forth generally in claim 9 hereof, wherein the portion for inclosing the electrolyte is a cylinder having a middle guard plate therein, and forming a part thereof.

19. An electric battery composed of successive cells separated by metal plates having electro-active portions of opposite polarities on their opposite surfaces.

20. An electric battery having the characteristics set forth in claim 19 hereof, wherein each plate has a flange on both sides for containing the active material.

21. An electric battery having the characteristics set forth in claim 19 hereof, wherein each cell is composed of separable elements, and all the elements of all the cells are clamped together in a gas-tight manner.

22. A secondary battery having active material upon its electrode plates disposed in sections limited by spaces for allowing expansion of the active material.

23. A cell of the general character set forth in claim 9 hereof, wherein the electrode plates are provided with active wings of opposite polarity extending toward and overlapping each other.

In testimony whereof I have hereto set my hand on this 20th day of November, 1919.

EDWIN R. GILL.