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[31] **40,037/65;**
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Continuation-in-part of application Ser. No. 580,716, Sept. 26, 1966, now abandoned.

[54] **PARTICULATE COATING METHOD**
9 Claims, 8 Drawing Figs.

[52] **U.S. Cl.** ..... **117/19,** 117/16, 117/23, 117/24, 117/26, 117/29, 117/33, 117/75, 117/104 R

[51] **Int. Cl.** **B44c 1/06,** B44f 9/04

[50] **Field of Search** ..... 117/16, 19, 23, 24, 26, 29, 33, 75, 104 R, 169 R, 30, 32; 118/308, 608, 610

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ABSTRACT: A method of producing a coated surface comprises the steps of grinding a natural stone to particle sizes of less than 1 mm., adjusting the proportions of particle sizes present to produce a mixture containing 20 to 30 percent by weight of particles of size less than 100 mu, applying at least one adhesive layer to the surface, depositing onto the adhesive layer to be secured thereby a layer of the said particle mixture to produce a substantially continuous adherent surface layer of contiguous particles obscuring the adhesive from view, and removing surplus nonadherent particles.

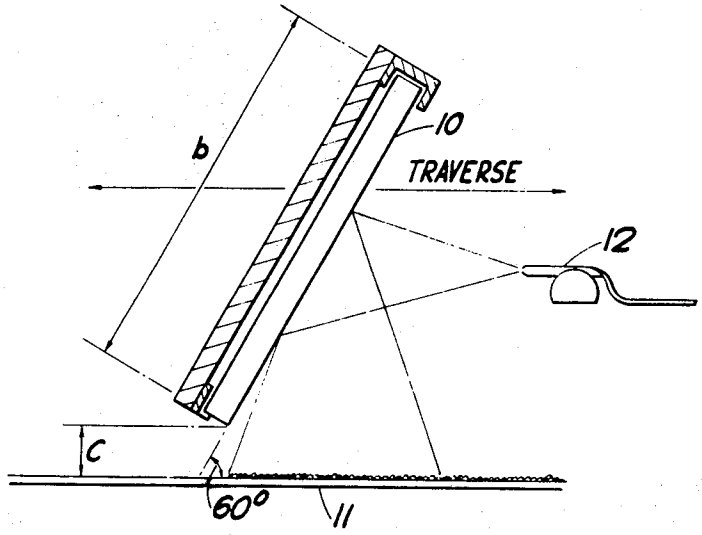


Fig. 1.

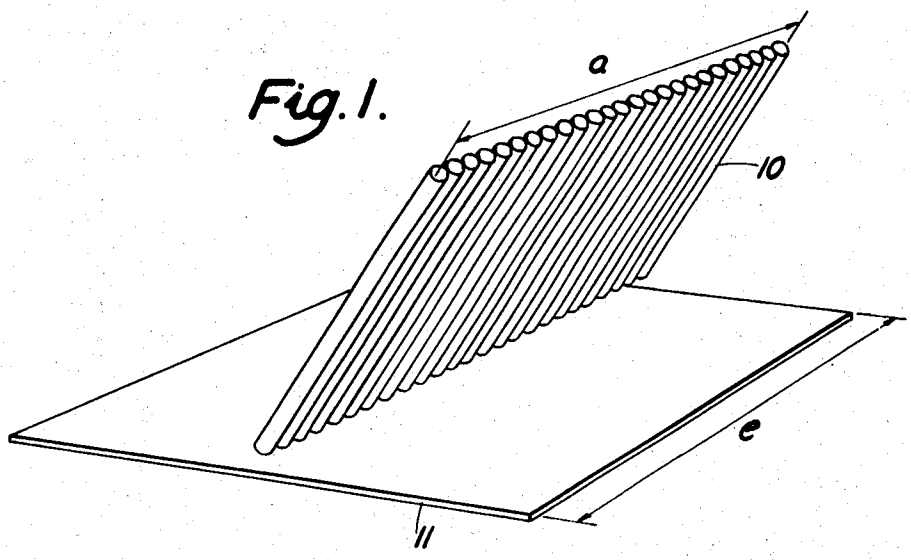
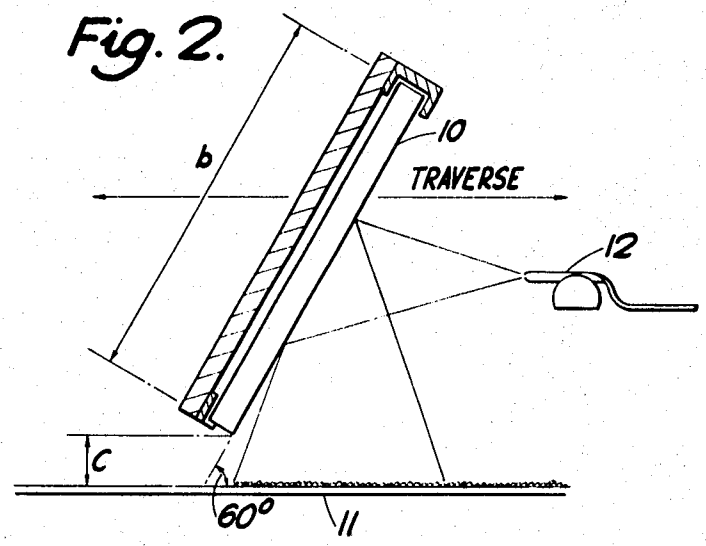


