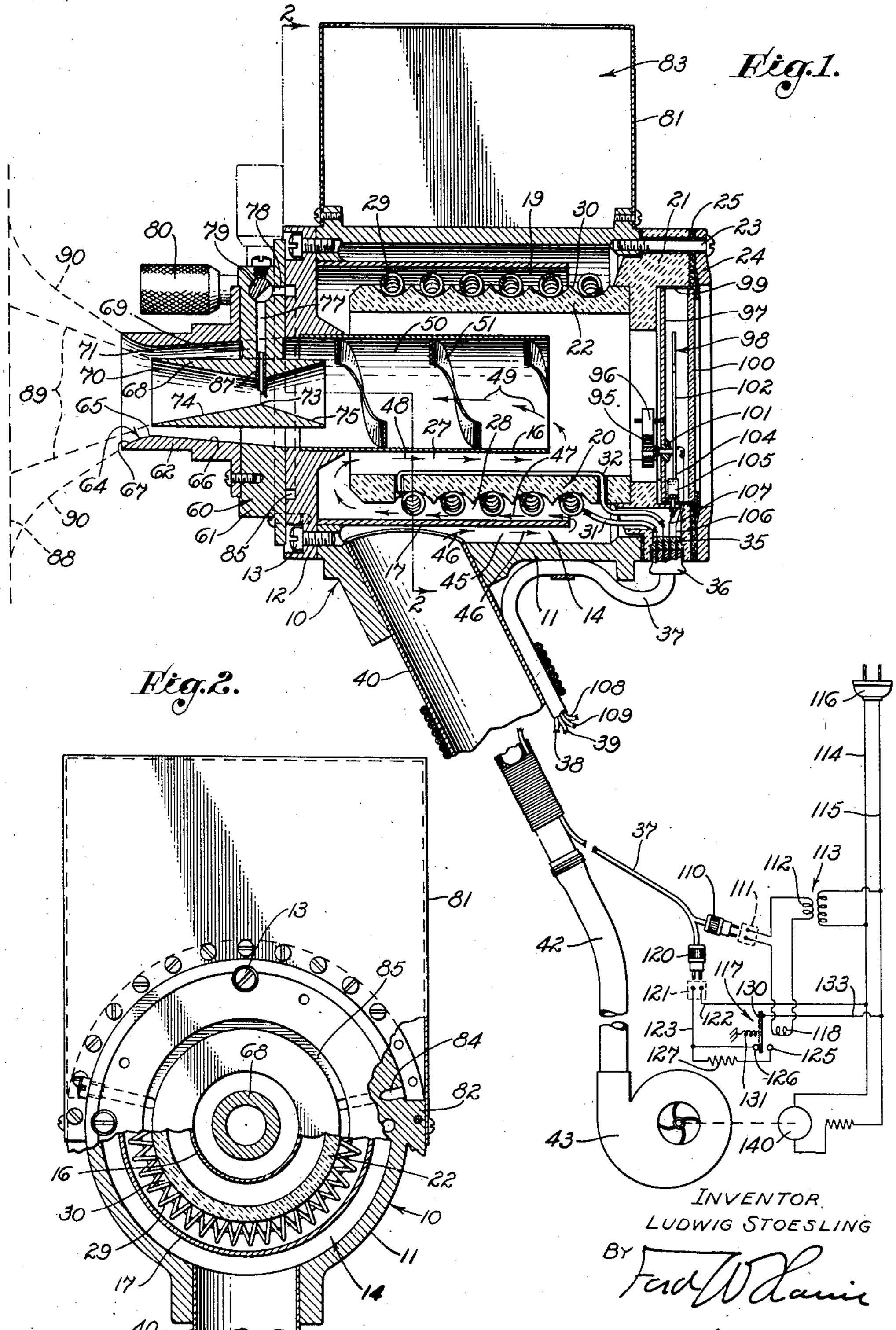
Dec. 14, 1937. L. STOESLING 2,101,922

SPRAYING APPARATUS

Filed Feb. 19, 1935 2 Sheets-Sheet 1



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SPRAYING APPARATUS

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Fig. 3.

