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(54) **Apparatus and method for the electrophoretic painting of metal structures, in particular of metal sheet coils**

Vorrichtung und Verfahren zum elektrophoretischen Lackieren von Metallstrukturen, insbesondere von gewickelten Metallblechen

Procédé et dispositif de peinture par électrophorèse de structures métalliques, en particulier de bandes métalliques enroulés

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Description

FIELD OF THE INVENTION

5 The present invention concerns a new apparatus and a new process for the electrophoretic anti-corrosion coating of metal sheet coils. The protective coat makes it possible to stamp the metal sheets without using lubricating oils, to electrically weld them, and it can, because of its composition, be removed by means of alkaline degreasing agents.

10 It is very important to have a coat of uniform thickness over the entire width of the coil. The optimum thickness of the paint coat was found to be 3 μm , plus or minus 0.5 μm . In fact the possibility of welding the sheets depends on the thickness of the protective coat, which, acting as an insulation, presents to the passage of an electric current a resistance which is directly proportional to the thickness of the protective coat. Ordinarily, a thickness higher than 3.5 μm requires voltages unacceptable for point welding, producing large amounts of fumes and carbon residues which reduce to a considerable extent the life of counter-electrodes.

15 On the other hand, a thickness lower than 2.5 μm , even if favourable in as far as the welding is concerned, does not allow, during the stamping of the sheets, to obtain the necessary lubrication, because it fails to cover the "points" coming out of the sheet surface.

Because of this, and of the high pressure exerted by the stamping press, seizure of the stamp on the sheet and breaking of the sheet take place.

PRIOR ART

20 The machinery mostly employed up to now for applying layers of a protective coating on coils consists essentially of rollers covered with the paint to be applied. In this way, it is possible to apply coatings of a required thickness, which however, is not constant throughout the sheet.

25 The difficulty of obtaining coats of strictly constant thickness increases with an increase of the band width, and for the often employed widths of 180 to 200 cm it becomes practically impossible.

This difficulty derives from the fact that the metal bands are not perfectly even, but show slight undulations, which produce concavities on one face corresponding to convexities on the opposite face.

30 As the protective paint has to be applied to both faces, in the roller application system, while one face of the metal band turns on a guiding steel roller, the other face is pressed by the roller applying the protective coat.

As a result of the opposite forces exerted on the band, the band itself, when the protective film is applied on the first face, is in most cases flat, and the thickness of the protective film results within the tolerance limits. On the other hand, when the protective coating application on the opposite face takes place with the aid of a similar roller, no counter-roller can be pressed on the freshly painted surface in order to make the sheet perfectly plane.

35 Therefore the thickness of the protective paint film on at least one face of the coil is not constant throughout; this is the cause of the problems which arise in the welding and stamping, as said.

In order to improve the welding of the sheets, the use of electricity conductor pigments and mineral charges was suggested.

40 These particles improve in fact the welding; however, during the stamping, these substances, in the form of microscopic powders, collect on the counter-stamp and coagulate, producing, because of the high pressure exerted, very serious damages to the stamps, with ensuing economic losses for the plant owner. For this reason, the use of substances of this type is avoided.

SUMMARY OF THE INVENTION

45 With the aid of the apparatus, which is an object of the present invention, the deposition of protective films of the special paint, having a rigorously constant thickness (optimum value: 3 μm), with very limited departures ($\pm 0.5 \mu\text{m}$) from the nominal value, may be obtained.

50 The electrodes employed in an apparatus of this type may advantageously be used for both anodic and cathodic electrophoresis.

The basic component of an electrophoretic paint is the binder, in practice a polymer or a resin. The resin may be of various types (alkyd, epoxy, acrylic, polybutadiene, polyester, etc.) depending on the mechanical, physical and chemical characteristics to be obtained. For instance, an acrylic resin shows a good light resistance, while an epoxy resin resists to corrosion. As said, in the case of coils epoxy resins are commonly employed to protect them from corrosion.

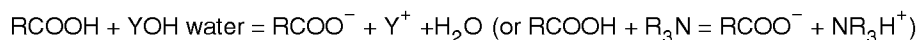
55 In paints for anaphoresis, the resin will be of RCOOH type, while in cathaphoresis it will be of R_3N type, R being a radical which may contain alkyd, epoxy, acryl, etc., groups.

In order to make these resins soluble in water, it is necessary to add a neutralising or solubilizing agent which forms soluble salts with resin; bases (in general amines) are added to the anodic resins, whereas acids are employed for the

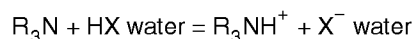
cathodic ones.

Thus the following reactions take place:

anodic resins



cathodic resins



Further paint ingredients are reticulating agents, pigments, solvents and additives, which are added to the resin prior to its solubilization in water.

Reticulants normally consist of ammine resins or blocked isocyanates and are added in order to polymerize the paint ingredients.

Pigments are added to impart colour and covering power to the paint or to improve in general its characteristics.

Solvents give stability to the system and improve all the film characteristics. Additives improve and exalt all the film characteristics.

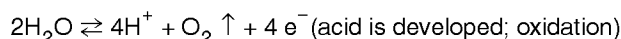
Electrolysis of water is one of the most important processes for the formation of a paint film.

It takes place in water containing ions due to the dissociation of alkalies, acids or salts; the amount of the electrolysis products depends on the density of the current passing through the bath and on time.

For convenience, we will consider anaphoresis; however, similar phenomena take place also in cathaphoresis.

The resins are charged negatively and are solubilized by positive charge bearing alkalies; under the action of the electric field, the acid parts (resin and any other acidic material) migrate to the anode at the rate 1-4 $\mu\text{m/sec.v.}$, while the alkaline parts migrate to the cathode in an amount equivalent to a rate of 2-7 $\mu\text{m/sec.v.}$

At the anode following reactions take place:

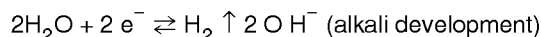


The acidity (H^+) developed in this reaction lowers the pH to 2.5-3.5 in a zone distant 25-30 μm from the metal, causing the rapid coagulation of the paint product which is soluble only at a pH higher than 6-8, according to the reaction:



At the cathode the basic neutralizing agent will be discharged, which returns immediately in the bath.

In substance, only water electrolysis takes place:



The neutralizing agent will be eliminated at the cathode only if it is gaseous and scarcely water soluble, or in case dialysis cells are employed which take it up from the bath.

At the anode the following phenomena take place:

- concentration of the paint product and of the acids which lose their electric charge, and rarefaction of the alkalies;
- lowering of the pH;
- development of O_2

At the cathode:

- rarefaction of the paint product and concentration of the alkalies, which adsorb electric charges corresponding to the ones listed at the anode;
- increase of the pH;
- development of H_2 .

In anode electrophoresis the protective paint may consist, as a non limiting example, of an acrylic thermoplastic carboxylated resin made water soluble by salification with bases such as ammonium hydroxide and/or amines, and of a dispersion of a wax having particular characteristics of hardness, melting point and average particle dimensions.

