An improved spray type apparatus for treatment of a metal surface with an aqueous solution containing a chemical reagent is disclosed. The apparatus has a spray chamber including a treating region, where the aqueous solution is sprayed onto the metal surface, and a rinsing region where rinsing water is sprayed onto the metal surface which has been previously treated at the treating region. The improvement includes the rinsing region having one zone as a last zone and at least one other zone. Conducting means are provided between the zones and the treating region such that the water, after rinsing, can flow from the last zone through all the other zones to the treating region. A supply means for providing fresh water is provided at the last zone and an evacuating means is mounted above the treating place so as to eliminate water therefrom in a vaporized form.

3 Claims, 6 Drawing Figures
FIG. 5

EVAPORATED AMOUNT OF RINSING WATER (kg H₂O/kg AIR (DRY))

FIG. 6

TEMPERATURE OF CHEMICAL SOLUTION (°C)

TEMPERATURE OF EVACUATED AIR (°C)
SPRAY TYPE APPARATUS FOR TREATMENT OF METAL SURFACE

The present invention relates to an improved spray type apparatus for treatment of a metal surface with an aqueous solution containing a chemical reagent. In the industry handling metal substances or materials, various treatments are made on metal surfaces: e.g. degreasing, phosphate conversion coating, chromate conversion coating, oxalate conversion coating, etc. Such treatments are often carried out by the use of a spray type apparatus, of which a typical example is shown in FIG. 4 of the accompanying drawings. Thus, FIG. 4 is a schematic sectional view of a conventional spray type apparatus wherein 1 is a metal substance to be treated, 2 is an overhead-conveyor for transporting the metal substance and 3 is a spray chamber provided with fan-attached ducts 4 and 4' respectively at the inlet and the outlet. The spray chamber 3 is usually divided into several zones depending on the kind of the treatment. The spray type apparatus as shown in FIG. 4 is employed for phosphate conversion coating, and the spray chamber 3 is divided into five zones, i.e. 3A, 3B, 3C, 3D, and 3E, where degreasing, water-rinsing, phosphating, water-rinsing and acidulating are performed, respectively. Each of the said 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 acidulating agent (hereinafter referred to as “chemical solution”) into the spray chamber 3. Tanks 6A to 6E, provided with pumps 5A to 5E for sending water or the chemical solutions to the nozzles 4A to 4E, are furnished to the zones 3A to 3E respectively and serve as reservoirs for water or the chemical solutions sprayed in the spray chamber 3. Usually, the tanks 6A and 6C are provided respectively with heaters 7A and 7C.

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 solutions, which causes the deterioration of the metal substance 1 in quality. 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, some of the rinsing water, resulting from the said supply of fresh water overflows and is discharged as, waste water. The waste water contains as a matter of course, the chemicals used in the zones 3A and 3C, usually acidic or alkaline substances, metals, surface active agents, oils and fats, etc., and the discharge of such waste water may have a serious influence on the environment. Because of this it is desirable to eliminate, harmful components in the waste water. Since, however, an apparatus for purification is quite expensive, the said elimination is usually not practised.

The object of this invention is to provide an improved spray type apparatus which is slightly modified from a conventional one but can considerably suppress the production of waste water in quantity. Such object can be attained by mounting an evacuating means on a spray type apparatus, particularly above a zone where a metal substance is treated with a chemical solution, so as to exhaust water in the waste water as vapor. Especially when water-rinsing is effected by a multistage system and the amount of fresh water to be supplied is decreased, the evacuation of the approximately corresponding amount of water to that as supplied is satisfactorily accomplished with ease.

In the spray type apparatus of this invention, there is provided a spray chamber having at least one treating region where a metal substance is treated with a chemical solution and at least one rinsing region where the metal substance, transported from the treating region, is rinsed with water. Characteristically, the apparatus has an evacuating means mounted on the spray chamber, favorably above the treating region. Further, it is preferred that the rinsing region is divided into two or more zones so as to effect water-rinsing by a multi stage system. Fresh water is supplied to the last zone in the rinsing region, and an excessive amount of water therefrom to overflows to the adjacent zone. Such overflowing proceeds successively from one zone to another zone in the rinsing region and ultimately to the treating region, which may be also divided into two or more zones. Thus, water contaminated with the chemical solution carried by the metal substance is discharged from the rinsing region to the treating region, all of the regions being within the apparatus itself. By the adoption of such system, the amount of fresh water to be supplied may be reduced to about 1/20 – 1/10 in the case that the rinsing region is divided into three zones and about 1/50 – 1/20 in the case that the rinsing region is divided into three zones, compared with that when the rinsing region consists of a single zone.

