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Govindan

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[54] **PROCESS FOR THE SPRAY APPLICATION OF AQUEOUS PAINTS BY UTILIZING AN AIR SHROUD**

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[51] **Int. Cl.** **B05b 1/06**

[58] **Field of Search** ..... 239/8, 11, 290, 291, 296, 239/297; 117/104 R

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[57] **ABSTRACT**

The improved process applies an aqueous paint to a substrate by air spraying a paint with a spray gun utilizing atomizing air at a flow rate of about 5-40 cubic feet per minute and at an air pressure of 30-95 pounds per square inch at the spray gun and a paint flow rate of about 5-30 ounces per minute, wherein the gun forms a cone or a fan of air atomized paint which is applied to the substrate and the paint is baked to form a uniform finish on the substrate; the improvement that is used with this process comprises utilizing an air shroud that substantially encircles the atomized paint spray with a cone or a fan of air that is at about 15°-95°C. and the flow rate of air for the shroud is about 10-250 cubic feet per minute; this shroud provides a uniform atmosphere for drying the paint during spraying on the substrate;

the improved process is particularly useful for applying exterior aqueous base paints on automobile and truck bodies to form a high quality finish of uniform color, hue and appearance.

11 Claims, 3 Drawing Figures

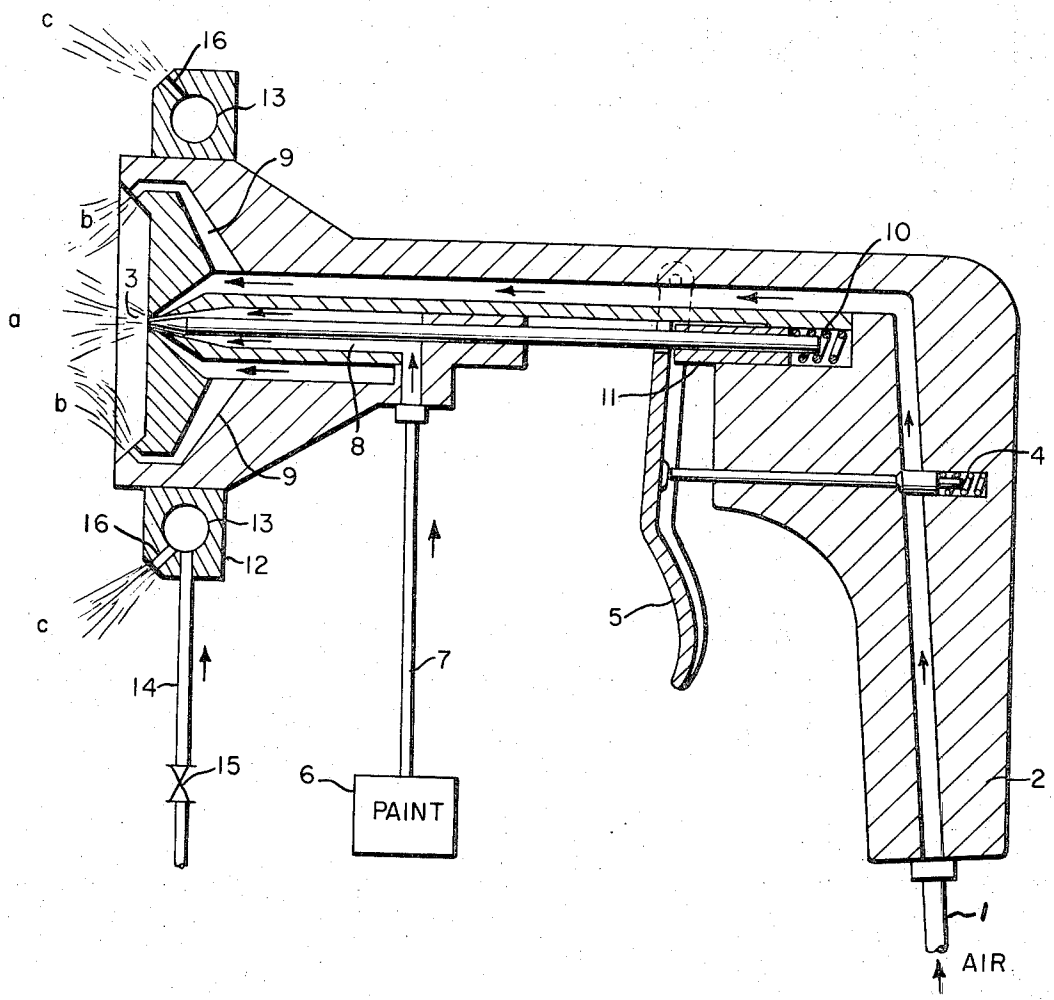


FIG. 1

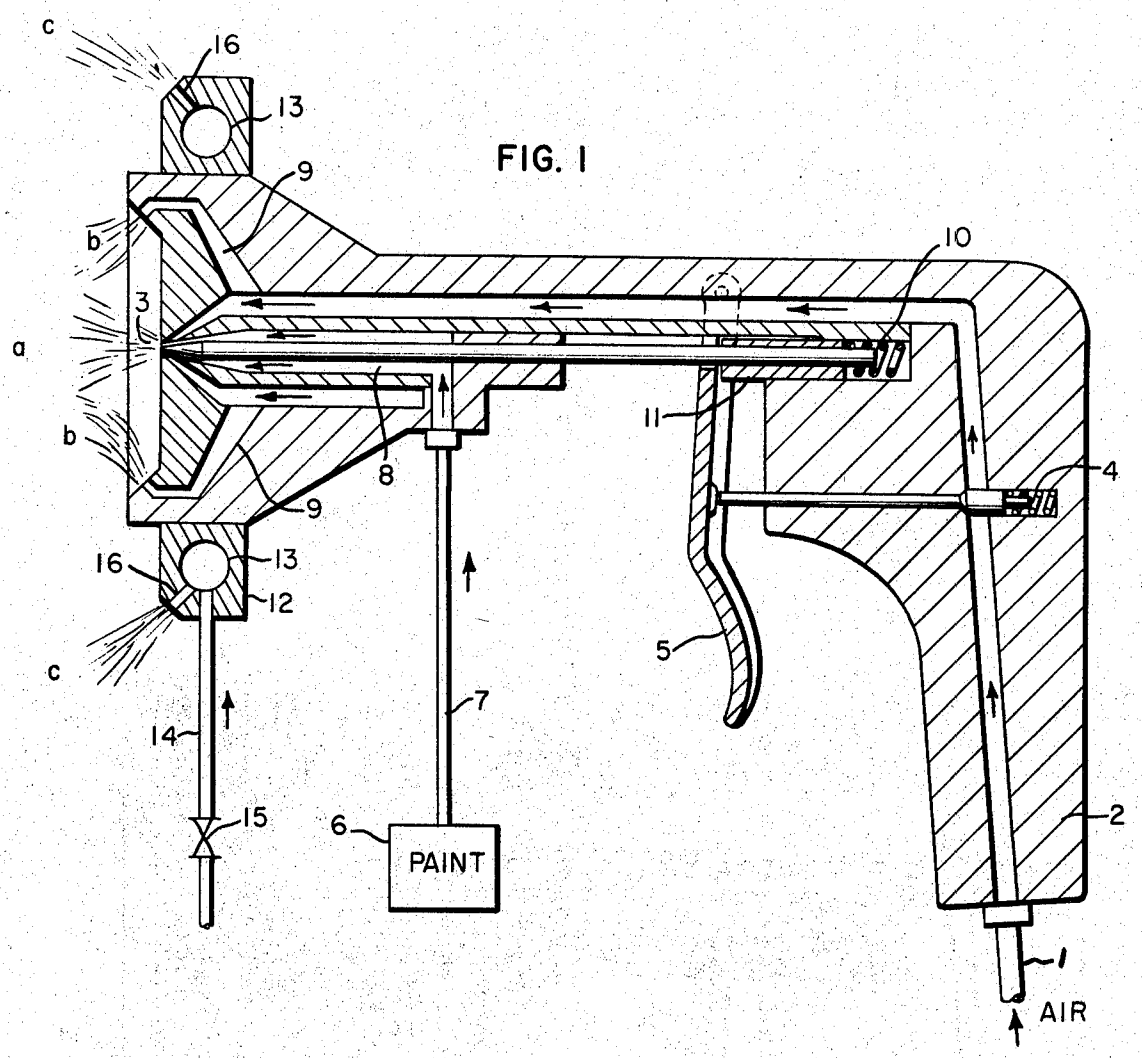
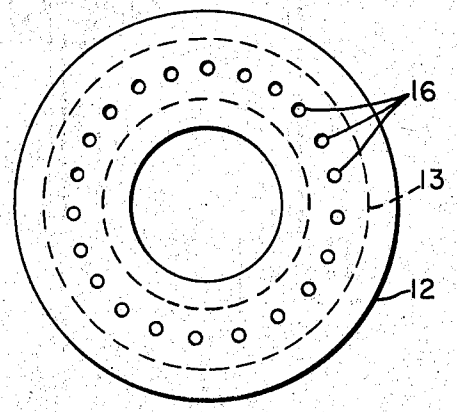


FIG. 2



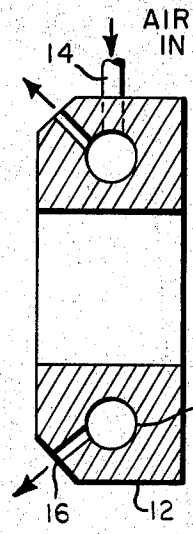


FIG. 3

PROCESS FOR THE SPRAY APPLICATION OF AQUEOUS PAINTS BY UTILIZING AN AIR SHROUD

BACKGROUND OF THE INVENTION

This invention relates to an improved process for applying aqueous coating compositions and in particular to an improved process for the application of a thermosetting acrylic enamel coating compositions to provide finishes having a uniform appearance.

