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METHOD OF IMPROVING THE CAPABILITY OF A PAINT COMPOSITION TO PRODUCE A COATING OF UNIFORM APPEARANCE
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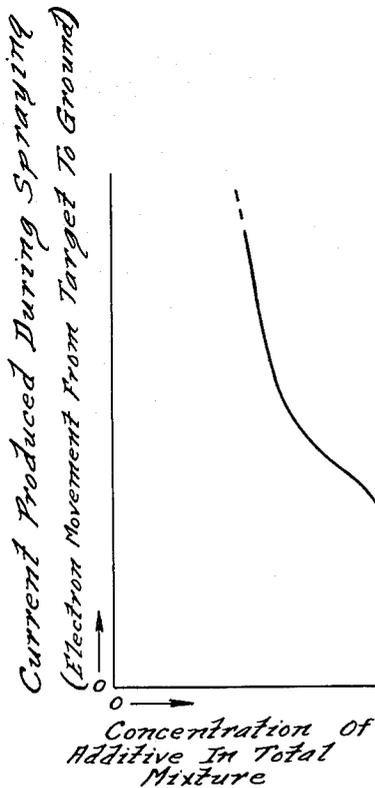
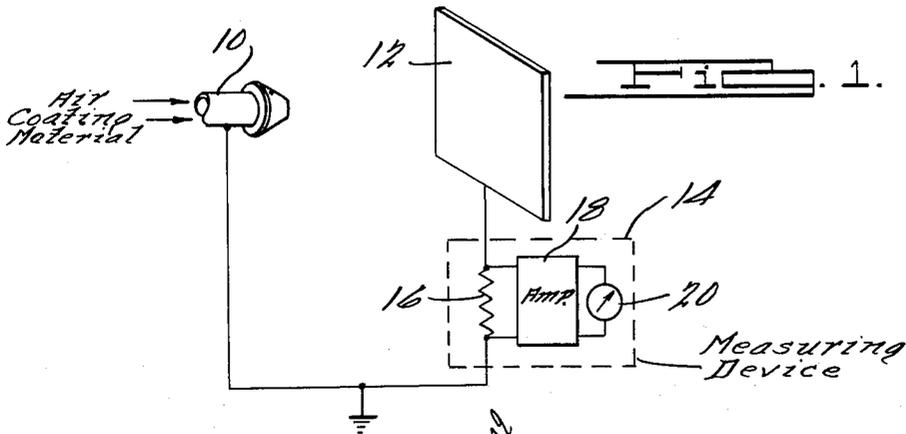


FIG. 3.

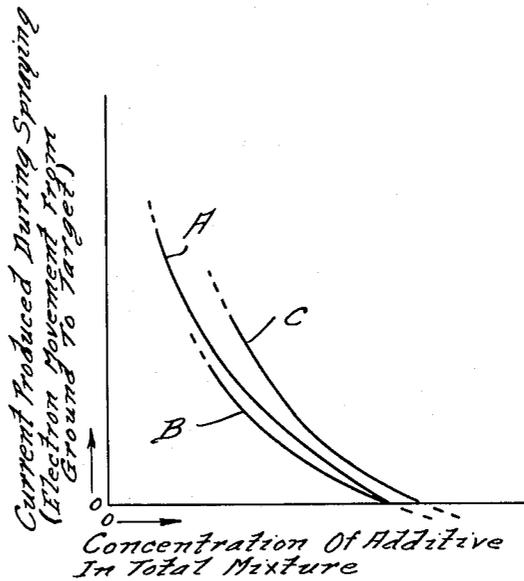


FIG. 2.

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3,260,616

METHOD OF IMPROVING THE CAPABILITY OF A PAINT COMPOSITION TO PRODUCE A COATING OF UNIFORM APPEARANCE

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Continuation of application Ser. No. 567,268, Feb. 23,
1956. This application Apr. 6, 1961, Ser. No. 103,673
14 Claims. (Cl. 117-93.4)

This application is a continuation of my application Serial No. 567,268 filed February 23, 1956 and entitled Paint and Methods and Apparatus for the Testing Thereof, now abandoned.

This invention relates to the application of protective coatings to surfaces and more particularly to the coating of surfaces with finishing materials such as paint.