Since the overflowed water is ultimately led to the treating region, the chemical solution therein may be diluted with the increase of 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 of the amount can be suppressed. The treating region is often heated to around 40° – 70°C for efficiently conducting 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 water coming from the rinsing region to the treating place can be balanced with the amount of water evaporating from the treating region by selecting an appropriate evacuating means and/or a suitable heating means.

The present invention will be hereinafter illustrated in details making reference to the accompanying drawings wherein:

FIG. 1 is a schematic sectional view of an embodiment of the spray type apparatus according to the invention;

FIG. 2 is a schematic sectional view of the said embodiment along the lines II – II in FIG. 1; and

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

FIG. 4 is a schematic sectional view of a conventional spray type apparatus;

FIG. 5 is a graph illustrating the relationship between the temperature of evacuated air and the amount of rinsing water which was evaporated.
FIG. 6 is a graph illustrating the relationship between the temperature of chemical solution and the temperature of evacuated air.

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

When the apparatus is used for phosphoric conversion coating, degreasing, water-rinsing, phosphating, water-rinsing and acidulating are effected in the zone 13A, the zones 13B and 13B', the zone 13C, the zones 13D and 13D' and the zone 13E, respectively. These zones are respectively provided with the nozzles 14A, 14B, 14B', 14C, 14D, 14D' and 14E for spraying water or a chemical solution and pumps 15A, 15B, 15B', 15C, 15D, 15D' and 15E for supplying the water or the chemical solution to the said nozzles, the said pumps being furnished on the tanks 16A, 16B, 16B', 16C, 16D, 16D' and 16E, which serve for recovering the water or the chemical solution sprayed in the spray chamber 13. The tanks 16A and 16C are respectively provided with the heaters 17A and 17C, which are used for heating the chemical solutions in the said tanks.

18B' and 18D' are pipes to supply fresh water to the tanks 16B' and 16D'. 18B and 18D are pipes to transfer the overflow water from the tanks 16B' and 16D' to the tanks 16B and 16D, and 18A and 18C are pipes to transfer the overflow water 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 bypath 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, which are 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 controlling the supply of fresh water thereto. In the tanks 16A and 16C, there are provided liquid level gauges 25A and 25C which are connected to detectors 26A and 26C, respectively for detecting the liquid level.

When the liquid level falls below a predetermined level and this is detected by the detector, the magnetic valves 20B', 20D' and/or 23A, 23C are actuated respectively through 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 circuits 28A and 28C, and the rinsing water overflowing from the tanks 16B, 16D and/or 16B', 16D' through the pipes 18A, 18C and/or 18B, 18D is discharged through the pipes 22A, 22C and/or 22B, 22D. Thus, the rinsing water contaminated with chemicals is discharged from the apparatus.

In order to avoid this result, the capacities of fans 31A and 31C are designed to be sufficiently large and the amount of fresh water to be supplied is so well controlled that the liquid levels in the tanks 16A and 16C do not rise over a predetermined level. Further, the openings of the valves 19B' and 19D' are, preferably, appropriately regulated so that the amount of fresh water supplied in the tanks 16B' and 16D' is maintained at an amount less than the decreasing amount of the chemical solution in the tanks 16A and 16C, whereby the liquid level always tends to decrease.

On the spray chamber 13, there are mounted ducts 30A and 30C, through which the air in the zones 13A and 13C is evacuated. The fans 31A and 31C are respectively provided in the ducts 30A and 30C to eliminate in a vaporized form, an amount of water which corresponds to the amount of overflow water travelling through the pipes 18A and 18C into the tanks 16A and 16C. For elimination of splashed chemical solution, the splasher means 32A and 32C are usually provided at the entrance of the ducts 30A and 30C. Further, condensers 35 and 35' are provided in the ducts 30A and 30C to condense the vaporized water in the evacuated air into reservoirs 36 and 36'. The thus condensed water is quite pure and may be used as a part of the fresh water supplied into 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 in the apparatus of this invention, but their provision is desirable in order to introduce fresh air around the conveyor 12 equipped along the upper wall of the spray chamber 13 so as to diminish the amount of the rinsing water and the chemical solution which can attach to the conveyor and which may cause the corrosion of the conveyor 12. The ducts 14 and 14' are also not essential in the apparatus of this invention but, if desired, may be provided for preventing the liberation of the splash or drop of the rinsing water and the chemical solution and also of moist air out of the apparatus.

