

[54] APPARATUS FOR MATERIAL INSERTION

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[51] Int. Cl.² **H01M 4/73**

[58] Field of Search **425/87, 110, 115, 218, 425/263, 267, 268; 136/67; 141/32, 125**

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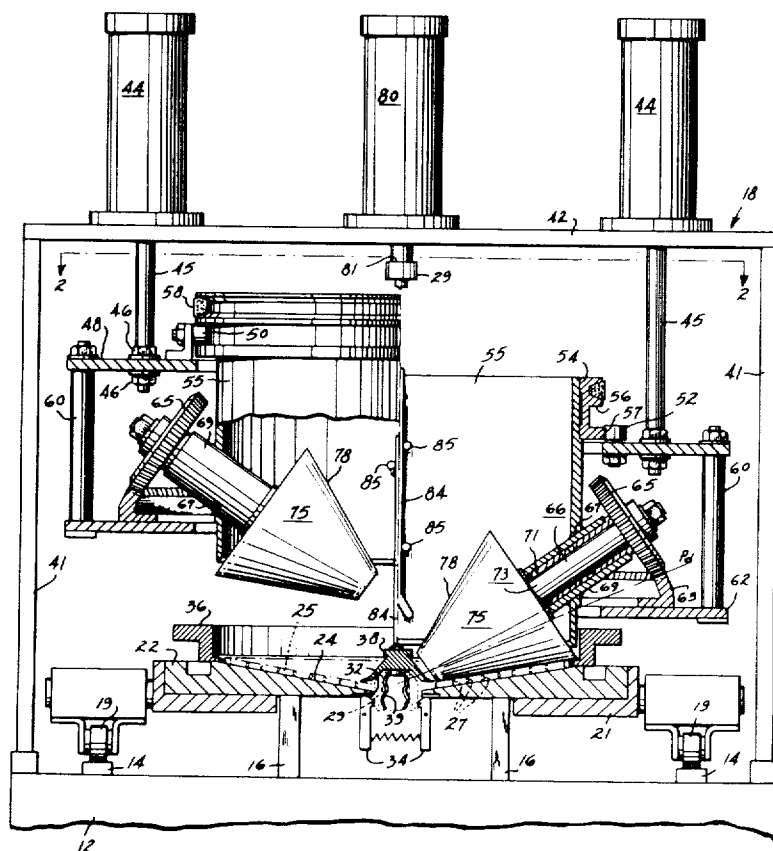
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[57]

ABSTRACT

This disclosure is directed to methods of and apparatus for inserting a material, e.g., the reactive paste and used in secondary batteries, into the apertures of an apertured workpiece, e.g., the plate or grid element of a secondary battery, wherein the material to be inserted is deposited on the workpiece, an insertion means, e.g., a roller, is advanced toward the workpiece against the material, and the insertion means is displaced over the surface of the workpiece against the material concurrently with the advancement of the insertion means.

