

- [54] **BATTERY PASTE PUMPING AND METERING SYSTEM**
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Related U.S. Application Data

- [62] Division of Ser. No. 244,485, April 17, 1972, Pat. No. 3,814,628.

- [52] U.S. Cl. **239/127; 239/142; 239/597; 239/601; 117/44; 136/19**
[51] Int. Cl. **B05b 9/00; B05c 1/16; H01m 35/00**
[58] Field of Search **117/201, 43, 44, 120, 102, 117/105.1; 136/19, 67, 33; 239/592, 594, 595, 128, 127, 142, 597, 601; 118/410**

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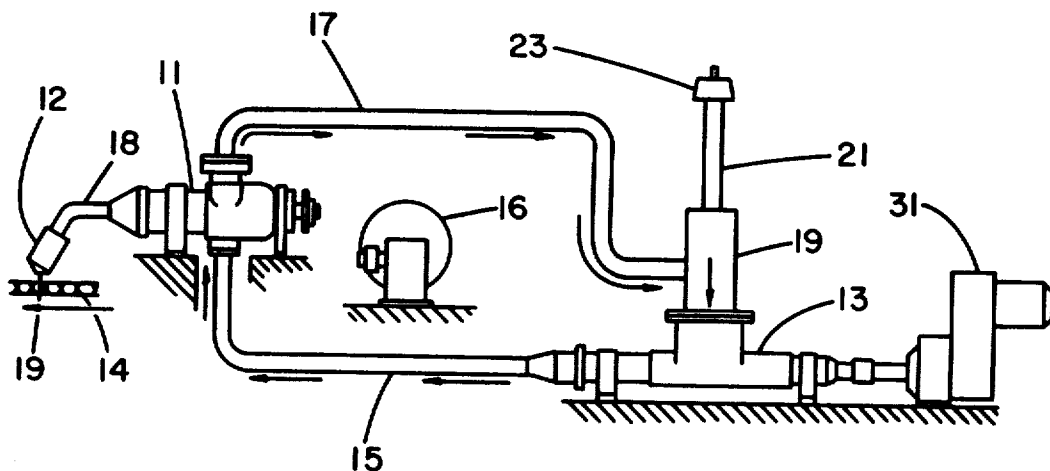
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[57] **ABSTRACT**

A closed loop pumping and metering system for pasting battery electrode plates with a viscous, thixotropic battery paste is disclosed. The closed loop includes an inlet for charging make-up paste, a first pump for agitating and circulating the paste around the loop, and a metering pump downstream of the circulating pump for initiating flow of a predetermined volumetric flow rate of paste through a discharge means onto a battery grid substrate, or the like. The paste consistency and working life are enhanced by the mixing effect provided by repeated passes through the circulating and metering pumps.

