DEVICE FOR TREATING THE SURFACE OF A WORKPIECE

Filed Sept. 22, 1958 2 Sheets-Sheet 1

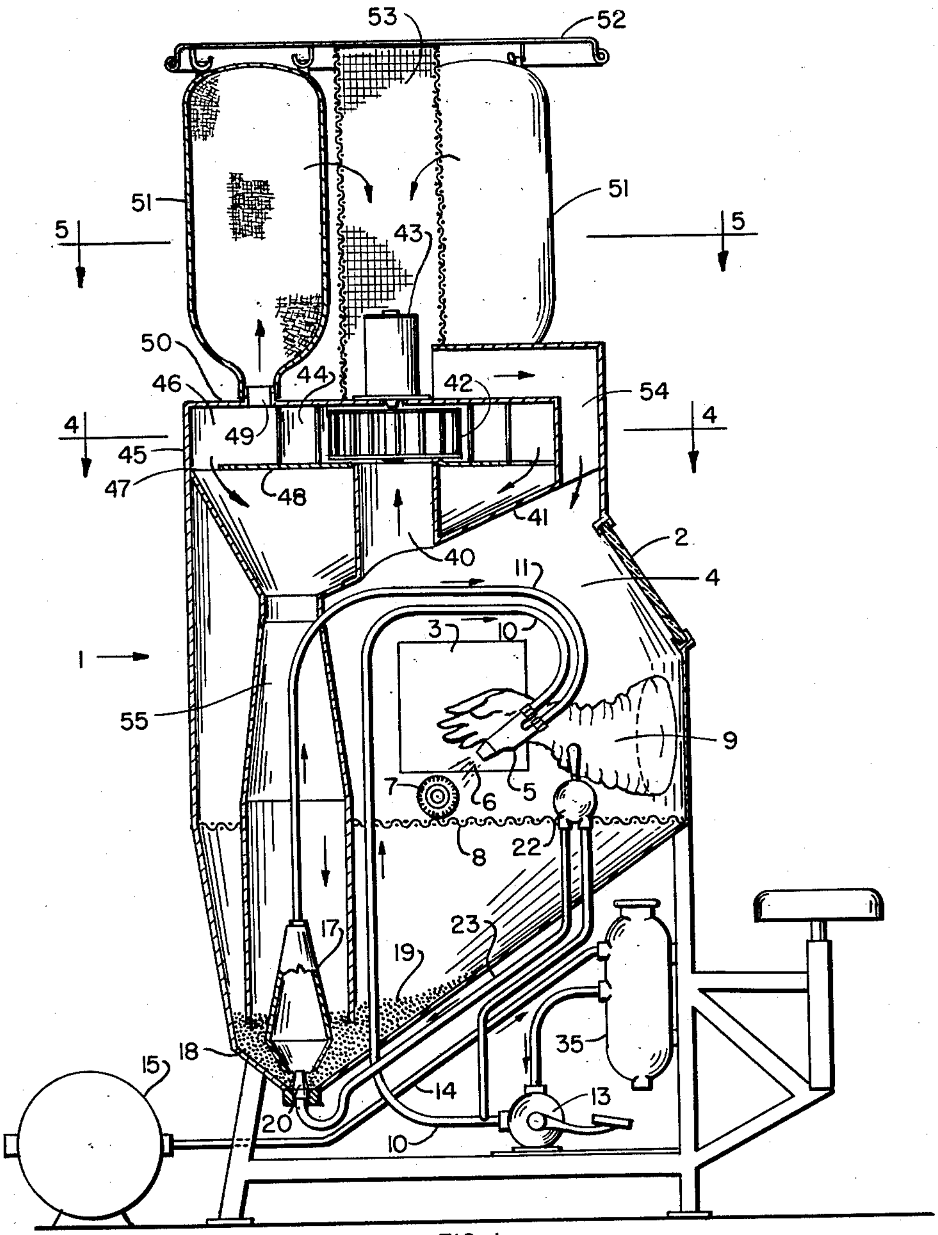

FIG. I

INVENTOR.
CHARLES F. ROCHEVILLE
BY Richard F. Carr
ATTORNEY

Aug. 13, 1963 C. F. ROCHEVILLE 3,100,724

DEVICE FOR TREATING THE SURFACE OF A WORKPIECE

Filed Sept. 22, 1958 2 Sheets-Sheet 2

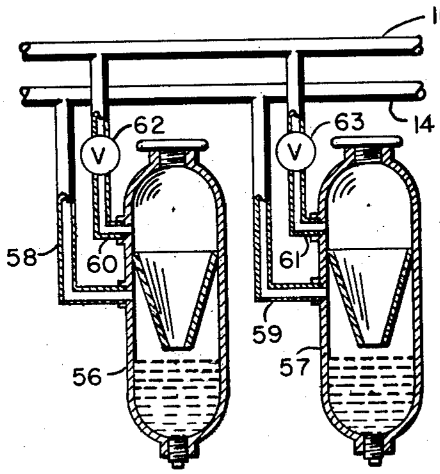

FIG. 6

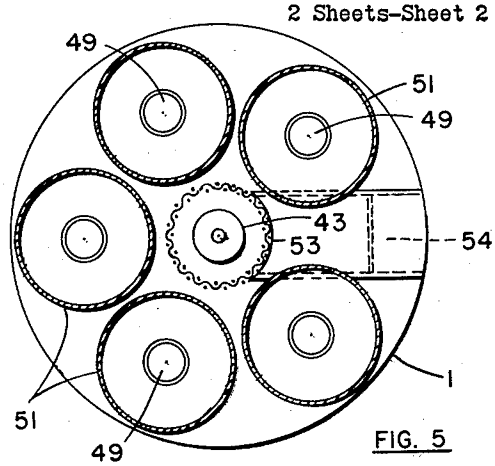

