

PATENT SPECIFICATION

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(54) APPARATUS EQUIPPED WITH SPRAYING MEANS FOR THE TREATMENT OF METAL SURFACES

(71) We, NIPPON PAINT CO. LTD of No. 1-1, Kita 2-chome, Oyodo-cho, Oyodoku, Osaka-shi, Osaka-fu, Japan, a body corporate organised under the laws of Japan do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

10 The present invention relates to an improved apparatus equipped with spraying means for the treatment of a metal surface with an aqueous solution containing a chemical reagent.

15 In the handling of metal substances or materials, various treatments are effected on their surface, e.g. degreasing, phosphate conversion coating, chromate conversion coating and oxalate conversion coating. Such

20 treatments are often carried out by the use of a spray type apparatus, of which a typical example is shown in Figure 4 of the accompanying drawings. Thus, Figure 4 is a schematic sectional view of a conventional

25 apparatus equipped with spraying means for the treatment of metal surfaces comprising a metal substance 1 to be treated an overhead conveyor 2 for transporting the metal substance and a spray chamber 3 provided with fan-attached ducts 4 and 4', at its inlet

30 and the outlet, respectively. The spray chamber 3 is usually divided into a plurality of zones depending on the kind of the treatment needed. The apparatus as shown in Figure 3 is employed for phosphate conversion coating, and the spray chamber 3

35 is divided into five zones, i.e. zones 3A, 3B, 3C, 3D and 3E, where degreasing, water-rinsing, phosphating, water-rinsing and acidulating are respectively performed. Each of these zones is provided with a nozzle 4A, 4B, 4C 4D or 4E for spraying water or an aqueous solution containing a degreasing agent, a phosphating agent or an

45 acidulating agent (hereinafter referred to as

a "chemical solution") into the spray chamber 3. Tanks 6A, to 6E provided with pumps 5A to 5E respectively for supplying water or the chemical solution to the nozzles 4A to 4E are associated with the zones 3A to 3E respectively and serve as reservoirs for water or the chemical solution, which is sprayed in the spray chamber 3. Usually, the tanks 6A and 6C are provided with heaters 7A and 7C respectively.

When the metal substance 1 is treated with an aqueous solution containing a degreasing agent in the zone 3A and also with an aqueous solution containing a phosphating agent in the zone 3C, some portions of these chemical solutions are carried from the zones 3A and 3C, respectively to the adjacent zones 3B and 3D by the metal substance 1. Thus, the rinsing waters in the zones 3B and 3D are contaminated with the chemical solution, and water-rinsing is not complete and satisfactory, which causes a deterioration in quality of the metal substance 1. In order to avoid such deterioration, fresh water is supplied to the tanks 6B and 6D so as to maintain a high efficiency of water-rinsing. In this case, an excessive amount of rinsing water resulting from the supply of fresh water overflows and is discharged as waste water. The waste water naturally contains the chemicals used in the zones 3A and 3C, usually e.g. acidic or alkaline substances, metal ions, surface-active agents or oils and fats and the discharge of such waste water may be a serious hazard to the environment. For this reason, it is desirable first to eliminate harmful components in the waste water. Since, however, a purification apparatus is very expensive, this elimination is not usually practised.

We have sought to provide an improved apparatus equipped with spray means for the treatment of metal surfaces in which the production of waste water in quantity is con-

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siderably suppressed. We achieve this effect by mounting an evacuating means on an apparatus equipped with spraying means, particularly above a zone where a metal substance is treated with a chemical solution, so as to exhaust the water in the waste water as vapour. Especially when water-rinsing is effected by a multi-stage system and the amount of fresh water to be supplied is decreased, the evacuation of an amount of water which substantially corresponds to that supplied is satisfactorily accomplished with ease.

The invention thus provides an apparatus equipped with spraying means for the treatment of a metal surface with an aqueous solution containing a chemical reagent, which apparatus comprises a spray chamber having a treatment station where the aqueous solution is sprayed on the metal surface and a rinsing station where rinsing water is sprayed on the treated metal surface, the rinsing place being divided into at least two zones and conduit means being provided between these zones and the treatment station in such manner that the water after rinsing can flow from the final zone through the other zone or zones to the treatment station, a supply means for providing fresh water provided at the final zone, and an evacuating means equipped with a vapour liquid separator mounted on the treatment station and arranged to eliminate water therefrom in a vapourised form and to separate the chemical reagent from the water, the treatment station and rinsing station being arranged so that the metal surface to be treated passes from the treatment station to the rinsing station.