22 Claims, 10 Drawing Figures



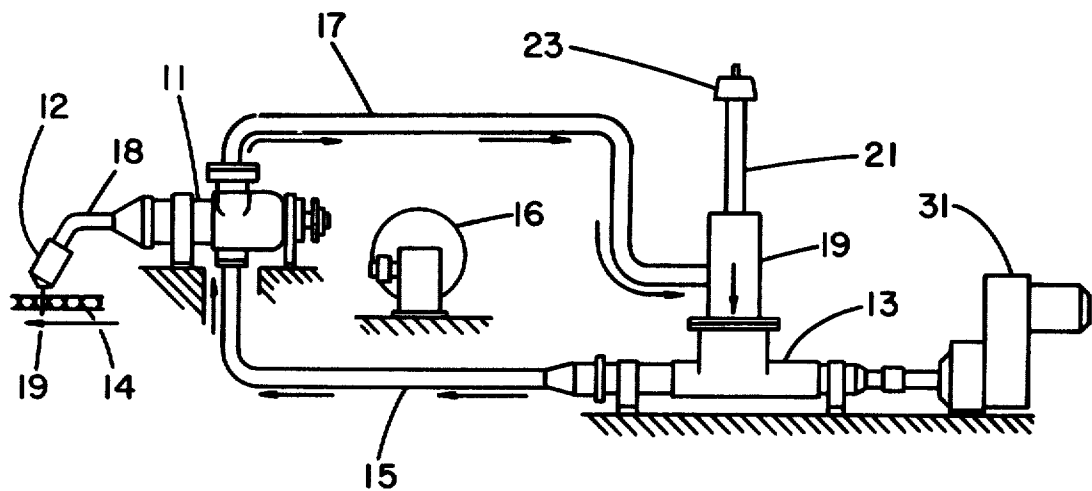


FIG. 1

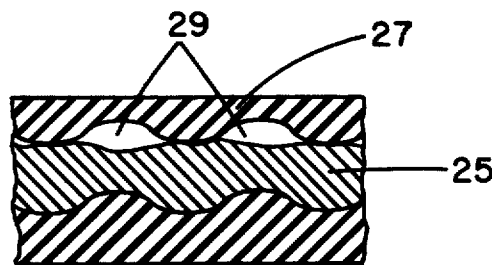


FIG. 2

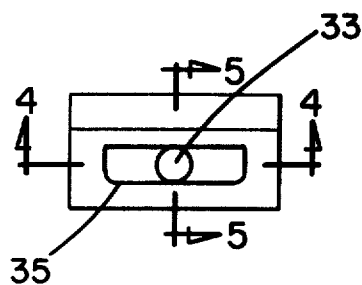


FIG. 3

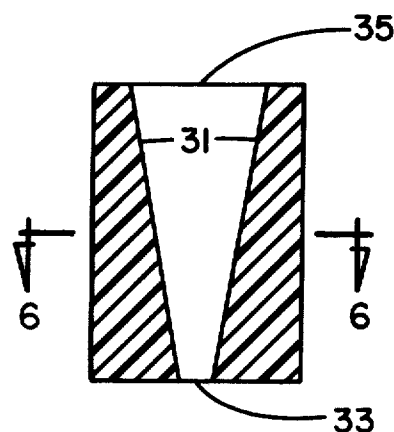


FIG. 4

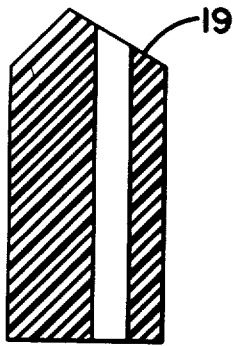


FIG. 5

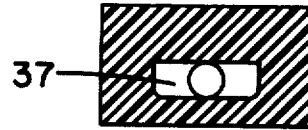


FIG. 6

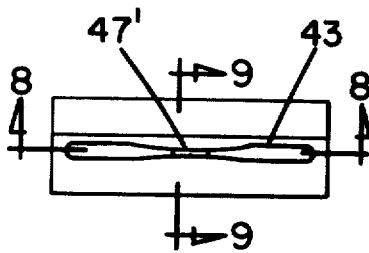


FIG. 7

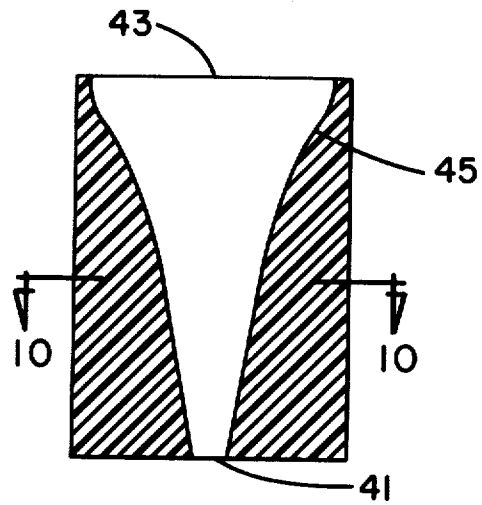


FIG. 8

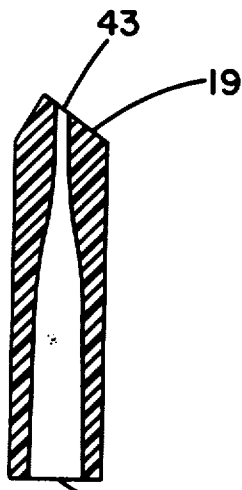


FIG. 9

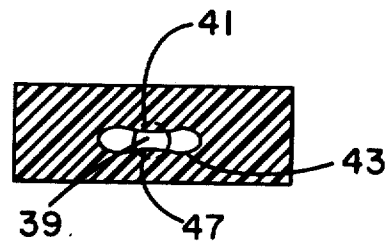


FIG. 10

BATTERY PASTE PUMPING AND METERING SYSTEM

This is a division of application Ser. No. 244,485, filed Apr. 17, 1972, now U.S. Pat. No. 3,814,628.

BACKGROUND OF THE INVENTION

This invention relates to systems for pasting battery plates, and particularly to such systems which are required to handle highly viscous, thixotropic, slurry-like suspensions of discrete crystalline finely divided particles.

In the assembly production of pasted battery plates, it has been common to pump the paste through a discharge means, such as a nozzle, with an open feed gear pump onto a moving grid, expanded mesh, or other type of conductive substrate. In such a system, it has been a common characteristic for a non-uniform volumetric flow rate of paste to be discharged upon the moving substrate, requiring the use of doctor blades or other means to scrape off the excess paste. This often results in the waste of paste, the non-uniform deposition of paste, and in the case where the substrate is of a non-grid character the deformation or flattening of the soft substrate by the doctor blade. These drawbacks are magnified when the paste is highly viscous, thixotropic, and resembles a slurry or suspension of fine solid particles in a vehicle. Such paste may rheologically resemble "quick clays," wet mortar, cement, or the like. The finely divided particles of solids are generally macromolecular in size, rather than colloidal. These paste materials are essentially non-plastic and behave like non-Newtonian fluids inasmuch as the viscosity of the paste varies with its rate of flow in the closed loop network. As such, significant problems are encountered in circulating and metering a predetermined amount of the paste at a given flow rate onto a passing substrate and in avoiding "setting up" of the paste.