FIG. 5

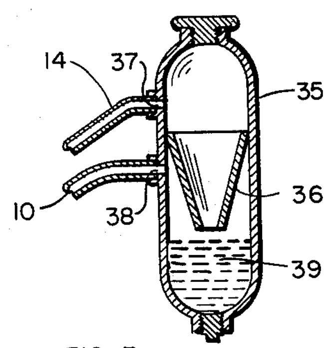

FIG. 3

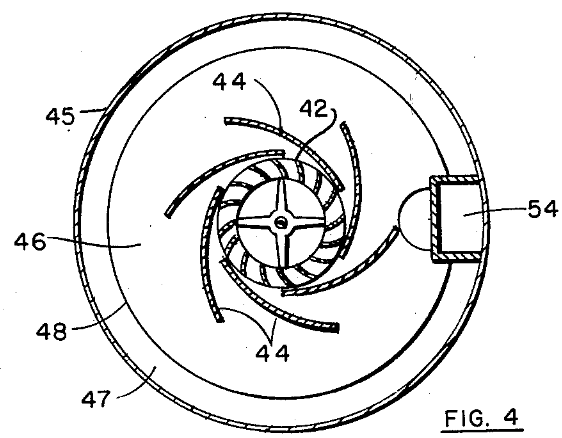

FIG. 4

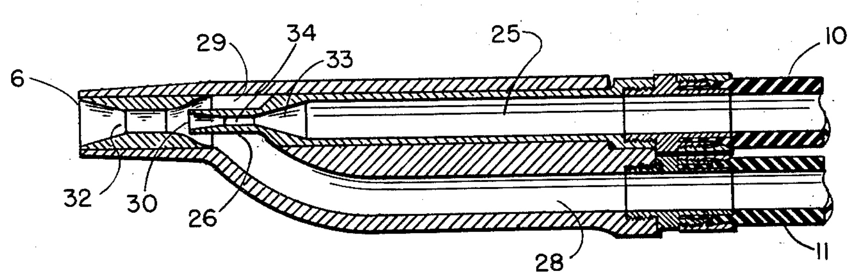

FIG. 2

INVENTOR.
CHARLES F. ROCHEVILLE

BY Richard F. Carr

ATTORNEY

3,100,724
Patented Aug. 13, 1963

3,100,724
DEVICE FOR TREATING THE SURFACE OF A WORKPIECE

Charles F. Rocheville, Torrance, Calif., assignor to Microseal Products, Inc.