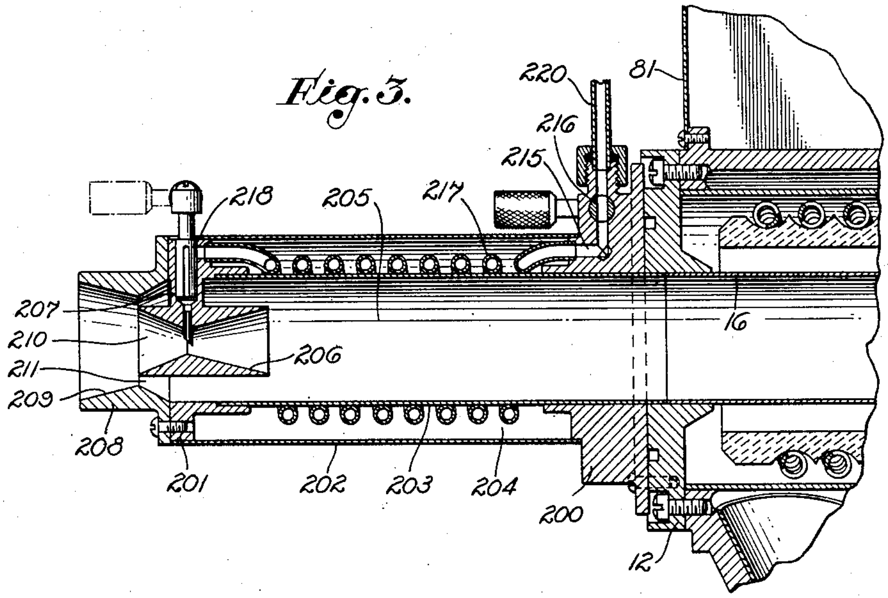


Fig. 4.

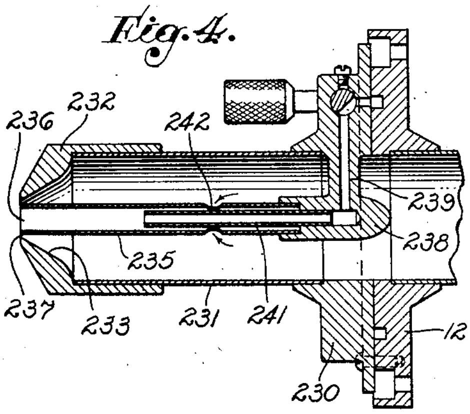


Fig. 5.

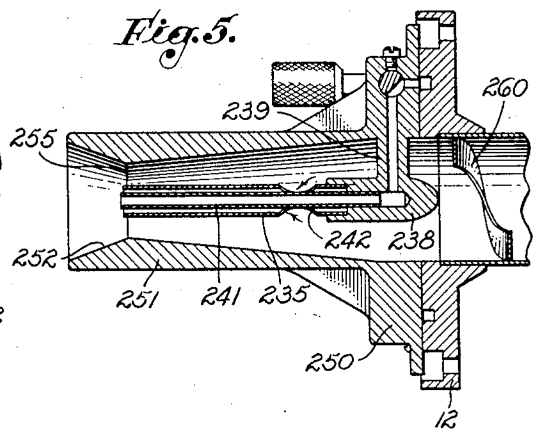
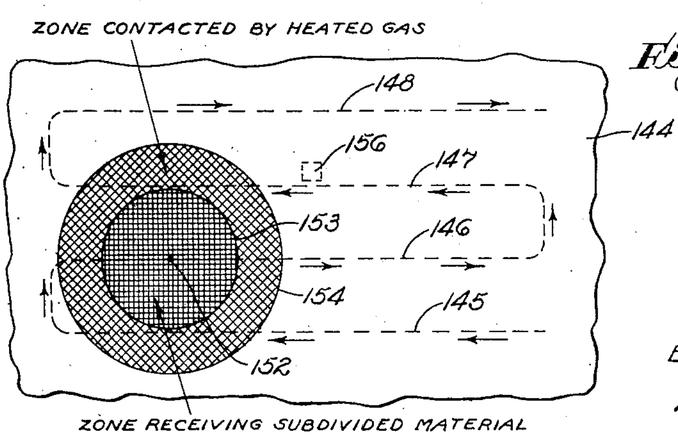


Fig. 6.