Fig. 2.



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Fig. 3.



Fig. 4.

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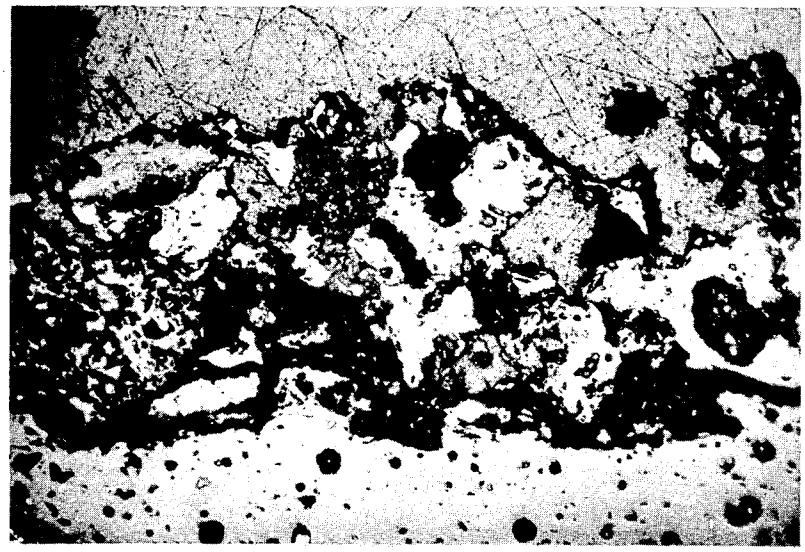


Fig. 5.



Fig. 6.

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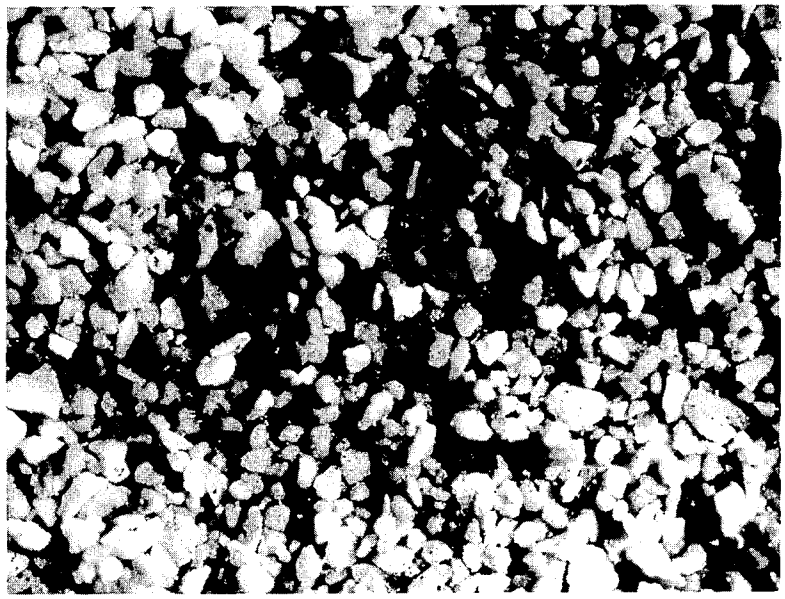


Fig. 7.



Fig. 8.