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9 Claims. (Cl. 118—308)

This application is a continuation in part of my copending application Serial No. 658,456 for Chemically Vaporized Lubritive Metallic Bonding of Material Surfaces, filed May 10, 1957, now abandoned.

This invention pertains to the treating of surfaces and more particularly to the formation of a thin coating on a surface, or the cleaning of a surface.

This invention provides an entirely new system usable in a variety of ways in treating surfaces, especially those of metal parts. One type of coating is a strongly adherent, thin metallic layer which in some instances is fused over the surface of the part. Other coatings include dry lubricants, and a binder may be added to the coating when the latter type is provided. Additionally, this invention provides for the cleaning of surfaces as well as for shot peening and the relief of surface strains.

The objectives of this invention are accomplished by directing a finely divided powder against a surface to be treated, in most instances striking the surface at a supersonic velocity.

Therefore, it is an object of this invention to provide an adherent, uniform, thin coating on a part.

Another object of this invention is to provide a dry lubricant on a part.

A further object of this invention is to prevent corrosion of a part.

Yet another object of this invention is to clean or shot peen a part.

A still further object of this invention is to direct a finely divided powdered material against a surface at supersonic velocities to cause said material to adhere in the pores of the part, and in some instances to fuse thereon.

Yet another object of this invention is to provide a nozzle in which air and a coating material are mixed for discharge against a workpiece.

An additional object of this invention is to recirculate powdered material used in a coating operation.

Another object of this invention is to provide an effective means of removing powdered material from air.

These and other objects will become apparent from the following detailed description taken in connection with the accompanying drawing in which:

FIG. 1 is an axial sectional view of the device of this invention,

FIG. 2 is an enlarged sectional view showing the construction of the nozzle,

FIG. 3 is an enlarged sectional view illustrating the internal arrangement of the liquid container,

FIG. 4 is a sectional view taken along line 4—4 of FIG. 1 showing the construction of the dust separator,

FIG. 5 is a sectional view taken along line 5—5 of FIG. 1 showing the arrangement of the filter bags and the housing inlet, and

FIG. 6 is a sectional view of an arrangement for manifolding together a plurality of fluid containers in the high pressure air line.

In carrying out the invention there preferably is provided a housing **1** which includes a window **2** and an access door **3** communicating with a chamber **4** within the housing. Nozzle **5**, which discharges at **6**, is located within chamber **4** for directing a stream of air and powdered material or liquid against workpiece **7** which may

rest upon grate or screen **8**. The nozzle may be adapted for hand operation by the operator through a flexible boot **9** of conventional design, which permits the operator to grasp the nozzle within the housing.

Other arrangements may be employed, such as a swivel mounting for the nozzle, or a stationary nozzle with provision for movement of the workpiece.

Two supply lines connect to nozzle **5**, these being a high pressure air line **10** and lower pressure supply line **11**. High pressure line **10** is controlled through foot operated valve **13**, connecting through line **14** to a suitable source of compressed air **15**.

Lower pressure supply line **11** connects to a mixing chamber **17** in the bottom portion of the housing, the latter forming a hopper **18** that receives a powdered material **19**. Directly below mixing chamber **17** an air jet **20** is provided, discharging upwardly into the mixing chamber. The jet of air from air jet **20**, therefore, blows powder **19** from hopper **18** to chamber **17** where the air and powder are thoroughly mixed and forced through supply line **11** to nozzle. Air jet **20** also connects to main air supply **14**, but is controlled by hand operated valve **22** downstream of valve **13**, connecting through line **23** to the air jet.

The internal construction of the nozzle may be seen by reference in FIG. 2, where it may be seen that high pressure air line **10** connects to main air passage **25** which directs the air to convergent-divergent nozzle **26**. Low pressure supply line **11** communicates with passageway **28** of the nozzle, being directed thereby to annular passage **29** disposed around divergent exit section **30** of the convergent-divergent nozzle **26**. The two streams are joined at this portion of the nozzle, continuing together through divergent exit section **32** which forms a continuation of divergent section **30**. In other words, the configuration within the nozzle provides a convergence at **33**, a throat **34** and a diverging section **30** and **32**. The stream from the secondary low pressure source mixes with the high pressure air stream in the divergent section of the nozzle. In this manner the air and powder from line **11** is mixed with the main air stream and discharged through the nozzle exit **6**.