Traditional systems for circulating common thixotropic types of materials, such as shown in U.S. Pat. No. 2,651,586 (Cooper et al.) employ a circulating pump in series with a type of constant pressure aided three-way valve for intermittent metering of the material. Such a valve type of metering device has been tested and found to be ineffective for discharging at a predetermined flow rate highly viscous, non-Newtonian fluids such as contemplated by the present invention. The general state of the art is also exemplified by the teachings of U.S. Pat. Nos. 2,479,603 (Chubb et al.), 2,972,546 (Adler et al.), and 3,529,626 (German).

SUMMARY OF THE INVENTION

Briefly, the present invention includes a system and process for metering viscous, thixotropic electrochemically active paste onto a suitable electrode substrate. The system comprises a closed loop conduit system connecting a circulating pump, fed through an inlet reservoir, with a pumping/metering device for initiating flow of a portion of the circulating paste and for metering a predetermined volumetric flow rate of the paste to a discharge nozzle, or the like. Paste consistency and working life are enhanced by the mixing effect of repeated passes of the paste through the pumps in the closed loop system. By discharging a substantially constant flow rate of paste, the speed of the traveling substrate may be chosen so that uniform pasting of the grid

is effected without waste of paste and without the use of doctor blades or other controlling devices.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be more particularly set forth in various of its embodiments by reference to the accompanying drawings, in which:

FIG. 1 is a flow diagram of the overall paste pumping and metering system of the invention;

FIG. 2 shows a fragmentary partial sectional view of the forward portion of a preferred type of positive displacement pump denoted either as pump 11 or pump 13 of FIG. 1;

FIG. 3 is an end view at the outlet of a discharge nozzle useful in the invention;

FIGS. 4, 5, and 6 are different sectional views of the nozzle of FIG. 3 taken along the designated sections;

FIG. 7 is an end view at the outlet of another type of nozzle useful in the present invention; and

FIGS. 8, 9 and 10 depict various sectional views of the nozzle of FIG. 7 taken along the sections as shown.