Thermosetting acrylic enamels are well known in the art as shown by Fraizer et al. U.S. Pat. No. 2,681,897, issued June 22, 1954; Vasta U.S. Pat. No. 3,338,860, issued Aug. 29, 1967; Fisk et al, U.S. Pat. No. 3,365,414, issued Jan. 23, 1968; Vasta U.S. Pat. No. 3,622,651, issued Nov. 23, 1971; Parker U.S. Pat. No. 3,637,546, issued Jan. 25, 1972. These enamels are solvent based systems and the spray application of these enamels has not posed a problem. However, aqueous based acrylic enamels, as illustrated by Taft U.S. Pat. No. 3,661,827, issued May 9, 1972, have problems in drying of the finish during and after application. If the spray application is in a very humid environment, the paint does not dry and runs and sags, and conversely, in a very dry environment, the paint dries excessively as it is sprayed onto the panel thereby giving a poor appearance. Also, variations in the humidity which do not cause difficulties in drying cause changes in the appearance of the finish and in particular, with paints pigmented with metallic flakes, such as aluminum flakes, the appearance changes substantially under varying humidity conditions.

The improved process of this invention utilizes an air shroud that encircles the atomized paint sprayed from the gun and provides initial drying conditions which are uniform, thereby resulting in finishes that consistently have an excellent appearance.

SUMMARY OF THE INVENTION

The improved process of this invention for applying an aqueous paint to a substrate by air spraying the paint with a spray gun utilizing atomizing air at a flow rate of about 5–40 cubic feet per minute and an air pressure of 30–95 pounds per square inch at the spray gun and a paint flow rate of 5–30 ounces per minute which forms a cone or fan of air atomized paint which is applied to the substrate and subsequently baked to form a uniform finish on the substrate;

the improvement used with this process comprises an air shroud that substantially encircles the cone of air atomized paint; the air of the shroud is at about 15–95°C. and at a flow rate of 10–250 cubic feet per minute; the shroud provides a uniform atmosphere for initially drying the aqueous paint during spraying of the substrate.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates the conventional spray gun equipped with a device to provide the air shroud.

FIG. 2 illustrates the plan view of the device in detail that provides the air shroud.

FIG. 3 illustrates the side view of the device in detail that provides the air shroud.