Fresh water is supplied to the last zone in the rinsing location, and an excessive amount of water therefrom overflows to the adjacent zone. Such overflowing proceeds successively from one zone to another zone in the rinsing location and ultimately to the treatment location, which may also be divided into two or more zones. Thus, the water contaminated with the chemical solution brought by the metal substance under transportation is discharged from the rinsing location only to the treatment location, both of them being within the apparatus itself. By the adoption of this system, the amount of fresh water to be supplied may be reduced to substantially $1/20$ th - $1/10$ th when the rinsing location is divided into two zones and to substantially $1/50$ th - $1/20$ th when the rinsing location is divided into three zones, as compared with the case when the rinsing location consists of a single zone.

Since the overflow water is ultimately led to the treatment location, the chemical solution therein may be diluted with the increase in the amount. Because of the evacuation

means mounted on the spray chamber, however, the water is continuously evaporated, and the dilution of the chemical solution and the increase in the amount can be suppressed. The treatment location is often heated to substantially 40°C .- 70°C for greater efficiency in the treatment of the metal substance with the chemical solution, and such heating is apparently advantageous for evaporation of the water. For instance, 1 kg of air can contain 0.0488 kg of water at 40°C . and 0.276 kg of water at 70°C . Thus, the amount of the water coming from the rinsing location to the treatment location can be balanced with the amount of water evaporating from the treating place by selecting an appropriate evacuating means and/or a suitable heating means.

The present invention will be hereinafter illustrated in detail with reference to the accompanying drawings wherein:

Figure 1 is a schematic sectional view of one embodiment of spray-type apparatus according to the invention;

Figure 2 is a section along the line II-II in Figure 1; and

Figure 3 is a schematic sectional view of part of another embodiment of the spray-type apparatus according to the invention.

Fig. 4 is a schematic sectional view of one typical embodiment of a conventional apparatus equipped with spraying means.

Fig. 5 is a graph showing the relationship between the temperature of the evacuated air and the evacuated amount of rinsing water using the apparatus of Figs. 1 and 2 to achieve evacuation.

Fig. 6 is a graph showing the relationship between the temperatures of the chemical solution and the temperature of the evacuated air using the apparatus of Fig. 1 and 2.

The apparatus shown in Figures 1 and 2, comprises a metal substance 11 to be treated, an overhead conveyor 12 for transporting the metal substance and a spray chamber 13 provided with fan-attached ducts 14 and 14' at its inlet and outlet respectively. The overhead conveyor 12 runs through the spray chamber 13, which is divided into seven zones.

When the apparatus is used for phosphate conversion coating, degreasing, water-rinsing, phosphating, water-rinsing and acidulating are effected in a zone 13A, zones 13B and 13B', a zone 13C, zones 13D and 13D' and a zone 13E, respectively. These zones are respectively provided with nozzles 14A, 14B, 14B', 14C, 14D, 14D' and 14E for spraying water or a chemical solution, and with pumps 15A, 15B, 15B', 15C, 15D, 15D' and 15E for supplying water or a chemical solution to these nozzles. The pumps 15 are furnished on tanks 16A, 16B, 16B', 16C, 16D, 16D' and 16E, which serve for the recovery of water or chemical solu-

tion sprayed in the spray chamber 13. The tanks 16A and 16C are respectively provided with heaters 17A and 17C which are used for heating the chemical solutions in these tanks.

Pipes 18B' and 18D' supply fresh water to the tanks 16B' and 16D'. Pipes 18B and 18D supply the water overflow from the tanks 16B' and 16D' to the tanks 16B and 16D, and pipes 18A and 18C supply the water overflow from the tanks 16B and 16D to the tanks 16A and 16C. The pipes 18B' and 18D' are provided with valves 19B' and 19D' and also with by-pass pipes 21B' and 21D' which are furnished with magnetic valves 20B' and 20D' respectively. The pipes 18A, 18B, 18C and 18D are branched to form the pipes 22A, 22B, 22C and 22D provided with the magnetic valves 20A, 20B, 20C and 20D, respectively. The tanks 16A and 16C are provided respectively with pipes 24A and 24C having magnetic valves 23A and 23C for the supply of fresh-water thereto. In the tanks 16A and 16C, there are provided liquid level gauges 25A and 25C to detect the liquid levels by the detectors 26A and 26C respectively.