The convergent-divergent contour of the nozzle is for the purpose of permitting a supersonic discharge from exit **6**, necessary for most coating operations. Such a configuration allows attainment of such supersonic velocity provided the pressure drop through the nozzle is adequate. For this reason, main air supply source **15** should be capable of providing air pressures around 150 p.s.i. gage, so that enough pressure drop can be realized. When the main air supply is at this preferred value of 150 p.s.i. gage, the pressure at annular section **29** is about ten to fifteen p.s.i. gage. Therefore, the secondary source of low pressure air and power mixture should be maintained at approximately the ten to fifteen p.s.i. gage value, or slightly higher. This permits the secondary supply to join the main air stream without causing excessive drag, and therefore without materially penalizing the velocity obtained from the nozzle. This should be contrasted with conventional injector nozzles where the secondary stream enters the main air stream at the throat of the nozzle where a vacuum exists, and the nozzle acts as a pump. The pumping action of such an injector nozzle severely reduces the velocity at the exit of the nozzle. Here, however, the secondary stream enters the nozzle at a location where the pressure is above atmospheric, and the secondary source itself is pressurized so that the main air stream has much less work to do. Also, the mass flow rate through the main air nozzle is much greater than the mass flow rate from the low pressure source, which further avoids velocity loss as the two streams are mixed.

The pressure of the secondary source is effectively controlled by the diameter of air jet **20** which provides a restriction and a pressure drop to the mixing chamber **17**. Additional control comes through hand operated valve **22**.

It is an important design feature of this invention that the mixing of air and powder is accomplished within the nozzle, rather than in the high pressure air source. Experiments have indicated that where an effort is made to mix a powdered material in the high pressure source upstream of the nozzle, the discharge from the nozzle acts only as a sandblaster and will not provide a coating on a workpiece.

Provision is also made in the device of this invention for discharging a small quantity of fluid along with the powdered material. Where the powdered material is metallic in nature, the fluid so discharged is primarily to act as a dampening agent to prevent dangerous combustion of the air and powder mixture. When a dry lubricant is employed as the powdered material, the fluid may be a binder for causing the powdered material to more firmly adhere to the surface of the part. In accomplishing the discharge of the fluid with the powder a container in the form of bottle **35** is connected in high pressure air line **14** upstream of foot-operated valve **13**. Therefore, the bottle is always charged with high pressure air from compressor **15** and is available instantly for supplying the fluid to the high pressure air line and the nozzle. Within bottle **35** is a frusto-conical baffle **36** (see FIG. 3) which directs the high pressure air from inlet **37** to outlet **38** so that it passes over the surface of the fluid **39** to be discharged with the air-powder mixture. In this manner the high pressure air is caused to pass over the fluid, picking up a very small quantity thereof, yet a sufficient amount to provide the dampening or the binder required.

After the air and powder, together with the minute quantity of fluid, have been discharged against the surface of the workpiece **7**, a small amount of the powder will adhere to the surface of the workpiece while other portions will drop downwardly through screen **8** into hopper **18** in the bottom of the housing. This powder then is available for movement by air jet **20** into mixing chamber **17** for transmission back to the secondary supply line of the nozzle. Such powder, therefore, is automatically recirculated.