In the application of pigmented finishes, it has been difficult consistently to obtain uniform appearance. Even when painting identical parts with a given applying equipment, the color, the color distribution, and the uniformity of distribution of the final coatings tend to vary from day to day and from batch to batch of the coating material. Such deviations also arise where a given paint mixture is applied to identical parts with different applying equipments. As an example, the same parts coated with the same paint material by hand spraying and by electrostatic machine spraying will normally exhibit a color disparity so noticeable that different formulations are employed in an attempt to reduce the difference.

Non-uniform distribution also occurs in many instances over the surface of a given part. In one manifestation, there is a variation in the thickness of the coating on the surface. With curved, profiled or, in general, non-planar parts, the condition may arise with any of the presently accepted machine spraying equipments, and is sufficiently severe that such parts may require hand spraying. Variations in film thickness also arise in certain electrostatic spraying operations even with parts which present a substantially planar surface to the spray equipment. It has been found that with both air-transporting and electrostatically transporting types (herein termed air and airless types) of electrostatic spray equipment there is a tendency towards streaking or striping, with the film thickness being greater at the edges of the spray pattern. The effect is particularly noticeable where the paint is applied using high-voltage electrostatic deposition equipment of the type in which the transportation of the spray is accomplished solely by electrostatic forces.

In another manifestation, the non-uniform appearance accrues from a non-uniform distribution or dispersion of the paint pigment in the applied coating. The non-uniformity tends to be particularly severe where the coating has been sprayed in the presence of an intentionally established electrostatic field. Similarly, while the condition appears to exist with substantially any paint containing solid materials, the uneven distribution of the particles is particularly noticeable and particularly objectionable when a polychromatic effect is sought, by applying a finish containing pigments of more than one color, one of which may be in the form of metallic particles such as aluminum or bronze. Poor pigment dispersion tends to produce that pigment separation customarily characterized, in accordance with its nature and extent, as flooding or floating. It has been observed that in some instances the solid particles in the paint seem to clump or cluster together, in many of those cases tending to catenate or form in trains of sufficient width and length to be apparent to the unaided eye. The size of the trains seems to increase with increases in voltage in certain electrostatic painting applications, and

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the degree of uneven particle dispersion varies, with any given method of application, from paint to paint.

It has previously been recognized that some improvement in the uniformity of pigment dispersion can be achieved by the addition of selected ones of a number of chemical compounds in appropriate quantities to the pigment-and-vehicle-containing coating mixture. The generally advanced theory is that unsatisfactory dispersion accrues from poor pigment wetting by the vehicle which in turn accrues from or is manifested in high surface tension between the vehicle and the pigment. On the basis of that thesis, proper dispersion can be achieved by utilizing an additive which serves as a wetting agent, acting by interfacial orientation and adsorption, to reduce that surface tension, and the additive compounds have therefore been termed "surface active agents." While the inventor's investigations establish that the addition in proper quantity of properly selected ones of the compounds characterized by others as "surface active agents" will produce a very substantial improvement in the uniformity of pigment dispersion, in the uniformity of film thickness, and in the appearance in the finished coating, those investigations neither necessarily prove or disprove the above-noted theory, that theory is not advanced as an explanation of the phenomena observed by the inventor nor relied upon as an explanation of the effectiveness of the herein disclosed techniques and apparatus, and the correctness of that theory, or of any theories hereinafter presented, will not affect the practicality or efficacy of the inventive principles herein described and claimed. It seems clear that the prior theory, if correct, is at least not the whole explanation of the phenomena which occur.

While surface active agents have previously been manufactured as additives to paint compositions (see, for example, the Organic Finishing Handbook, Finishing Publications Inc., 1954 edition), it is the inventor's understanding that these agents, where used, have been employed in quantities constituting in the order of 0.1% of the total paint mixture volume, a quantity much too small to produce the results accruing from the practice of the principles of the present invention. Additionally, there is evidence that many of those agents which change the surface tension most markedly, do not effectively change those characteristics of paints herein considered.

The general objects of this invention are to improve coating compositions, to improve the methods for determining the capability of a liquid coating composition to produce a coating having a uniform appearance, to provide an apparatus which may be employed to aid in that determination, and to improve the methods for adjusting a liquid coating composition to produce coatings of uniform appearance.

