

The invention relates to a galvanic cell, having a spiral-shaped electrode body which is produced by winding strip-shaped positive and negative electrodes with the interposition of a strip-shaped separator, having a current collector which serves as a winding mandrel and to which the one electrode is electrically connected, having a metal housing for receiving the spiral electrodes, to which housing the other electrode is electrically connected, and a cover which closes the opening of the housing and which is electrically contacted as a connection pole to the current collector for one electrode.

In the manufacturing technology which has been conventional hitherto for electrode windings, the winding mandrel is generally a steel needle which is approximately 5 to 7 mm in diameter and which is provided with an elongate slot for the insertion of the strip electrodes. It is generally rigidly connected to the winding machine and, since it remains on the winding machine, after producing the electrode winding it leaves a free space in the centre thereof.

Since this free space, in certain circumstances, for example during impact loads on the cell, involves the risk of the winding being displaced in the direction of its longitudinal axis or indeed of the electrodes being mutually offset, attempts have been made to resolve this disadvantage by using winding mandrels in the form of plastics rods which are intended as a so-called support core to remain permanently in the windings and thus form the basis of a compact arrangement of the set of electrodes.

However, it is necessary in both cases to provide the individual winding electrodes with separate current conductor lines and to connect them by way of the latter to the outer cell terminals, of which one can advantageously be formed by the cover. The production of such connections, which frequently has to be effected by way of wire bridges, is cumbersome, it being possible, moreover, for considerable transition resistances at active welding points.

It is more favourable to connect at least one electrode directly to a connection pole with the aid of a pole current-collector plate in accordance with DE-C-2 438 296, provided the

winding electrode, e.g. a sintered foil strip, has an edge which is not adhered to by means of active material and on which the plate is supported at the end side of the winding.

DE-A-3 412 890, FR-A-1 328 296 and JP-A-58 30 073 as well as DE-C-3 014 435 disclose winding cells in which a winding core originally used to produce the set of electrodes also takes on the role of the pole current-collector plate mentioned above as a current collector for one of the electrode polarities, while the housing is the pole current collector for the counter-electrode. The latter must form the outside of the winding, so that it bears against the inner wall of the housing.

According to the last-mentioned patent specification, there is placed onto the upper end of a rod-like collector, which is constructed in the manner of a flange, a helical spring which presses against the underside of the metal cell cover and thus produces the conductive connection between the collector and its outer pole.

Such a spring part requires particular care during assembly, in particular precision handling on positioning it on the collector top, there being a risk of the helical coil springing away from the handling tool as a result of being unintentionally compressed.

The object of the invention is to provide a current collector for a galvanic cell according to the generic type formulated at the outset, which is as simple as possible and which is easy to assemble, can at the same time constitute the winding mandrel and from which an unproblematic electrical connection to the housing cover as the outer pole for the electrode connected to the collector is possible.

According to the invention, the object is achieved by means of a galvanic cell, as is specified in Claim 1.

According thereto, the winding cell according to the invention has a slotted metal needle as the current collector for the one electrode, which is preferably the positive electrode, and in which the electrode is securely clamped to its support frame in the centre of its strip length. The top end of the needle is closed and can, in order to be securely gripped by the

winding machine, be shaped or thickened in various. Advantageously, the slot length is matched to the width of the electrode strip, as a result of which an optimum contact, between the sides of the support frame, with the needle legs is created.

According to a preferred embodiment of the invention, the slotted needle is a metal split pin having a closed top end. One leg is extended to form an eyelet, it being possible for the two legs of the split pin also in this case to have different lengths.

All that is necessary to effect the contact is to place the current collector or metal split pin onto the carrier material of the electrode which has previously been freed of active material, generally a stretch metal or fine-mesh net of Ni, Ag, Ti or stainless steel. However, it is advantageous to additionally spot-weld the two legs above the intermediate support net.

According to the invention, the current collector is not mounted on an end of the strip electrode, but approximately in the centre of its strip length, so that the electrode strip, starting from the central strip of the support net which is held in a material-free manner for the purpose of effecting the contact with the current collector, divides into two approximately equal cathode portions. Consequently, the start of the winding for this electrode also lies in the centre of the strip.

Since the slotted needle remains in the electrode winding after the winding procedure, to this extent it represents a lost winding needle, but in the new capacity of a current collector, whereof the advantages if a new metal split pin is used and because of the decreasing costs of this mass-produced article, its simplicity and unproblematic assembly are particularly convincing.

