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Electrodeposition of Film-Forming Macroions

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Electrodeposition of Film-Forming Macroions*

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ABSTRACT

Ionizable film-forming macromolecules (RCOOH, RNH_2, etc.) have recently found large-scale application as electrodepositable paints. Using bases or acids as solubilizers, macroanions ($RCOO^-$) or macrocations (RNH_3^+) are deposited from aqueous dispersions on the anode or cathode, respectively.
The electric current deposits the paint solids practically free from volatile organics on the outer and inner surfaces of merchandise, resulting in higher corrosion protection at substantially lower cost. Bath droplets adhering to freshly electrocoated objects are rinsed back into the bath by a process involving ultrafiltration. Thus electrocoating is one of the ecologically and commercially most viable paint processes.

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INTRODUCTION

Paint coats are applied to the surfaces of merchandise for the two-fold purpose of pleasing appearance and corrosion protection. Spray painting produces very smooth coats of reasonably uniform film thickness on all essentially visible surfaces. Highly recessed surfaces, such as the inner surfaces of automotive rocker panels (Fig. 1), cannot be reached by spray painting.

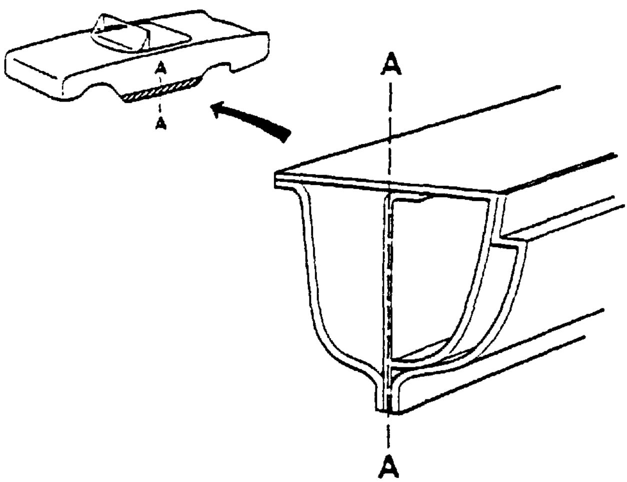

FIG. 1. Rocker panel multichannel structure (schematic).

Dip coating definitely gets paint onto recessed surfaces, but it is difficult to obtain a paint coat of uniform film thickness. Inspection of the inner surfaces of a rocker panel shows heavy paint accumulation at the bottom and extremely thin paint coats on certain other areas. Here, paint solvent—be it water or organic solvent—has washed off the dip paint during the bake cycle. The phenomenon is called "solvent wash" or "reflux damage," and is produced by vapors condensing on relatively cooler and poorly ventilated inner surfaces.

Thus the problem of successful painting and protecting highly recessed surfaces is in reality the problem of the application of paint solids in the virtual absence of volatile solvents.

This can be achieved by use of the electrocoating paint process which was conceived in the late 1950's and is now being rapidly adopted worldwide. Electrocoated merchandise is available in practically all colors, and it ranges in size from building trusses, automobile bodies, furniture and appliances, to toys and nuts and bolts.

ELECTROCOATING MATERIALS

Many leading paint manufacturers have developed proprietary paint formulations which are water dispersable, large ions. Thus, if we symbolize a suitable resin system as "RCOOH," it will become water dispersable when reacted with a base;

$$RCOOH + YOH \rightarrow RCOO^- + Y^+ + H_2O$$

$RCOO^-$, being a macroanion, will seek the anode in an electric cell where it will deposit.

The art of the paint maker has given us electrodepositable resins from practically all desirable resin systems, such as acrylics and epoxies. The aqueous dispersions of these resins in combination with suitable pigments are used as electrocoating baths.

A typical electrocoating bath, as used by Ford Motor Company, contains 8 g resin nonvolatiles, 3 g pigment, <2 g volatile organic matter, and 87 g water.

ELECTROCOATING PROCESS

The paint bath is placed in a steel tank, which serves as one electrode (see Fig. 2), or in a plastic-lined steel tank with inserted electrodes. A direct current power source is circuited so that the merchandise to be coated becomes the electrode of the other polarity. Due to the action of the electric current, the paint solids are deposited on the work piece. Such a freshly deposited coat is virtually free from volatile organic matter, since most volatiles remain in the bath. Indeed, the paint solids are so compacted by the electric current that the freshly deposited coat does not show tackiness when touched.

Thus the freshly painted merchandise emerges from the tank coated with an almost dry, water-insoluble coat. Some paint bath droplets adhere to the coat and some of the bath may be carried out of the tank with the merchanidse in the corners or undercuts.