The paint maintains, after the application and drying (at 180°C), a thermoplastic structure such as to be easily removed by an alkaline wash.

The dried paint film has a friction coefficient of between 0.04 and 0.08 which allows the forming of the sheet without breakage of the film, and a lowering of the "stickiness" of the cut and stacked sheets.

The protective film obtained with a paint of this type has a low resistance to arc discharge in a thickness interval comprised between 2.5 and 3.5 μm . Such thicknesses allow in fact a point welding with discharges of 6 V at 10,000 A, with a negligible formation of fumes and carbon depositions.

Our polymer is obtained by the copolymerisation of 4 monomers, has an average molecular weight (M_w) between 5,000 and 50,000, in particular between 8,000 and 15,000 and a mEq. value in the dry state of between 30 and 100, in particular between 50 and 60.

Furthermore, it shows a viscosity (Brookfield) in a 50% solution 1/1 in butylglycol/water of between 1,500 and 150,000 mPa·s, at 20°C, in particular of between 2,500 and 6,000 mPa·s at 20°C.

The introduction in the paint of a polymeric wax with a melting point of between 75 and 110°C, in particular of between 93 and 99°C, a hardness (ASTM-D.5) of between 2 and 3, in an amount of between 1 and 40%, in particular 1 and 10% on the paint solids determines a very low friction coefficient which allows to stamp the sheets without seizure of the stamps.

A paint thus obtained may be employed in traditional ways (dip-coating, flow-coating, coil-coating, spraying): however, the best results are obtained by the electrophoretic process according to the invention.

An acrylic polymer which may be used in the preparation of a protective paint is produced as follows.

Butylglycol, 165.2 parts and isopropyl alcohol, 10.11 parts (all parts by wt.) are charged in a reaction vessel equipped with stirrer, temperature control means, container for the addition of monomers, condenser and with a means apt to maintain the reagents in a nitrogen atmosphere.

The reaction vessel is equipped for direct recycling of the solvent.

The vessel is then heated, under stirring, in the nitrogen atmosphere, to 140°C.

A mixture of monomers A is prepared in the meantime, having the following composition by wt.:

Ethyl acrylate	108.49
Butyl acrylate	95.92
Methyl methacrylate	114.64
Styrene	69.90
Methacrylic acid	76.81
Tertiary Dodecylmercaptane	0.93

The number of acidity is brought to 110-111 by adding methacrylic acid.

A mixture B is then prepared in another vessel, consisting of:

Butylglycol	65.21 parts by wt.
Tert.butyl perbenzoate	6.47 parts by wt.

At this point, 46 parts by wt. of mixture A are introduced in the reaction vessel and the temperature is brought to 135°C. Then the rest of mixture A with 55 parts by wt. of mixture B is added within 6 hours.

Once this addition is completed, the rest of mixture B is added within one hour, always keeping the temperature at 135°C. The heating at 135-137°C is maintained for an hour.

Then, vacuum is applied and approximately 75 parts by wt. of solvent are extracted. The vessel is then cooled to 95-100°C and 270.13 parts by wt. of butylglycol are added.

After cooling to 50°C, 16-18 parts by wt. of 28 Bé ammonia solution are added.

After stirring for 3 hours at that temperature, the characteristics of the mixture are controlled. They should be:

Dry residue:	50 $\pm$ 1 (30' at 180°C)
mEq.:	58-60 on the solids
Viscosity:	3,000 - 5,000 cps (Brookfield)
Na:	95-110 on the solids
PMW:	approximately 10,000

A paint for the temporary protection of metal coils utilizing the preceding resin is prepared as follows: to 730g of resin solution prepared as described, 50g of a polymeric wax dispersing with 18% active substance, melting point 93-99°C and average particle diameter 2-5 μm are added, stirring rapidly for 10'.

Then 100g butylglycol and 100g demineralized water are added under stirring, and under slow mixing, diisopro-

pylamine to pH 8.

While with the traditional electrodeposition equipment it was impossible to obtain satisfactory results in the painting of coils with such a strict tolerance (0.5 μm) on the thickness of the coat, with the process which is an object of the present application perfectly homogeneous paint layers (3.5 μm) are obtained which are within the tolerance.

In fact, with the use of traditional counter-electrodes, consisting essentially of a plate of stainless steel, a thickening of the electric field on the electrode edges takes place. Because of this, the paint layers along the coil edges are thicker than the layers at the centre. This lack of homogeneity is the cause of the mentioned serious inconveniences.

The newly conceived counter-electrode which is employed in the electrophoresis apparatus and relative process which are objects of the present invention, consists in its preferred but not limitative embodiment, of a rectangular metal plate, generally of stainless AISI 316 steel, in which holes are punched.

Instead of plates, cylinders may be used as counter-electrodes, obtained by rolling on themselves metal bands on which the holes and the points associated with them are located.

To each hole at least one point is associated, protruding in the direction of the coil to be painted. Around the holes a thickening of the electric charges takes place which flow toward the point; the tension difference between the points on the counter-electrode and the coil thus provides a perfectly homogeneous electric field. This provides for a perfect paint deposition on the coil.

The points may also be more than one for each hole: a very advantageous embodiment of the invention provides points formed while punching the holes: by making cross-cuts in the locations where the holes are wished, four triangular sectors are obtained which are pushed outside to form the points.

More than four points can be obtained employing a similar technique. To this regard, the punching of the plate is very advantageous in order to obtain at the same time both the holes and the protruding points.

Each line of holes and of points may be staggered with respect to the two adjacent ones, thus obtaining an electric field as uniform as possible.

A same inventive conception includes all electrodes providing for any plurality of points, with or without adjacent holes, which protrude from the main electrode surface thus creating a uniform electric field.

The present invention concerns an apparatus and a related process for the electrophoretic painting of metal structure, in particular of metal sheet coils.

It consists of at least one electrode on which the structure is electrically charged, at least one tank containing the paint, at least two counter-electrodes having a polarity opposite to the one of the electrode dipped into the paint bath, at least one over-flow tank in which the metal structure is washed, at least one oven for the polymerization and at least one cooling system.

The apparatus and process are characterized in that said at least two counter electrodes consist of at least two metal elements situated on opposite sides with respect to the metal structure and that on each of the elements there is at least a series of holes associated with a series of metal points directed toward the metal structure in order to obtain on it a uniform electric field.

LIST OF FIGURES

Fig. 1 shows, in a cross-section, the plant for the electrophoretic painting which is an object of the present invention. For simplicity's sake, anodic electrophoresis is considered; however, similar statements may be made in connection with cathodic electrophoresis.

Fig. 2 shows a plan view of the plant of Fig. 1, to which other elements not present in Fig. 1 have been added.

Figs. 3 and 4 show one of the at least two counter-electrodes contained in Fig. 1.