In an embodiment of the apparatus of the invention as shown in FIG. 2, the entrance of the duct 30A is forked 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 FIG. 3, the rinsing water sent from a tank to another tank is not simply allowed to overflow but is sprayed into the latter tank. Thus, the rinsing water collected in the tank 16D' is sent through the pump 15D' and the pipe 14D' and a part of the water is sprayed in the zone 13D'. The other part of the rinsing water is further sent through the pipe 40D' and the valve 41D' 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 a part of the same 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 allowed to overflow 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 FIGS. 1 and 2 while keeping the temperature of the chemical solution in the tanks 16A and 16C at 40° to 70°C, the graphs as shown in FIGS. 5 and 6 of the accompanying drawings were obtained respectively on the relationships between the temperature of evacuated air and the amount of rinsing water which was evaporated 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
3,906,895

each of the fans 31A and 31C, 60 m³/min for air of 20°C.

In FIG. 5, the solid line and the dotted line represent the measured value and the calculated value on the humidity chart in case of the humidity of evacuated air being 100%. The reason why the measured value is partly over the calculated value may be that a portion of the chemical solution sprayed into the spray chamber 13 is accompanied with evacuated air. However, the measured value is nearly equal to the calculated value.

When the phosphate conversion coating was carried out with the apparatus of the invention as shown in FIGS. 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'. Water corresponding in amount to the supplied amount of fresh water was eliminated in a vaporized form by evacuation, and no amount of water was not discharged as waste water:

| Area of the treated surface (average) | Outer boxes of electric freezer, 100 m²/hour | 70°C |
| Liquid temperature in the tank (16A) | 65°C |
| Liquid temperature in the tank (16C) | 20 to 25°C |
| Atmospheric temperature | 70 to 75% |
| Water temperature | 18°C |

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

From such comparison, it is obvious that the amount of fresh water to be supplied is greatly reduced (e.g. about 1/10) 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 invention that the chemical which contaminates the rinsing water is recovered into the original chemical solution and can be used again. Thus, the consumption of the chemical solution is greatly economized, for instance, to an extent of 10 to 30%.

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

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

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

Sixty automobile bodies each having a surface of 40 m² were subjected to degreasing, water-rinsing, phosphating, water-rinsing and acidulating. For each water-rinsing, three zones were provided. By the adoption of such water-rinsing in a three stage system, a sufficient effect of water-rinsing was attained by using fresh water supplied at a rate of 500 to 1000 liters per hour. (When a conventional apparatus wherein each water-rinsing is effected in a single stage is adopted, the supply of fresh water at a rate of 20000 to 30000 liters per hour is required to attain a satisfactory water-rinsing.)

When a necessary 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 to be capable of evacuating this amount of water in a vaporized state. In the case of the temperature of the chemical solution being 60°C, the evaporation of water is understood to be 0.12 kg/water/kg.air (dry) from FIGS. 4 and 5. Accordingly, the amount of evacuation can be calculated as follows:

\[2000 \times 0.12 = 17000 \text{ kg.air (dry)/hour}\]

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

Still, the various means contained in the apparatus of this invention may be wholly or partly automated by a per se conventional manner.

What is claimed is:

1. In a spray type, tunnel type apparatus for treatment of a metal surface with an aqueous solution containing a chemical reagent including a spray chamber having a treating region where the aqueous solution is sprayed onto the metal surface and a rinsing region where rinsing water is sprayed onto the metal surface previously treated at the treating region, the improvement which comprises the rinsing region being comprised of at least two zones including a last zone; conducting means provided between said zones and the treating region and the zone adjacent thereto in such manner that the water, after rinsing, can flow from the last rinsing zone through all the other zones to the treating region; a fresh water supply means provided at the last zone; and an evacuating means provided with a vapor-liquid separator and mounted in the treating region so as to eliminate water therefrom in a vaporized form.

2. The improved spray type, tunnel type apparatus as recited in claim 1, further comprising a plurality of tanks, one tank communicating with each zone in the rinsing region for accommodating rinsing water, the rinsing water in each tank being transferred to the tank in an adjacent zone.

3. A spray type, tunnel type apparatus having a spray chamber including a treating region for treatment of a metal surface with an aqueous solution containing a chemical reagent, a rinsing region for rinsing the metal surface after treatment with water, said rinsing region comprised of at least two zones, conducting means provided between at least one of said zones and the treating region for sending the water, after rinsing, from the zone to the treating region, and an evacuating means provided with a vapor liquid separator and mounted in the treating region so that the air in the treating region is evacuated with evaporated water.

* * * * *