In the drawings:

FIG. 1 is a schematic representation of a testing or determinative apparatus embodying certain of the principles of the invention and adapted to facilitate the performance of the processes embodying others of the principles of the invention;

FIG. 2 is a graphical representation of the effect upon the electrical characteristics of a selected paint of the addition of varying amounts of selected compositions; and

FIG. 3 is a graphical representation of the effect upon the electrical characteristics of a different, selected paint of the addition of varying amounts of a different, selected composition.

As is noted in Patent 2,574,528, granted November 13, 1951, to the present inventor, it has previously been observed that agitation or relative movement of liquids, gases, solids, or combinations thereof, results in the production of an electrical charge. This phenomenon has previously been characterized as the development or gen-

eration of frictional electricity, and that terminology may conveniently be here employed. The inventor has found that the magnitude of this charge varies with changes in the proportions of the components of the mixture, and it is his belief that the quantity of frictional electricity which is developed depends on the ratio of polar and non-polar compounds in the mixture.

The present inventor has now determined that finishing materials or paints, when agitated, tend to develop an electrical charge. The degree of agitation produced, for example, during spraying (electrostatic or nonelectrostatic, air or airless atomization) is sufficient to develop a charge of substantial magnitude. The existence of this charge, or of some condition of which the charge is a reflection or indication, tends to substantially affect the uniformity of thickness of the surface film and upon the uniformity of the pigment dispersion in that film. The extent of the charge seems also to control the orientation or attitude of pigment particles, particularly where metallic particles are employed as or as a part of the pigment material.

As the result of this charge, if a conventional paint is applied to a metallic article, such as by spraying, and if that article is so connected that free electrons can move to or from the article through a metering device, the metering device will indicate the existence of an electron flow. The time rate of flow of electric charge from paint to paint varies both in magnitude and in direction. The magnitude of the flow seems to vary as a function of the volume of paint reaching the article in unit time.

On the basis of these observations, it is believed that the condition imparted to the paint composition as an incident, and probably as a result, of agitation is a net electrical charge, with the paint arriving at the article being coated with either an excess or a deficiency of free electrons. The paint particles or droplets per se and/or the solids within each particle or droplet apparently become shaped, oriented or grouped due to the attraction-repulsion forces in the system, that system probably including the article being coated. At least under the normal circumstances where the article being coated is electrically connected to the earth by a path offering less than infinite impedance to the flow of charge, it does not appear that there is any residual net charge in the final coatings, all or effectively all of the charge being dissipated as a result of the association of the particles or sub-particles with the article. However, the orientation achieved during transportation to and at impingement upon the surface appears to control not only the pattern and uniformity of distribution of the material on the article but also the attitude and location of the individual solid particles, those particles becoming substantially immobilized upon or shortly after contact with the article due to mechanical forces, due to the dissipation of the electrically produced forces, or both. In any event, it has been found that paints which do develop a charge during agitation (including spraying) produce surfaces of much less uniformity of material thickness and color distribution than do paints which are effectively neutral, that is, paints which apparently arrive at the work surface with neither a substantial excess nor a substantial shortage of free electrons.

It will be observed that the charge here discussed is one developed as a result of agitation of the coating composition, as opposed to any electrical condition produced by an intentionally established electrical field as in electrostatic spraying or detearing operations. The expression "agitationally developed charge" is employed to mark that distinction, and a paint which, when agitated, produces little or no electrical charge is herein termed an electrically neutral paint. More particularly, as employed herein, an electrically neutral paint is one which arrives at the work surface with no or substantially no agitationally developed charge, and "agitation" is intended to include stirring the movement of the paint to and

through a spray gun, the atomization of the paint, the movement of the paint droplets through the air, and other movements of the paint or paint particles tending to produce an electrical charge.

The actual current flow to or from the work when painting in an intentionally established electrostatic field, however established, is apparently many thousands of times greater than the magnitude of the agitationally produced current here discussed. Despite the small relative magnitude of these agitationally produced currents or charges, their effect upon the characteristics of the final coating is very great, suggesting that there is some difference in character and effect between the agitationally developed electrical condition here treated and the electrical condition produced externally by an electrostatic field. It has been noted during experimentation, using an electrically neutral paint and spraying with electrostatic equipment in the presence of a continuous electrostatic field, that no detectable difference exists in the magnitude of the current flow between the applying source and the article whether the paint material is being sprayed or not. Additionally, paints which do not develop an electrical charge as a result of agitation produce coatings of substantially identical appearance whether applied with or without an external electrostatic field.