An additional portion of the powder remains airborne and is drawn into exhaust **40** located in upper wall **41** of chamber **4** of the housing. Air and powder is sucked into this outlet by centrifugal impeller **42** rotated at high speed by motor **43**. The impeller directs the air and powder radially outwardly through guide vanes **44** which impart a rotative movement to the air and powder mixture. From the guide vanes, the air and powder is forced outwardly against peripheral wall **45** of cylindrical separating chamber **46**. The dust in the air, being the heavier component, collects against circumferential wall **45**. Continued movement of the air and powder causes the dust so collecting against the outer wall to be forced downwardly through annular opening **47** around the outer edge of radial side wall **48**. Opening **47** is located adjacent outer wall **45** of the separator chamber so that only these heavier components will be transmitted thereby. The air, on the other hand, being lighter is caused to exit from the separator chamber through plurality of openings **49**, spaced inwardly of opening **47** and located in the other radial side wall **50**. The air transmitted by openings **49** passes into filter bags **51** of conventional design such as vacuum cleaner bags. These bags are suspended from top support **52** and surround screened air inlet **53** of the housing. The latter connects through duct **54** with the interior of chamber **4** of the housing. Only minute quantities of powder will enter the filter bags due to the highly efficient separator provided by the design of this invention. Additionally, any small quantities which may escape the filter bags normally will pass into inlet **53** of the housing, which is at a pressure lower than ambient in view of the action of impeller **42**. Accordingly, the amount of powder which escapes into the room from the filter bags is infinitesimal and causes no inconvenience or harm to the operator of the machine.

The dust which collects against wall **45** is forced out through opening **47** drops downwardly through passageway **55** communicating with hopper **18** at the bottom of the housing. Therefore, all of the dust which the nozzle discharges that does not adhere to the surface of the part automatically is recirculated. This includes the dust which drops into the hopper by gravity after discharge from the nozzle as well as that returned from the separator. In this manner, the nozzle is continually supplied with a powder, the chamber is maintained free of excessive air-borne powder, and the exhaust from the machine is exceptionally clean.

In a typical operation of the machine it may be desired to provide a thin metallic coating on a workpiece. For example, the workpiece may require a coating of aluminum, magnesium, lead or other desired material, or a mixture of such materials. The hopper of the housing will be provided with a supply of the metal to be applied to the part in a finely divided form, such as microfine particles. The operator, by controlling foot-operated valve **13** for the main air supply and hand operated valve **22** for the secondary supply, controls the material conducted to the nozzle. For a metallic coating, and where the air compressor provides air at around 150 p.s.i. gage, both valves normally will be wide open. By manipulating the nozzle, therefore, a supersonic blast of air and powder is directed against the workpiece. As a result, the powder adheres to the surface of the workpiece, partly by entering the pores of the surface where it is firmly retained thereon. A thin layer of around .0001 inch thickness forms on the part and is uniform over the entire surface. This occurs because the coating will build up over the surface of the part, but will not build up upon itself. Therefore, it is a simple matter to obtain a uniform, thin and continuous coating because the adherence always will be the same regardless of the manner in which the nozzle discharge is directed against the part.

While the adherence to the part apparently is to some extent from the entry of the microfine dust particles into the pores of the surface of the part, some actual fusing of the metallic powder may take place where a lower melting point powder such as lead is used. This occurs because the friction of the metallic particles passing through the nozzle raises the temperature within the nozzle to around 700° F. Such temperature actually causes melting or partial melting of low melting point metallic powders so that they form a fused layer over the surface of the part. On the other hand, should it be desired to obtain a coating where no fusion has taken place, the low melting point material is mixed with one having a higher melting point. This effectively can prevent melting of the mixture and preclude fusion of the coating on the workpiece.

In this manner a very adherent, smooth, protective coating is obtained over the workpiece, usable for any of a variety of purposes. Minor imperfections in the surface of the workpiece will be filled in and smoothed out. The coating is sufficiently thin so that close tolerances of a machined part will not be affected. The coating is so adherent, that whether or not it is fused on the workpiece, it resists abrasion and no corrosion can take place beneath the film.

The feature whereby the metallic dust is recirculated has an additional advantage over and above its savings in time and materials as the machine is operated. As the material is continually directed against the part at a supersonic velocity, the particles of the dust break down into even finer fragments than when introduced into the housing. Therefore, even if relatively coarse dust particles are initially provided within the hopper, these particles soon will be broken down into the very fine powder necessary for use in obtaining a coating. Therefore, the invention not only automatically recirculates the powder, but also automatically provides powder of the correct size for obtaining the proper coating on the workpiece.

Where the coating is metallic, the bottle **35** is provided with a dampening solution, as mentioned herefore, which prevents combustion or explosion of the air-powder mixture. This solution may be a slow drying resinous solvent.

