FLEXIBLE BATTERY SEPARATOR

A separator used between positive and negative electrode plates in a battery comprises a sheet of flexible material capable of being wrapped around an electrode plate with a central part of the sheet in contact with one main surface of the electrode plate and two side parts of the sheet alongside the other main surface of the electrode plate, each side part having an edge portion, the edge portion of one side part overlapping the edge portion of the other side part when the sheet is wrapped around the electrode plate, the width of the two edge portions being sufficient to prevent the occurrence of an electrical short in use.
FLEXIBLE BATTERY SEPARATOR

This invention relates to a separator as used between positive and negative electrode plates in a battery cell.

Separators are commonly used in cells for the prevention of electrical shorts between the positive and negative electrodes which are often in the form of flat rectangular plates. Commonly these separators are in the form of sheets of semi-porous material which may be rigid or flexible that allow the passage of electrolyte and electric current but prevent the active materials of the electrodes coming into contact and causing a short circuit.

When cells are repeatedly charged and discharged there is a tendency for the active materials of the electrodes to migrate to the edges and they may eventually build up to such an extent as to cause a short circuit around the edges of the separator. To prevent the creation of these short circuits various methods have been used to insulate the edges of the electrodes. These include:

- the application of insulating strips along the edges of the electrodes;
- the bonding of adjacent separators with plastic or hot melt adhesive;
- the welding together of two separators along the edges to make a tube into which the electrode may be placed;
- or the use of a double width separator which is folded and welded to make a tube.

The use of insulating strips along the edges of the electrodes necessitates the introduction of extra materials into the cells. These cells require an exceptional resistance to an acid and oxidising environment. The application of the strips is time consuming and costly. The resultant edge protection is not absolute and it may still be possible for active material to create a bridge between the electrodes of opposite polarity and thus cause a short circuit.

The conversion of separator material into a tube ensures absolute edge protection but is in itself an additional manufacturing process and therefore adds costs to manufacture. The resultant tube, if it is to be made from the minimum amount of material, will be a tight fit on the electrode and therefore be difficult to locate. Making the tube a loose fit requires the use of more material and may
make it difficult to insulate the group of electrodes into the cell box.

Attempts have been made to form the tube around the electrode but this is difficult when it is required to seal the edge of a separator along the edge of the electrode. The reason for this is that because of the nature of the electrodes they do not lend themselves to a process that will permit the sealing operation to take place. If the tube is located around the negative electrodes in a conventional cell design, although assembly may be easier it requires the use of extra separator material which increases the cost of manufacture. It has the added disadvantage of reducing the efficiency of the design by necessitating a reduction in the general thickness of the separator between plates. This in turn reduces the amount of electrolyte available for the reaction.

All of these various problems make the manufacture of a cost effective electrode edge protection system difficult to achieve and must give rise to variations in the life of cells and batteries.

It is an object of the invention to provide a separator that gives full edge protection to the electrodes and yet is easy to manufacture and assemble.

In accordance with the invention a separator comprises a sheet of flexible material capable of being wrapped around an electrode plate with a central part of the sheet in contact with one main surface of the electrode plate and two side parts of the sheet alongside the other main surface of the electrode plate, each side part having an edge portion, the edge portion of one side part overlapping the edge portion of the other side part when the sheet is wrapped around the electrode plate, the width of the two edge portions being sufficient to prevent the occurrence of an electrical short in use.

A suitable material for the sheet may be flexible rubber, polyvinyl chloride (pvc) or polyethylene. The material must be sufficiently flexible to be wrapped around and closely engage the side edges of the electrode plate and must be capable of forming an acceptable closure along the overlapping edge portions.

The separator sheet may have flat major surfaces or have projections on at least one of the major surfaces. The edge portions may have projections e.g. ribs or undulations, which have the effect of increasing the path length between electrodes of opposite polarity between which the separator is
sandwiched in use. The edge portions may each be thinner than the central and remainder of the side parts of the sheet, whereby when one edge portion overlaps the other edge portion the total thickness of the two edge portions is equal to or approximately equal to the thickness of the central and/or the remainder of the side parts.