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UNITED STATES PATENT OFFICE

2,101,922

SPRAYING APPARATUS

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Application February 19, 1935, Serial No. 7,237

21 Claims. (Cl. 91—45)

My invention relates to devices and methods for applying coatings or deposits on a surface, and more particularly to a novel method and apparatus for spraying various materials onto such a surface for protecting or other purposes such as for water-proofing, acid-proofing, alkali-proofing, etc.

For purpose of definiteness and illustration the invention will be particularly described in conjunction with a novel water-proofing process which also produces an acid-proof and alkali-proof, though it should be understood that various materials can be applied and that various functions can be performed by the applied coating materials.

Various processes of applying water-proofing coatings are known to the art, but all are subject to many objections as to mode of application, effectiveness, or cost. Thus, it has been proposed to apply paraffin coatings to porous surfaces such as concrete, brick, rock, etc. by application of paraffin in melted condition by means of a brush. This process is not only objectionable in its mode of application but tests have demonstrated that the paraffin does not penetrate to the desired depth to be completely effective in the absence of auxiliary steps performed only at prohibitive cost. So also, one of the most widely used processes applies paraffin while dissolved in a solvent, evaporation of this solvent leaving a deposit of paraffin. This process is unsatisfactory for many existing conditions in that the resultant deposit is of a sponge-like character and will not completely prevent the passage therethrough of water or other liquids.

Generally speaking, the invention has two aspects, especially with regard to the problem of spraying materials such as paraffin. These two factors or aspects involved can best be explained and illustrated in conjunction with a paraffin-spraying system, and for this reason the invention will be particularly described with reference thereto, though it will be clear that somewhat similar factors are present in the spraying of various materials. In the first place, spraying any material such as paraffin has been heretofore impractical due to the fact that the atomized paraffin solidifies to form a snow as soon as it is discharged from the spraying device, thus preventing any material amount of penetration. In the present invention the atomized stream of paraffin or other material is protected from contact with the atmosphere as it moves toward the surface on which the deposit is to be formed. In the second place, the problem as to how to secure greater penetration of the coating material has been a serious and unsolved one. In the present invention greater penetration of the material is obtained by the proper application of heat, the spraying devices herein illustrated effecting a novel pre-heating and post-heating of a particular zone in the surface, as will be hereinafter described.

It is an object of the present invention to provide a novel method of spraying a material onto a surface and which has superior penetrating and pressure-withstanding powers, and which produces a coating which has superior protecting properties.

It is a further object of the invention to spray a liquid or powdered material onto a surface in such a manner that the material is protected from contact with the atmosphere during its travel from the spraying device to the surface.

Another object of the invention is to provide a novel spraying method in which the spray of subdivided material is surrounded by a moving stream of gas as it is projected toward the surface to be coated.

It is another object of the present invention to provide a novel method of spraying which is very satisfactory for use with materials which solidify upon cooling, such as paraffin, the material being atomized while in melted state and being prevented from cooling while in this atomized state by heat applied to the atomized material before it reaches the surface, or by surrounding the atomized material with an envelope of gas preventing direct heat transfer between the atomized material and the atmosphere.

A further object of the present invention is to provide a novel method of pre-heating and post-heating a zone of the surface to increase the penetration or otherwise increase the effectiveness or integrity of the coating.

It is another object of the present invention to provide a novel low-pressure method of spraying applicable to various uses and very satisfactory for spraying various materials.

The apparatus for supplying such a coating, constructed as shown or suggested herein, is also believed to be novel, and it is an object of the present invention to provide a novel concentric-stream spraying device for spraying various materials in subdivided form.

It is a further object of the present invention to provide a novel spraying device having a novel relationship between a heating means and the other elements of the device and also a device in which the heating means is of novel construction.