In order to effect the contact of the current collector with the housing cover, there is provided according to the invention a leaf spring which is secured to the inside of the housing cover and which projects obliquely downwards from the inside and bears with resilient tension on the top of the collector in the assembled cell.

In a particularly advantageous arrangement of the contact, the collector is again a metal split pin having an eyelet forming

its top end, while a hole is punched in the leaf spring the diameter is however smaller than the eyelet. As a the leaf spring only bears by means of the punched edge hole on the eyelet, so that a very high specific contact pressure is produced.

This measure is suitable to reliably prevent disruption of the arrangement of the contact according to the invention, with the most vigorous jolting of the cell. Electrochemical systems which can be used for operating the galvanic cell according to the invention are generally Li systems with non-aqueous electrolytes. Heavy metal oxides and sulphides, such as $\text{Ni}(\text{OH})_2$, CuO , CrO_x , FeS_2 or MnO_2 are possible as cathode-active substances.

Producing the cathode material from for example MnO_2 with additives of a binder of PTFE powder and graphite as the conducting material is carried out by means of a simple dry mixing process. By rolling the dry mixture into a metal net or stretch metal as the dry material in a through-going operation, the positive electrode strip is obtained. From this, even before being cut into the desired strip lengths, the material can easily be removed from the carrier material again at the respectively provided split-pin contact points. A particularly suitable aid for this purpose is compressed air.

The "dry" operating method eliminates not only all the disadvantages associated with a wet-chemical material preparation, but also results as a further advantage in a larger porosity of the finished rolled electrode, which enables this electrode to be loaded at a current density which is at least 50% higher than an electrode produced by the wet process. A consequence of this is that given that the load is equal the electrode in accordance with the dry mixing process yields more capacitance with less expense on carrier material, less separator material and in conjunction with a lower Li excess. Costs are correspondingly lower.

The strip-shaped lithium electrode is produced in basically the same manner as the other known winding cells and is jacketed in a sleeve-shaped separator of polyethylene or polypropylene

with welded edges.

The constructional features of the galvanic cell according to the invention will be described in detail below with reference to a preferred embodiment.

Figure 1 shows a complete set of electrodes with a split pin current collector according to the invention, before winding,

Figure 2 shows the spooling of the set of electrodes around the metal split pin, at the start of winding,

Figure 3 shows a finished electrode winding in section, and

Figure 4 shows a galvanic cell according to the invention, opened up.

According to Figure 1, the support net 2 of a positive strip electrode 1 is freed in the centre of the strip of the rolled-on positive material 3, so that the strip electrode comprises the cathode halves 4, 5, between which the metal split pin 6 is pushed with frictional contact onto the support net and can where appropriate also be spot-welded thereto.

As a result of a cutout 7 in the cathode, the lower end of the current collector can be accessed by a cutting tool more easily, without damaging the winding, than when an excess length which projects beyond the height of the winding has to be removed.

The metal split pin first serves as a winding needle. Before winding, the strip electrode 1, with the material coatings facing inward, is folded over onto the interposed Li electrode 8, which abuts by means of the front edge of its separator covering 9 against the winding needle.

The length of the negative strip electrode, but at least that of the separator jacket, must be of a dimension such that it is greater than the length of the positive electrode 1 in the folded state by at least a peripheral length of the finished winding.

The end of the negative electrode is provided with a contact element 10 in the form of a thin metal plate in which holes 11 are made by pressing in pointed punched ridges 12 (visible in Figure 2), the punched ridges penetrating the lithium electrode, including the separator coverings, on pressing on the plate. On

their subsequent positioning in the housing cup, the grid points which project on the underside grip in the manner of claws onto the housing wall and provide the lithium with a good electrical contact with the housing wall.

The particular advantage which is associated with the division of the cathode strip into two strip portions and with the securing of the split pin current collector in the centre of the strip is apparent inter alia during winding. Thus, it is clear from Figure 2 that as a result of dividing the cathode strip up into two thin part halves 4, 5 instead of an electrode plate which is equally long, but is double the thickness, greater flexibility of the strip is achieved in that both parts can be displaced with respect to one another and their front ends are thus gripped by the winding-on split pin 6 with a clear offset carrying along the Li electrode 8 which is covered by the separator 9. In this manner, the three-layer electrode arrangement which recurs in the winding is gradually formed during winding, which enables a narrower winding radius and a better exploitation of the space in the housing cup. The risk of active material chipping off is greater in the case of a thick cathode which is wound from its end.