PREFERRED EMBODIMENTS OF THE INVENTION

Referring to FIG. 1, a closed loop pumping, circulating, and battery paste metering system generally includes a circulating pump 13 and metering pump 11 connected through forward conduit 15 and return conduit 17. Battery paste is charged to the closed loop through an inlet means such as reservoir 19 provided with a biasing means for applying a net positive suction head to the circulating pump 13, and discharged through conduit 18 and nozzle 12 onto electrode substrate 14. This biasing means at the inlet side may be selected from a number of suitable devices well known and appreciated by those skilled in the art. Examples include piston ram 21 provided with a weight 23, a spring, dead weight, fluid pressure head or rolling diaphragm membrane. The biasing means preferably isolates the battery paste from exposure to the atmosphere to preclude possible degradation.

The rheological nature of the battery paste circulated within the system has been described hereinabove as being highly viscous, thixotropic and exhibiting non-Newtonian character. While viscosity measurements on a Brookfield viscosimeter of the battery paste are not too meaningful for non-Newtonian fluids, apparent viscosity readings of typical battery paste compositions of the invention will often be at least about 3 million centipoises, and quite often greater than about 7 million centipoises. * Examples of such paste compositions include negative and positive lead-acid battery pastes which comprise a major proportion of oxides of lead, e.g. litharge, suspended in a minor proportion of a vehicle, e.g. water. The litharge particles preferably are discrete crystalline finely divided solids of a ceramic nature of macroscopic size. Oftentimes additional paste constituents, such as an expander, lead and Pb_3O_4 are present. It is preferred that the battery paste contain no entrained fluids which may have the effect of degrading the paste by oxidation or other mechanism.

* Measured with a TF helipath spindle at 1 r.p.m. after at least one and up to 50 minutes elapsed time.

In order to circulate such cement-like pastes about a closed loop, circulating pump 13 is preferably of the positive displacement type, exemplified by a diaphragm pump or archimedes' screw type pump. This latter type

of pump (preferred for lead-acid pastes) is exemplified by the MOYNO pumps (a registered trademark of the Robbins and Myers Corporation) utilizing a progressing cavity arrangement as shown partially in FIG. 2. The operating principle of the pump is based on two pumping elements consisting of a helical roter 25 turning within a double threaded helical stator 27. The meshing helical surfaces push the battery paste ahead along the progressing cavities 29 with uniform movement and low turbulence similar to a slow moving piston in a cylinder of infinite length. The screw-like roter rolls within the nut-like stator with an eccentric rolling movement. The speed of the roter 25 and hence the rate of flow of the paste within the closed loop may be varied according to the output speed of a variable speed drive pump motor 31.

It has been found that in order to achieve uniform deposition of battery paste from the nozzle 12 onto a suitable electrode substrate 14, such as an expanded mesh grid or perforated sheet, more than just a passive mechanism (e.g. a three-way valve) is required to meter a predetermined volumetric flow rate of paste to the discharge nozzle 12. A three-way valve has been found to be ineffective inasmuch as the valve is incapable of diverting and initiating flow of a particular desired portion of the circulating paste away from the closed loop without eventual plugging, channeling and stoppage. In order to divert and initiate flow of the desired amount of paste away from the circulating loop represented in part by conduits 15 and 17, a positive displacement metering pump 11 is required. This pump may suitably be driven by a motor 16 whose speed is preferably directly proportional to the speed of the battery substrate material 14 as it passes beneath and in close proximity to the discharge nozzle 12. This positive displacement metering pump 11 may be of various types although the archimedes' screw type, exemplified by the aforementioned MOYNO type, is preferred. By varying the speed of the roter within the pump by means of motor 16, the volumetric flow rate of paste to the discharge means 12 may be controlled within any desired range. This capability holds virtually independent of temperature and the internal pressure of the paste exerted within the closed loop, provided a net positive suction head exists at the pump inlet and the pump has not cavitated.