For simplicity, a planar counter-electrode is shown, but similar considerations will apply to cylinder counter-electrodes or counter-electrodes of any other shape.

DETAILED DESCRIPTION

In Figs. 1 and 2, as an illustrative, non limitative example, a plant for anaphoretic electrodeposition is shown. 1 indicates the tank where the paint electrodeposition on the coil is carried out: it is normally made out of PVC coated steel. Next to tank 1 is an overflow tank 5 with circulation pumps 17 and an ultrafiltration station 6.

To roller 4 a hole is connected, which in the case of anaphoresis (as in the figure) is positively charged (anode) and positively charges coil 19. The electrically insulated roller 2 guides the coil 19 into the tank 1: the roller idles on the shaft and is cooled inside. Counter-electrodes 3,20, which, in the case represented by the figure, are negatively charged (cathodes) dip into tank 1; in a preferred, non limitative, embodiment each of them consists of a plate 21 (Figs. 3 and 4), generally of AISI 316 stainless steel, on which holes 22 are bored; to each of the holes at least one point 23 corresponds which protrudes toward coil 19 to be painted. Around holes 22 electric charges concentrate flowing toward points 23; in this way, a perfectly homogeneous electric field is created between negative counter-electrode 3,20 and coil 19.

Thus, a perfect deposition of paint on coil 19 is obtained.

Normally a three-phase, 380V, 50 Hz current is fed, which at the exit is adjusted at between 30 and 400 V depending on the bath conditions. The highest current in a continuous service is approximately 400 A.

The coil, up to 2,000 mm wide, runs at the rate of 70 m/minute. This rather high speed requires a high "penetration" of the counter-electrodes in order that the coil be covered in a few seconds with a constant thickness ($3 \pm 0.5 \mu\text{m}$) of protective paint.

The applicant has now found that the best results with regard to the "penetration" are obtained when: (for plate counter-electrodes):

Hole diameter **D = 10-20 mm**

Distance from the edge of the first series of holes

1 = 25-50 mm

Distance between two hole series (pitch) **p = 50-100 mm**

Nr. of holes per sq decimetres **N1 = 4-9**

Ratio between full/hollow areas **(1/0.03)-(1/0.28)**

Point height **h = 1-3 mm**

Nr. of points around each hole **N2 = 3-4**

(for cylindrical counter-electrodes):

Counter-electrode diameter **D1 = 60-150 mm**

Hole diameter **D2 = 10-20 mm**

Distance between two hole series (pitch) **p = 50-100 mm**

Nr. of holes in each series **N1 = 4-8**

Nr. of holes with points in each series **N2 = 3**

Point height **h = 1-3 mm**

Nr. of points around each hole **N2 = 3-4**

Ratio between full/hollow areas **(1/0.03)-(1/0.28)**

Through experimental tests the applicant has furthermore found that, in case cylindrical counter-electrodes are employed, only the ones facing the coil must be provided with points.

Out of the electrophoresis tank, the coil is washed in 14.

The washing operation is very important; in fact, the coil 19, covered by perfectly compact and adhering paint layer, drags out of the tank physically adherent, non-electrodeposited portions of the bath which must be removed. The washing is made first with tap water, followed by rinsing with demineralized water or by ultrafiltration. Normally, ultrafiltration is employed which requires less water and allows to recover a considerable amount of paint, which otherwise would be lost.

For the ultrafiltration, a permeable membrane on a support is employed, through which the electrophoresis bath is passed, at a rate of 2-3 m/sec. under a 2 to 4 bar pressure, tangentially to one side of the membrane; the heavier paint particles adhere to the membrane, while water, neutralizing agents, soluble salts, solvents and fractions of resin go through and are returned to the rinsing nozzles 14.

Tubular or plate ultrafilters may also be employed.

The plant further comprises dialysis cells 11 for controlling the neutralizing agent contents in the bath; the cells 11 consist of a semipermeable membrane placed in front of the counter-electrodes forming a cell; only the neutralizer ions

go through, while colloidal resin particles present in the bath are stopped. The neutralizer ions go by dialysis through the membrane and are then removed by a controlled flow of demineralized water which starts as the cell conductivity reaches a predetermined value.

After the wash, the coil goes through a polymerisation furnace where in 5 sec. a temperature of 180°C is reached.

An infrared furnace is suitable for this purpose.

16 indicates the installation for cooling the coil.

It is very important to keep the paint bath at a constant temperature (about 25°C), and to that end heat-exchangers 10 are provided to cool the paint which tends to heat up by Joule effect.

The plant is completed by a group 8 for the continuous refilling of the paint, a group 9 of paint tanks, a current rectifier group 12 and electric service and regulation boards 13.

The painting process, in the case of anaphoresis takes place as follows:

A - The coil 19, which can be up to 2,000 mm wide, is passed at the rate of 70 m/minutes through tank 1 which contains the cited type of paint; it is positively charged (in the case of anaphoresis) on roller 4, is deviated by roller 2, which is electrically insulated and internally cooled, and pushed into the bath.

B - The coil passes through counter-electrodes 3 negatively charged (in anaphoresis), of the type claimed according to the present invention, where the electrodeposition takes place.

C - The coil passes in overflow tank 5 where it is washed with ultrafiltered water by nozzles 14; thus paint particles, which are dragged out but not electrodeposited on the coil, are washed out.

D - The coil goes through the polymerization furnace 15 where, at 180°C, the paint film is polymerized in 5 sec..

E - The coil is cooled in 16.

The applicant successfully experimented the newly conceived electrodes in traditional plants for electrophoretic painting (in substitution of the previous plate electrodes without holes or metal points) obtaining the following results:

1 - Test OLMO MOTORS

Tank 5.5 mc

Cathodic surface 1.5 mq

Penetration increased of 40-50%

2 - Test WARM

The cathodic surface in the tank was reduced by 45%, thus obtaining a thickness increase from 3-8 µm to 15-22 µm.

Claims

1. An apparatus for the electrophoretic painting of metal structures (19) in particular for the electrophoretic painting of metal sheet coils, comprising at least one electrode (4) on which said structure (19) is electrically charged, at least one tank (1) containing a paint bath (18), at least two counter-electrodes (3, 20) dipped into said bath (18) having a polarity opposed to the one of said at least one electrode (4), an overflow tank (5) in which said structure (19) undergoes washing, a polymerization furnace (15) and finally a cooling device (16), the apparatus being characterized in that said at least two counter-electrodes (3; 20) consist of at least two metal elements (21) situated on opposite sides with respect to the metal structure (19), and that on each of said elements (21) there is at least a first series of holes (22) associated to at least a second series of metal points (23) directed toward said structure (19) so as to create on it a uniform electric field.

2. An apparatus as claimed in claim 1, characterized in that said at least one electrode (4) is positively charged, and that said at least two counter-electrodes (3,20) are negatively charged.

