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Beckman

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[54] **METHOD FOR FORMING AND PLACING TUBULAR BATTERY SEPARATORS AND MEANS EMBODYING THE METHOD**

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[52] **U.S. Cl.** **29/592,** 93/81, 72/60, 264/339

[51] **Int. Cl.**.....**B31c 3/00**

[58] **Field of Search**.....264/339, 322; 29/592; 72/54, 56, 60, 146; 425/112, 326, 387; 93/81 R; 271/74, 26; 214/1 BF, 1.4; 302/25, 30, 31, 46

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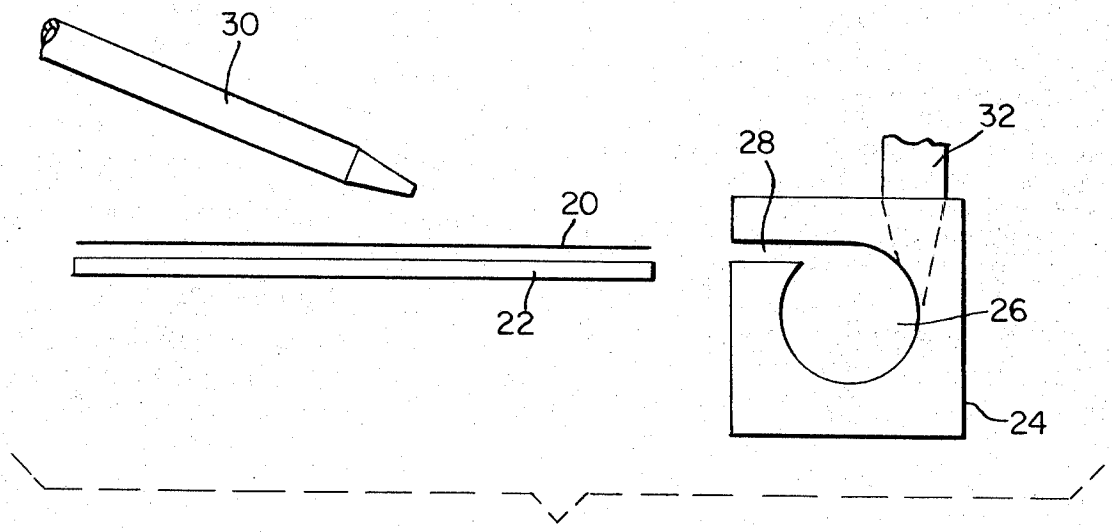
[57] **ABSTRACT**

Battery separator material in strip form and cut to proper size is entered tangentially into a borehole. Air streams directed tangentially to the borehole cause the strip of material to roll up into a tube of controlled diameter. When the tube is wound, a pressure differential between the two ends of the borehole causes the tube to eject into a waiting battery assembly placed on the trajectory of the rolled tube.