DESCRIPTION OF THE INVENTION

In a conventional process for applying aqueous paints

to a substrate by air spraying the paint, a spray gun is utilized which atomizes the paint to a fine spray to apply the paint to a substrate. Generally, the atomizing air is utilized at a flow rate of 5–40 cubic feet per minute and under a pressure of 30 to 95 pounds per square inch at the spray gun. The flow rate of paint passing through the gun is about 5–30 ounces per minute. The spray gun forms a uniform cone or fan of air atomized paint which is applied to the substrate and subsequently the substrate is baked at about 75°–200°C. to provide a high quality finish. One preferred baking cycle for aqueous thermosetting acrylic enamels comprising a pre-bake at about 75°–95°C. for about 5–30 minutes and then a final bake at about 125°–200°C. to form the finish. The resulting finish is about 0.5-3.5 mils in thickness and preferably, 1.0–2.5 mils in thickness. Generally, these finishes can be rubbed or polished in accordance with conventional techniques to improve smoothness, gloss or both.

This conventional spray application process provides adequate finishes under ideal drying conditions for example, 25°C. and 50 percent relative humidity. However, problems arise under high humidity conditions, for example, a relative humidity of 90 percent and above allows the aqueous finish to dry at a very slow rate and results in a finish having a poor appearance caused by sagging and running of the paint. Also, a color change is often noted under these conditions. Conversely, under low relative humidity conditions, the atomized paint dries excessively while being sprayed onto the substrate and results in a gritty, uneven finish which has a poor appearance. Even under conditions which are conducive to adequate drying, the aqueous paint has a different tone or shade at various levels of relative humidity; in particular, this is most pronounced with paints containing metallic flake pigments.

The improved process of this invention provides a controlled atmosphere for the initial drying of the finish which is extremely important for the appearance of the finish. This is accomplished by the utilization of an air shroud that completely encircles the atomized paint from the spray gun. This air shroud is held at constant temperature and flow rate and preferably, under constant humidity conditions. The air shroud is at a temperature of 15°–95°C. and a flow rate of 10–250 cubic feet per minute is utilized. Generally, the lower the volume of air the higher the temperature of the air shroud is maintained, and conversely, the larger the volume of air the lower the temperature of the air shroud is maintained. When a small volume of air at a relatively high temperature is used, the volume and temperature are chosen so that when the shroud air is mixed with the ambient air during spraying, practical drying conditions are achieved, i.e., the air mixture will have the desired temperature and humidity. The shroud air can be maintained at about 0 percent R.H. by utilizing the moisture free compressed air that is used in the spray gun to atomize the paint. The air can be humidified by the injection of water into the compressed air or by controlling the quality of the air by conventional techniques to a given relative humidity range of 40 to 60 percent.

The spray process can be further controlled by heating the atomizing air from 40° to 150°C. which heats the paint on atomization and enhances the drying. This technique is particularly useful under high relative humidity conditions and allows for rapid drying of the paint.

After the paint is sprayed onto the workpiece, the air shroud can be blown onto the painted surface for an additional several seconds to several minutes to enhance drying. For example, 5 seconds to 2 minutes of additional drying is used. This provides for flexibility in the novel process since the drying rate can be increased in a humid atmosphere.

Generally, it is preferred to adjust the air shroud such that the initial drying conditions for the paint are provided by air that has a driving force value of about 0.002 to 0.004, and preferably 0.003, humidity units (pounds of water per pound of dry air). The driving force value of the air is the humidity of the air corresponding to the adiabatic saturation temperature expressed in pound of water per pound of dry air less the humidity of the ambient air expressed in the above units. These humidity values are determined with a standard humidity chart, for example, shown in John H. Perry's Chemical Engineer's Handbook, (McGraw Hill Chemical Engineering Series).

The novel process of this invention is particularly advantageous in that it allows for a uniform spray application of the aqueous based paints under all types of relative humidity conditions and does not require the manufacturer to completely air condition the spray area. This technique reduces the manufacturer's costs since the manufacturer does not have to purchase or run air conditioning equipment in order to uniformly apply aqueous based paints. The novel process of this invention is substantially more economical since only the small amounts of air utilized in the air shroud are conditioned rather than conditioning the air used in the entire spray area.

FIG. 1 illustrates a conventional spray gun equipped with the air shroud device. Compressed air is passed through the line 1 into the housing 2 of the spray gun and passes through the housing and then atomizes the paint at the nozzle 3 into a fine mist. The compressed air is controlled by the valve assembly 4 which is coupled to the trigger mechanism 5 attached to the housing 2. A portion of the compressed air is passed through the two channels 9 to aid in the atomization of the paint. This is indicated as (*b*) on the drawing. As the compressed air is sprayed through the nozzle 3, a vacuum is created which causes paint to flow from the container 6 through the line 7 into the channel 8 in the housing. When the paint mixes with the compressed air, it is atomized into a fine spray indicated at (*a*) on FIG. 1. The flow of paint is controlled by the needle assembly 10 which has a flange 11 attached thereto which is engaged with the trigger assembly 5. When the trigger assembly is engaged, it forces the needle assembly to open at the nozzle 3 allowing the paint to flow. The air shroud is provided by the shroud assembly 12. Heated air is passed through line 14 and is controlled by valve 15 into the air shroud assembly 12, and then is forced into the manifold 13 within the air shroud assembly and passes out through holes 16 in the air shroud assembly and forms the air shroud indicated as (*c*) on FIG. 1 which completely encircles the cone of atomized paint. As mentioned before, the air for the shroud may be the compressed air used to atomize the paint.

FIGS. 2 and 3 illustrates the air shroud assembly in detail. The plan view shows the front of the air shroud assembly and illustrates that the holes 16 are uniformly spaced around the assembly and the position of the manifold 13 in relationship to the holes. The sectional view shows the manifold 13 and the relationship of the holes 16 in the manifold. By the proper choice of the size of the manifold 13 and the size and number of holes, substantially uniform distribution of the air is obtained.

It is also possible to utilize a shroud assembly that does not completely encircle the spray gun opening but that omits 45°–90° from the top and bottom of assembly. This structure still provides an ample amount of air so that the air shroud encircles the atomized spray of paint.

External heating of the air for the shroud may be accomplished by positioning a circular heater in close relation to the shroud assembly thereby heating the air for the shroud as it emerges from the shroud assembly.

Optionally, the paint in the container 6 can be under pressure and need not rely on the vacuum created at the nozzle to cause a flow of paint. The compressed air utilized to spray the paint and also the air for the shroud can be of the same source with the exception that the air for the shroud is heated to 15°–95°C. The compressed air also may be heated to increase the drying rate of the paint as pointed out above.