8 Claims, 6 Drawing Figures

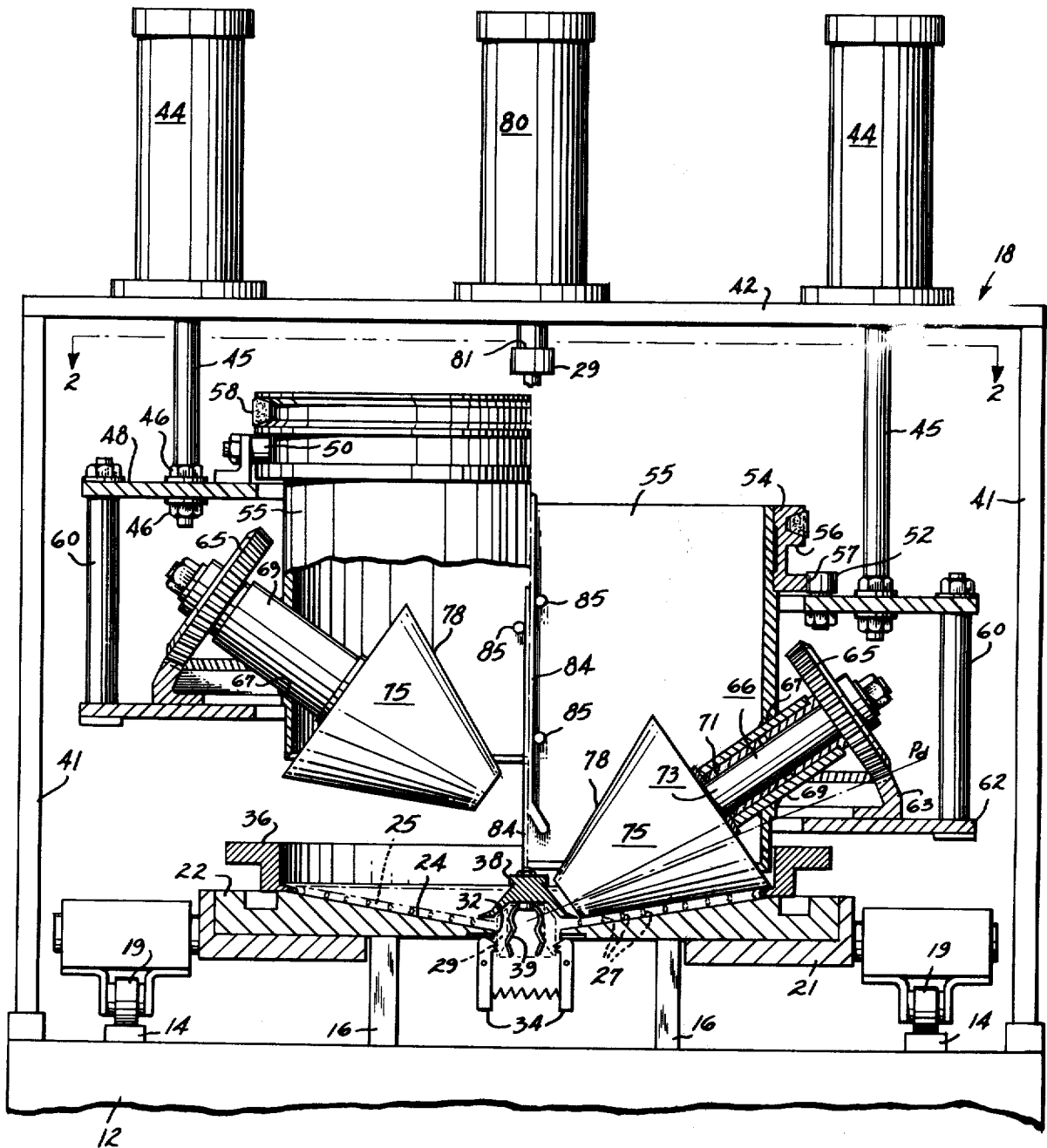
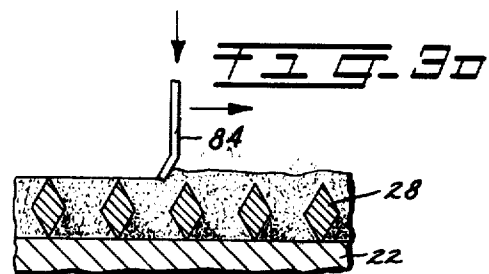
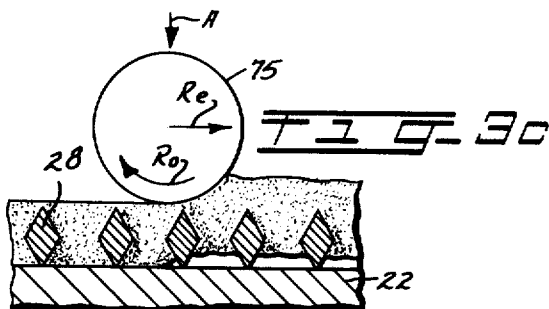
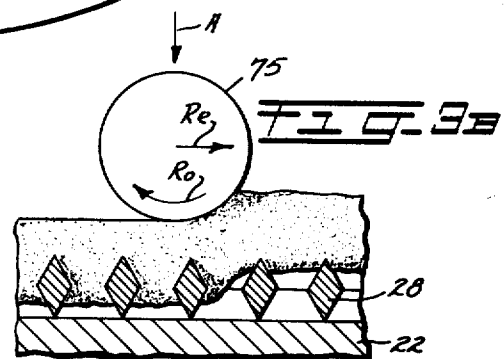
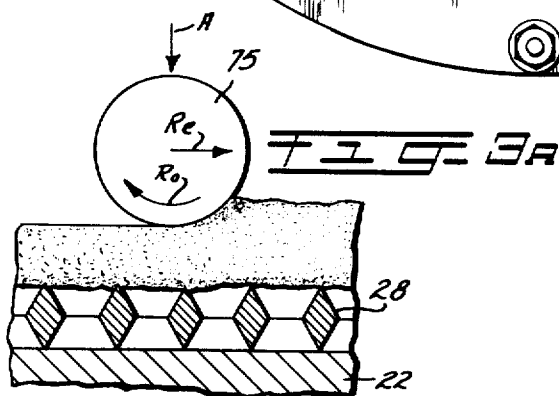
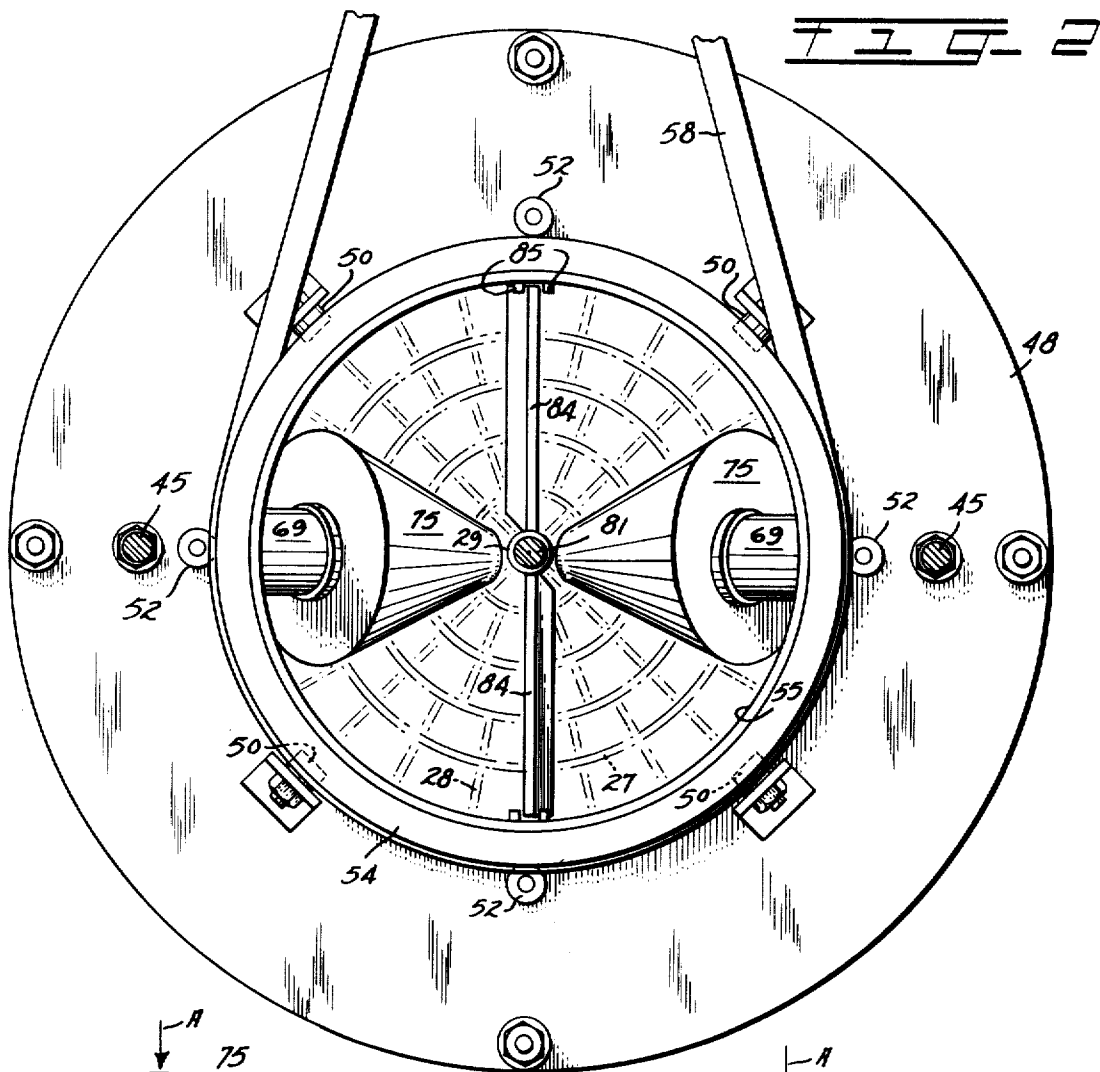