While in an effort to suggest an explanation for the observed phenomena, the concepts of charge and electron movement are utilized, it is very possible that the conditions observed by electrical instrumentation, while presenting a valuable indication of the coating characteristics of the paint, is but a symptom of the existence of more fundamental structural or conditional differences.

The term "paint," as used herein, is intended to include compositions capable of forming a lasting film upon a surface, those compositions including, in general, a substance which tends to form such a film, a pigment which may be or include metallic particles, a catalyst or retarder and a volatile liquid solvent or thinner. All of the compositions so classifiable include non-polar materials as constituents.

While the principles of the invention have particular utility where the paint is applied by spraying, the practice of those principles is also beneficial where the paint is applied by brushing, dip-coating and the like.

THE TESTING EQUIPMENT

A suitable form of test equipment embodying certain of the principles of the present invention and adapted to facilitate the practice of the processes hereinafter described is represented in FIGURE 1 of the drawings. The representatively disclosed equipment includes a spray gun 10 which may be of any conventional type adapted to discharge a mixture of air and finely divided coating material. In the majority of the tests, a gun having an external mix nozzle was employed. A target 12 is disposed in spaced proximity to the gun 10. In the disclosed arrangement, target 12 is a metallic sheet lying in a plane perpendicular to and having its center intersected by the spray axis. As an example of arrangements found to operate successfully, the gun 10 was supplied with air at a pressure of thirty pounds per square inch, the target 12 was placed about twenty inches from the nozzle of the gun 10, and the size of the target 12 was so selected that some overspray existed on all sides of the target. As will be noted, it is desirable that the target be at least about eight inches from the gun. In a preferred testing arrangement, the selected physical size was twelve inches square. The gun 10 was, during experimentation, maintained effectively at "ground" potential, although it does not appear that this is an essential of operability. The target 12 was connected to that same reference potential through a measuring device 14. While any adequately sensitive galvanometer may be employed, the preferred arrangement used in testing included a high-value precision resistor 16 serially con-

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nected between the target 12 and ground, it being understood that the term "ground" as employed herein refers to any body of such material and mass as to be capable of supplying electrons to and accepting electrons from another body such as the target. Any voltage appearing across that resistor was applied, in amplified form by a vacuum-tube amplifier 18, across a galvanometer 20. Since the value of the resistor is known, the galvanometer scale may be calibrated either in terms of current or voltage, or arbitrary units. In a constructed device, a plurality of resistors were provided, connectable to offer a resistance of a selectable value up to about 100 megohms (1×10^{11} ohms), and the vacuum-tube amplifier circuitry and the galvanometer were appropriately selected so that a one-division deflection of the needle with the greatest of these resistors in circuit would represent a current through that resistor of one micro-micro ampere (1×10^{-12} amperes). Means were provided for zeroing the meter with zero current through the resistor or with a resistor of infinitely high value (an open-circuit condition).

It will be apparent that other metering arrangements may be employed for detecting the magnitude of the electrical energy, that is, the magnitude of the potential difference between the target 12 and a reference point or the magnitude of the electron flow (the time rate of flow of electrical charge) through a path including target 12. The instrument should be capable, by connection, switching or design, of measuring voltage differences of either polarity or current flow in either direction, and for best results should have, in combination with the spray volume and target size, at least the above-noted degree of sensitivity. Micro-micro ammeters and milli-micro-micro ammeters and sensitive electrometers which are capable of or readily adaptable for measuring energy at the desired levels are presently available on the commercial market. Similarly, it will be appreciated that other means may be employed for agitating the mixture and for measuring the average charge or the time rate of flow of electrical charge resulting from such agitation. However, the described test apparatus is preferred on the basis of its similarity to industrial paint-applying equipment.