In one preferred set of conditions for the air shroud, the air flow rate is about 10°–50° cubic feet per minute and the air is heated to about 60° to 85°C. without controlling the humidity. Preferably, the humidity of the air for the shroud is held at about0 to 30 percent R.H. The air for the shroud can be humidified as well as heated by injection of water or steam into the air stream for the shroud to provide the desired humidity.

The novel process of this invention can be utilized with a variety of aqueous based paints to improve the drying and appearance of the finish. Preferably, the novel process is utilized with aqueous thermosetting acrylic coating compositions and in particular thermosetting acrylic coating compositions in which the film-forming constituents comprise

1. acrylic polymer of styrene, methyl methacrylate or a mixture of styrene and methyl methacrylate, an alkyl acrylate or a alkyl methacrylate having 2–12 carbon atoms in the alkyl group, optionally a hydroxy alkyl acrylate or a hydroxy alkyl methacrylate and an α,β-unsaturated carboxylic acid; and

2. a water-soluble or water-dispersible cross-linking agent.

One useful thermosetting acrylic enamel coating composition that can be used with the process of this invention has as the film-forming constituents:

1. 60–90 percent by weight of an acrylic polymer of
   a. 20–60 percent by weight of methyl methacrylate or styrene or a mixture of methyl methacrylate and styrene;
   b. 20–40 percent by weight of an alkyl acrylate having 2–12 carbon atoms in the alkyl group or an alkyl methacrylate having 4–12 carbon atoms in the alkyl group;
   c. 4–20 percent by weight of an α,β-ethylenically unsaturated carboxylic acid such as acrylic acid, methacrylic acid or itaconic acid;
2. 10–40 percent by weight of a water dispersible or water-soluble cross-linking agent such as an alkylated melamine formaldehyde resin having 1–4 carbon atoms in the alkyl group; and

wherein the composition is at least partially neutralized to a pH of 6–9 with a water-soluble basic compound.

One preferred aqueous thermosetting acrylic enamel coating composition utilized with the process of this invention comprises 10–60 percent by weight of film-forming constituents; wherein the film-forming constituents consist essentially of

1. 60–90 percent by weight, based on the weight of the film-forming constituents, of an acrylic polymer having a uniformity factor of at least 75 percent which consists essentially of

a. 20–60 percent by weight, based on the weight of the acrylic polymer, of a hard constituent which is either methyl methacrylate, or a blend of methyl methacrylate and styrene wherein the styrene comprises up to 40 percent by weight of the acrylic polymer;

b. 20–40 percent by weight, based on the weight of the acrylic polymer, of a soft acrylic constituent that is either an alkyl acrylate having 2–12 carbon atoms in the alkyl group, an alkyl methacrylate having 4–12 carbon atoms in the alkyl group, or a mixture of the above alkyl acrylate and alkyl methacrylate;

c. 4–20 percent by weight, based on the weight of the acrylic polymer, of a hydroxy-containing constituent which is either a hydroxyalkyl methacrylate or a hydroxyalkyl acrylate or a mixture thereof in which the alkyl groups have 2–4 carbon atoms,

d. 4–20 percent by weight, based on the weight of the acrylic polymer, of α,β-unsaturated carboxylic acid;

wherein the polymer has a carboxyl to hydroxyl ratio of 1:0.2 to 1:1.8 and an acid number of about 35–150 and a weight average molecular weight of 5,000–80,000; and

2. 10–40 percent by weight, based on the weight of the film-forming constituent, of a water dispersible or water soluble cross-linking resin, preferably, an alkylated melamine formaldehyde resin having 1–4 carbon atoms in the alkyl group; and

the composition is at least partially neutralized with a water-soluble amine and has a pH of about 6–9.

The aforementioned coating composition is usually pigmented and contains about 0.1–40 percent by weight of pigment, but preferably, about 0.1–30 percent by weight of pigment. In particular, the composition can contain metallic flake pigments such as aluminum flake in amounts of 0.1–3.0 percent by weight. A variety of conventional pigments are utilized in the aforemention compositions, such as metallic oxide, for example, titanium dioxide, iron oxide, zinc oxide and the like, metal hydroxides, metal powders, chromates, sulphates, carbonates, carbon black, silicate, talc, phthalocyanine blues and greens, indanthrone pigments and other organic pigments and dyes.

The water-dispersible and water-soluble cross-linking resin in the aforementioned enamel preferably are alkylated melamine formaldehyde resins which are compatible with the acrylic polymer used in the enamel. Preferably, the enamel contains 65–85 percent by weight of the acrylic resin and 35–15 percent by weight of an alkylated melamine formaldehyde resin, and more preferably, about 70 percent by weight of the acrylic polymer is used in combination with about 30 percent by weight of an alkylated melamine formaldehyde resin.

Preferably, the alkylated melamine formaldehyde resins used in the aforementioned enamel have 1–4 carbon atoms in the alkyl group and are prepared by conventional techniques in which an alcohol, such as methanol, ethanol, propanol, isopropanol, butanol is reacted with the melamine formaldehyde resin. The melamine formaldehyde resin is reacted with isopropanol is another useful resin. Also, urea formaldehyde resins can be used as cross-linking agents.

The acrylic polymer used in the aforementioned enamel coating composition is partially soluble and partially dispersed in the aqueous medium. About 30–50 percent by weight of the acrylic polymer is dispersed and has a particle size of about 0.01–0.10 micron and preferably about 0.02–0.06 micron and the residual 50–70 percent by weight of the acrylic polymer is soluble and dissolved in the aqueous medium. To obtain water-solubility and dispersibility, the acrylic polymer preferably has a carboxyl to hydroxyl ratio of 1:0.2 to 1:1.8, which is the molar ratio of carboxyl groups to hydroxyl groups of polymer.

The acrylic polymer used in the aforementioned enamel composition has a uniformity factor of at least 75 percent and preferably, 80–95 percent. The uniformity factor is the percent of polymer in which the constituents are in plus or minus 15 percent of the average amount given for the polymer. For example, if the average composition of the acrylic polymer is 54 percent methyl methacrylate, 34 percent butyl acrylate, 6 percent 2-hydroxyethyl acrylate and 6 percent acrylic acid; 75 percent of the polymer will be within plus or minus 15 percent of these average values or 54 percent plus or minus 8 percent methyl methacrylate, 34 percent plus or minus 5 percent butyl acrylate, 6 plus or minus 0.9 percent 2-hydroxyethyl acrylate and 6 plus or minus 0.9 percent acrylic acid.