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PARTICULATE COATING METHOD

This application is a continuation-in-part of my application Ser. No. 580,716 now abandoned.

The invention relates to coated surfaces and to a method of and apparatus for coating surfaces. The invention is particularly, but not exclusively, concerned with the coating of the surfaces of buildings or components therefor, such as facing sheets or slabs, pipes or beams.

Stones generally from metamorphic or sedimentary deposits are used as building materials not only for their durability and strength but also for their appearance, and it is an object of the invention to provide on a backing sheet (e.g. of metal) a surface layer which is indistinguishable in appearance and resistance to weathering from a dressed natural stone.

Another object is to transfer particles of material from a block of natural stone to a backing sheet to form a new surface which is indistinguishable from the original block, just as good silver plating cannot be distinguished from solid silver by its appearance alone.

Over several years I have observed from many experiments that a mass or block of mineral, such as sedimentary stone, can be broken down by pounding or trituration to give a fairly consistent pattern and range of particles sizes.

It appeared to me that if a collection of particles corresponding in size and proportions of size to a collection of particles obtained by grinding a mineral was deposited on, and secured to, a backing surface, the resulting coated surface should appear much the same as the natural stone surface such as that of a sawn and sanded stone block such as an ashlar.

In practice, however, if particles are deposited onto an adhesive-coated surface it is mainly the lowermost particles which adhere to the surface. Most of the upper particles, since they land on top of other particles, form an unsecured excess which may be washed or brushed off. Similarly gaps between relatively large particles tend to be bridged by similar or smaller particles and relatively small particles are unable to get between the larger particles to adhere and form a continuous surface, and the bridging particles themselves can be washed or brushed off.

It is important if the objects of the invention are to be achieved that no material other than the mineral particles should be seen on the finished surface. Interweaving lines or scattered areas of foreign matter such as an adhesive of resin, glass, or cement will be readily detected by the naked eye and the surface will be rejected by an observer as being different in appearance from a natural stone.

In order to overcome or reduce this problem in packing I have established that it is necessary to adjust the sizes and proportions of sizes of the particles in order to provide a surface indistinguishable from natural stone. The particle sizes and more especially the size of the largest particles, may be selected to represent different degrees of dressing of the stone.

The invention provides the method of producing a coated surface which comprises the steps of grinding a natural stone to particle sizes of less than 1 mm., in naturally occurring proportions, adjusting the proportions of the particle sizes present to produce a mixture containing 20 to 30 percent by weight of particles of size less than 100 μ (millimicrons), applying at least one adhesive layer to the surface, depositing onto the adhesive layer to be secured thereby a layer of the said particle mixture to produce a substantially continuous adherent surface layer of contiguous particles obscuring the adhesive from view, and removing surplus nonadherent particles.

The invention further provides the method of producing a coated surface which comprises the steps of grinding a natural stone to particle sizes of less than 1 mm., separating substantially all the smaller particles of the ground material of size less than 100 μ from the larger particles of size greater than 100 μ, remixing with at least a size range of the larger particles from 100 μ upwards a proportion of the particles of less than 100 μ to produce a mixture containing 20 to 30 percent by weight of the smaller particles, applying at least one adhesive layer to

the surface, depositing onto the adhesive layer to be secured thereby a layer of the said particle mixture to produce a substantially continuous adherent surface layer of contiguous particles obscuring the adhesive from view, and removing surplus nonadherent particles.

The surface may be of metal, asbestic material, cementation material, wood, compressed paper or hardboard, glass, rigid or flexible plastics material, or textile material.

When the method is applied to a metal surface, it may comprise the steps of forming a coating of vitreous enamel on the metal, then applying to the enamel a layer of vitreous enamel forming materials, applying a layer of the said particle mixture to the layer of vitreous enamel forming materials, and then firing the layer of vitreous enamel forming materials to constitute an adhesive layer by which the particles are bonded to the enamel coating while leaving the particles projecting from the bonding layer.

Preferably the layer of vitreous enamel forming materials is applied as an aqueous suspension, the layer is wetted after coating and the particles are then applied to the layer.

The invention will be more fully described hereinafter with reference to the drawing.

In the drawing:

FIG. 1 is a perspective view of one preferred embodiment of baffle used in practicing the process of the present invention.

FIG. 2 is a side view of the baffle of FIG. 1.