THE DETERMINATIVE TEST PROCEDURE

The arrangement shown in FIG. 1 is set up with no external electrostatic fields being applied, with no paint being sprayed and with the measuring instrument being zeroed. The finishing material is then sprayed so that at least a portion of the material impinges upon the target 12. The meter is read during the spraying. The meter reading, when interpreted, has been found to provide an accurate indication of the extent to which the pigment will be dispersed in a final coating resulting from the application to a surface of the composition which was tested and the capability of that material to produce a coating of uniform thickness. By employing the apparatus in this manner, a series of coating mixtures may be rapidly compared and an accurate prediction made of the extent to which each will form a final coating of uniform appearance.

It has been found that a finishing material will have the greatest uniformity of film-thickness and of pigment distribution in the final coating when no current flows in the test path when that material is tested in the noted manner. In practice, a finishing composition, which when sprayed with the disclosed test arrangement at normal rates, results in a current (as measured, for example, with a very high input impedance meter connected across a 100 megohm resistor) in the order of a few micro-micro-amperes, will be capable of producing a final coating having highly improved uniformity both in the dispersion of the pigment and in the thickness of the film. The type and particularly the color of the paint seems to affect the extent to which departures from exact neutrality will produce noticeable non-uniformity of the finished coating.

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A yellow or orange paint, for example, may produce a coating of adequate apparent uniformity even though the adjustment deviates from neutrality sufficient to produce a current upon testing with the noted equipment, of in the order of thirty to forty micro-micro amperes. A blue paint, on the other hand, seems to require a much closer adjustment if the coating is to appear uniform. Experiments demonstrate that a further substantial improvement occurs if even a closer approximation to zero current flow is achieved. In practice, the inventor prefers to employ mixtures producing as nearly zero needle deflection as possible, the magnitude of the current in the test path desirably being in the order of one micro-micro ampere or less.

The foregoing and following representative current values are believed to be accurate in that great care has been exerted accurately to design and calibrate the test equipment. While it should be appreciated that the present values may not be absolute, they do represent accurate relationships for a selected volume per unit time of material sprayed. The principle, implicit in the foregoing description, however, is simply to employ an exceedingly sensitive indicator, to accurately zero that instrument, and to observe how much or how little the needle departs from its zeroed position when each mixture is tested.

It has been observed during experimentation that the extent and nature of the agitation of the paint appears to affect the magnitude of the measured charge. As an example, the type and degree of agitation occurring as the paint is moved through a spray gun may produce a current flow, in either direction, in a path between the gun and ground. While, as taught hereinafter, the paint composition may be adjusted so that no or effectively no current flow will exist in such a path, the existence or non-existence of a current flow in a path between the target and ground is the preferred test where the paint is to be applied to articles by spraying apparatus. The distinction appears to be significant, for it seems that paints which are so adjusted that they arrive at the target with neither an excess nor a deficiency of agitationally developed free electrons may, at least in some cases, nonetheless produce a current flow in a test path between the spray gun and ground. Conversely, there is evidence that a paint producing no current flow in a target-and-ground test path may produce current flow in a target-and-ground test path.

It has also been noted that a paint which arrives at the target with an excess or deficiency of electrons may evidence a charge which varies with changes in the gun-to-target distance, that change in charge being additional to that which would be expected as a result of the variation in the percentage of the spray pattern which is intercepted. While with a non-neutral paint the magnitude of the current in a target-and-ground test path may vary with gun-to-target distance, it has been found that if the paint is brought to effective neutrality with a test arrangement such as that disclosed herein, changes in the gun-to-target distance will not appreciably affect that result as long as the target is not brought closer than about eight or ten inches to the gun. It is therefore concluded that a paint which is found to be neutral in that manner will arrive at the work with neither an appreciable excess nor an appreciable deficiency of agitationally developed electrons as long as the gun is at least eight to ten inches from the work.

It should be emphasized that a paint which is found to arrive at the target with neither a substantial excess nor a substantial deficiency of electrons when tested with the disclosed non-electrostatic testing arrangement, produces, when sprayed with electrostatic equipment of either the air or airless types, a coating having a much greater uniformity than does a paint which is not neutral.