It is a further object of the invention to provide a heat-responsive structure in such a spraying device for indicating or controlling the temperature developed.

A further object of the invention lies in the provision of a spraying device with a main passage in which is positioned a tube, a stream of gas being moved through this tube and another stream of gas being moved through an annular space between the tube and the walls of the main passage.

It is a further object of the invention to provide an outer Venturi tube in conjunction with a tube therein, or sometimes in conjunction with a structure in which this tube is in the form of an inner Venturi tube, this double-venturi having been found to be very effective in producing the concentric streams.

Another object of the invention lies in the provision of a novel low-pressure spraying device, and is very satisfactory in spraying materials which solidify when exposed to the atmosphere.

Further objects and advantages of the invention will be made evident to those skilled in the art from the following description of several embodiments of the invention.

Referring to the drawings:

Fig. 1 is a vertical sectional view of one embodiment of the spraying device together with a wiring diagram of one mode of connection.

Fig. 2 is an end view partially in section taken as indicated by the line 2—2 of Fig. 1.

Figs. 3, 4, and 5 illustrate modified head structures which can be substituted for the head structure shown in Fig. 1.

Fig. 6 is a diagrammatic view illustrating the relationship between the concentric streams and a given zone of the surface to be coated.

In Fig. 1 I have illustrated one structure which falls within the objects enumerated above. The spraying device therein shown is of the manually-supported or portable type and includes a body structure 10. This body structure may be formed of a single member, but is preferably formed of a cylindrical shell 11 with a plate 12 extending across the forward end thereof and detachably connected thereto as by screws 13, this body structure forming a chamber 14 inside the shell 11.

Extending rearwardly in the chamber 14 are inner and outer tubular members 16 and 17 suitably secured at their forward ends to the body structure 10. In the embodiment shown the inner tubular member 16 is pressed into an opening of the plate 12, while the outer tubular member 17 is pressed into an opening of the shell 11. These tubular members are spaced from each other to define an annular space 19 into which a heating unit 20 extends.

This heating unit 20 may take any one of a various number of forms. In the embodiment illustrated it includes a rear head 21 and a forward-extending sleeve 22 formed integrally or separately of a suitable heat-resistant material such as baked fireclay, the material which I prefer using being "Alundum". The rear head 21 may be used to wholly or partially close the rear end of the chamber 14, being shown as being connected to the shell 11 by screws 23 which extend through a protecting ring 24 and through a packing of asbestos or other material 25 separating this ring from the rear head 21.

The sleeve 22 divides the annular space 19 between the inner and outer tubular members 16 and 17 into inner and intermediate annular passages 27 and 28. The forward end of the sleeve 22 terminates short of the plate 12 so as to throw the forward ends of these annular passages into communication, thereby providing a tortuous passage through which a stream of gas may be moved, as will be hereinafter described.

A suitable heating means 29 is supported by the sleeve 22 and is shown as comprising a coil of resistance wire wound helically around the sleeve 22. The several turns of this helically-disposed winding are permanently spaced from each other by winding the coil in a helical groove 30 which is preferably of greater radius of curvature than the coil itself. With such a construction it is possible to obtain a maximum heating of the gas moving through the intermediate passage 28 for the gas comes into contact with substantially all portions of the resistance wire, the only portion not contacted by the gas being the small portion thereof engaging the bottom of the helical groove 30. This gas is also heated by contact with the heated sleeve 22 as it flows therealong.

The requisite current may be supplied to the heating unit 20 through conductors 31 and 32 connected to suitable terminals of a socket 35 retained in the rear head 21. A plug 36 provides correspondingly placed terminals supplied with current through two conductors of a cable 37, these conductors being indicated by the numerals 38 and 39.