FIG. 1

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APPARATUS FOR MATERIAL INSERTION

This is a continuation, Ser. No. 35,106 filed May 6, 1970, now abandoned, which is a division of application Ser. No. 831,001, filed June 6, 1969, now Pat. No. 3,660,161.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to apparatus for inserting material into the apertures of an apertured workpiece. This invention is particularly related to methods of and apparatus for inserting semi-fluid material, e.g., reactive paste into the apertures of a workpiece such as a battery plate or grid.

2. Description of the Prior Art

The prior art discloses many approaches to the problem of inserting semi-fluid material into the apertures of an apertured workpiece. Among these approaches include rolling, wiping, agitation and hand insertion.

With respect to the term "semi-fluid material," this term is used to connote material exhibiting plastic characteristics, e.g., putty, paste, and the like. Such plastic characteristics include the capability to maintain a shape although unsupported and the capability to be plastically deformed by the exertion of pressure thereon. Thus, for purposes of this specification and the appended claims, the term "semi-fluid material" is used in this context.

Each of the above-noted approaches to the problem of inserting semi-fluid material has demonstrated disadvantages. Known methods of rolling, for example, contemplate that a roller be passed over the surface of material to be inserted and, at the point of contact between the material and the roller, that the relative velocity therebetween is zero. Since rolling contact is for the most part substantially a line contact, such rolling effectively impresses only compressive forces. Thus, although such known methods of rolling have been generally satisfactory for exerting compressive forces on the material being inserted, they have not been satisfactory where the material to be inserted is not readily insertable merely through the exertion of compressive forces. Further, where the material being inserted has adhesive characteristics, rolling has proven generally unsatisfactory in that adhesion of the material to the roller has caused the material to be removed from the apertures as the roller passes over the aperture.

Wiping as a method for inserting semi-fluid materials has been found to be unsatisfactory for inserting materials demonstrating high resistance to flow and, with respect to other materials, has been found to leave uneven surfaces on the materials being inserted. More specifically, the insertion of semi-fluid material by wiping, e.g., by passing a blade having a canted edge over the surface of an apertured workpiece to be filled, generates two force components against the semi-fluid material, viz. a compressive force which tends to force the material into the apertures of the workpiece and a force tangential to the surface of the workpiece which tends to smear the semi-fluid material around the workpiece. Thus, the passage of such a wiping blade over the surface of a workpiece to accomplish insertion causes the material being inserted both to be passed into the apertures and to be pushed along in front of the blade. The result of this technique has been the generation of "wavy" surfaces in the inserted semi-fluid material,

particularly in situations where the resistance to flow of the semi-fluid material is such as to require high compressive force components.