THE ADJUSTING PROCEDURE

As will be discussed hereinafter, a finishing material

may be adjusted to produce a neutral composition in the sense stated by the addition of additives in proper amounts. The procedure for the adjustment is to repetitively vary the additive and the concentration thereof, performing the foregoing determinative test upon each mixture, and observing the change in meter reading as an indication of the quality of each mixture and as a guide to the preparation of the next composition. Since any change in composition is likely to change the reading, the manner in which the reading changes is a ready guide to further necessary adjustments.

THE EXPERIMENTAL RESULTS

A series of experiments have been conducted upon finishing materials including large number of paints commercially employed at the present time by the manufacturers of automobiles and automobile body parts. With the above-described test apparatus, the commercial paints of these types, as received from the manufacturer, produced a measurable current flow in the testing circuit. The variation was great. Some paints, when sprayed, produced an electron flow in the test circuit in one direction, others produced a charge of the opposite polarity. On the average, the paints resulted in the production of a current in the testing circuit, in one direction or the other, which was measured to be in the order of one millimicro ampere (1×10^{-9} amperes) although certain paints which were tested resulted in the production of currents one hundred or more times as great. All tests noted herein were conducted at a fixed rate of material feed, at a fixed air pressure, and at a fixed gun-to-target distance, all approximating commercial practices.

In general, the addition of any of various hydrocarbon thinners of the types presently commercially employed did not appear to materially affect the agitationally producer charge developed in these paints. Conversely, a number of additives were found which, when added in appropriate quantity, produced a vast change in the charge developed during agitation. Each of the tested additives which successfully modified these electrical characteristics of the paint to which it was added was a polar compound, and the most effective of these are classifiable as alcohols, glycols and glycol ethers. Among the glycol ethers which were particularly effective are the ethylene glycol mono ethers, including ethylene glycol mono butyl ether, ethylene glycol mono ethyl ether and ethylene glycol mono methyl ether. Technical grade n-butyl Cellosolve ($\text{HOCH}_2\text{—CH}_2\text{—O—CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$) was the most effective, on the average, of this group. Diethylene glycol mono ethers, including diethylene glycol mono methyl ether, diethylene glycol mono butyl ether, and Carbitol (diethylene glycol mono ethyl ether,



were also effective. The technical grade Carbitol (containing about 28% of ethylene glycol) was the most effective, on the average, of this group. The experimental data also indicate that ethylene glycol per se, n-butanol, diacetone alcohol and hexylene glycol



serve, when employed as additives, to reduce the magnitude of the generated electricity. Hexylene glycol and n-butanol appear to be particularly useful in conjunction with the noted monoethylene and diethylene glycols, and may also be employed, as blending agents with ethylene glycol. Ethylene glycol, with a blending agent, is effective to produce neutrality in many paints. In general, those paints for which technical grade Carbitol is found to be a good neutralizing additive can also be neutralized with a smaller quantity of ethylene glycol and a blending agent. However, the results with ethylene glycol do not appear to be as uniform or as predictable as they are with technical grade Carbitol.

It was found that equal quantities of all of the noted additives were not equally effective with any given paint

composition. With certain paints certain of these additives were most efficacious; with other paints, others brought the mixture to a state of effective electrical neutrality with a smaller quantity of additive. As an example, as noted, certain of the tested paints (negative-charge paints) apparently carried an excess of free electron to the target, so that their impinging upon the target produced an electron flow from the target and through the meter resistor to ground, whereas other paints (positive-charge paints), apparently arriving at the target with a deficiency of free electrons, resulted in an electron flow from ground, through the meter resistor and to the target. While all of the noted additives have been found to be effective to modify the extent of the charge attained or developed by the paint, the ethylene glycol ethers such as n-butyl Cellosolve appeared to be particularly effective in changing a negatively charged paint towards neutrality (although they also tend to change certain positively charged paints towards neutrality), while the diethylene glycol ethers such as Carbitol appeared to be particularly effective in changing a positively charged paint towards neutrality (although they also tend to change certain negatively charged paints towards neutrality).

An example of the addition of varying concentrations of diethylene glycol monoethyl ether to an automotive paint (designated as "dark brown metallic" by its manufacturer, the Pontiac Varnish Company) partly thinned with commercial hydrocarbon thinners (toluene, E407 solvent and Cyclosolve 53, mineral oil fractions, the latter two of which are manufactured by the Shell Oil Company) is represented in curve A of FIG. 2 of the drawings. The paint with its hydrocarbon thinner was of the positively charged type, and neutrality was achieved when about 14% of the volume of the mixture was the noted glycol ether. Technical grade Carbitol (curve B) and diethylene glycol mono methyl ether (curve C) produced closely corresponding curves.