The acrylic polymer utilized in the above composition is prepared by a programmed addition of the monomers, polymerization catalysts and solvents. This programmed addition process is an attempt to form polymer at all stages of the polymerization process which is essentially the same as the predetermined composition, and results in a polymer composition upon completion of the process which has a uniformity factor of at least 75 percent This process allows for high percentage conversion of momomers to polymer and also provides a polymer having a relatively uniform molecular weight. These polymers when used in this invention provide high quality finishes.

The above programmed addition polymerization process is based on a computer program which uses known polymerization equations and activity ratios of monomers to determine the monomer addition rates and ratios and polymer polymerization temperatures and times. This forms a polymer that has a uniform composition throughout. The above programmed addition procedure can be based on a computer program which uses a polymerization equation in which the polymerization values of the monomers are used.

In general, the programmed polymerization procedure comprises and initial charge of monomers and solvents which are heated to the reflux temperature in the polymerization vessel, then at given intervals monomers and polymerization initiator are charged into the vessel while maintaining a reflux temperature accord-

ing to the programmed polymerization procedure. Throughout the polymerization reaction, the polymer being formed has a uniformity factor of at least 75 percent. In general, the polymerization is conducted at about 75–125°C. over a 2–4 hour period to form a polymer that has a weight average molecular weight of about 5,000–80,000, and preferably, about 10,000–50,000 determined by gel permeation chromotography. The polymer has an acid number of about 35–150, preferably about 35–80.

Water miscible solvents are used in the polymerization process to prepare the acrylic polymer such as isopropanol, n-propyl alcohol, 2-ethylhexanol, diacetone alcohol and other alcohols, acetone, acetyl acetone, ethylene glycol monoethylether, ethylene glycol monobutyl ether and ethylene glycol monomethyl ether acetate. Minor amounts of solvents of limited water solubility can be used such as methylethyl ketone, ethylene glycol monoethyl ether acetate. The novel composition can contain up to about 20 percent by weight of water miscible solvent but preferably contains 5–15 percent by weight of solvent. If desired the novel composition may be made solvent free.

About 0.1–4 percent by weight, based on the weight of the monomer used to prepare the acrylic polymer, of the polymerization catalyst is utilized. Typical catalysts are azo-bisisobutyronitrile, azo-bis-(α,γ-dimethylvaleronitrile), benzoyl peroxide, t-butyl peroxypivalate, t-butyl peracetate and the like. Chain transfer agents such as lauryl mercaptan are also used.

The acrylic polymer contains 20–60 percent by weight of a hard constituent which can be methyl methacrylate or a mixture of methyl methacrylate and styrene; up to 40 percent by weight of the polymer can be styrene. The acrylic polymer can contain 5 to 30 percent by weight of styrene in combination with 15 to 30 percent by weight of methyl methacrylate. Preferably, the polymer contains about 52–57 percent by weight of methyl methacrylate.

The acrylic polymer contains 20–40 percent by weight of a soft acrylic constituent which is either an alkyl acrylate that has 2–12 carbon atoms in the alkyl group, an alkyl methacrylate having 4–12 carbon atoms in the alkyl group or a mixture of these two constitituents. Preferably, the acrylic polymer contains 28 to 38 percent by weight of the soft acrylic constituent, preferably, an alkyl acrylate having 2–8 carbon atoms in the alkyl group. The following are typical soft acrylic monomer which can be utilized: ethyl acrylate, propyl acrylate, isopropyl acrylate, butyl acrylate, isobutyl acrylate, hexyl acrylate, 2-ethylhexyl acrylate, octyl acrylate, nonyl acrylate, lauryl acrylate and the like, butyl methacrylate, isobutyl methacrylate, pentyl methacrylate, hexyl methacrylate, octyl methacrylate, 2-ethylhexyl methacrylate, decyl methacrylate, lauryl methacrylate and the like. Butyl acrylate is the preferred soft acrylic constituent since it forms a high quality polymer that has excellent physical properties.

The acrylic polymer contains 4–20 percent by weight of a hydroxy containing constituent such as a hydroxy alkyl acrylate or a hydroxy alkyl methacrylate or a mixture of these two compounds. Preferably, the polymer contains about 5–10 percent of the hydroxyl containing constituent. These constituents contain 2–4 carbon atoms in the alkyl groups and are, for example, hydroxyethyl acrylate, hydroxybutyl acrylate, hydroxyethyl methacrylate, hydroxypropyl methacrylate, and hydroxybutyl methacrylate.

The acrylic polymer also contains 4–20 percent by weight, based on the weight of the acrylic polymer, of an α,β-unsaturated carboxylic acid. Typically useful acids are acrylic acid, methacrylic acid, crotonic acid, itaconic acid, propyl acrylic acid, and the like. Preferably, acrylic acid and methacrylic acid are used in amounts of 4–10 percent by weight since these acids form high quality polymers useful in the novel composition of this invention.

One preferred acrylic polymer used in this invention contains 50–60 percent by weight of methyl methacrylate, 30–40 percent by weight of a soft acrylic constituent, preferably butyl acrylate, 5–10 percent by weight of the hydroxy containing constituent, preferably hydroxyethyl acrylate or hydroxy-propyl methacrylate, and 4–12 percent by weight of acrylic acid, methacrylic acid, or itaconic acid. These preferred methacrylic acid, or itaconic acid. These preferred acrylic polymer have a weight average molecular weight of about 10,000–50,000, an acid number of about 30–100 and a carboxyl to hydroxyl ratio of about 1:1.03 to 1:1.5.

Another particularly useful acrylic polymer which gives a high quality finish contains about 28–32 percent by weight of styrene, 22–26 percent by weight of methyl methacrylate, 30–35 percent by weight of butyl acrylate, 7–9 percent by weight of hydroxy ethyl acrylate and 4–6 percent by weight of acrylic acid and has an acid number of about 30 to 50, a carboxyl to hydroxyl ratio of 1:0.4 to 1:1.5 and a weight average molecular weight of about 1,000–50,000.