When the liquid level falls below a predetermined level and this is detected by the detector, the magnetic valves 20B', 20D' and/or 34A, 23C are actuated respectively through the circuits 27A and 27C so that fresh water is supplied to the tanks 16B', 16D' and/or 16A, 16C. Usually, it is preferred that the liquid level be raised by the actuation of the magnetic valves 20B' and 20D' only. When the liquid level rises up above a predetermined level, the magnetic valves 20A, 20C and/or 20B, 20D are actuated through the circuits 28A and 28C, and the rinsing water overflowed from the tanks 16B, 16D and/or 16B', 16D' through the pipes 18A, 18C and/or 18B, 18D are discharged away through the pipes 22A, 22C and/or 22B, 22D. Thus, the rinsing water contaminated with chemicals is discharged out of the apparatus. In order to avoid such a result, the capacities of the fans 31A and 31C are sufficiently large and the amount of fresh water to be supplied is controlled in such manner that the liquid levels in the tanks 16A and 16C do not exceed a predetermined value. Further, the openings of the valves 19B' and 19D' are preferably appropriately regulated in such manner that the amount of fresh water to be supplied in the tanks 16B' and 16D' is maintained at a value below the decreasing amount of the chemical solution in the tanks 16A and 16C whereby the liquid level always has an inclination to diminish.

On the spray chamber 13, there are mounted ducts 30A and 30C, through which the air in the zones 13A and 13C is evacuated. Fans 31A and 31C are respectively

provided in the ducts 30A and 30C to eliminate in a vaporised form an amount of water corresponding to the amount of the water overflowed through the pipes 18A and 18C into the tanks 16A and 16C. To eliminate the splash liquid of the chemical solution, splasher devices 32A and 32C are usually provided at the entrance to the ducts 30A and 30C respectively. Further, condensers 35 and 35' are desirably provided in the ducts 30A and 30C to condense the vaporised water in the evacuated air into reservoirs 36 and 36'. The thus condensed water is highly pure and may be used as part of the fresh water supply to the tanks 16B' and 16D'.

The fan 34, the ducts 33A, 33B, 33B', the fan 34' and the ducts 33C, 33D, 33D' and 33E are not essential to the apparatus of this invention, but their provision is favourable for the introduction of fresh air around the conveyor 12 equipped along the upper wall of the spray chamber 13 so as to diminish any clinging splashed or dripped rinsing water or chemical solution which might cause corrosion of the conveyor 12. The ducts 14 and 14' are also not essential to the apparatus of this invention but if desired, may be provided for preventing the liberation of the splashed or dripped rinsing water, chemical solution or water vapour from leaving the apparatus.

In an embodiment of the apparatus of the invention, as shown in Figure 2, the entrance to the duct 30A forks into two branches so that the air in the spray chamber 13 can be more uniformly evacuated.

In an embodiment of the apparatus of the invention as shown in Figure 3, the rinsing water sent from one tank to another tank is not simply overflowed but is sprayed into the latter. Thus, the rinsing water collected in the tank 16D' is sent through the pump 15D' and the pipe 14D' and part of it is sprayed into the zone 13D'. The other part of the rinsing water is further sent through the pipe 40D' and sprayed through the pipe 42D' into the zone 13D. Similarly, the rinsing water collected in the tank 16D is sent through the pump 15D and the pipe 14D and part of it is sprayed in the zone 13D. The other part is further sent through the pipe 40D to spray into the next zone (not shown) for water rinsing. When the next zone is not for water rinsing but for any other treatment, the rinsing water may be simply overflowed from the tank 16D to the next tank (not shown). In such case, the pipe 40D can be omitted.

When the evacuation was made in the apparatus of the invention as shown in Figures 1 and 2 while keeping the temperature of the chemical solution in the tanks 16A and 16C at 40°C to 70°C, the graphs as shown in Figures 5 and 6 of the accom-

panying drawings were respectively obtained. These show the relationships between the temperature of evacuated air and the evacuated amount of rinsing water and between the temperature of chemical solution and the temperature of evacuated air under the following conditions: atmospheric temperature: 22°C; relative humidity: 72%; capacity of each of the fans 31A and 31C: 60 m³/min for air at 20°C.

In Figure 5, the solid line and the dotted line represent respectively the measured value and the calculated value on the humidity chart when the humidity of the evacuated air is 100%. It is believed that the reason why the measured value is partly above the calculated value is that a portion of the chemical solution sprayed into the spray chamber 13 is as such accompanied by the evacuated air. Nevertheless, the measured value is substantially equal to the calculated value.

When the phosphate conversion coating was carried out with the apparatus of the invention as shown in Figures 1 and 2 using an alkaline degreasing solution and a zinc phosphate solution respectively in the zones 13A and 13C under the following conditions, the necessary amount of fresh water to be supplied was 200 to 300 liters per hour in each of the pipes 18B' and 18D'. The corresponding amount of water to the supplied amount of fresh water was eliminated in a vaporised form by evacuation, and no water was discharged as waste water:

Area of the treated surface (average):	Outer boxes of electric freezer, 100 m ² /hour.
Liquid temperature in the tank 16A:	70°C.
Liquid temperature in the tank 16C:	65°C.
Atmospheric temperature:	20°C to 25°C.
Relative humidity:	70 to 75%
Water temperature:	18°C.