The separator may have the plurality of projections in the form of spaced apart ribs or undulations on one or both main surfaces.

In a battery cell, the two edge portions may be held in place by being sandwiched between two adjacent electrodes. The overall width of an electrode plate is increased by the thickness of the sheet at each edge of the plate.

The electrode plates are arranged alternately e.g. positive, negative, positive, negative, positive, etc in a group. In one known example a group comprises six positive electrode plates and seven negative electrode plates, but other numbers may be used depending on the battery performance required. Preferably the electrode plate of one polarity e.g. the positive electrodes only, are each wrapped in a separator sheet, but the electrodes of both polarities may be wrapped.

One embodiment of the invention will now be described by way of example only with reference to the accompanying drawings, of which:-

Figure 1 shows the end view of a right-hand part of a separator in accordance with the invention;

Figure 2 shows the end view of a left-hand part of the separator shown in Figure 1;

Figure 3 shows an end view of a positive electrode plate and of the separator shown in Figures 1 and 2 on a smaller scale being wrapped around the plate; and

Figure 4 shows an end view of part of a positive electrode plate and part of a negative electrode plate, with the two edge portions in overlapping arrangement, the separator having been wrapped around the positive electrode plate.

Separator sheet material is provided in the form of a long length, often in the form of a roll, from which shorter pieces may be cut, the length of each piece
being slightly longer than the length (height) of an electrode plate.

The width of the separator 1 of this embodiment is 412 mm for wrapping around a positive electrode 2 having a width \( W \) of 174.6 mm plus semi-circular side edges 3 and a thickness \( T \) of 9.8 mm.

As shown in Figure 3 the separator has a central part \( P \) alongside which two intermediate parts \( I_R \) and \( I_L \), one on each side of the central part \( P \). Outwardly of each intermediate part lies two corresponding side parts \( S_R \) and \( S_L \), each side part having a corresponding edge portion \( E_R \) and \( E_L \).

The lower main surface 4 of the separator 1 is formed with a plurality of regularly spaced apart small ribs 5 which extend lengthwise of the long length of sheet material from which the individual pieces abut. These small ribs 5 are all 0.14 mm high and are spaced apart by a distance of 1 mm. The small ribs 5 are located across the whole width of the separator except in one edge region \( E_L \), shown at the left-hand side of Figures 2 and 3.

The left-hand edge region is 20 mm wide and is provided on its lower surface with six larger ribs 6 spaced apart by 3.0 mm (measured from the centre of one rib to the centre of the next rib). The width of each rib at its extremity is 0.432 mm. Each rib tapers so that it is wider at its base where it joins the lower main surface 4 of the separator. The larger ribs 6 in this left-hand edge region are not of equal height: the rib closest to and at a distance of 2 mm from the extremity 9 of the separator is 1.0 mm high, the next closest rib is 1.1 mm high, and the remaining four ribs are all 1.2 mm high. The upper surface 8 of the separator is devoid of any ribs or other projections in its edge portion \( E_L \). The thickness of the sheet material (without taking the ribs into account) is 0.3 mm over a distance 13 mm measured from the extremity 9 of the edge portion \( E_L \) and increases steadily to a thickness of 0.55 mm.

The other edge portion \( E_R \) (on the right-hand side of Figures 1 and 3) has, as stated above, small ribs 5 on its lower surface and, on its upper surface, six larger ribs 7 having the same spacings and dimensions as the six larger ribs on the lower surface of the left-hand edge portion \( E_L \). The thickness of the sheet is 0.3 mm for a distance of 14 mm inwards from the right-hand extremity 10 i e up to a fifth rib. The thickness of the sheet is 0.4 mm between the fifth and sixth
ribs and 0.5 mm between the sixth and seventh ribs.