It has been found that in some cases mixtures of the noted additives produce neutrality of the paint composition at a more satisfactory volumetric addition (thinning) and at a lesser cost than any one of the additives alone. Thus, a cheaper additive may be employed to reduce the magnitude of the charge developed by the untreated but thinned paint partly towards neutrality, and a more expensive but more effective additive employed to carry the mixture the rest of the way to neutrality.

As an example of the use of a mixture of additives, a paint presently commercially employed ("blue interior enamel," a metallic-particle containing paint manufactured by the Jones-Dabney Company) was partially thinned with xylol (25 volumes of thinner to 100 volumes of the supplied paint). The mixture developed a high negative charge when tested. A mixture consisting of 5 volumes of n-butyl Cellosolve, 5 volumes of n-butyl alcohol and 10 volumes of hexylene glycol (of the above-noted formulation) was then added in increments with a determinative test being performed after each incremental addition. The mixture was adjusted to neutrality when the additive mixture constituted about 10% of the total mixture volume. As can clearly be seen in the curve of FIG. 3, representing these tests, the point of neutrality is critical and requires testing with small incremental changes in additive in the critical range if optimum results are to be achieved. The curve further demonstrates how difficult it would be to adjust the paint to produce optimum coating uniformity without practicing the techniques here taught. An additive which will carry the paint mixture to neutrality will, if employed in excess, cause the mixture to develop a charge of the opposite polarity.

Various proportions of additive are required for various paints. While the concentrations of course vary with the additive for any given paint, extending from about 4½% of the total volume to an amount in excess of 25%, the majority of those additive and paint mixtures which

were adjusted to neutrality by the techniques here taught contained in the order of 10% to 20% of the additive. Thus, as examples, 20 volumes of technical grade Carbitol were required to neutralize a .100 volume quantity of pine green metallic paint, formulated for use on current automobiles by the Ditzler Color Division of the Pittsburgh Plate Glass Company, previously thinned with 24 volumes of commercial mineral-oil fraction thinners, and a blue metallic paint used by another automobile parts manufacturer was neutralized by the addition, to 100 volumes thereof, of 18 volumes of a mixture consisting of four parts of a commercial mineral-oil-fraction thinner, eight parts of hexylene glycol, four parts of n-butanol and four parts of technical grade n-butyl Cellosolve.

A phenomenon was observed in the selection of additives for certain paints, the explanation for which has not been fully developed. It was discovered that in certain cases, the sequence of mixing produced significant differences in the electrical characteristics of the mixture. As one example, to a 100 milliliter sample of the blue interior enamel, noted above, was added a thinner, xylol (dimethyl benzene) and an additive composition consisting of 6 milliliters of n-butanol, 6 milliliters of n-butyl Cellosolve (technical grade) and 12 milliliters of hexylene glycol. A reduction in the electrical charge developed by the paint was experienced when the additive composition was first stirred into the paint, and the thinner stirred in a few minutes later. However, when the thinner was added first and the additive composition stirred in a few minutes later, the reduction was appreciably greater and the composition tested effectively neutral (see FIG. 3). As another example, an automotive paint which could be brought to neutrality by the addition, to 100 volumes of paint, of 80 volumes of mineral-oil fraction commercial thinners followed, after a few minutes, by the addition of a mixture of 10 volumes of n-butanol and 10 volumes of n-butyl Cellosolve, could not be brought to neutrality with the same constituents if the thinner and the two additives were first mixed together and then added to the paint.