When a conventional apparatus as shown in Figure 4 was employed for the phosphate conversion coating as above, 2000 to 4000 liters of fresh water per hour were required for each of the tanks 6B and 6D. This means that waste water contaminated with the chemical used in an amount corresponding to the amount of fresh water supplied was overflowed and discharged out of the apparatus.

From the comparison, it is clear that the amount of fresh water to be supplied is much reduced (e.g. substantially 1/10th) and the discharge of waste water resulting from the supply of fresh water is avoided by the use of the apparatus of the invention. Further, it is a great advantage of this in-

vention that the chemical previously contaminating the rinsing water is recovered into the original chemical solution and can be used again. Thus, the consumption of the chemical solution is much reduced, for instance, to an extent of 10% to 30%.

In the apparatus of the invention as shown in Figures 1 and 2, two zones are provided for each water rinsing. The number of such zones is generally from 2 to 8, preferably from 2 to 5.

Further, the apparatus has been explained above in the case of its application to successive degreasing, water-rinsing, phosphating, water-rinsing and acidulating operations, but it may be applied also to a single chemical treatment and water-rinsing and also to the performance of two or more kinds of chemical treatments and water-rinsing operations.

The present invention will be understood more readily by reference to the following Example which is concerned with the application of the apparatus as shown in Figures 1 and 2 to the treatment of automobile bodies.

Sixty automobile bodies having each a surface of 40 m² were subjected to degreasing, water-rinsing, phosphating, water-rinsing and acidulating. For each water-rinsing, 3 zones were provided. By the adoption of such water-rinsing in a three-stage system a sufficient water-rinsing effect was attained in practice by the supply of fresh water at a rate of 500 to 1000 liters per hour. When a conventional apparatus in which each water-rinsing is effected in a single stage is adopted, the supply of fresh water at a rate of 20,000 to 30,000 liters per hour is required to attain a satisfactory water-rinsing.

When the amount of fresh water to be supplied is set at 2000 liters per hour, this corresponds to the increase of the chemical solution in the tank. Thus, a fan may be so designed as to be capable of evacuating this amount of water in a vapourised state. When the temperature of the chemical solution is 60°C, the evaporation of water is understood to be 0.12 kg water/kg. air (dry) from Figures 4 and 5. Accordingly, the amount of the evacuation can be calculated as follows:

$$2000/0.12 = 17,000 \text{ kg. air (dry)/hour}$$

This evacuation amount can be easily realised with a conventional fan available on the market.

The various devices contained in the apparatus of this invention may be wholly or partly automated in conventional manner.

WHAT WE CLAIM IS:—

1. An apparatus equipped with spraying means for the treatment of a metal surface with an aqueous solution containing a



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vention that the chemical previously contaminating the rinsing water is recovered into the original chemical solution and can be used again. Thus, the consumption of the chemical solution is much reduced, for instance, to an extent of 10% to 30%.

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Further, the apparatus has been explained above in the case of its application to successive degreasing, water-rinsing, phosphating, water-rinsing and acidulating operations, but it may be applied also to a single chemical treatment and water-rinsing and also to the performance of two or more kinds of chemical treatments and water-rinsing operations.

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The various devices contained in the apparatus of this invention may be wholly or partly automated in conventional manner.

WHAT WE CLAIM IS:—

1. An apparatus equipped with spraying means for the treatment of a metal surface with an aqueous solution containing a
130

chemical reagent, which apparatus comprises a spray chamber having a treatment station where the aqueous solution is sprayed on the metal surface and a rinsing station 5 where rinsing water is sprayed on the treated metal surface, the rinsing place being divided into at least two zones and conduit means being provided between these zones and the treatment station in such 10 manner that the water after rinsing can flow from the final zone through the other zone or zones to the treatment station, a supply means for providing fresh water provided at the final zone, and an evacuating means 15 equipped with a vapour liquid separator mounted on the treatment station and arranged to eliminate water therefrom in a vapourised form and to separate the chemical reagent from the water, the treatment 20 station and rinsing station being arranged so that the metal surface to be treated passes from the treatment station to the rinsing station.

2. A spraying process for the chemical 25 treatment of metal surfaces which comprises

spraying the surface with an aqueous solution containing a chemical reagent at a treatment station and then rinsing the treated metal surface with water at a rinsing station consisting of at least two zones, fresh 30 water being supplied at the final zone of the rinsing station, transferred from the final zone through the other zone or zones to the treatment station and thereafter eliminated in vapourised form. 35

3. An apparatus according to claim 1 substantially as herein described with reference to the accompanying drawings and/or the specific examples.

4. A process according to claim 2 substantially as herein described with reference 40 to the accompanying drawings and/or the specific examples.

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