The insertion of semi-fluid materials by agitation processes is only possible when the material being inserted exhibits very little resistance to flow. Thus, if any compressive force is necessary to cause flow of the material into the apertures to be filled, a mode of insertion other than agitation must be utilized.

The disadvantages of inserting semi-fluid material into an apertured workpiece by hand, e.g., high cost, time inefficiency and poor quality control are considered to be obvious. Notwithstanding these disadvantages, there are many situations presently occurring in the art wherein the insertion of semi-fluid materials into apertured workpieces is accomplished by hand.

It can be seen from the foregoing that the known modes of material insertion have recognized disadvantages. Additionally, however, developments in certain art areas which utilize apertured workpieces having their apertures filled with semi-fluid materials have emphasized the need for improved methods of and apparatus for inserting semi-fluid materials in apertured workpieces.

In the storage battery art, for example, efforts to improve battery life and performance have resulted in stress reducing battery plate or grid designs which minimize stresses in the plate and maximize the capability of the plate to retain the semi-fluid paste therein. An example of such a stress reducing battery design is shown in U.S. Pat. No. 3,434,883 issued to Babusci et al. on Mar. 25, 1969 for CYLINDRICAL LEAD ACID CELL. This patent discloses conical battery plates having apertures which are irregularly shaped.

In addition to the stress reducing plate designs, improved paste retaining characteristics have been accomplished by shaping the structural members of battery grids so as to define an irregular configuration, e.g., a diamond shaped configuration. Such configurations, while increasing the capability of the battery plate to retain the paste material once inserted, have further complicated the problem of accomplishing initial insertion of the paste into the apertures. In this regard, the problem of inserting paste material into such irregularly shaped apertures in battery plates has been such as to require that the paste be inserted by hand. Such a procedure involves working the paste into the apertures from one side of the battery plate using, for example, a putty knife, and thereafter inverting the plate so as to insert paste material from the other side thereof in the same manner. This procedure has proven unsatisfactory in that the paste material inserted from one side of the plate has demonstrated a tendency to resist fusion with paste material inserted from the other side of the battery plate. This resistance has resulted in the separation of the one paste portion from the other paste portion thereby resulting in an operational failure in the grid at the point of separation.

In addition to the above-mentioned developments in the battery structure art, developments in the battery paste art have also added to the complexity of inserting the paste in an apertured battery plate. For example, a new paste compound, viz. tetra-basic lead sulfate ($4\text{PbO} \cdot \text{PbSO}_4$) has been found to demonstrate excellent qualities as a battery paste. Its physical characteristics, however, e.g., its crystalline structure, adhesiveness and resistability to deformation in response to

pure compression, render it extremely difficult to insert into apertures, particularly, irregularly shaped apertures. Thus, insertion of this material has also been accomplished, heretofore, by hand.

SUMMARY OF THE INVENTION

The present invention includes method of and apparatus for overcoming the above-noted problems both as they relate to the insertion of materials into apertured workpieces broadly, and as they relate to the particular problem of inserting semi-fluid material such as paste into the apertures of workpieces such as a battery plate.

One aspect of this invention, therefore, involves a method for inserting a material into the apertures of an apertured workpiece wherein the material is deposited on the workpiece, an insertion means is advanced toward the workpiece and against the material, and the insertion means is displaced over the surface of the workpiece during the advancement thereof so as to effect insertion of the material into the apertures.

Another aspect of the present invention involves apparatus for inserting a material in the apertures of an apertured workpiece including an insertion means, advancing means for reciprocating the insertion means toward and away from the workpiece, and displacing means for displacing the insertion means over the surface of the workpiece.

A particular aspect of the present invention involves an apparatus for inserting paste in the apertures of a conical battery plate comprising a conical nest for supporting the conical battery plate, a drum disposed concentrically of the axis of the conical battery plate, means for advancing and retracting the drum toward and away from the conical battery plate, means for revolving the drum around the axis of the conical battery plate, rollers mounted on and journaled for rotation with respect to the drum, and gear means for imparting a rotational movement to the rollers, the apparatus accomplishing insertion of semi-fluid material into the battery plate apertures by a rolling, revolving, advancing motion of the rollers.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other various aspects of this invention may be better understood from a consideration of the following detailed description, particularly in the light of the attached drawings, wherein:

FIG. 1 is a cross-sectional elevation view of an apparatus according to the invention;

FIG. 2 is a cross-sectional view through the plane 2-2 of FIG. 1; and

FIGS. 3a, b, c and d are schematic diagrams of the operation of the apparatus of FIGS. 1 and 2.

DETAILED DESCRIPTION

Considering the invention in detail with reference to FIGS. 1 and 2, an apparatus according to the invention is designated generally by the reference numeral 10.

Apparatus 10 comprises a base 12 on the upper surface of which are mounted a pair of tracks 14, a pair of guide rails 16 and a structural frame designated generally by the reference numeral 18. Tracks 14 define support means for the rollers 19 of a conveyor 21, the movement of which is guided by guide rails 16. Retained in conveyor 21 is a nesting plate 22, the upper surface 24 of which is provided with a conical bed for receiving a workpiece 25 thereon.

The workpiece 25 shown resting in the apparatus 10 is a conical battery plate having a plurality of concentric ribs 27 and a plurality of radially extending ribs 28 (FIG. 2) which radiate from a hub 29. The ribs 27 and 28 are substantially diamond shaped in cross-sectional configuration so as to provide a good structural basis for supporting a filler of paste therein.