As specific initial adjusting procedures, it is recommended that the paint to be adjusted, partially thinned with hydrocarbon thinners, be tested. If the test evidences that the paint is positively charged, it is suggested that n-butyl Cellosolve (technical grade) be employed as an initial additive, whereas if the paint is negatively charged, technical grade Carbitol should be selected. The extent of the charge will serve as a guide to the amount of additive to be initially used. In general, the addition of sufficient additive to constitute about 10% to 15% of the total volume would serve as a good starting point. If the measuring equipment indicates that the mixture is not yet at neutrality, and additional quantity of additive should be stirred into the mixture and the test repeated until neutrality is achieved. If, on the other hand, the initial quantity of additive produces an indication on the instrument that the mixture is charged to a polarity opposite to the original polarity, a new sample should be prepared containing a lesser quantity of additive and the testing and adjusting continued until neutrality is achieved. The reduction of the paint to neutrality may thereafter be performed, if desired, using other additives or combinations of additives in order to determine the optimum additive from all standpoints including those of the quantity required and cost.

It is not possible, with present knowledge, to predict for each paint, without testing, the optimum type and quantity of additive which should be employed to produce neutralization and maximum uniformity of appearance of the final coatings. Paint compositions differ from one another in any of a vast number of ways and even ostensibly identical paints produced in successive batches tend to have difference which affect their electrical characteristics. However, with the teachings here presented, a person even but limitedly skilled in the art can readily

determine the capability of any paint to produce a uniform-appearing surface and can readily produce an effectively neutral paint mixture. With additional time expenditure, but without necessarily exercising any higher level of skill, a mixture of the paint and other agents or combinations of agents may be tested and the concentration adjusted to produce an effectively neutral mixture as above noted.

A tendency was observed for certain of the mixtures to shift their electrical condition with time after being adjusted. In those cases either the neutralization should preferably be performed within a few hours of the time of use of the mixture or else sufficient additive should be employed to carry the mixture beyond neutrality an amount appropriate to the expected delay before use. The presence of hydrocarbon thinners seemed to retard the rate of change in the electrical characteristics of the paint.

While it will be apparent that the embodiments of the invention herein disclosed are well calculated to fulfill the objects of the invention, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the proper scope or fair meaning of the subjoined claims.

What is claimed is:

1. The method of improving the capability of a paint composition to produce a surface coating of uniform appearance on a work, said paint composition containing a film-forming substance, a volatile hydrocarbon solvent and substantially insoluble pigment particles and being one which develops an electrical charge when agitated, said method comprising:

agitating said paint composition, measuring the electrical charge which is developed as an incident of the agitation, and

adding to said paint composition an organic polar compound selected from the group consisting of alcohols, glycols and glycol ethers in sufficient quantity that when the resulting mixture is similarly agitated it will have effective electrical neutrality.

2. The method of claim 1 wherein said agitation is accomplished by spraying said paint composition.

3. The method of claim 1 wherein said polar compound comprises an ethylene glycol mono ether.

4. The method of claim 1 wherein said polar compound comprises n-butanol.

5. The method of claim 1 wherein said polar compound comprises diacetone alcohol.

6. The method of claim 1 wherein said polar compound comprises hexylene glycol.

7. The method of claim 1 wherein said polar compound comprises a diethylene glycol mono ether.

8. The method of claim 7 wherein said ether is diethylene glycol mono ethyl ether.

9. The method of claim 3 wherein said ether is ethylene glycol mono n-butyl ether.

10. The method of claim 2 wherein said paint composition is sprayed upon a work, said electrical charge being measured at said work.

11. The method of claim 10 wherein the minimum distance between said work and the source of the spray is in the range from about 8" to about 10".

12. The method of improving the capability of a paint composition to produce a surface coating of uniform appearance on a work, said paint composition containing a film-forming substance, a volatile hydrocarbon solvent and substantially insoluble pigment particles and being one which develops an electrical charge when agitated, said method comprising:

converting a sample of said paint composition into a mist,

collecting at least a portion of said mist, measuring the electrical charge of said collected portion resulting solely from said conversion,

adding to said paint composition an organic polar compound selected from the group consisting of alcohols,

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glycols, and glycol ethers in sufficient quantity to diminish the electrical charge of said paint composition when converted to a mist, and repeating the foregoing steps until the magnitude of the measured charge approaches zero.

13. The method of claim 12 wherein said conversion is accomplished in the presence of an intentionally established electrostatic field.

14. The method of claim 12 wherein at least a portion of said mist is collected on an electrically conductive member, said measurement being accomplished by connecting said member electrically with a reference potential and measuring the electrical current flow between said member and reference potential.

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