FIGS. 3–8 are photomicrographs of the surface of several samples of the product produced by the process of the present invention.

I have discovered that, provided certain steps are taken, a very effective method of applying the particles is to spray them onto the adhesive coated surface from a spray gun. For practical purposes it is advantageous to spray the particles parallel to the surface and use a baffle to deflect the particles onto the surface. When conventional flat smooth baffle plates were used however, I discovered that they were not satisfactory and produced a disruptive pattern in the finisher work, however much the angle of incidence was varied during traverse or scanning. Rough surface metal or other plates also produced poor results and were rejected. Even a baffle constituted of smooth or rough metal tubes arranged in a plane side by side and parallel to one another to produce a continuous ribbed surface having a section of convex arcs like a rectified sine wave failed, but it was discovered that if a similar shaped surface, whether of tubes or sheet material, composed of strawboard, soft cardboard, or similar soft material was used then the results were instantly and surprisingly good.

Accordingly the invention also provides a method of producing a coated surface as described above, in which the particles are sprayed in a direction substantially parallel to the adhesive coated surface and are deflected onto the surface by a substantially flat baffle, at least the deflecting surface of the baffle having a cross section in the form of a succession of convex arcs, as viewed along the plane of the baffle towards the adhesive coated surface, and at least the deflecting surface of the baffle being constructed of material having a softness equivalent to that of strawboard.

The invention includes a baffle for use in deflecting sprayed particles onto a surface, the baffle being substantially planar and at least the deflecting surface of the baffle having a cross section in the form of a succession of convex arcs, as viewed in one direction along the plane of the baffle, and at least the deflecting surface of the baffle being constructed of soft resilient material.

When coating a metal surface using vitreous enamel adhesive as aforesaid the particles may be taken from the sedimentary or metamorphic rocks providing they are sufficiently refractory to retain, after fusion of the bonding layer, their main physical properties. The temperature of the fusion will depend upon the composition of the layer which in turn may be chosen to suit the metal base but will usually be within the range of 400° C. to 1,000° C.

The particles may be chosen from the alumino-silicic acids. However it is, in practice, immaterial from the point of view of reaction with the molten matrix, whether the particles are acid, neutral or basic, since the molten condition of the matrix generally persists for only 5 to 30 minutes.

It will be appreciated that the first coating is entirely of glass-forming components or contains a sufficiently high proportion thereof to be, after firing in the normal manner, substantially nonporous. There may be two or more such coatings.

It is important to avoid the use of base metals which have such a high content of surface or subsurface impurities or gas (e.g. nitrogen in steel) which will result in the glass layers being disturbed during fusion or while molten. Thus excessive gas can rise to the surface during firing and cause craters which may, on the one hand, leave the metal unprotected and, on the other hand, spoil the appearance of the finished coating.

In carrying out the invention, the first coating is applied as an aqueous suspension of glass-forming materials, and fired as in normal enamelling. A further coating of an aqueous suspension of the same or different glass-forming materials is then applied and, while the coating is still wet, a layer of rock particles as described above is applied. The coating is then dried and fired.

It is important that the coating should be suitably wet when the particles are applied. It has been found that when using a normal suspension of glass-forming materials under normal atmospheric conditions, there may well be insufficient time to apply the particles before the coating has become too dry. It may therefore be necessary, and commonly is necessary, to wet the coating by applying a fine spray or mist of moisture before the particles are applied. The particles themselves may also be moistened before application but not sufficiently to cause them to agglomerate. This also helps to reduce dust. About 6 percent by weight of water is suitable for many particles, and 8 percent seems to be about the maximum which can satisfactorily be used.

The particles may be sieved or sprayed onto the wet layer. If they are sprayed it is preferred to employ a baffle as described. It is further preferred, in each case, to apply a substantial excess of particles, the excess being shaken or brushed off after firing.

The method as applied, for example, to the cladding of steel with a limestone, such as from Portland, or a clay mineral which has previously been fired for use as a solid refractory and subsequently broken down, may include the following procedures.

The metal is a mild steel of a quality known as cold-reduced, extra-deep drawing, and with a full finish to avoid surface irregularities.

The stone material to provide the upper and visible layer or layers is calcined, if necessary, to remove any volatile, combustible or otherwise harmful compounds that might be present.