Where a dry lubricant is to be provided on the surface of the workpiece, the dampening solution is replaced with a binder, such as an epoxy resin binder. When applying a dry lubricant, the powder within the hopper of the housing then will be any dry lubricant material desired as a coating on the part. This includes all soft, dry lubricants of a metallic material, graphite, molydisulphide, and other dry lubricants. The dry lubricants are retained by the workpiece primarily by the binder and therefore normally are not discharged against the workpiece at supersonic velocities to penetrate the surface of the part. The foot-operated valve **13** then is not opened the full extent, but only so much as to give a pressure around 75 p.s.i. gage at the nozzle. Similarly, hand-operated valve **22** is only partially opened. Again, however, the nozzle is manipulated to coat the part with the mixture of the dry lubricant powder and the binder.

When a part is treated with dry lubricant and removed from the housing, it generally then is baked in an oven to cure the binder and assure that the coating will be retained on the workpiece. In this manner again a superior, thin, uniform, highly adherent coating is obtained. No other means has been found for providing a dry lubricant having such a low coefficient of friction and with the ability to withstand high pressures as the coating provided by this invention.

This invention has still another application, wherein the surface of the workpiece is cleaned rather than being coated. When this is the case, the dust in the hopper should be in the form of glass beads of under 300 mesh. No fluid need be provided in bottle **35**. The operation of the machine then is as before, the discharge against the part preferably should be supersonic in obtaining the best results. In cleaning the parts, the nozzle usually is directed against the workpiece at an angle with respect to the surface, which thoroughly cleans the surface without any damage whatsoever thereto. In addition to the cleaning effect it is possible to provide shot peening and the removal of surface strains from the workpiece, in which event the discharge should be more nearly perpendicular to the surface of the part. The use of the fine glass beads provides an ideal cleaning action, but will not result in any coating on the part and will have no adverse effects on the part. It should be noted that where glass beads are employed for cleaning the particles do not break down as where other powdered materials are used. Therefore, greater care should be exercised in assuring that the particles placed in the hopper are of the exact size desired.

The invention may be used also in applying liquid alone to a part, in which event no powder is supplied to hopper **18** and valve **22** of the secondary supply remains closed. Bottle **35** then is provided with an appropriate liquid to be applied to the part, and the nozzle again is directed to discharge against the surface of the part. Among the liquids which may be used in this manner are polymers such as polytetrafluoroethylene which is marketed by E. I. du Pont de Nemours & Co., Wilmington, Delaware, under the trademark Teflon.

In some instances two or more liquids are mixed and applied to the workpiece, in which event the fluid containers are manifolded together as shown in FIG. 6. Here it may be seen that bottles **56** and **57** both connect through lines **58** and **59** with high pressure supply **14**, discharging into line **10** through conduits **60** and **61**. Valves **62** and **63** are included in the latter lines to control the discharge of

fluid therefrom. Thus, it is possible to discharge several fluids against the surface of a part, and the proportions may be regulated.

The possibilities of this invention are also limitless, by no means being restricted to the examples described herein. Many different materials and combinations of materials may be discharged against the workpiece in treating its surface. Any finely divided powdered material may be directed against the part, and bottle **35** may contain other fluids besides those mentioned.

It should be borne in mind, when practicing the invention, that where no binder is employed it is important that the discharge against the workpiece be at supersonic velocity. Only at such speeds will the proper adherence between the part and the dust particles take place.

The foregoing detailed description is to be clearly understood as given by way of illustration and example only, the spirit and scope of this invention being limited solely by the appended claims.

I claim:

1. A device for treating surfaces, comprising a housing, a nozzle in said housing, a hopper in said housing for receiving and retaining solid finely divided material, a mixing chamber communicating with said hopper, an air jet in said hopper dischargeable into said mixing chamber for forcing therein a combination of air and finely divided material from said hopper, conduit means interconnecting said mixing chamber and said nozzle for transmitting said air and finely divided material to said nozzle, a source of air under relatively higher pressure than said combination of air and finely divided material connected to said nozzle for discharge therefrom with said air and finely divided material, and separator means in said housing, said separator means having an inlet for receiving material discharged from said nozzle, an air outlet for discharging air therefrom, and an additional outlet communicating with said hopper for returning said finely divided material to said hopper.