The remaining sections of the two side parts $S_L$ and $S_R$ are each 78.0 mm wide, and have on the upper surfaces twenty-seven ribs 11 each 1.30 mm high, 0.432 wide at their upper extremities and spaced apart by a distance of 3.0 mm (measured from the centre of one rib 11 to the centre of the next rib).

The two intermediate parts $I_R$ and $I_L$ are both 21 mm wide and devoid of any ribs, undulations or other projections on the upper surface 12.

The central part $P$ has a width of 174.00 mm and is provided with fifty-nine ribs 13 spaced apart by a distance of 3.0 mm. These ribs 13 and their dimensions are the same as those in the remaining sections of the two side parts $S_R$ and $S_L$. Small ribs 5, as described above, are provided on the lower surface 4 of the separator sheet. The thickness of the separator sheet 1, i.e. without taking the ribs on the upper or lower surfaces into account, is 0.55 mm in this central part $P$.

The separator sheet 1 as described is folded around a positive electrode 2 plate as illustrated in Figures 3 and 4. As shown in Figure 3 the upper surface 14 of the central part $P$ is placed against the lower surface 15 of the electrode plate 2 in the direction of arrows A. The left-hand side part $S_L$ is then folded around the left-hand edge of the electrode plate in the direction of arrow B so the upper surface (now lower) lies against the upper surface 16 of the plate. The right-hand side part $S_R$ is then folded around the right-hand edge of the electrode plate so that the upper surface of the separator (now lower) lies against the upper surface 16 of the plate 2, but with the right-hand edge portion $E_R$ of the separator overlapping the left-hand edge portion $E_L$. A negative plate 17 is placed against the overlapping edge portions $E_L$ and $E_R$ so they are held in the positions shown in Figure 4 with the larger ribs of one portion positioned between the larger ribs of the other portions. Further, because the edge portions have the dimensions as described above, the overlapping portions together have a total thickness approximately equal to the overall thickness of the remaining sections of the side parts $S_R$ and $S_L$.

By having the intermediate parts devoid of large ribs, the overall thickness of the separator at the edge of the plate is minimised.
To assemble the groups of plates for a single cell, a stack of negative electrode plates, a stack of positive electrode plates and a roll of separator sheet material is provided. A piece of separator material of the required length is cut from the roll, placed on a negative electrode plate with the smaller ribs in the central part P against the upper surface of the plate. A positive electrode is then placed centrally onto the separator sheet and the side part $S_L$ with the edge portion $E_L$ having the smaller ribs on its lower surface folded over onto the upper surface of the positive plate. The other side part $S_R$ of the separator is then folded over onto the upper surface of the positive plate so an overlap as shown in Figure 4 is formed. Another negative electrode plate 17 is then placed centrally on top thus holding the overlapping edge portions in position. The process is then repeated until a group is formed, the last electrode being a negative electrode plate. There is thus one more negative electrode plate than the number of positive electrode plates, each positive plate being wrapped in a separator according to the invention.

Alternatively if outer positive electrode plates are required (i.e. there is one more positive plate than the number of negative plates) then the separators are wrapped around the negative plates and the overlapping edge portions held in position by unwrapped positive plates.

When the group of plates for a cell is formed, the negative plates are joined together and the positive plates are joined together e.g. by welding, and construction of the cell completed by any one of the methods known in the industry.
CLAIMS

1. A separator comprising a sheet of flexible material capable of being wrapped around an electrode plate with a central part of the sheet in contact with one main surface of the electrode plate and two side parts of the sheet alongside the other main surface of the electrode plate, each side part having an edge portion, the edge portion of one side part overlapping the edge portion of the other side part when the sheet is wrapped around the electrode plate, the width of the two edge portions being sufficient to prevent the occurrence of an electrical short in use.

2. A separator according to claim 1 wherein the material of the sheet is chosen from flexible rubber, polyvinyl chloride and polyethylene.