Formed in the center of the conical bed and extending vertically axially through nesting plate 22, as shown in FIG. 1, is an aperture 32. Aperture 32 accommodates the reception of hub 29 therethrough during positioning of workpiece 25 on nesting plate 22. Positioned below aperture 32 are a pair of spring loaded finger latches 34 which are provided with teeth which engage complementary grooves in the outer surface of hub 29 to rigidly lock workpiece 25 in position on nesting plate 22.

The circumferential surface of workpiece 25 is received within an annular collar 36 mounted on nesting plate 22. Collar 36 cooperates with aperture 32 to position workpiece 25 in the center of the conical bed of nesting plate 22.

As can be seen in FIG. 1, a cap 38 is positioned over hub 29 of workpiece 25 and retained in position by a spring clip 39 which frictionally engages the surface of a bore extending through hub 29. Cap 38 is sized to cover workpiece 25 within the innermost concentric rib so as to preclude the insertion of semi-fluid paste material in the space between the innermost rib and the hub 29. The purpose of maintaining such an unpasted area is to provide a passage for gases generated during the operation of a battery in which workpiece 25 may be used. Thus, the provision of cap 38 is related specifically to the pasting of a workpiece 25 such as the battery plate shown and may be omitted when inserting semi-fluid materials in other types of workpieces without departing from the teaching of the invention.

As noted above, there is also mounted on the base 12 a structural frame 18 which comprises a plurality of vertically extending support posts 41 and a horizontally extending motor support plate 42. Rigidly mounted on motor support plate 42 are a pair of fluid motors 44, the driving rods 45 of which extend downwardly through suitable apertures in motor support plate 42. The lower ends of rods 45 are threaded to accommodate the reception thereon of nuts 46 which serve to support and position an annular bearing plate 48 below and substantially parallel to motor support plate 42. Thus, the cooperative operation of fluid motors 44 displaces rods 45, and therewith bearing support plate 48, vertically in such a manner as to maintain plate 48 substantially parallel to motor support plate 42.

Mounted on bearing support plate 48 are a plurality of roller bearings 50 which rotate about horizontally disposed, radially extending axes, and a plurality of roller bearings 52 which rotate about vertically extending axes. Bearings 50 and 52 are rigidly mounted on bearing support plate 48 adjacent its inner edge, and cooperate to position and support a drive cylinder 54 which is rigidly secured, such as by shrink fitting, to a drum 55. Specifically, drive cylinder 54 is provided with an annular channel 56 formed in its outer surface, which annular channel receives roller bearing 50 therein. The upper surface of channel 56 rests on the bearings 50 thereby supporting cylinder 54 in such a manner as to allow revolution about a vertically extending central axis. Roller bearings 52 are positioned on bearing sup-

port plate 48 concentrically of the vertically extending central axis of revolution of cylinder 54 and in contact with the circumferential surface of an annular, radially outwardly extending flange 57 formed on the lower edge of cylinder 54.

Formed in the upper outer surface of drive cylinder 54 is a tapered annular groove which accommodates the reception of a drive belt 58. Belt 58 transfers power from a suitable motor (not shown) to cylinder 54 so as to cause the revolution of cylinder 54 within bearings 52 and about its vertically extending central axis. As noted above, cylinder 54 is rigidly secured to drum 55. Thus, as cylinder 54 is caused to revolve, so also is drum 55.

The outer surface of bearing support plate 48 is provided with a plurality of apertures for receiving hang bolts 60, which hang bolts support, at their lower end, an annular gear mounting plate 62. Gear mounting plate 62 is suspended on hang bolts 60 in such a manner as to be vertically displaced from and substantially parallel to bearing support plate 48. Thus, vertical movement of bearing support plate 48 toward and away from motor support plate 42 in response to the cooperative operation of fluid motors 44, is accompanied by a corresponding vertical displacement of gear mounting plate 62. Additionally, the central openings of bearing support plate 48 and gear mounting plate 62 are of diameters which are substantially greater than the diameter of drum 55 so that drum 55, which through cylinder 54 and bearings 50, 52, is positioned both concentrically within and vertically with respect to annular plates 48 and 62, can revolve freely within plates 48 and 62. Thus while drum 55 is constrained by roller bearings 50 to move vertically with plates 48 and 62, it is free to revolve within the plates 48 and 62 notwithstanding their vertical position.

Rigidly secured to the upper surface of bearing support plate 62 is a beveled ring gear 63. Ring gear 63 acts as a reaction gear for a roller driving pinion 65 which is mounted on a shaft 66 which is journaled in drum 55.

Formed in the wall of drum 55 are a plurality of apertures 67 through which the rigidly mounted, such as by welding, bearing barrels 69. The longitudinal axis of each barrel 69 extends downwardly and radially inwardly as seen in FIG. 1.

Extending through each bearing barrel 69 and supported therein by sleeve bearings 71 is a shaft 73 on one end of which is rigidly mounted a beveled or frusto-conical roller 75 and on the other end of which is mounted pinion gear 65. In that roller 75, shaft 73 and pinion gear 65 are rigidly secured, they rotate within barrel 69 as a unit. Thus, rotational movement of pinion 65 in response to movement with respect to ring gear 63, causes a corresponding rotation of beveled roller 75.