To form the aqueous dispersion, the acrylic amine and then dispersed in water. Typical water-soluble amines that can be used are primary amines, secondary amines, tertiary amines, polyamines and hydroxyamines, such as ethanolamine, diethanolamine, triethanolamine, n-methylethanol amine, N,N-diethylethanolamine, N-aminoethanolamine, N-methyldiethanolamine, monoisopropanolamine, diisopropanolamine, triisopropanolamine, hydroxyamine, butanolamine, hexanolamine, methyl diethanolamine, N,N-diethylaminoethylamine, ethylene diamine, diethylene triamine, diethylene tetramine, hexamethylene tetramine, triethylamine and the like. The acrylic polymer is usually 50–60 percent neutralized and can be 100 percent neutralized. Neutralization of 50–60 percent is preferred since this degree of neutralization forms an aqueous dispersion which permits enamel formulation at high solids. The pH of the resulting aqueous coating composition is generally adjusted to a pH of 6–9, preferably 7.1–7.5.

The novel process of this invention can be utilized to apply the paints over a variety of substrates such as metal, wood, glass, steel, iron, plastics, and the like. Preferably, the novel process is utilized for applying aqueous coatings over primed metal substrates. Typical alkyd primers and epoxy primers pigmented with iron oxide, carbon black, titanium dioxide are used. The primer can be applied on the metal by electrodeposition or can be applied by conventional spray or dipping techniques. The process can be utilized to provide coatings directly over galvanized steel to form a durable finish.

The preferred aqueous acrylic enamel can be applied directly over the primed metal substrates without the use of an intermediate sealer coat. However, a sealer

coat can be used to provide a finish ith excellent adhesion and smoothness. These sealers may be water based or solvent based. One typically useful sealer composition is disclosed in Rohrbacher U.S. Pat. 3,509,086, issued Apr. 28, 1970.

Finishes applied by the novel process of this invention are characterized by a glossy, smooth and even finish that has a uniform appearance, that has excellent water spot resistance, craze resistance, good durability and weatherability and gloss retention and excellent gasoline resistance. These characteristics of the finish applied by the novel process of this invention makes the process particularly attractive for applying the exterior finishes on automobile and truck bodies.

The following Examples illustrate the invention. The parts and percentages are by weight unless otherwise specified.

EXAMPLE 1

A coating composition is prepared by first forming the following acrylic polymer:

	Parts By Weight
Portion 1	
Methyl methacrylate monomer	17.080
Butyl acrylate monomer	19.130
2-Ethyl hexyl acrylate monomer	2.720
Acrylic acid monomer	1.150
Isopropanol	6.140
Ethylene glycol monobutyl ether	9.680
Lauryl mercaptan	0.294
Portion 2	
Benzoyl peroxide	0.672
Methylethyl ketone	1.580
Ethylene glycol monomethyl ether acetate	1.580
Ethylene glycol monobutyl ether	2.360
Portion 3	
Methyl methacrylate monomer	24.530
Butyl acrylate monomer	11.520
2-Hydroxyethyl acrylate	3.910
Acrylic acid	2.090
Benzoyl peroxide	0.906
Isopropyl alcohol	3.000
Ethylene glycol monobutyl ether	9.800
Portion 4	
Methyl methacrylate monomer	25.720
Butyl acrylate	12.080
2-Hydroxyethyl acrylate monomer	4.090
Acrylic acid monomer	2.200
Benzoyl peroxide	1.248
Isopropanol	4.120
Ethylene glycol monobutyl ether	13.150
Portion 5	
Ethyl methacrylate	9.570
Butyl acrylate	4.490
2-Hydroxyethyl acrylate	1.520
Acrylic acid monomer	0.820
Benzoyl peroxide	0.440
Isopropanol	1.460
Ethylene glycol monobutyl ether	4.760
Portion 6	
Diethylethanolamine	7.900
Demineralized water	101.300
Portion 7	
Demineralized water	169.096
Total	492.100

Portion 1 is charged into a reaction vessel equipped with a stirrer, a heating mantle, and a reflux condenser and then heated to the reflux temperature which is about 160°C. Portion 2 is premixed and then added and then Portion 3 is premixed and added at a uniform rate over a 20-minute period, while maintaining the reaction mixture at its reflux temperature. Portion 4 is premixed and added at a uniform rate over a 60-minute period while the reaction mixture is maintained at its reflux temperature. Portion 5 is premixed and added at a uniform rate over a 100-minute period, then the reaction mixture is maintained at its reflux temperature for an additional 1/2 hour. Portion 6 is premixed and then added to the reaction mixture and then Portion 7 is added to the reaction mixture and the reaction mixture is cooled to room temperature and filtered to remove any coagulum.

The resulting polymer dispersion has a 34 percent polymer solids content in which the particle size is about 0.02–0.06 microns. The polymer has a relative viscosity of 1.16 measured at 25°C. in dimethyl formamide at about 0.5 percent polymer solids and has an acid number of about 33 to 35 and a carboxyl to hydroxyl ratio of 1 to 1.5. The polymer has the following composition: methyl methacrylate/butyl acrylate/2-hydroxyethyl acrylate/acrylic acid in a weight ratio of about 54.2/33.1/8.4/4.3 and uniformity factor of about 75–85 percent.

A phthalocyanine blue mill base is prepared as follows:

	Parts By Weight
Portion 1	
Hexa(methoxymethyl) melamine	546
Isopropanol	630
Portion 2	
Phthalocyanine blue pigment	210
Portion 3	
Hexa(methoxymethyl) melamine	285
Isopropanol	426
Total	2097

Portion 1 is mixed with Portion 2 over a 30 minute period and then Portion 3 is added and the constituents are mixed for 30 minutes. The resulting composition is passed through a standard sand mill and ground two passes to provide a uniform mill base.

A blue mill base is prepared as follows:

	Parts By Weight
Portion 1	
Hexa(methoxymethyl) melamine	78
Isopropanol	90
Portion 2	
"Monastral" blue pigment	30
Portion 3	
Hexa(methoxymethyl) melamine	41
Isopropanol	61
Total	300

Portion 1 is mixed with Portion 2 over a 30-minute period and then Portion 3 is added and the constituents are mixed for 30 minutes. The resulting composition is passed through a standard sand-mill and ground for two passes to provide a uniform blue mill base.