Because paste consistency and working life are enhanced by the mixing of paste provided by repeated passes through the pumps 11 and 13, the relative speeds of the two pumps are chosen so that only a desired proportion of the circulating paste is diverted to the discharge means 12. Normally, the ratio of the amount of paste allowed to recirculate in the closed loop to the amount of paste material metered to the discharge means is preferably from about 50:1 to about 15:1, and more preferably from about 30:1 to about 20:1.

The discharge means 12 is preferably in the configuration of a nozzle whose geometry is designed to accommodate substantially unobstructed flow of the viscous, thixotropic paste. One embodiment of the discharge means includes a depending nozzle 12 which conducts fluid from the metering pump 11 through curved conduit 18. The head of the nozzle 12 preferably has a tapered surface 19 which is arranged substantially parallel to the moving substrate material 14. In the instance where the substrate material is of a soft

and deformable nature (e.g. high purity expanded lead mesh) it is preferred to position the surface 19 slightly above the moving substrate. In this manner, the nozzle acts similarly in function to a doctor blade without deforming the substrate 14. Those skilled in the art will appreciate the use of other discharge means suitable for applying the paste onto an electrode substrate.

Preferred nozzle configurations are those which convert a substantially cylindrical input flow from the positive displacement pump to a ribbon-like rectangular output for application to the substrate. Because of the rheology of the paste composition, traditional nozzle structures have not been found workable inasmuch as the paste has tended to cling to the interior surfaces of the nozzle, allowing the paste to be discharged only through the central portions of the nozzle, a phenomenon commonly known as "channeling."

It has been found that two types of nozzle configurations can effectively accommodate such a viscous non-Newtonian fluid after hours of continuous use without significant channeling. The first type is depicted in FIGS. 3-6 in which substantially straight nozzle sides 31 are employed in the transition from the cylindrical or circular input 33 to the substantially rectangular output 35. In this first embodiment having straight sides 31, it is important that the cross-sectional area of the interior of the nozzle, such as noted by the reference numeral 37 in FIG. 6, increases essentially monotonically from the inlet point 33 to the outlet point 35.

The second type of nozzle configuration is shown in FIGS. 7-10 and employs a constant or substantially constant cross-sectional area as a progression is made from the cylindrical inlet 41 to the rectangular-like outlet 43. To maintain such a substantially constant cross-sectional area, it is important that the internal fluid flow surfaces 45 of the nozzle as shown in FIG. 8 be substantially diverted or curved outwardly, apparently to minimize boundary frictional force which seem to predominate over internal paste shear forces. Preferably this curved surface 45 is a portion of or substantially resembles a portion of one of the conic sections, as viewed perpendicularly to the direction of fluid flow and to the length of rectangle-like surface 43. It is also preferred that while progressing from the inlet point 41 to the outlet point 43 that cross-sectional area 39 contains inwardly curved depressions 47 to further inhibit boundary frictional problems which might lead to channeling. The outlet slit 43 also preferably contains centrally located slight depressions 47' to prevent channeling. It is believed that those skilled in the art will appreciate additional nozzle configurations useful and within the scope of the present invention.

While various materials and constructions of nozzles may be employed, machined or cast thermosetting polymeric materials such as cast epoxy or polyester resins or machined acrylic have been found suitable.

It should be understood that the invention is capable of a variety of modifications and variations which will become apparent to those skilled in the art upon reading of the specification. Such modifications are intended to be encompassed within the scope of the invention as defined by the appended claims. For instance, while the description and drawings depict a stationary discharge means and a moving electrode substrate, clearly the reverse roles could be taken and still maintain the desired relative movement.

What is claimed is:

1. A substantially closed loop system for pumping and metering viscous thixotropic electrochemically active paste through a discharge means comprising:

- a. inlet means for charging make-up paste to said closed loop system;
- b. first pump means for agitating and circulating said paste around the loop;
- c. second pump means, downstream of said first pump means, for initiating flow of a portion of the circulating paste away from the closed loop to the discharge means;
- said second pump means metering a predetermined volumetric flow rate of paste to said discharge means.