The material is reduced, as in a ball mill, to give a quantitative analysis of particle sizes of, in one example, both proportions and sizes being approximate:

25% of 500–250 μ
40% of 250–225 μ
20% of 225–175 μ
5% of 175–150 μ
7% of 150–100 μ
3% of 100–40 μ

All percentages being by weight.

The proportion of the smallest particles (less than 100 μ) present is then increased to 20 to 30 percent by weight by the addition of refractory color oxides, to obtain a more complete coverage of the adhesive.

The particle grading will also influence the final appearance and may be varied to suit the degree of stone dressing it is desired to simulate.

First a coating of glass is formed on the steel. After this has been fired an aqueous suspension of glass forming silicates (similar to those used for the first coating) is applied.

It is desirable that the wet bonding silicate matrix should be sufficiently fluid (e.g. having a viscosity about equal to that of water) that it is displaced, generally partially but sometimes almost totally, by the deposited particles which it receives.

The matrix, being an aqueous suspension of finely divided solids, tends to dry at its surface too rapidly for convenient working, and therefore, after application its initial low viscosity is maintained by an immediate wetting with a fine spray of water, after which the particles are delivered with the minimum of delay. The delivered stone particles are able, according to their mass velocities, to displace not only the surface water but also some of the precipitate of finely divided fritted silicates.

This delivery can be by various means, but for small areas may be by riddling through a mesh held above the receiving matrix on the workpiece, or for larger areas it may be by means of a spray from a gun.

So as to have the advantages which flow from spraying horizontally, a deflecting baffle is, preferably suspended above the workpiece, if it is horizontal or substantially so.

During spraying this baffle is traversed across the length of the target area of the workpiece, generally twice, one sweep across, and a return sweep and is followed by the gun at a reasonably constant distance. The baffle may, with advantage, be set at an angle of about 60° to the plane of the workpiece, should have a length approximately equal the greatest width of the workpiece and deep enough to exceed the diameter of the spray cone from the gun when fired from a conveniently short distance.

So as to deliver the spray as evenly as possible across the workpiece and avoid preferential deposits the baffle is constructed as shown in the accompanying drawing FIGS. 1 and 2 so as to form a wall **10** of tubes in tangential contact longitudinally, and whose axes lie in a plane. This is to say, the baffle may consist of a row of parallel tubes in close contact the tubes lying in a plane at about 60° to the surface of the workpiece **11** with the axes of the tubes sloping upwardly and over the surface. The useful deflecting surface of the baffle accordingly consists, in section, of a succession of convex semicircular arcs (i.e. is similar to a full rectified sine wave).

It is important in order to avoid the effects of specular reflection of the particles and to obtain diffuse reflection of their paths, to make the tubes of a soft compressible material, having a surface texture which is irregular, such as strawboard.

In order to maintain these conditions of delivery, the gun **12** is kept at a reasonably constant range from the baffle and scanned to and fro across it.

The mass velocity of the particles clearly varies greatly, the denser particles readily reaching the target whereas those of the lowest mass tend to remain airborne and obscure vision or are carried away by extracting ventilation necessary for practical operating conditions, before they can reach the target.

To reduce this, the charge to the gun is damped by the addition of about 6 percent by weight of water to the solids. As already mentioned this addition is found to be a little critical, since approximately 8 percent or more of water leads to a clogged delivery where the particles bombard the target in damaging groups or where there is sufficient water delivered with them to produce unsightly tracts upon the surface of the matrix, thereby breaking the contiguity of the deposit.

The particles thus deposited are permanently fixed to the workpiece by firing in a furnace (after drying out the coating to avoid the disruptive effects of violent boiling) so as to fuse the matrix.

The matrix becomes miscible with its base during firing, and at the same time it penetrates around and into the interstices of the mineral particles.

Microscopic examination shows, after firing finally, that although some particles have become totally immersed in the

fusible matrix, the majority are partially submerged, an average degree being about 55 percent, but as little as some 5 percent being sufficient to obtain a satisfactory mechanical key due generally to the incursion of the molten silicates into and around the irregular or eroded solids.

It is an advantage of the coated material that the surface provides an effective bond or key for paint and also for cement and other setting liquids.

The material has good weathering properties and an attractive appearance, e.g. for buildings.

It is not essential to use glass as the adhesive and, of course, inappropriate to do so when the base material, or the particles, will not withstand the firing temperature. Other adhesives which may be used include the organic compounds which set from the liquid state and do not require high temperature for fusion and solidification.