2. A device for separating air and a finely divided powder mixed therein, comprising a substantially cylindrical housing having two radial side walls connecting to an outer circumferential wall, a centrifugal blower at the axis of said housing, an inlet to said housing at said axis for providing said blower with a mixture of air and finely divided powder, guide vanes around said blower and interposed between said side walls for directing said mixture outwardly toward said circumferential wall in a rotative pattern, outlet means for said powder in a side wall adjacent said circumferential wall, said outlet means defining an opening extending substantially the entire periphery of said side wall in which said outlet means is located and outlet means for said air, said outlet means for said air being in a side wall and radially interposed between said first mentioned outlet means and said guide vanes.

3. A device as recited in claim 2 including in addition filter means connected to said outlet means for said air.

4. A device as recited in claim 3 in which said substantially cylindrical housing is associated with a chamber having an air inlet, and in which said filter means comprises a plurality of filter elements arranged circumferentially around said chamber inlet, whereby at least a portion of the air drawn into said chamber inlet is provided from said filter means.

5. A device as recited in claim 4 in which said chamber includes a hopper, and means interconnecting said outlet means for said powder and said hopper.

6. A device for treating the surface of a workpiece comprising a nozzle, said nozzle having a convergent-divergent contour terminating in an open exit aperture for discharging directly therefrom against an adjacent object, means for supporting a workpiece adjacent said exit aperture of said nozzle, a source of compressed air, conduit means connecting said source of compressed air to said nozzle for discharge from said nozzle, said air being under pressure sufficient to create a supersonic

velocity upon such discharge, a source of air and finely divided coating material, said last-mentioned source of air being at a relatively lower pressure than said first-mentioned source of air, said source of air and coating material being connected to said nozzle for mixing therein with said first-mentioned source of air, whereby when said nozzle exit aperture is directed toward the surface of a workpiece, said finely divided coating material is caused to strike said workpiece at a supersonic velocity and a quantity of said material adheres to said surface and forms a coating thereon.

7. A device as recited in claim 6 including in addition a closed container, and a liquid for association with said finely divided coating material partially filling said container, said container being series connected in said conduit means upstream of said nozzle with said conduit means entering and leaving said container above said liquid.

8. A device for applying dry lubricant to a workpiece comprising a nozzle, said nozzle having a convergent-divergent contour, means for supporting a workpiece adjacent said nozzle, a source of compressed air, conduit means connecting said source of compressed air to said nozzle, said compressed air having a pressure sufficient to create a supersonic velocity upon discharge from said nozzle, a source of air and finely divided dry lubricant material, said last mentioned source of air being in a relatively lower pressure than said first mentioned source of air, said last mentioned source of air and finely divided dry lubricant material being connected to said nozzle for mixing with said first mentioned source of air for discharge from said nozzle therewith, a closed container, and a liquid binder for said dry lubricant material partially filling said container, said container being series connected in said conduit means upstream of said nozzle, whereby said first mentioned source of air picks up relatively small quantities of said liquid upon passage through said container for securing said dry lubricant material to a workpiece engaged by the discharge from said nozzle.

9. A device for treating the surface of a workpiece comprising a nozzle, said nozzle having a convergent-divergent contour, means for supporting a workpiece adjacent said nozzle, a source of compressed air, conduit means connecting said source of compressed air and said nozzle, said air having a pressure sufficient to create a supersonic velocity upon discharge from said nozzle, a hopper means, a quantity of finely divided solid coating material in said hopper means, a mixing chamber communicating with said hopper means, an air jet in said hopper means dischargable into said mixing chamber for providing in said mixing chamber a combination of said finely divided coating material and pressurized air at a pressure below that of said first mentioned source of compressed air, conduit means interconnecting said mixing chamber and said nozzle for conducting said combination to said nozzle for mixture therein with said first mentioned source of compressed air and discharge from said nozzle with said first mentioned source of compressed air at a supersonic velocity.

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