3. An apparatus as claimed in claim 1, characterized in that said at least one electrode (4) is negatively charged and that said at least two counter-electrodes (3,20) are positively charged.

4. An apparatus as claimed in claims 1, 2 and 3, characterized in that said elements (21) are plates.

5. An apparatus as claimed in claims 1, 2 and 3, characterized in that said elements (21) are cylinders.

6. An apparatus as claimed in claims 1, 2, 3, 4 and 5, characterized in that said holes (22) and said points (23) are obtained by punching of plates (21).

7. An apparatus as claimed in claim 1, characterized in that it comprises a device (2) apt to dip the structure (19) in the bath (18).

8. An apparatus as claimed in claim 7, characterized in that said device (2) is situated between said first means (4) and said second means (3) and consists of a movable roller, which is electrically insulated and internally cooled.

9. An apparatus as claimed in claims 1-8, characterized in that said structure (19) moves forward at the speed of 70 m/minutes.

10. An apparatus as claimed in claims 1-9, characterized in that said polymerization furnace (15) heats said structure to 180°C in 5 sec.

11. A process for the electrophoretic painting of metal structures, in particular of metal sheet coils, in which said structure is passed first on at least one electrode on which it is electrically charged, and right after between at least two counter-electrodes dipped in the paint bath and having a polarity opposite to the one of said at least one electrode; in which said structure passes into a overflow tank in correspondence of which it undergoes a washing; in which said structure goes through a polymerization oven and finally through a coil device, the process being characterized in that said at least two counter-electrodes consist of at least two metal elements situated on opposite sides of the structure and that on each of said elements there is at least a first series of holes associated with at least one series of metal points directed toward said structure in order to realize in it a uniform electric field.

12. A process as claimed in claim 11, characterized in that it is a process for anaphoretic painting.

13. A process as claimed in claim 11, characterized in that it is a process for cathaphoretic painting.

14. A process as claimed in claim 11, characterized in that said elements consist of plates.

15. A process as claimed in claim 11, characterized in that said elements consist of cylinders.

16. A process as claimed in claim 11, characterized in that it employs a paint bath produced as follows:

in a reaction vessel, equipped with stirrer, temperature control means, container for the monomers to be added, condenser and means to keep the reagents in a nitrogen atmosphere, 165.2 parts by wt. butylglycol and 10.11 parts by wt. isopropyl alcohol are charged, equipping the vessel for direct recycling of the solvent; the vessel is heated on reflux under stirring and in a nitrogen atmosphere, to 140°C; in the meantime a mixture of monomers A is prepared as follows (parts by wt.):

Ethyl acrylate	108.49
Butyl acrylate	95.92
Methyl methacrylate	114.64
Styrene	69.90
Methacrylic acid	76.81
Tert.dodecylmercaptane	0.93;

the acidity number is controlled and adjusted to 110-111 by addition of methacrylic acid; in another container a mixture B is prepared made out of:

Butylglycol	65.21 by wt.
Tert.butylperbenzoate	6.47;

then, 46 parts by wt. of mixture A are introduced in the reaction vessel and the temperature is brought to 135°C; then the residue of mixture A is added, always with direct recycling, with the addition of 55 parts by wt. of mixture B; this operation should be completed in 6 hours; then the rest of mixture B is added in 1 hour time, keeping

the temperature at 135°C; this temperature is kept for an hour longer at 135°C-137°C; then, under vacuum, approximately 75 parts by wt. of solvent are distilled off; after cooling to 95-100°C, 270.13 parts by wt. butylglycol are added, and then at 50°C, 16-18 parts by wt. of 28 Be ammonia are further added to the mixture; that temperature is kept under stirring for 3 hours, then the prescribed data are controlled which should be:

Dry residue:	50 ± 1 (30' to 180°C)
mEq.:	58-60 on the solids
Viscosity:	300-500 mPa·s (Brookfield)
Na:	95-110 on the solid
PMW by wt.:	ca. 10,000;

to 730 g of the resin solution thus prepared, 50g of a dispersion of a polymeric wax with 18% active substance of melting point 93-99°C and average particle diameter 2-5 µm are added, stirring rapidly for 10'; under stirring, 100g butylglycol and 100g demineralized water are added, then di-isopropylamine up to pH 8, under low mixing.

17. A process as claimed in claim 11, characterized in that the metal structure goes through the paint bath at the rate of 70 m/minutes.
18. A process as claimed in claim 11, characterized in that said polymerization furnace heats up the metal structure to 180°C within 5 sec.
19. A process as claimed in claim 11, characterized in that between said at least one electrode and said at least two counter-electrodes a tension of 150 V is applied.
20. A process as claimed in claim 11, characterized in that between said at least one electrode and said at least two counter-electrodes a tension of 400 V is applied.
21. A process as claimed in claim 11, characterized in that the electro-applied paint film has a thickness of $3 \pm 0.5 \mu\text{m}$.

Patentansprüche

1. Vorrichtung zur elektrophoretischen Lackierung von Metallstrukturen (19), insbesondere zur elektrophoretischen Lackierung von Metallblechrollen, mit mindestens einer Elektrode (4), an der die Struktur (19) elektrisch geladen wird, mindestens einem Tank (1), der ein Lackbad (18) enthält, mindestens zwei Gegenelektroden (3, 20), die in das Bad (18) eingetaucht sind und eine Polarität aufweisen, die derjenigen der mindestens einen Elektrode (4) entgegengesetzt ist, einem Überströmtank (5), in dem die Struktur (19) einer Wäsche unterzogen wird, einem Polymerisationsofen (15) und schließlich einer Kühleinrichtung (16), wobei die Vorrichtung dadurch gekennzeichnet ist, daß die mindestens zwei Gegenelektroden (3, 20) aus mindestens zwei Metallelementen (21) bestehen, die in bezug auf die Metallstruktur (19) auf entgegengesetzten Seiten angeordnet sind, und daß sich auf jedem der Elemente (21) mindestens eine erste Reihe von Löchern (22) befindet, die mindestens einer zweiten Reihe von Metallpunkten (23) zugeordnet ist, die zu der Struktur (19) hin gerichtet sind, um darauf ein gleichförmiges elektrisches Feld zu schaffen.
2. Vorrichtung nach Anspruch 1, **dadurch gekennzeichnet**, daß die mindestens eine Elektrode (4) positiv geladen ist und daß die mindestens zwei Gegenelektroden (3, 20) negativ geladen sind.
3. Vorrichtung nach Anspruch 1, **dadurch gekennzeichnet**, daß die mindestens eine Elektrode (4) negativ geladen ist und daß die mindestens zwei Gegenelektroden (3, 20) positiv geladen sind.
4. Vorrichtung nach einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet**, daß die Elemente (21) Platten sind.