A violet mill base is prepared as follows:

	Parts by Weight
Portion 1	
Hexa(methoxymethyl) melamine	13.6
Isopropanol	45.1
Portion 2	
"Monastral" violet pigment	7.0
Portion 3	
Hexa(methoxymethyl) melamine	7.6
Isopropanol	26.7
Total	100.0

Portions 1 and 2 are blended together and then mixed for 30 minutes and then Portion 3 is added and the composition is mixed for an additional 15 minutes. The resulting composition is then ground two passes in a standard sandgrinding mill to form a uniform mill base.

A phthalocyanine green-yellow mill base is formed as follows:

	Parts By Weight
Portion 1	
Hexa(methoxymethyl) melamine	78
Isopropanol	90
Portion 2	
Phthalocyanine green-yellow pigment	30
Portion 3	
Hexa(methoxymethyl) melamine	41
Isopropanol	61
Total	300

Portion 1 is blended with Portion 2 in a mixing vessel for 30 minutes and then Portion 3 is added and blended to an additional 15 minutes. The resulting composition is then ground two passes in a standard sand-grinding mill to form a uniform mill base.

An aluminum flake mill base is prepared as follows:

	Parts By Weight
Aluminum flake	1.71
Hexa(methoxymethyl) melamine	5.75
Isopropanol	11.05
Total	18.51

The above constituents are thoroughly blended together for 30 minutes to form a uniform dispersion.

A paint composition is prepared by blending together the following ingredients:

	Parts By Weight
Portion 1	
Phthalocyanine Blue mill base (prepared above)	6.35
Blue mill base (prepared above)	0.20
Violet mill base (prepared above)	0.70
Phthalocyanine green-yellow mill base (prepared above)	0.45
Aluminum flake mill base (prepared above)	11.05
Portion 2	
Hexa(methoxymethyl) melamine	20.40
Portion 3	
Acrylic polymer dispersion (prepared above)	272.40
Portion 4	
Deionized water	18.00
Portion 5	
Butyl acrylate/acrylic acid copolymer solution — (80% polymer solids in alcohol of an 85/15 butyl acrylate/acrylic acid copolymer)	3.30
Silicone anti-cratering agent solution (10% low molecular weight silicone resin in water)	3.35
Deionized water	31.00
Total	367.10

Portion 1 is charged in a mixing vessel and thoroughly blended together and then Portion 2 is added then blended with Portion 1 and Portions 3, 4 and 5 are added consecutively with blending after each addition. The resulting composition has a 30 second viscosity using a No. 2 Fisher cup and a total solids content of 28.1 percent.

A Binks 62-A spray gun is used with a 63 PB cap, paint flow rate 16 ounces per minute, atomizing air pressure 70 psi. All spraying is done with an Eclipse automatic machine with an index speed set at 900 inches per minute travel. Four coats of paint are applied with two spray passes for each coat and with a 2 minute flash time between coats. The gun is positioned 14 inches from the panel. The panels are 4 inches = 6 inches of phosphatized steel primed with a 1.5 mil iron oxide pigmented alkyd resin primer. After application, each of the panels is baked for 15 minutes at 85°C. and then 45 minutes at 150°C.

An air shroud is utilized in which the air flow rate is 15 cubic feet per minute and the temperature of the air is about 90°C. Ambient air temperature is about 24°C. The results are as follows:

Panel Number	Per Cent R.H. Of Ambient Air	Application Conditions	Appearance
1	50%	Control	Good
2	70%	No air shroud	Sagging and edge build
3	70%	Shroud air at 85°C. during spraying	Good — no sagging — very little edge build
4	70%	Shroud air at 85°C. during spraying and continued for 30 seconds after spraying panel	Good — no sagging or edge build
5	70%	Shroud air at 85°C. during spraying and continued for 60 seconds after spraying panel	Good — no sagging or edge build

EXAMPLE

A coating composition is prepared as follows:

	Parts By Weight
Portion 1	
Polymer dispersion (70% polymer solids in which the polymer is methyl methacrylate/butyl acrylate/2-hydroxyethyl acrylate/acrylic acid in a weight ratio of about 54/34.2/5.7/6.1 and having a relative viscosity of about 1.09 measured at 25°C. in dimethyl formamide at 0.5% polymer solids content and an acid number of about 47)	200
Portion 2	
Diethylaminoethanolamine	14
Portion 3	
Deionized water	318
Portion 4	
Hexa(methoxymethyl)melamine	60
Total	592

Portion 1 is charged into a mixing vessel and then Portion 2 is added and blended with Portion 1. Portion 3 is then slowly added with constant agitation. After Portion 3 is added, all of Portion 4 is then added and mixed in. The resulting coating composition has a solids content of about 33 percent and a spray viscosity of about 30 seconds using a No. 2 Parlin cup.

The above coating composition is applied to the same primed steel panels using the identical spray gun and application procedure and baking conditions as in Example 1. The panels are sprayed under the same ambient air conditions as in Example 1 and the same air shroud conditions are used as in Example 1. The resulting panels have about the same appearance as the panels in Example 1.

EXAMPLE 3

A coating composition is prepared by blending the following ingredients:

	Parts By Weight
Portion 1	
Polymer dispersion (polymer solids content of 71% of a polymer of methyl methacrylate/butyl acrylate/hydroxyethyl acrylate/acrylic acid – 53.8/28.2/6.0/12.0 and a uniformity factor of about 75–85% and has a relative viscosity of 1.096 measured at 25°C. in dimethyl formamide at about 0.5% polymer solids, and has an acid number of about 93 to 94 and a carboxyl to hydroxyl ratio of 1 to 0.31)	200
Portion 2	
Diethylaminoethanolamine	15
Portion 3	
Deionized water	318
Portion 4	
Hexa(methoxymethyl)melamine	60
Total	593

Portion 1 is charged into a mixing vessel and then Portion 2 is added with constant agitation and then Portion 3 is slowly added to the reaction mixture and after Portion 3 has been added, Portion 4 is added and blended with the reaction mixture. The resulting composition has a 33 percent polymer solids content and a spray viscosity of 30 seconds measured in a No. 2 Parlin cup.