6 Claims, 7 Drawing Figures



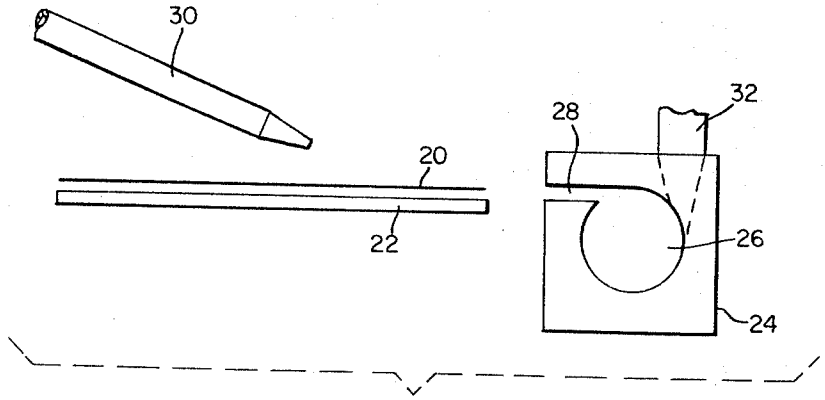


Fig. 1

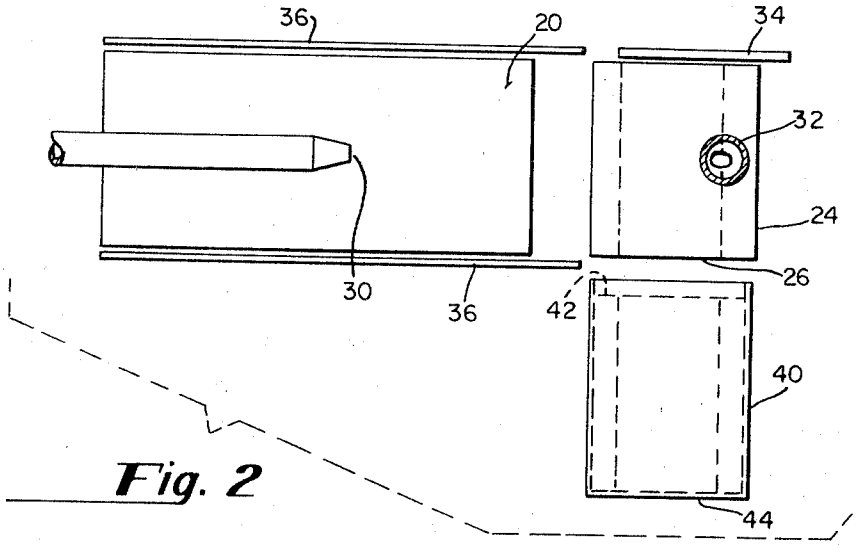


Fig. 2

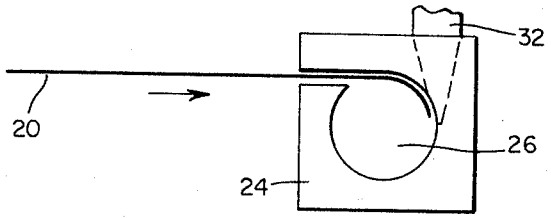


Fig. 3

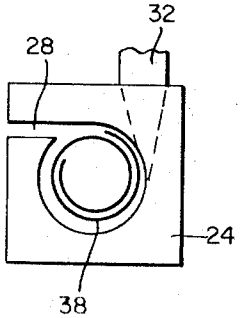


Fig. 4

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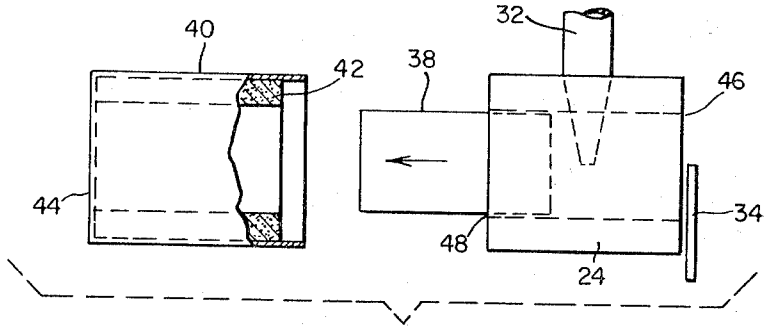