5. Vorrichtung nach einem der Ansprüche 1 bis 3,
dadurch gekennzeichnet, daß
die Elemente (21) Zylinder sind.
- 5 6. Vorrichtung nach einem der Ansprüche 1 bis 5,
dadurch gekennzeichnet, daß
die Löcher (22) und die Punkte (23) durch Stanzen der Platten (21) erhalten werden.
- 10 7. Vorrichtung nach Anspruch 1,
dadurch gekennzeichnet, daß
sie eine Einrichtung (2) umfaßt, die eingerichtet ist, um die Struktur (19) in das Bad (18) einzutauchen.
- 15 8. Vorrichtung nach Anspruch 7,
dadurch gekennzeichnet, daß
die Einrichtung (2) zwischen der ersten Einrichtung (4) und der zweiten Einrichtung (3) angeordnet ist und aus einer beweglichen Walze besteht, die elektrisch isoliert und im Inneren gekühlt ist.
- 20 9. Vorrichtung nach einem der Ansprüche 1 bis 8,
dadurch gekennzeichnet, daß
die Struktur (19) sich mit einer Geschwindigkeit von 70 m/min. vorwärtsbewegt.
- 25 10. Vorrichtung nach einem der Ansprüche 1 bis 9,
dadurch gekennzeichnet, daß
der Polymerisationsofen (15) die Struktur in 5 sec. auf 180 °C aufheizt.
- 30 11. Verfahren zur elektrophoretischen Lackierung von Metallstrukturen, insbesondere von Metallblechrollen,
wobei die Struktur zuerst auf mindestens eine Elektrode geführt wird, an der sie elektrisch geladen wird, und gleich
danach zwischen mindestens zwei Gegenelektroden hindurchgeführt wird, die in das Lackbad eingetaucht sind und
eine Polarität aufweisen, die derjenigen der mindestens einen Elektrode entgegengesetzt ist; wobei die Struktur in
einen Überströmtank geführt wird, wo sie einer Wäsche unterzogen wird; wobei die Struktur durch einen Polymer-
isationsofen hindurchläuft und schließlich durch eine Kühleinrichtung, wobei das Verfahren dadurch gekennzeichnet
ist, daß die mindestens zwei Gegenelektroden aus mindestens zwei Metallelementen bestehen, die auf entgegen-
gesetzten Seiten der Struktur angeordnet sind, und daß sich auf jedem der Elemente mindestens eine erste Reihe
von Löchern befindet, denen mindestens eine Reihe von Metallpunkten zugeordnet ist, die zur Struktur hin gerichtet
sind, um an dieser ein gleichförmiges elektrisches Feld zu realisieren.
- 35 12. Verfahren nach Anspruch 11,
dadurch gekennzeichnet, daß
es ein Verfahren für anaphoretische Lackierung ist.
- 40 13. Verfahren nach Anspruch 11,
dadurch gekennzeichnet, daß
es ein Verfahren für kathaphoretische Lackierung ist.
- 45 14. Verfahren nach Anspruch 11,
dadurch gekennzeichnet, daß
die Elemente aus Platten bestehen.
- 50 15. Verfahren nach Anspruch 11,
dadurch gekennzeichnet, daß
die Elemente aus Zylindern bestehen.
- 55 16. Verfahren nach Anspruch 11,
dadurch gekennzeichnet, daß
es ein Lackbad verwendet, das folgendermaßen hergestellt wird:
In einem Reaktionsgefäß, das mit einem Rührer, einer Temperatusteuerereinrichtung, einem Behälter für die
hinzuzufügenden Monomere, einem Rückflußkühler und einer Einrichtung zur Haltung der Reagenzien in einer

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Stickstoffatmosphäre ausgestattet ist, werden 165,2 Gewichtsteile Butylglycol und 10,11 Gewichtsteile Isopropylalkohol eingefüllt, wobei das Gefäß für eine direkte Rückführung des Lösungsmittels eingerichtet ist; das Gefäß wird im Rückstrom auf 140 °C erhitzt, unter Rühren und in einer Stickstoffatmosphäre; in der Zwischenzeit wird eine Mischung von Monomeren A folgendermaßen vorbereitet (Gewichtsteile) :

Ethylacrylat	108,49
Butylacrylat	95,92
Methylmethacrylat	114,64
Styrol	69,90
Methacrylsäure	76,81
Tertiäres Dodecylmercaptan	0,93;

die Säurezahl wird gesteuert und durch Hinzufügen von Metacrylsäure auf 110-111 eingestellt; in einem anderen Behälter wird eine Mischung B vorbereitet, die aus folgendem besteht:

Butylglycol	65,21 nach Gewicht
tertiäres Butylperbenzoat	6,47;

dann werden 46 Gewichtsteile der Mischung A in das Reaktionsgefäß eingeführt und die Temperatur wird auf 135 °C gebracht; dann wird der Rest der Mischung A zugefügt, immer mit direkter Umwälzung, und zwar unter Hinzufügung von 55 Gewichtsteilen der Mischung B; dieser Vorgang sollte in 6 Stunden vollendet werden; dann wird der Rest der Mischung B in einer Stunde Zeit hinzugefügt, wobei die Temperatur auf 135 °C gehalten wird; diese Temperatur wird für eine weitere Stunde bei 135 °C - 137 °C gehalten; dann werden unter Vakuum ungefähr 75 Gewichtsteile des Lösungsmittels ausdestilliert; nach einer Kühlung auf 95 - 100 °C werden 270,13 Gewichtsteile Butylglycol hinzugefügt, und bei 50 °C werden dann 16 - 18 Gewichtsteile von 28 Bé Ammoniak weiter zur Mischung hinzugefügt; diese Temperatur wird unter Rühren für 3 Stunden aufrechterhalten, und dann werden die vorgeschriebenen Daten kontrolliert, die folgendermaßen sein sollten:

Trockener Rückstand:	50 ± 1 (30' bis 180 °C)
mEq.:	58 - 60 auf die Feststoffe
Viskosität:	300 - 500 mPa's (Brookfield)
Na.:	95 - 110 auf den Feststoff
MPW nach Gewicht:	ca. 10.000;

auf 730 g der so zubereiteten Harzlösung werden 50 g einer Dispersion von Polymerwachs mit 18 % Wirkstoff mit einem Schmelzpunkt von 93 - 99 °C und einem durchschnittlichen Teilchendurchmesser von 2 - 5 µm zugesetzt, wobei für 10 min. schnell umgerührt wird; unter Rühren werden 100 g Butylglycol und 100 g entmineralisiertes Wasser zugefügt, dann unter geringem Mischen Di-Isopropylamin bis auf einen pH-Wert von 8.

17. Verfahren nach Anspruch 11,
dadurch gekennzeichnet, daß

die Metallstruktur mit der Rate von 70 m/min. durch das Lackbad läuft.

18. Verfahren nach Anspruch 11,
dadurch gekennzeichnet, daß

der Polymerisationsofen die Metallstruktur innerhalb 5 sec. auf 180 °C erhitzt.

19. Verfahren nach Anspruch 11,
dadurch gekennzeichnet, daß

zwischen der mindestens einen Elektrode und den mindestens zwei Gegenelektroden eine Spannung von 150 V aufgebracht wird.