The arcuate movement of roller 75 is, at all times, equal to the arcuate movement of pinion gear 65. Thus, a 90° rotation of pinion gear 65 results in a corresponding 90° rotation of roller 75. It should be noted, however, that all points along the tapered surfaces 78 of rollers 75 can be seen from FIG. 1 to fall outside the projected pitch diameter "pd" of pinion 65. Thus, in that rollers 75 and pinions 65 are rigidly secured through shaft 73, and in that the rotation of pinion 65 is positively controlled by the meshing engagement of the teeth of pinion 65 with the teeth of beveled ring

gear 63, the surface 78 of rollers 75 will not define a pure rolling action along their lines of bottom dead center. Rather, because of increased diameters of rollers 75 with respect to the projected pitch diameter of pinion 65, the rollers experience a tangential speed at their points of bottom dead center which causes a "wiping" effect during the operation of the apparatus.

More specifically, the pure rolling motion of any generally round body along a support surface is evidenced by a zero relative velocity between the surface of the generally round body and the support surface at the point or line of contact therebetween. Where such a pure rolling motion is not experienced, a relative velocity occurs between the support surface and the surface of the generally round body. With respect to a conically shaped body rolling on a support surface, pure rolling occurs when all points on the surface of the conically shaped body are contained within a single cone. Where such is not the case, i.e., where some portions of the surface of the body fall elsewhere than in the single cone, the surface of the body at such a point will experience a relative velocity with respect to a stationary surface with which it may be in contact. Relating this to the structure of FIG. 1, the rotational movement of pinion gears 65, shafts 73 and rollers 75 is controlled by gear 65 which is in meshed engagement and thus in compulsory rolling engagement with beveled ring gear 63. Accordingly, pure rolling engagement of the surfaces of any of shafts 73 and rollers 75 will occur only when a point of contact between the surfaces of shafts 73 or rollers 75 and their adjacent surfaces falls along a cone defined by the extension of the pitch diameter "pd" of beveled ring gear 63. As is evident from FIG. 1 wherein "pd" extended is shown in phantom line, all points on the surface of shaft 73 fall within the cone whereas all points on the surface of roller 75 fall outside the projected cone. Thus, referring only to the surface of roller 75, there will be experienced, at all times during the rotation of roller 75 by the cooperation of pinion 65 with gear 63, a relative velocity of "wiping" action between the roller surface and any stationary surface with which it may come into contact. Such a motion is commonly referred to as curtate cycloidal motion.

The magnitude of the relative velocity imparted to the surface 78 of the rollers 75 can be determined by one having skill in the art based upon the amount of variation of the diameter of the roller surface at any point therealong from the diameter of the extended pitch diameter cone at that same point. With respect to such relative velocities, it has been found that an increase in absolute tangential velocity of (10 percent) to (30 percent) over the absolute tangential velocity experienced along the surface of the cone of the extended pitch diameter is generally satisfactory in practicing the present invention.

Considering the various possible motions of rollers 75 in the light of the foregoing, it can be seen that all motion of rollers 75 is in response to some motion of drum 55 which thus defines a displacing means for roller 75. Specifically, vertical displacement of drum 55, e.g., between the positions shown to the left and right of center in FIG. 1, causes a corresponding vertical displacement of rollers 75. Revolution of drum 55 around its vertical axis, on the other hand, causes both the revolution of rollers 75 around the vertical axis of drum 55 and the rotation of rollers 75 around the axes of shafts

73. As noted above, the rotation of rollers 75 is in response to the meshed rolling engagement of pinion gear 65 with beveled ring gear 63 as the pinion gear is revolved with the revolution of drum 55.

Thus, it can be seen, that each of rollers 75 is subject to vertical displacement, revolution and rotation. As is discussed below with respect to the operation of apparatus 10, each of these motions plays a part in the insertion of semi-fluid material in the practice of the method of the invention by apparatus 10.

Referring again to FIG. 1, there can be seen to be mounted also on motor support plate 42 a fluid motor 80, the shaft 81 of which extends through a suitable aperture in support plate 42. Fluid motor 80 imparts vertical movement (as seen in FIG. 1) to a wiper blade 84 which is mounted on a lower end of shaft 81. The outer edges of wiper blade 84 are slidably received between a plurality of guide pins 85 which are rigidly secured to and extend radially inwardly from the inner surface of drum 55. Guide pins 85 serve to accommodate the vertical movement of wiper blade 84 as well as to impart revolving movement to wiper blade 84 in response to the revolution of drum 55.

The lower edge of wiper blade 84 is shaped to correspond to the tapered surface of conical workpiece 25 and is also canted at a slight angle, e.g., 10° , away from the direction of revolution of the wiper blade. Thus, when wiper blade 84 is extended toward the surface of the workpiece 25, revolution of drum 55 causes a corresponding revolution of wiper blade 84 thereby wiping the surface of workpiece 25 as is discussed below.

When not in position to accomplish its wiping function, wiper blade 84 is retracted upwardly by fluid motor 80. The amount of vertical movement imparted to wiper blade 84 by fluid motor 80 during retraction is such as to allow wiper blade 84 to be positioned above the upper edge of rollers 75 during the operation thereof.

The apparatus 10 is operated as one step or station of a manufacturing operation for forming finished pasted grid plates for use in secondary batteries.