These include natural and synthetic resins, thermoplastic and thermosetting plastics materials, setting over varying periods in air at ambient temperature, those which rely on reaction with a hardener to set, and some of whose final physical and chemical strengths are best achieved by curing at low elevated temperatures.

Although thermosetting compounds such as the epoxy resins are preferred, thermoplastic materials may be used in which group the adhesive matrix may be liquified by heat, although each at its own appropriate and low temperature.

In order to achieve uniform application and the correct degree of partial submersion, the viscosity of the adhesive matrix should be low. Where, for chemical or other reasons this is not practicable or advisable, the necessary partial submersion of the contiguous particles may be achieved by the application of pressure, air pressure by preference, which is increased in proportion to the increased viscosity of the adhesive. As already indicated, the use of an organic adhesive as described above allows the contiguous particle layer to be deposited and fixed permanently to base supports which include, in addition to metals, such materials as compressed asbestos, timber, compressed paper or hardboard, rigid or flexible resins, textiles, or any other support to which the matrix will properly adhere. The supports may be of sheet or slab form.

The following is a specific example of the use of an epoxy resin adhesive. The adhesive contains a solvent and is used with a hardener. The adhesive used is that known as Araldite GY278 (trademark) to which is added 10 percent toluene followed by 60 percent of its hardener Araldite HY931. This is to say the adhesive is a reaction product of 2,2'bis(4 hydroxyphenyl) propane with epichlorhydrin in the presence of an alkali and having an epoxide equivalent of 175–210, to which is added a monoglycidyl ether as a reactive diluent; and a hardener which is an aromatic amine in a product obtained from the distillation of coal tar.

After applying the adhesive by spraying to a thickness of 0.004–0.008 inches on a degreased and shotblasted aluminum workpiece the adhesive matrix is allowed a gelation period, between approximately 40 and 100 minutes before the rock particles are delivered (as above described). The workpiece is then allowed to cure in air at 20°–25° C. for a minimum of 24 hours, or better is cured for not less than 1 hour at 60° C., before the excess particles are removed by wet brushing. Although spraying then becomes more difficult, it is better, if practicable, to avoid dilution of the resin so as ultimately to retain its best chemical and weathering properties. Using the same resin and hardener, which mixture has a viscosity of 10–14 poises at 21° C., without dilution, the gelation period is rather extended so that the rock particles should not be applied before about 1½ hours.

If insufficient gelation period is allowed, the particles disturb the matrix layer too violently and turbulently for uniformity of appearance and furthermore even the uppermost particles tend, during the curing process, to be wetted by capillary attraction, thereby spoiling their appearance.

When carrying out the invention on a nonmetallic and porous support such as compressed asbestos, or asbestos-cement product, polyurethane, or expanded polystyrene, it may be an advantage to apply more than one film of adhesive, in which case the gelation period, which is a function of temperature and thickness, should be extended appropriately.

The average density of the stone facing, together with its securing matrix is very low, having an apparent specific gravity of 2.0 to 4.5. Cladding 14-gauge mild steel with an oolitic deposit such as the limestone from Portland increases its weight by only 9 percent, and 16-gauge aluminum by 24 percent.

It is to be appreciated that, especially when using an organic adhesive, some of the particles may become completely embedded within, and encompassed by, the adhesive. Indeed it has been found that the particle layer is frequently up to five or six particles thick in places. The lowermost particles may, or may not, be wholly encompassed by the adhesive. The upper particles may be supported by the lower particles and secured by adhesive which is displaced upwardly (e.g. by the impact of the particles or by capillary action) between the lower particles. The general effect is to produce cavities between the particles which reproduces the appearance of the natural stone. It is an advantage of the invention that this effect is produced with a minimum thickness of particle layers.

An example of particle size distribution has already been given, in that case for a clay mineral which has been fired and broken down.

An example of particle size and distribution from Portland limestone is:

50% of 250 μ or above
25% of 250–225 μ
5% of 225–175 μ
5% or 175–150 μ
5% of 150–100 μ
10% of 100 μ or less

and a corresponding adjusted mix may be, for example:

traces of 750–500 μ
20.50% of 500–400 μ
22.25% of 400–300 μ
6.25% of 300–235 μ
10.25% of 235–200 μ
4.75% of 200–175 μ
2.75% of 175–150 μ
4.75% of 150–100 μ
28.50% of 100 μ or less

All percentages in the above examples are by weight.