20. Verfahren nach Anspruch 11,
dadurch gekennzeichnet, daß

zwischen der mindestens einen Elektrode und den mindestens zwei Gegenelektroden eine Spannung von 400 V aufgebracht wird.

21. Verfahren nach Anspruch 11,
dadurch gekennzeichnet, daß
 der elektroaufgebrachte Lackfilm eine Dicke von $3 \pm 0,5 \mu\text{m}$ aufweist.

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Revendications

1. Appareil pour la peinture par électrophorèse de structures métalliques (19), en particulier pour la peinture par électrophorèse de rouleaux de feuille métallique, comprenant au moins une électrode (4) sur laquelle ladite structure (19) est chargée électriquement, au moins un réservoir (1) contenant un bain de peinture (18), au moins deux contre-électrodes (3, 20) plongées dans ledit bain (18) ayant une polarité opposée à ladite au moins une électrode (4), un réservoir à trop plein (5) dans lequel ladite structure (19) subit un lavage, un four de polymérisation (15) et enfin un dispositif de refroidissement (16), l'appareil étant caractérisé en ce que lesdites au moins deux contre-électrodes (3, 20) consistent en au moins deux éléments métalliques (21) situés sur des côtés opposés par rapport à la structure métallique (19), et en ce que, sur chacun desdits éléments (21), se trouve au moins une première série de trous (22) associée à au moins une deuxième série de pointes métalliques (23) orientée vers ladite structure (19), de manière à créer sur elle un champ électrique uniforme.
2. Appareil selon la revendication 1, caractérisé en ce que ladite au moins une électrode (4) est chargée positivement et en ce que lesdites au moins deux contre-électrodes (3, 20) sont chargées négativement.
3. Appareil selon la revendication 1, caractérisé en ce que ladite au moins une électrode (4) est chargée négativement et en ce que lesdites au moins deux contre-électrodes (3, 20) sont chargées positivement.
4. Appareil selon les revendications 1, 2 et 3, caractérisé en ce que lesdits éléments (21) sont des plaques.
5. Appareil selon les revendications 1, 2 et 3, caractérisé en ce que lesdits éléments (21) sont des cylindres.
6. Appareil selon les revendications 1, 2, 3, 4 et 5, caractérisé en ce que lesdits trous (22) et lesdites pointes (23) sont obtenus par emboutissage des plaques (21).
7. Appareil selon la revendication 1, caractérisé en ce qu'il comprend un dispositif (2) adapté pour plonger la structure (19) dans le bain (18).
8. Appareil selon la revendication 7, caractérisé en ce que ledit dispositif (2) est situé entre ledit premier moyen (4) et ledit deuxième moyen (3) et consiste en un rouleau déplaçable qui est isolé électriquement et refroidi intérieurement.
9. Appareil selon les revendications 1 à 8, caractérisé en ce que ladite structure (19) se déplace vers l'avant à la vitesse de 70 m/minute.
10. Appareil selon les revendications 1 à 9, caractérisé en ce que ledit four de polymérisation (15) chauffe ladite structure à une température de 180 °C en 5 sec.
11. Procédé pour la peinture par électrophorèse de structures métalliques, en particulier de rouleaux de feuille métallique, dans lequel ladite structure est d'abord passée sur au moins une électrode sur laquelle elle est chargée électriquement, et juste après, entre au moins deux contre-électrodes plongées dans le bain de peinture et ayant une polarité opposée à ladite au moins une électrode; dans lequel ladite structure passe dans un réservoir à trop plein en correspondance duquel elle subit un lavage; dans lequel ladite structure passe par un four de polymérisation et enfin par un dispositif à bobine, le procédé étant caractérisé en ce que lesdites au moins deux contre-électrodes consistent en au moins deux éléments métalliques situés sur les côtés opposés de la structure et en ce que sur chacun desdits éléments se trouve au moins une première série de trous associée à au moins une série de pointes métalliques orientée vers ladite structure, en vue de réaliser dans cette dernière un champ électrique uniforme.
12. Procédé selon la revendication 11, caractérisé en ce qu'il est un procédé de peinture par anaphorèse.
13. Procédé selon la revendication 11, caractérisé en ce qu'il est un procédé de peinture par cathaphorèse.
14. Procédé selon la revendication 11, caractérisé en ce que lesdits éléments consistent en des plaques.

15. Procédé selon la revendication 11, caractérisé en ce que lesdits éléments consistent en des cylindres.

16. Procédé selon la revendication 11, caractérisé en ce qu'il utilise un bain de peinture obtenu comme suit : dans une cuve réacteur, pourvue d'un agitateur, d'un moyen de commande de température, d'un récipient pour les monomères à ajouter, d'un condenseur et d'un moyen pour maintenir les réactifs dans une atmosphère d'azote, 165,2 parties en poids de butylglycol et 10,11 parties en poids d'alcool d'isopropyle sont ajoutées, en équipant la cuve pour un recyclage direct du solvant; la cuve est chauffée lors du reflux, sous agitation et dans une atmosphère d'azote, à une température de 140 °C; entre temps, un mélange de monomère A est préparé comme suit (en parties en poids) :

Acrylate d'éthyle	108,49
Acrylate de butyle	95,92
Méthacrylate de méthyle	114,64
Styrène	69,90
Acide méthacrylique	76,81
Tert.dodecylmercaptane.	0,93;

la valeur de l'acidité est contrôlée et ajustée pour se situer entre 110 et 111 par addition d'acide méthacrylique; dans un autre récipient, un mélange P est préparé comme suit :

Butylglycol	65,21 parties en poids
Tert.butylperbenzoate.	6,47;

ensuite, 46 parties en poids du mélange A sont introduites dans la cuve réacteur et la température est amenée à 135 °C; puis, le résidu du mélange A est ajouté, toujours avec un recyclage direct, avec apport de 55 parties en poids du mélange B; cette opération doit être achevée en 6 heures; puis, le reste du mélange B est ajouté en 1 heure, en maintenant la température à 135 °C; cette température est maintenue pendant une heure de plus à une température allant de 135 °C à 137 °C; puis, sous vide, à peu près 75 parties en poids de solvant sont distillées; après un refroidissement à une température allant de 95 à 100 °C, 270,13 parties en poids de butylglycol sont ajoutées et, ensuite, à 50 °C, 16 à 18 parties en poids d'ammoniac 28 Bé sont en outre ajoutées au mélange; cette température est maintenue sous agitation pendant 3 heures, puis les données prescrites sont contrôlées, ces données devant être :

Résidus de matière sèche :	50 ± 1 (30° à 180 °C)
mEq. :	58 à 60 sur les matières solides
Viscosité :	300 à 500 mPa.s (Brookfield) 95 à 110 sur les matières solides
PMW en poids : (poids moléculaire pondéral)	environ 10000;

et sont ajoutées, à 730 g de la solution de résine ainsi préparée, 50 g d'une dispersion de cire polymère à 18 % de substance active de point de fusion compris entre 93 à 99 °C et de diamètre particulaire moyen de 2 à 5 µm, en agitant rapidement pendant 10'; sous agitation, 100 g de butylglycol et 100 g d'eau déminéralisée sont ajoutés, puis du di-isopropylamine jusqu'à l'obtention d'un pH 8, en mélangeant à faible vitesse.