2. The system of claim 1 wherein the flow rate of the discharged paste is virtually independent of the internal pressure of the paste exerted within the closed loop.

3. The system of claim 1 wherein said inlet means comprises a reservoir, battery paste within the reservoir, and biasing means applying a net positive suction head urging said battery paste to enter said closed loop.

4. The system of claim 1 wherein said paste has the characteristics of a non-Newtonian fluid comprising a major proportion of discrete finely divided crystalline particles slurried in a minor proportion of vehicle.

5. The system of claim 4 wherein said finely divided particles comprise oxides of lead.

6. The system of claim 5 wherein said vehicle comprises aqueous medium.

7. The system of claim 1 wherein said first pump means is located downstream from said inlet means and is a pump of the positive displacement type.

8. The system of claim 7 wherein said first pump means is a positive displacement pump of the archimedes' screw type.

9. The system of claim 1 wherein said second pump means is a positive displacement pump of the archimedes' screw type containing a metering valve.

10. The system of claim 1 wherein the ratio of the amount of paste allowed to recirculate in the closed loop to the amount of paste metered to said discharge means is from about 50:1 to about 15:1.

11. The system of claim 1 wherein said discharge means comprises a nozzle which converts a substantially cylindrical input flow from said second pump means to a substantially rectangular output flow for uniform delivery to a moving substrate.

12. The system of claim 11 wherein the internal fluid flow surfaces of said nozzle are substantially straight sided and further characterized by defining a passageway having an increasing cross-section from input to output as measured transverse to the direction of fluid flow.

13. The system of claim 11 wherein the internal fluid flow surfaces of said nozzle define a passageway which is substantially conical as viewed perpendicularly to the direction of fluid flow and the length of the rectangular

output.

14. The system of claim 13 wherein the passageway of the nozzle is characterized by a substantially constant cross-section from input to output as measured transverse to the direction of fluid flow.

15. A system including a substantially closed circulation loop for handling battery paste and metering it to a moving substrate in the production of battery electrode plates of the lead-acid type, comprising:

- a source of highly viscous non-plastic thixotropic battery paste comprising a major proportion of oxides of lead suspended in a minor proportion of aqueous vehicle;

inlet means for charging make-up thixotropic paste to said closed loop system;

first pump means for agitating and circulating said paste around the loop;

discharge means positioned adjacent the substrate for applying said paste to the substrate;

second pump means in connection with said discharge means, downstream of said first pump means, for initiating flow of a portion of the circulating paste away from the closed loop to the discharge means;

said second pump means metering a predetermined volumetric flow rate of paste to said discharge means which is in turn metered to the substrate at the predetermined volumetric flow rate.

16. The system of claim 15 wherein said second pump means is a positive displacement pump of the progressing cavity type.

17. The system of claim 15 wherein the ratio of the amount of paste allowed to recirculate in the closed loop to the amount of paste metered to said discharge means is from about 50:1 to about 15:1.

18. The system of claim 15 wherein said discharge means comprises a nozzle which converts a substantially cylindrical input flow from said second pump means to a substantially rectangular output flow for uniform delivery to the substrate.

19. The system of claim 18 wherein the internal fluid flow surfaces of said nozzle define a passageway having an increasing cross-sectional area from input to output as measured transverse to the direction of paste flow.

20. The system of claim 18 wherein the internal fluid flow surfaces of said nozzle define a passageway which is substantially curved outwardly from input to output as viewed perpendicularly to the direction of paste flow and the length of the rectangular output.

21. The system of claim 18 wherein the passageway of the nozzle is characterized by a substantially constant cross-sectional area from input to output as measured transverse to the direction of paste flow.

22. The system of claim 18 wherein the outlet portion is substantially parallel to the surface formed by the substrate onto which the paste is to be deposited.

* * * * *