Fig. 5

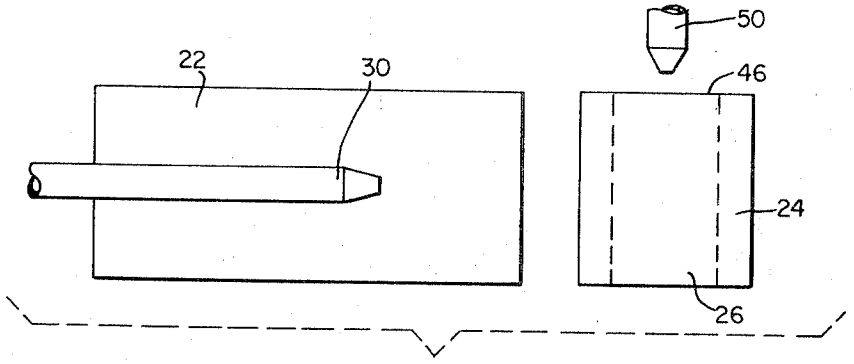

Fig. 6

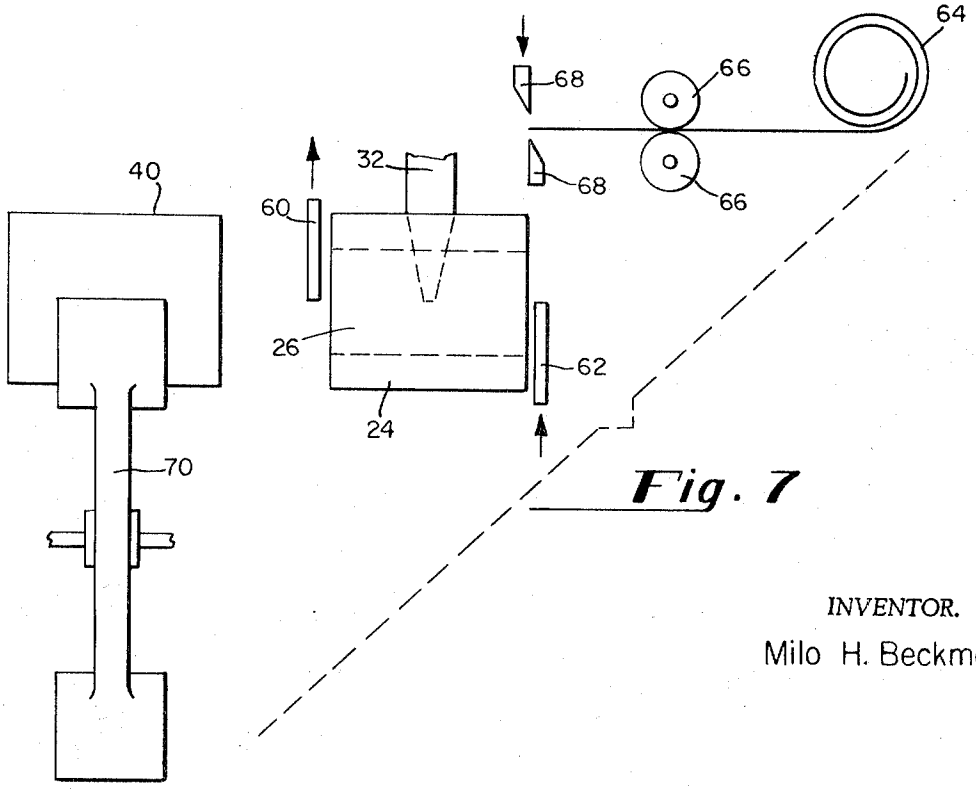

Fig. 7

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METHOD FOR FORMING AND PLACING TUBULAR BATTERY SEPARATORS AND MEANS EMBODYING THE METHOD

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a method and apparatus for forming short tubes of non-woven textile material. Specifically, it relates to the method and the equipment required for the formation of a battery separator of tubular shape.

2. Description of the Prior Art

The manufacture of tubular articles of paper and paper-like materials has been developed to a high degree of refinement. A great many tubes are formed by spiral winding techniques and this is the generally accepted production method. Machines are available which will produce spiral wound tubes at rates up to one or more yards per second. Such tubes are usually bonded by adhesive applied during the lay-up operation. The spiral wound equipment usually includes a mandrel on which the tube is formed. Automatic cut-off devices can be provided on the tube winding machine to provide tubes of a suitable length for the produce needs.

In another form of tube making equipment, the paper web is fed tangentially to a rotating mandrel to form a parallel wound tube. This form of machine is used in general where the volume of production does not warrant the spiral wound type of equipment. This type of equipment is also used when it is desired to construct tubes having a thick wall. Paper tubes up to a foot or more in diameter and having walls up to ½ inch thick can be so prepared. The length of the tube is, of course, determined by the width of the paper web available. It is usual in this case to bond the paper with glue to prevent the tube from unwinding.

In certain forms of small batteries, a tube of non-woven fabric material is used for separation between the depolarizer mix and the anode material. In this form of battery, it is desirable to avoid, if possible, the use of a glue material on the separator as this can provide a source of undesirable chemical contamination in the cell. In the assembly of these cells, the separator is placed within a cylindrical cavity formed by the depolarizer. It is desirable that the tube of separator material be slightly smaller in diameter than the cavity so that it can easily be inserted therein. After the separator is inserted, it should then be expandable so as to form a tight lining on the inside wall of the depolarizer mix. This is another reason for forming the tube without a binder. The usual spiral wound tube does not lend itself to this application for the following reasons. First, the tube must be wound without glue. It is very difficult to wind and even more difficult to cut a spiral wound tube formed without a binder. Second, the spiral wind leaves angular pointed ends which can easily catch during insertion or which may become mispositioned in later steps of cell manufacture. Third, the spiral wound tubes without glue tend to unwind of themselves and thus make insertion more difficult.