The above example of adjusted mix particle sizes is also applicable to other sedimentary minerals similar to Portland limestone.

The accompanying six photomicrographs referred to hereinbefore show the following:

FIG. 3 Limestone from Portland Quarry Rock face, natural fracture × 20

FIG. 4 Limestone from Portland on black vitreous matrix on Aluminum. × 20

FIG. 5 Limestone from Portland on black vitreous matrix on Aluminum. Section × 200

FIG. 6 Artificial stone from prefired shale or clay mineral on vitreous matrix containing fines and color oxide (approximately 30–50 microns) on mild steel × 20

FIG. 7 Artificial stone from prefired shale or clay mineral on epoxy resin adhesive matrix on Aluminum. Section × 200

FIG. 8 Artificial stone from prefired shale or clay mineral on epoxy resin adhesive matrix on Aluminum. × 20

It can be seen from these photomicrographs that FIGS. 4 and 5 correspond very closely to FIG. 3 but, as is required in practice, to a higher degree of dressing than is given by a natural fracture. FIGS. 6 and 7 embody the broken down fired clay described above. It can be seen in FIG. 8 that some of the lower particles have been wetted by the adhesive but this cannot be distinguished by the naked eye. The photograph of FIG. 7 shows the particle distribution. The distribution of the matrix cannot be clearly determined from this photograph because it was necessary to apply an additional supporting resin in order to prepare the section.

I claim:

1. The method of producing a coated surface which comprises the steps of grinding a natural stone to particle sizes of less than 1 mm., adjusting the proportions of particle sizes present to produce a mixture containing 20 to 30 percent by weight of particles of size less than 100 μ, applying at least one adhesive layer to the surface, depositing onto the adhesive layer to be secured thereby a layer of the said particle mixture to produce a substantially continuous adherent surface layer of contiguous particles obscuring the adhesive from view, and removing surplus nonadherent particles.

2. The method of producing a coated surface which comprises the steps of grinding a natural stone to particle sizes of less than 1 mm., separating substantially all the smaller particles of the ground material of size less than 100 μ from the larger particles of size greater than 100 μ, remixing with at least a size range of the larger particles from 100 μ upwards, a proportion of the particles of less than 100 μ to produce a mixture containing 20 to 30 percent by weight of the smaller particles, applying at least one adhesive layer to the surface, depositing onto the adhesive layer to be secured thereby a layer of the said particle mixture to produce a substantially continuous adherent surface layer of contiguous particles obscuring the adhesive from view, and removing surplus nonadherent particles.

3. A method as claimed in claim 2 in which the surface is metal, asbestic material, cementation material, wood, compressed paper or hardboard, glass, rigid and flexible plastics materials or textile materials.

4. The method of producing a coated metal surface which comprises the steps of grinding a natural stone to particle sizes of less than 1 mm., separating substantially all the smaller particles of the ground material of size less than 100 μ from the larger particles of size greater than 100 μ, remixing with at least a size range of the larger particles from 100 μ upwards, a proportion of the particles of less than 100 μ to produce a mixture containing 20 to 30 percent by weight of the smaller particles, forming a coating of vitreous enamel on the metal, then applying to the enamel a layer of vitreous enamel forming materials, applying a layer of the said particle mixture to the layer of vitreous enamel forming materials, and then firing the layer of vitreous enamel forming materials to bond the particles to the enamel coating while leaving the particles projecting from the bonding layer.

5. A method as claimed in claim 4 in which the layer of vitreous enamel forming materials is applied as an aqueous suspension, the layer is wetted after coating and the particles are then applied to the layer.

6. The method as claimed in claim 2 in which the particle mixture is sprayed onto the adhesive layer.

7. The method as claimed in claim 6 in which the particles are sprayed in a direction substantially parallel to the adhesive coated surface and are deflected onto the surface by a substantially flat baffle, at least the deflecting surface of the baffle having a cross section in the form of a succession of convex arcs, as viewed along the plane of the baffle towards the adhesive-coated surface, and at least the deflecting surface of the baffle being constructed of soft resilient material.

8. The method as claimed in claim 7 in which the baffle is constructed of strawboard.

9. The method as claimed in claim 7 in which the baffle is traversed across the adhesive coated surface and a spray gun spraying the particles is traversed across the baffle.

* * * * *