17. Procédé selon la revendication 11, caractérisé en ce que la structure métallique passe dans le bain de peinture à la vitesse de 70 m/minute.

18. Procédé selon la revendication 11, caractérisé en ce que ledit four de polymérisation chauffe la structure métallique pour atteindre une température de 180 °C en 5 sec.

19. Procédé selon la revendication 11, caractérisé en ce que, entre ladite au moins une électrode et lesdites au moins deux contre-électrodes, est appliquée une tension de 150 V.

20. Procédé selon la revendication 11, caractérisé en ce que, entre ladite au moins une électrode et lesdites au moins deux contre-électrodes, est appliquée une tension de 400 V.

- 21.** Procédé selon la revendication 11, caractérisé en ce que le film de peinture électro-appliqué présente une épaisseur de $3 \pm 0,5 \mu\text{m}$.

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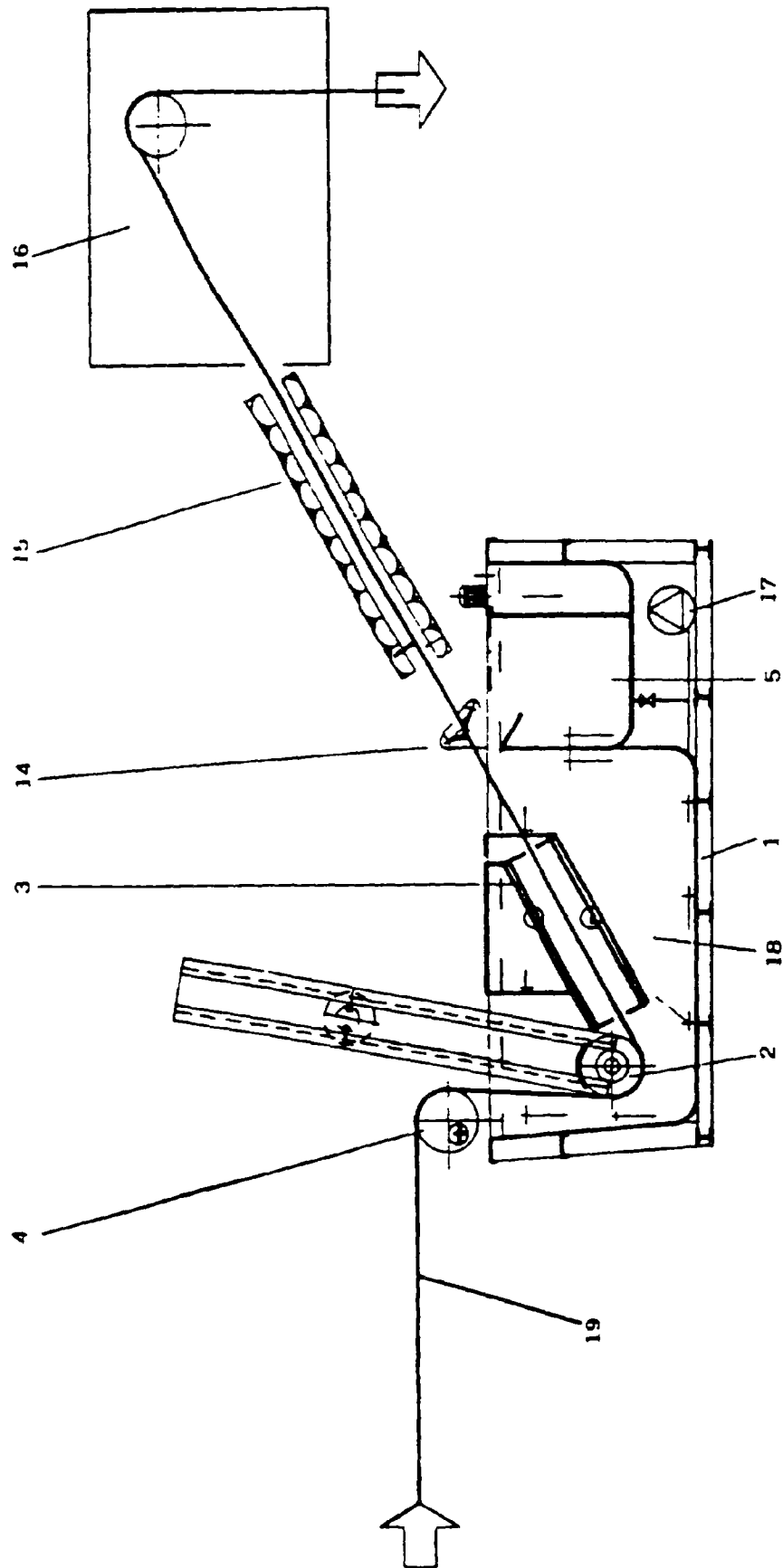
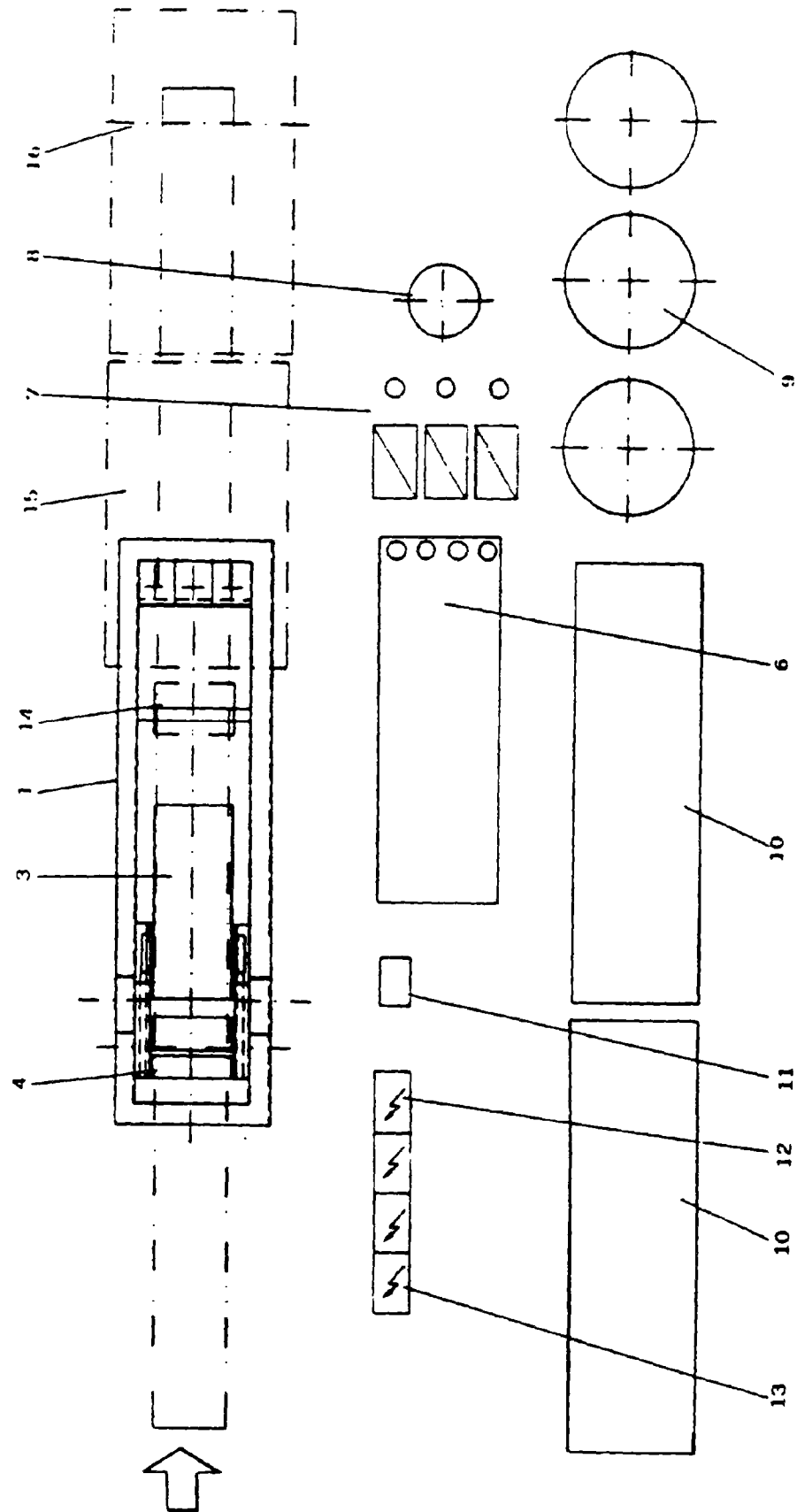