Thus, the parallel wound tube is a better choice for use as a battery separator. However, the usual form of parallel wound tube is bonded. If it is not bonded, it will unroll and thus it becomes difficult to handle.

SUMMARY OF THE INVENTION

A web of material suitable for use as a battery separator is fed from a roll to a cutting device where pieces of material of suitable size are successively cut. As each sheet of material is severed from the web, it is transported by a first air jet to a slot in a block of material. The slot is directed tangentially to a borehole in the block. A second air jet, tangential to the borehole, pulls the sheet into the borehole and causes it to roll up into a tubular shape. When the tube is completely formed, it is ejected from the borehole and into a battery cell assembly positioned on its trajectory.

The transfer of the tube from the borehole is accomplished by establishing a pressure differential between the two ends of the borehole. This can be accomplished by a third air jet directed through the borehole or by closing or partially closing one end of the borehole so as to bias the exhaust of the second jet in the desired direction of movement.

The simplicity of this quite specialized tube forming device is its most obvious feature. There are no handling devices needed other than the air blasts. Controls, either for the auxiliar air blast or for the borehole closing pressure differential establishing means can be simple and dependable.

The entire operation starting from flat sheet and ending with the finished tube located in its final position in the cell assembly takes place in a very short period of time.

The time required to transfer the tube from the borehole to the cell is so short, that the tube is not able to unwind or otherwise hinder its insertion in the cell. Finally, the locations and the adjustments of the several air blasts are not critical.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows an elevation of one form of machine for implementing the method of the invention;

FIG. 2 shows a plan view of the same machine;

FIG. 3 and 4 show in elevation a detail of a part of the machine of FIG. 1 at two phases of its operational cycle;

FIG. 5 shows an end view of the machine of FIG. 1 near the end of the operational cycle;

FIG. 6 shows a plan view of a second embodiment of a machine for implementing the method of the invention; and

FIG. 7 shows a plan view of a third embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1, an elevation of a tube forming machine made in accordance with the invention, a sheet 20 of non-woven fabric or other separator forming material of suitable size has been placed on table 22. A block of metal 24 having a cylindrical borehole 26 therethrough and a slot 28 tangential to the borehole and on the same plane as the surface of the table 22 is located at one of the table ends. An air jet 30 is located above table 22 and is adjusted to convey the sheet 20 into the tangential slot 28 of block 24. A second air jet 32 is located in block 24 in a position tangential to the borehole and roughly perpendicular to slot 28. FIG. 2, a plan view of the machine shows in addition to the parts enumerated, a baffle 34 covering part of the opening of the borehole, and guide plates 36 attached to the sides

of table 22. The baffle is omitted from FIG. 1 for clarity. The transverse location of the air jet 32 at the longitudinal midpoint of block 24 is also shown. A cylindrical cell can assembly 40 having a tubular lining 42 of depolarizer mix is located on the axis of the bore hole 26. The open end of cell can 40 faces block 24 and the closed end 44 faces away from it.

In FIG. 3, the action of air jet 30 has caused the sheet 20 to enter slot 28 and start to curl. In FIG. 4, due to the action of air jet 32, the entire sheet is rolled up into a tube 40. The external diameter is approximately, but slightly less than, the borehole. FIG. 5 illustrates the condition occurring as soon as the tube is fully formed. Baffle 34 is shown partially covering the right hand end 46 of borehole 26. The effect of baffle 34 is to cause a higher pressure at the right hand end 46 of the borehole than at the left hand end 48. The pressure differential causes more exhaust air from jet 32 to move to the left of FIG. 5 than to the right. While the tube is being formed, it is constrained from moving because of the guide plates 36. However, as soon as the tube 40 is formed and free of the constraint of guides 36, it is ejected by the pressure differential from the borehole 26. In FIG. 5, tube 38 is shown passing to the left out of borehole 26 and into the cell assembly. The velocity of tube 38 is sufficient to place it in its permanent location in the cell assembly. When the finished tube has come to rest in the cell assembly, it springs outward due to its inherent resiliance and conforms to the inside of the lining of depolarizer in the cell assembly.