3. A separator according to claim 1 or claim 2 wherein the sheet has flat surfaces.

4. A separator according to claim 1 or claim 2 wherein the sheet has projections on at least one of the major surfaces.

5. A separator according to claim 4 wherein the edge portions have projections which have the effect of increasing the path length between electrodes of opposites polarity between which the separator is sandwiched in use.

6. A separator according to claim 5 wherein the projections of one edge portion are positioned between the projections of the other edge portion when one edge portion overlaps the other edge portion.

7. A separator according to any of the preceding claims wherein the edge portions are thinner than the central and remainder of the side parts of the sheet, whereby when on edge portion overlaps the other edge portion the total thickness of the two edge portions is equal to or approximately equal to the thickness of the central and/or the remainder of the side parts.

8. A separator substantially as described herein with reference to and as illustrated in the accompanying drawings.

9. A battery cell comprising alternately disposed adjacent positive and
negative electrode plates, the plates of one polarity being wrapped by a separator according to any one of claims 1 to 8.

10. A battery cell according to claim 9 wherein the overlapping edge portions are held in place by being sandwiched between two adjacent electrode plates.

11. A battery cell according to either claim 9 or claim 10 wherein the width of each electrode plate wrapped in a separator is increased by the thickness of the sheet at each edge of the plate.

12. A battery cell comprising six positive electrode plates and seven negative electrode plates arranged alternatively, the positive plates being wrapped in a separator according to anyone of claims 1 to 8.

13. A battery cell substantially as described herein with reference to the accompanying drawings.
A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 HO1M2/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
IPC 7 HO1M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>Y</td>
<td>PATENT ABSTRACTS OF JAPAN vol. 006, no. 176 (E-130), 10 September 1982 (1982-09-10) &amp; JP 57 092749 A (MATSUSHITA ELECTRIC IND CO LTD), 9 June 1982 (1982-06-09) abstract</td>
<td>2, 4-6, 9-12</td>
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Further documents are listed in the continuation of box C.

| Patent family members are listed in annex. |

* Special categories of cited documents:
* "A" document defining the general state of the art which is not considered to be of particular relevance
* "E" earlier document but published on or after the international filing date
* "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
* "O" document referring to an oral disclosure, use, exhibition or other means
* "P" document published prior to the international filing date but later than the priority date claimed

Date of the actual completion of the international search
17 October 2000

Date of mailing of the international search report
06.11.00

Name and mailing address of the ISA
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Authorized officer
Engl, H
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<td>GB 2 088 118 A (OLDHAM BATTERIES LTD) 3 June 1982 (1982-06-03) page 4, line 15-21 figures</td>
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<td>A</td>
<td>EP 0 899 801 A (GEN MOTORS CORP) 3 March 1999 (1999-03-03) page 2, line 13-43 claims; figures</td>
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<td>03-03-1999</td>
<td>US 6001503 A</td>
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INTERNATIONAL SEARCH REPORT

Box I  Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [ ] Claims Nos.: because they relate to subject matter not required to be searched by this Authority, namely:

2. [X] Claims Nos.: 8,13 because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

   see FURTHER INFORMATION sheet PCT/ISA/210

3. [ ] Claims Nos.: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II  Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant’s protest.

[ ] No protest accompanied the payment of additional search fees.
Continuation of Box I.2

Claims Nos.: 8,13

Claims 8 and 13 are drawn to a battery separator and a battery cell, respectively, "substantially as described in the specification with reference to and as illustrated in the accompanying drawings".

Pursuant to Art. 6 PCT, the claims shall define the subject matter for which protection is sought. They shall be clear and concise. Pursuant to Rule 6.3a PCT, the claims shall define the scope of protection in terms of the technical features of the invention.

Said claims 8 and 13 do not fulfill these requirements, because it cannot be known with the required degree of precision which of the technical features, or which combination of features, presented in the description and the drawings constitute the essential technical characteristics of the claimed invention.

Hence no search could be carried out on said claims.

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.