FIG. 1

FIG. 2



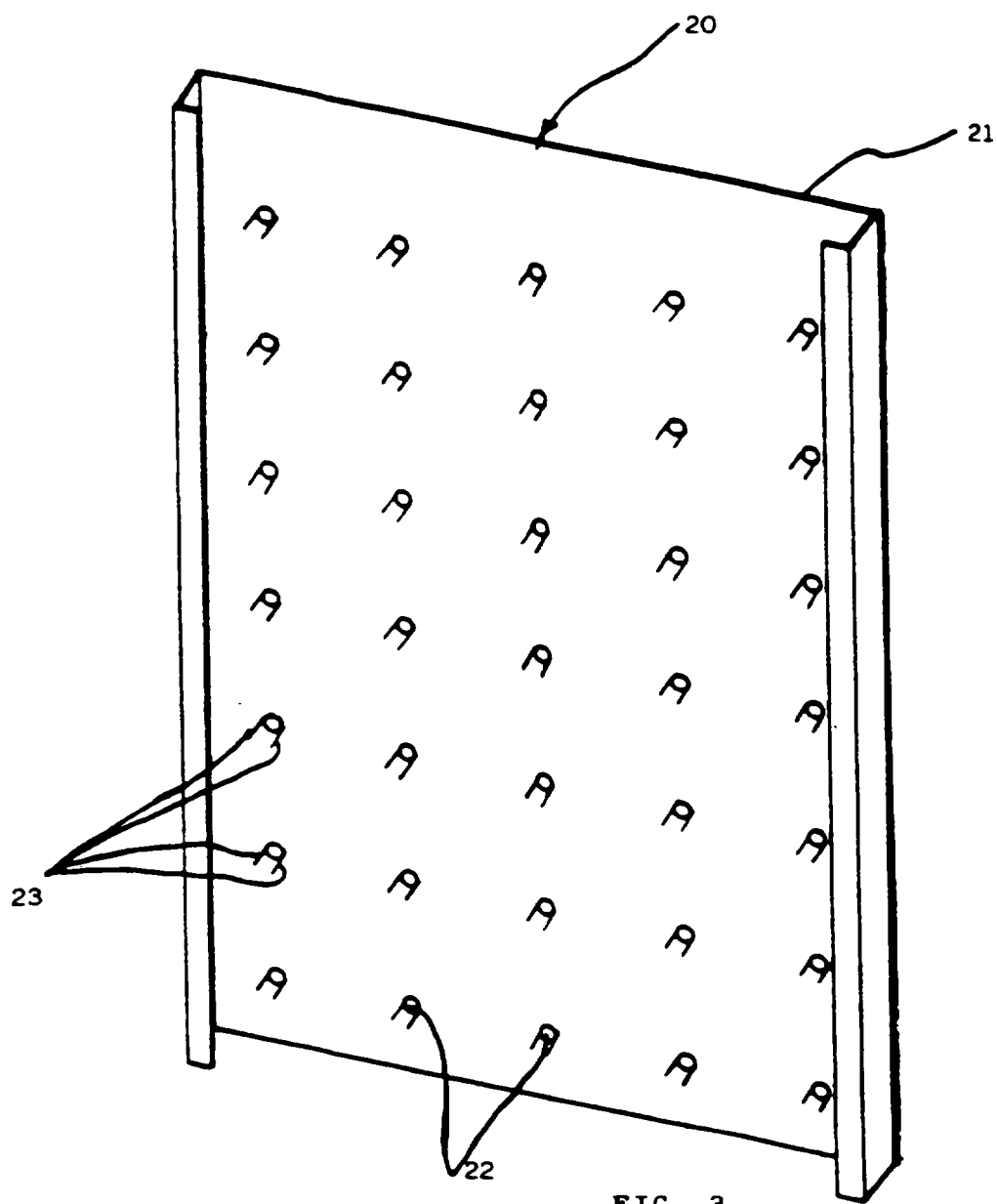


FIG. 3

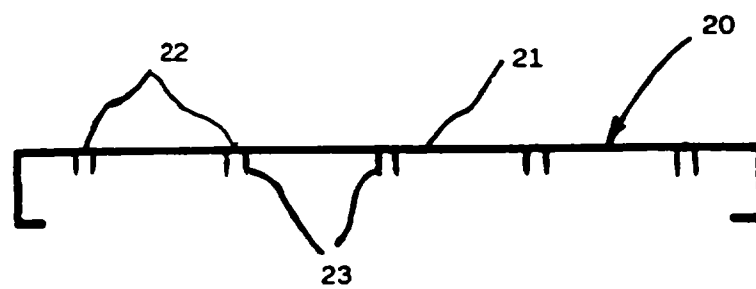


FIG. 4