The "double cathode" which is wound from the centre further has the advantage that it is not discharged at the net-reinforced side.

The winding procedure is assisted from start to finish by a housing template (not illustrated) from which the finished winding is ejected and transferred directly into the cell housing kept ready.

Figure 3 shows a cross-sectional illustration of the winding cell according to the invention, with the positive split-pin current collector 6 - also the winding needle -, the part cathode 4, the part cathode 5, the Li electrode 8 packed in the separator sleeve 9, and the housing cup 13. Here, there is produced in the winding a position of the two part cathodes with their support nets 5 back to back and with their "layer sides" facing the Li

electrode.¹

The figure further shows the contact of the Li electrode with the cup wall by means of the contact element 10, whereof the claws 12 are pressed through the Li strip, including the separator sleeve.

The covering of the cell is effected in accordance with Fig. 4 in a technically very simple manner by means of a sleeve cap closure. To this end, either the inner edge 15 of the cap 14 or the outside of the cup collar 16 is provided with a plastics coating, so that the cap which is pressed on after electrolyte has been poured in closes the cup with a secure press fit and in fluid-tight manner. At the same time, the leaf spring 17 which is welded in the cap 14 and which is laid with the punched ridge of the hole 18 onto the eyelet 19 of the split pin 6 is subjected to a high permanent voltage. A more stable electrical contact is ensured as a result between the split-pin current collector and the metal cap 14 as the positive outer pole.

The Li electrode 8 with its separator sleeve 9 and the contact element 10, whereof the punched ridges 12 penetrate the electrode, together with the separator, from the rear side and ensure its conductive contact with respect to the inside of the cup 13, can also be seen in the cut-open illustration in the Figure.

¹ Translator's Note: Two lines of text are repeated here at the top of (German) page 8.



Claims

1. Galvanic cell, having a spiral-shaped electrode body which is produced by winding strip-shaped positive and negative electrodes with the interposition of a strip-shaped separator, having a current collector which serves as a winding mandrel and to which the one electrode is electrically connected, having a metal housing for receiving the spiral electrodes, to which housing the other electrode is electrically connected, and a cover which closes the opening of the housing and which is electrically contacted as a connection pole to the current collector for the one electrode, characterized in that the current collector (6) is a slotted metal needle which is placed onto the support frame of the one electrode (1) in the centre of its strip length.
2. Galvanic cell according to Claim 1, characterized in that there is provided a contact element, which bridges the spacing between the cover (14) and the current collector, in the form of a leaf spring (17) which is secured to the inside of the cover, which contact element bears on the top end of the current collector under resilient tension.
3. Galvanic cell according to Claim 2, characterized in that the slotted needle is formed by a metal split pin whereof the closed top end is formed as an eyelet (19).
4. Galvanic cell according to Claim 3, characterized in that there is punched in the leaf spring a hole (18) whereof the diameter is smaller than the eyelet of the metal split pin, so that the leaf spring bears merely by means of the punched edge of the hole at high specific contact pressure on the eyelet.
5. Method of manufacturing a galvanic cell according to one of Claims 1 to 4, characterized in that the support frame of the one electrode is freed of adhering active material in the region to



be detected by the current collector, in the centre of the strip length, and the slotted needle is placed onto the bared cutout in the support frame, in that the other electrode, whereof the strip length is greater than that of the one electrode by at least a peripheral length of the finished winding and which is completely encased by a separator, is laid by means of the front edge of the separator casing against the needle, in that the electrode secured to the needle, with the material coatings facing inward, is folded over onto the other electrode, and in that the three-layer arrangement of the electrodes is rolled up.

6. Method according to Claim 5, characterized in that the legs of the slotted needle are spot-welded above the intermediate cutout of the support frame.

7. Method according to one of Claims 5 or 6, characterized in that the electrode (1) which is connected to the current collector is the positive electrode.

8. Method according to Claim 7, characterized in that the material of the positive electrode is MnO_2 .

9. Method according to Claims 7 or 8, characterized in that the negative electrode is an Li electrode.

10. Method according to Claim 9, characterized in that the electrically conductive connection between the lithium and the housing cup is produced by means of a contact element (10).