The overall operation of which this apparatus and its operation is a part, includes the steps of positioning a workpiece 25 in conical bed 22, which bed as noted above is mounted on a conveyer 21, advancing the conveyer to an indexing station where the workpiece is indexed to insure that it is accurately shaped to the desired conical configuration, and thereafter advancing the conveyer and workpiece to a paste inserting station such as that shown in FIGS. 1 and 2. At this pasting station, paste is inserted in the apertures of the workpiece whereafter the workpiece is moved to a subsequent station and excess material is removed from the plate by inverting the plate over a suitable collecting means. Finally, a finishing wiper may be applied to the surface of the material so as to insure a smooth finish, and the finished plate is removed from bed 22.

Considering now the operation of the apparatus 10 in the paste inserting step, the conveyer section containing bed 22 and a workpiece 25 is positioned so that the vertical axis of workpiece 25 as seen in FIG. 1 is coaxial with the axes of shaft 81 of fluid motor 80 and the central axis of revolution of drum 55. With the workpiece 25 so positioned, a measured amount of battery paste is positioned on the surface of the workpiece 25 under rollers 71. The measured amount is preferably slightly

more than that required to fill the apertures in workpiece 25.

Fluid motors 44 are then operated to advance bearing support plate 48 and therewith drum 55 and rollers 75 from a retracted position such as that shown to the left of center in FIG. 1, downwardly to a position where rollers 75 are brought into initial contact with the battery paste as shown in FIGS. 3(a). Revolution of drum 55 is then commenced to cause displacement of the rollers over the surface of the workpiece and to cause gears 65 to roll along beveled ring gear 63. As noted above, the revolution of drum 55 in cooperation with the rolling of gears 65 on ring gear 63 imparts both a revolving and a rotational movement to rollers 75.

Concurrently with the revolution and rotation of rollers 75, fluid motors 44 are again operated to advance drum 55 and therewith rollers 75 downwardly toward workpiece 25. This advancement is preferably accomplished at a relatively slow rate, e.g., 0.5 inches per minute for some pastes, but it should be recognized that the optimum rate for any particular paste inserting operation may be determined empirically. The cooperative advancement, revolution and rotation of the rollers 75 cause an insertion of paste within the apertures of battery plate 25 so as to completely fill the apertures.

Considering this insertion in detail, and referring to FIG. 3a, b and c, there is shown insertion of the material in progressive steps from the initial revolutions of a roller 75 over the material through the final pass of rollers 75 thereover. The motion of the roller 75 is shown with respect to the surface of the paste as being revolving in a direction from left to right as shown in FIG. 3 and indicated by arrow R_r , rotating in a clockwise direction as shown by arrow R_o , and downwardly advancing as shown by arrow A.

The revolving movement of roller 75 as indicated by arrow R_r , if considered alone and not in conjunction with the advancement or rotation of roller 75, is similar in effect to the action of a squeegee or wiper blade in that the material contacted by roller 75 is, by this revolving movement, caused to be pushed downwardly and ahead of the roller.

Pushing material ahead of the roller is not a desirable condition when inserting paste into the apertures of a workpiece such as the battery plate 25. The rotational movement R_o experienced by roller 75, however, overcomes this undesirable pushing of material by tending to drag the material downwardly toward the underside of the roller. More specifically, the rotational movement of roller 75, which as noted above is at such a rate as to cause a tangential velocity of the roller with respect to the paste in the area of contact, tends to pull paste material from in front of the roller downwardly under the roller, thereby to increase the amount of material being inserted by each roller pass.

A second effect of the rotational movement of roller 75 is that the tendency of the paste material to stick to the roller surface and be withdrawn from the workpiece apertures by the roller is minimized and in most cases eliminated. It was noted above that a problem with prior art roller devices has been the tendency of the material being inserted to stick thereto and thus be withdrawn from the workpiece apertures after having been inserted. The invention overcomes the problem in that the rotation of rollers 75, so as to maintain a relative velocity between the surface of the paste and the roller, is such as to generate shear forces between the

roller and the paste material, which shear forces assist in separating the paste material from the roller surface. Thus, the shear forces created between the roller surface and the paste material are sufficient to overcome the adhesive force between the roller surface and the paste material and no adhesive bond therebetween is established.

As noted above, the rotating movement of the roller tends to drag paste material downwardly under the roller thereby causing additional material to be drawn into the area under the roller for insertion into the workpiece. In this regard, the efficiency of this motion can be improved and still additional material can be drawn downwardly with the roller by providing the roller with a roughened surface, e.g., by knurling or ribbing or the like, which roughened surface increases the frictional relationship between paste material and the roller.

The advancement of rollers 75 concurrently with the revolution and rotation thereof allows insertion of the paste material to be accomplished by a plurality of passes of the roller thereover. Each pass of a roller generates a "pulse" of material insertion force. Thus, insertion of the paste material is accomplished by what may be described as a pulsing action rather than by the exertion of a single force as is generally known in prior art methods of insertion by rolling. Such a pulsing action accomplishes a relatively gradual insertion of the paste material as is depicted schematically in FIGS. 3 (a), (b) and (c).