The above coating composition is applied to the same primed steel panels using the identical spray gun and application procedure and baking conditions as in Example 1. The panels are sprayed under the same ambient air conditions as in Example 1 and the same air shroud conditions are used as in Example 1. The resulting panels have about the same appearance as the panels in Example 1.

EXAMPLE 4

A paint composition is prepared by blending together the following ingredients:

	Parts By Weight
Portion 1	
Mill base (described in Example 1)	6.35
"Monastral" blue mill base (prepared in Example 1)	0.20
"Monastral" violet mill base (prepared in Example 1)	0.70
Phthalocyanine green-yellow mill base (prepared in Example 1)	0.45
Aluminum flake mill base (prepared in Example 1)	11.05
Portion 2	
Hexa(methoxymethyl) melamine	20.40
Portion 3	
Acrylic polymer dispersion (polymer solids content of 26% by weight and the polymer has a relative viscosity of about 1.15 measured at 25°C. in dimethyl formamide solvent at about 0.5% polymer solids and has an acid number of about 46 to 47 and a carboxyl to hydroxyl ratio of 1 to 0.62 and has the following composition: methyl methacrylate/butyl acrylate/2-hydroxyethyl acrylate/acrylic acid in a weight ratio of about 54/34/6/6 and a uniformity factor of about 75-85%)	272.40
Portion 4	
Deionized water	18.00
Portion 5	
Butyl acrylate/acrylic acid copolymer solution (described in Example 1)	3.30
Anti-cratering solution (10% silicone solution)	3.35
Deionized water	31.00
Total	367.20

Portion 1 is charged into a mixing vessel and thoroughly blended together and then Portion 2 is added and blended and then Portion 3 is added and the constituents are thoroughly blended together. Portion 4 is added and blended with the mixture and then Portion 5 is added and thoroughtly blended with the mixture. The resulting paint composition has a 28 percent solids content and a spray viscosity of 31 seconds using a No. 2 Zahn cup.

The above coating composition is applied to the same primed steel panels using the identical spray gun and application procedure and baking conditions as in Example 1. The panels are sprayed under the same ambient air conditions as in Example 1 and the same air shroud conditions are used as in Example 1. The resulting panels have about the same appearance as the panels in Example 1.

What is claimed is:

1. In the process for applying an aqueous paint of a thermosetting acrylic enamel to a substrate by air-spraying the paint with a spray gun utilizing atomized air at a flow rate of 5–40 cubic feet per minute and at an air pressure of 30–95 pounds per square inch at the spray gun and a paint flow rate of 5–30 ounces per minute which forms a cone of air atomized paint which is applied to the substrate and baked to form a uniform finish on the substrate, the improvement in the use therewith comprising

an air shroud that substantially encircles the cone of air atomized paint, wherein the air of the shroud is at 15°–95°C. and the air flow rate is 10–250 cubic feet per minute, and wherein the air shroud provides a uniform atmosphere for drying the aqueous paint during spraying of the substrate.

2. The process of claim **1** in which the air shroud is at about 60°–85°C. and the air flow rate is about 10–50 cubic feet per minute.

3. The process of claim **2** in which the aqueous thermosetting acrylic paint contains the film-forming constituents:

1. an acrylic polymer of styrene, methyl methacrylate or a mixture thereof, an alkyl acrylate or an alkyl methacrylate having 2–12 carbon atoms in the alkyl group, optionally a hydroxy alkyl acrylate or a hydroxy alkyl methacrylate and an α,β-unsaturated carboxylic acid; and

2. a water-soluble or water-dispersible cross-linking agent.

4. The process of claim **2** in which the acrylic enamel comprises 10 to 60 percent by weight of film-forming constituents and correspondingly 9 to 40 percent by weight of water and up to 20 percent by weight of a solvent for the film-forming constituents; wherein the film-forming constituents consist essentially of

1. 60–90 percent by weight, based on the weight of the film-forming constituents, of an acrylic polymer that consists essentially of

a. 20–60 percent by weight, based on on the weight of the acrylic polymer, of a hard constituent which is either methyl methacrylate, styrene, or a blend of methyl methacrylate and styrene;

b. 20–40 percent by weight, based on the weight of the acrylic polymer, of a soft constituent that is either an alkyl acrylate having 2–12 carbon atoms in the alkyl group or an alkyl methacrylate having 4–12 carbon atoms in the alkyl group or a mixture of the above acrylate and methacrylate;

c. up to 20 percent by weight, based on the weight of the acrylic polymer, of a hydroxy containing constituent which is either a hydroxy alkyl methacrylate, or a hydroxy alkyl acrylate, or a mixture thereof in which the alkyl groups have 2–4 carbon atoms;

d. 4–20 percent by weight, based on the weight of the acrylic polymer, of an α,β-ethylenically unsaturated carboxylic acid;

2. 10–40 percent by weight, based on the weight of the film-forming constituents, of a water-dispersible alkylated melamine formaldehyde resin having 1–4 carbon atoms in the alkyl groups, and the composition is at least partially neutralized with a water-solublel amine and has a pH of about 6–9.

5. The process of claim **4** in which the acrylic polymer enamel consists essentially of 50–60 l percent by weight of methyl methacrylate, 30–40 percent by weight of butyl acrylate, 5–10 percent by weight of hydroxyethyl acrylate, and 4–12 percent by weight of acrylic acid and the polymer has an acid number of about 35–100 and a carboxyl to hydroxyl ratio of about 1:0.3 to 1:1.5, then the acrylic polymer has a weight average molecular weight of about 10,000–50,000.

6. The process of claim **4** in which the acrylic polymer of the enamel consists essentially of 28–32 percent by weight of styrene, 22–26 percent by weight of methyl methacrylate, 30–35 percent by weight of butyl acrylate, 7–9 percent by weight of hydroxyethyl acrylate, 4–6 percent by weight of acrylic acid and has an acid number of about 30–50 and a carboxyl to hydroxyl ratio of 1:0.4 to 1:1.5 and the polymer has a weight average molecular weight of about 10,000–50,000.

7. The process of claim **1** in which he atomizing air is heated to 40°C. to 150°C.

8. The process of claim **1** in which the air utilized for the air shroud is bone dry air.

9. The process of claim **1** in which the spray gun is a hand spray gun.

10. The process of claim **1** in which the spray gun is an automatic spray gun.

11. The process of claim **1** in which the substrate that is painted is steel.

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