If the merchanidise is now baked, each paint droplet could give rise to an unsightly blemish, and the puddles of bath in corners, etc., could

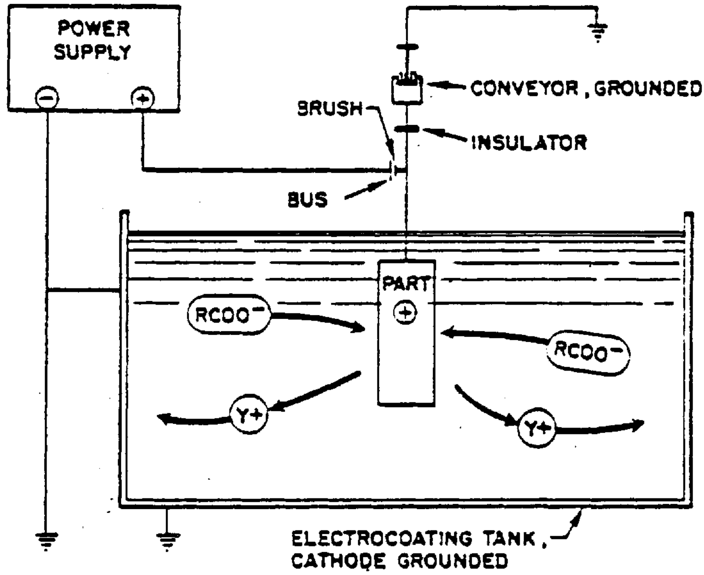

FIG. 2. Electrocoat process energizing system. Y+ is the solubilizer and $RCOO^-$ is the resin.

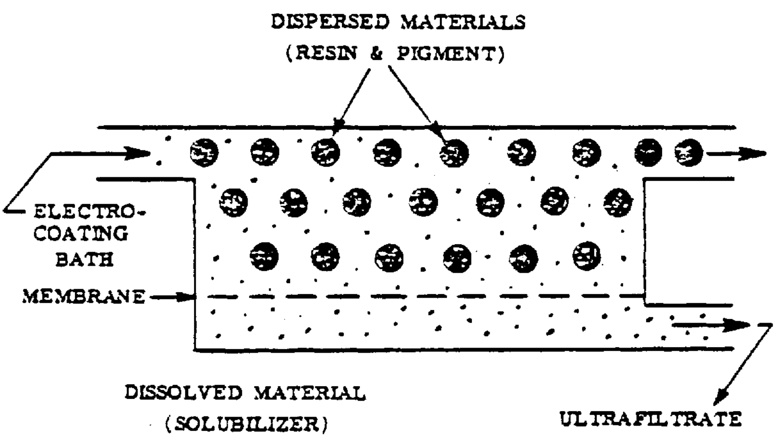

FIG. 3. Ultrafiltration.

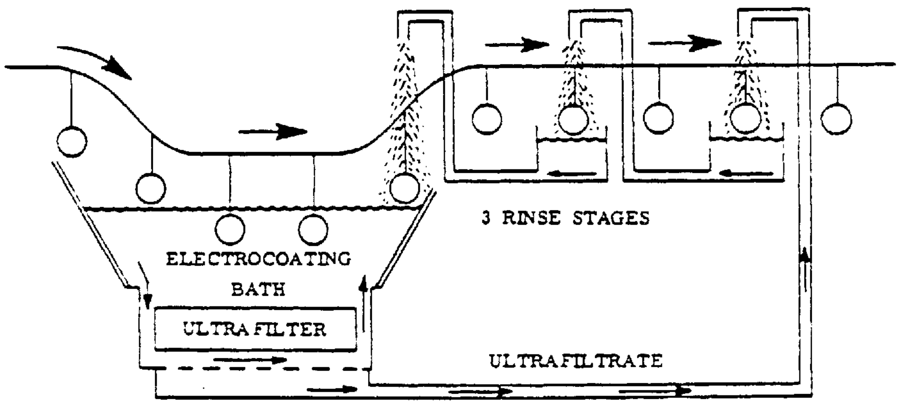

FIG. 4. Closed loop ultrafiltrate rinse.

reduce not only the appearance but also the corrosion protection. However, since the freshly deposited film is water insoluble, the water-miscible bath can be rinsed off with water.

RINSE WATER MANAGEMENT

In the 1960s the rinse water from the electrocoating process had to be disposed of through a clearing basin and waste water treatment. Recently, however, the paint solids have become reclaimable and are returned to the bath through a process involving ultrafiltration.

Plastic membranes have been developed with pores so small that they retain macroions and pigments which are the paint solids of the electrocoating bath (Fig. 3).

The clear ultrafiltrate contains usually less than 1% of water-soluble, volatile organic substances.

The electrocoat rinse is then accomplished by use of ultrafiltrate, which cascades over the freshly electrocoated merchandise, flushing the paint solids back into the bath (Fig. 4). This process is sometimes referred to as a "closed loop rinse."

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