The gradual advancement of the rollers in cooperation with this revolving and rotating motions has been found to cause insertion of the paste into the irregularly shaped apertures in such a manner as to completely fill the apertures including those areas below the central restrictions defined by the diamond-shaped structural ribs 27 and 28. Upon the completion of the insertion operation by the rollers, the rollers are retracted at a relatively rapid rate by the operation of fluid motors 44. The rapid rate of retraction, e.g., a rate of 10 inches per second, has been found to be desirable in cooperating with the "wiping" action of the roller surface against the material being inserted to effect a complete separation of material being inserted from the roller surface, thereby avoiding withdrawal of inserted material as discussed above. A wiper blade 84 then may be advanced toward the surface of the workpiece and revolved with drum 55 along the surface of the workpiece in such a manner as to smooth over and loosen any excess of paste material from the surface of the workpiece (see FIG. 3(d)). Upon completion of the wiping operation, the wiper is retracted by the operation of the fluid motor 80 and the now pasted workpiece is advanced by the operation of conveyer 21 as discussed generally above.

An apparatus substantially the same as that of FIGS. 1 and 2 has been utilized to insert the above mentioned tetra-basic lead sulfate paste into a conical lead battery grid. Specifically, during the insertion of the paste, the drum and rollers were revolved at 50 revolutions per minute and the rate of advance of the rollers toward the workpiece was approximately 0.5 inches per minute. The pressure thus generated by the rollers against the paste material was approximately 70-80 pounds per square inch and, using this method, complete filling of the grid apertures was accomplished.

It is to be recognized that workpieces having ribs of virtually any configuration can be filled according to

the method of the invention. Further, the step of wiping the surface of the workpiece after insertion of the material by the rollers can be eliminated if desired and in such situations, the rollers are advanced until they come into intimate contact with the ribs.

It is also to be recognized that certain situations may occur wherein rotation of the rollers in a direction opposite to that disclosed above with respect to the apparatus of FIGS. 1 and 2 may be desired. Such reverse rotation can be accomplished simply, for example by providing a gear drive between the beveled gear and the roller.

Finally, it should also be recognized that the method and apparatus of the invention, although disclosed with respect to the specific utility of pasting a conical battery grid, can be utilized to insert other materials into the apertures of other types of workpieces of other shapes. In this regard, many modifications and adaptations may be made in the present invention without departing from the scope and spirit thereof.

What is claimed is:

1. Apparatus for inserting material into apertures formed in a workpiece, such material having been deposited on the surface of the workpiece, the apparatus comprising:

means for positioning the workpiece adjacent at least one roller;

means for reciprocating the roller toward and away from the surface of the workpiece to move portions of the roller into and out of contact with the material on the surface of the workpiece;

means for displacing the roller over the surface of the workpiece; and

means for positively rotating the roller at a relative velocity to effect curvate cycloidal motion to impart wiping motion between the surface of the roller and the surface of the workpiece to move the deposited material toward the apertures of the workpiece and to generate shear forces between the roller and the material which is both on the surface of the workpiece and in contact with the roller to urge such material to separate from the roller.

2. Apparatus according to claim 1, wherein the roller is mounted on the displacing means and the reciprocating means is for reciprocating both the displacing means and the roller toward and away from the workpiece.

3. Apparatus according to claim 2, wherein the rotating means comprises:

a gear mounted on the reciprocating means; and at least one pinion, such pinion mounted on the roller, the pinion and the gear cooperating to impart rotating movement to the roller.

4. Apparatus according to claim 3, wherein the workpiece is circular, the gear and the pinion are circular bevel gears, and the roller is frustoconically shaped, wherein the displacing means rotates about a central axis through the workpiece, to revolve the rollers about the axis, and wherein the pinion is displaceable on the gear in response to the revolution of the roller to rotate the roller and impart the wiping motion thereto.

5. Apparatus according to claim 4, wherein the workpiece is a conically shaped workpiece and the roller is tilted about its axis to establish line contact with the workpiece.

6. Apparatus according to claim 5, wherein the pinion is a beveled gear and each point on the surface of

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the frustoconical roller is outside the surface of a cone projected from the beveled pitch surface of the beveled gear.

7. Apparatus for inserting paste in the apertures of a conical battery plate, comprises:

a conical nest for supporting said conical battery plate said nest having a central axis;

a drum disposed concentrically of the central axis of said conical battery plate;

means for advancing and retracting said drum toward and away from said conical battery plate;

roller means mounted on and journaled for rotation with respect to said drum;

gear means formed on one end of said roller means for cooperation with a rigidly mounted ring gear to impart rotational movement to said roller means in response to the revolution of said drum, the pitch diameter of said gear means falling on a cone, the projection of which is contained within the volume of said roller means;

wiper means mounted coaxially of said drum and said battery plate;

means for advancing and retracting said wiper means

toward and away from said battery plate; and means for securing said wiper means to said drum for rotating said wiper means with said drum.

8. Apparatus for inserting material into the apertures of an apertured workpiece, which comprises:

means for inserting the material into the apertures of said workpiece;

advancing means for reciprocating said insertion means toward and away from said workpiece;

means for displacing said insertion means over the surface of said workpiece;

means for loosening excess material on the surface of said workpiece and for smoothing material remaining on said surface;

means for advancing said loosening and smoothing means toward and away from said workpiece; and

means for connecting said loosening and smoothing means to said displacing means to displace said loosening and smoothing means over the surface of

said workpiece when said advancing means has advanced said loosening and smoothing means

toward said workpiece.

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