The amount of pressure differential and hence the speed with which the formed tube 38 is forced from the borehole 26 is controlled by the amount by which baffle 34 covers the end 46 of the borehole.

An alternate embodiment is shown in plan view in FIG. 6. In this view, the baffle 34 and the guide plate 36 shown in FIG. 2 are omitted. Instead, these is a third air jet 50, directed along the axis of the borehole. With this embodiment, the tube, after being formed by the action of air jet 32, remains in the borehole 26 until air jet 50 is activated. This causes an increase of pressure at the right end 46 of the borehole which in turn forces the completed tube 38 out of the borehole.

In a third embodiment, shown in end elevation in FIG. 7, two moveable baffles 60 on the left and 62 on the right are shown partially covering either end of the borehole 26 in block 24. When the tube is fully formed, baffle 60 is raised to clear the borehole. A pressure differential is established between the two ends of the bore hole causing the full exhaust blast of air jet 32 to escape to the left, carrying the finished tube with it. In FIG. 7, a device for feeding and cutting the separator web is also shown. The roll of web material 64 is led through a pair of indexing feed rolls 66. From the feed rolls, the web passes through shears 68. By well known mechanical means (not shown) feed rolls pull a measured length of web material from roll 64. Shears 68 cut the measured length of web allowing it to drop on the table in front of block 24. The web is immediately picked up by the first air jet, and rolled up by jet 32. Baffles 60 and 62 then raise causing the wound separator tube to shoot into waiting cell assembly 40. Cell assembly 40 is shown located in an indexing device, in this case, a dial feed wheel. Means (not shown) are provided for coordinating the motion of the feed device with the motion of the shear 68 and the baffles 60 and 62, so as to move an empty cell assembly into line with the borehole 26 each time a sheet of web material is cut.

It will be seen from this description that the method of the invention for forming tubular battery separators is simple and speedy and the equipment used in its embodiment is neither costly nor complicated. Although three methods for causing the formed tube to eject from the borehole are described, the invention is not limited to these only, but covers the broader area of providing a differential air pressure at the two ends of the borehole.

Having thus fully described the method of my invention and given examples for its embodiment by the use of simple machine elements, I hereby claim:

1. A method for forming a tubular battery separator from a sheet of battery separator material which comprises:
   a. transporting a sheet of battery separator material by first air jet means into a slot formed in a block of material tantential to a borehole through the block;
   b. rolling the sheet into a tube in the borehole by second air jet means tangential to the borehole; and
   c. ejecting the rolled tube from the borehole by means causing a pressure differential between the ends of the borehole.

2. A method as defined in claim 1 in which the means causing the pressure differential comprises at least one baffle cooperating with a borehole end.

3. A method for forming a tubular battery separator and placing it in a cell assembly which comprises:
   a. transporting a sheet of battery separator material material by first air jet means into a slot formed in a block of material tangential to a borehole through the block;
   b. rolling the sheet into a tube in the borehole by second air jet means tangential to the borehole; and
   c. transferring the rolled tube by means causing a pressure differential between the ends of the borehole from the borehole to a hollow cell assembly located outside the borehole and on the axis thereof.

4. A method for forming a tubular battery separator from a continuous web of material and placing it in a cell assembly which comprises:
   a. cutting a piece of separator material from a continuous web;
   b. transporting the sheet of material by first air jet means into a slot formed in a block of material tangential to a borehole through the block;
   c. rolling the sheet into a tube in the borehole by second air jet means tangential to the borehole; and
   d. transferring the rolled tube by means causing a pressure differential between the ends of the borehole from the borehole to a hollow cell assembly located outside the borehole and on the axis thereof.

5. A method for forming a tubular battery separator as define in claim 9 wherein the means causing the pressure differential comprises baffle means covering parts of the borehole.

6. A method for forming a tubular battery separator as defined in claim 7, wherein the means causing a pressure differential between the ends of the borehole comprises air jet means directed along the axis of the borehole.

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