A stream of gas is supplied to the spraying device preferably through a handle 40 which may be formed of a length of pipe, the cable 37 extending therealong and being held in place by a cord or other member wound therearound. In many instances this gas can be air supplied to the handle 40 through a hose 42 detachably connected thereto, a suitable pumping means 43 being utilized, this pumping means being illustrated as a conventional low-pressure blower. The air moving upward in the handle 40 is discharged into an annular space 45 between the shell 11 and the outer tubular member 17, flowing peripherally around this tubular member and toward the rear end thereof as indicated by the arrows 46. This stream of gas then moves through the intermediate annular space 28 as indicated by the arrows 47, being therein heated by the coil of resistance wire and by contact with the heated sleeve 22. This air continues its movement through the tortuous passage by moving through the inner annular space 27 as indicated by the arrows 48, being additionally heated therein by contact with the sleeve 22 and being then guided so as to move as a main stream through the inner tubular member 16, as indicated by the arrows 49. If desired, this main stream may be given a rotary movement as it moves through the inner tubular member 16 by rifling the passage 50 defined thereby or by providing helically-disposed vane means 51 therein. However, it should be clear that it is not essential to the operativeness of the device that such a rotary movement be imparted to the main stream of gas, though this auxiliary factor is desirable in certain instances.

While separate sources may be utilized for supplying the concentric streams of atomized material and gas moving toward the surface to be coated, I prefer to divide the main stream of gas moving through the passage 50 into inner and outer streams, the inner stream being utilized to carry the subdivided material to the surface. In the embodiment shown in Fig. 1 this is accomplished by the use of a head structure 60 shown as comprising a head 61 detachably connected to the plate 12 and carrying a nozzle 62 extending forward from this head. The head structure 60 provides an opening 64 forming a part of the main passage and which, in the embodiment shown in Fig. 1, is in the form of an outer Venturi providing a throat 65 which is somewhat smaller in diameter than the rearward and forward flared portions 66 and 67 thereof. A tube 68 is centrally disposed in the opening 64, being preferably secured to the head 61 as by an arm 69. This tube 68 is of smaller diameter than the opening 64, the forward end thereof bounding an inner orifice means 70, this sleeve cooperating with the opening 64 in defining an outer orifice means 71 of annular shape.

Means is provided for supplying to the inner orifice means 70 the subdivided material. In the embodiment shown in Fig. 1 this is accomplished by forming the tube 68 as an inner venturi, the atomized material being discharged therefrom in or near the throat 65 of the outer venturi. This inner venturi is shown as providing a passage including a throat 73 and forward and rearward diverging portions 74 and 75. The rear end thereof is relatively sharp so as to divide the main stream of gas into two streams, one flowing through the passage of the inner venturi, and the other flowing through the annular space between the tube 68 and the walls of the opening 64.

The material to be atomized or subdivided is moved into the tube 68 preferably at a position adjacent the throat 73. A suitable passage means is utilized in this regard, being shown as including a vertical passage 77 extending through the arm 69 and communicating with a horizontal passage 78, the flow of material through these passages being controlled by the setting of a valve 79 shown in open position. A handle 80 serves to permit manual movement of this valve, the valve being closed when this handle is in its dotted-line position.

While any suitable conduit means may be utilized to supply the material to the passages 78 and 77, the preferred embodiment of the invention includes a receptacle 81 for this material and positioned in heat-transferring relation with the same heating unit 20 as is utilized for heating the gas. As best shown in Fig. 2 this receptacle is secured to flanges 82 extending sidewise from the shell 11 and cooperates with the upper periphery of this shell in defining a chamber 83, the lower portions of which are below the uppermost part of this shell, extending downward therearound. The material therein receives heat through the shell 11. Thus, in spraying paraffin the paraffin can be introduced into the chamber 83 in solid state, being therein melted.

The material flows from the lowermost portions of the chamber 83 through one or more passages 84 extending through the shell 11 and the plate 12 and opening on an annular chamber or groove 85 formed in the forward face of the plate 12, this groove being in communication at its upper end with the horizontal passage 78. The material thus flows by gravity from the receptacle 80 to the throat of the inner venturi. In addition, the reduced pressure in the throat of the inner venturi (due to the increased velocity of the gas flowing therethrough) acts to forcibly withdraw the material from the receptacle 80. In this connection it is possible with the structure shown to completely drain the chamber 83, a very desirable factor.

If desired, a nipple 87 may be positioned in the passage 77 to extend a distance into the throat of the inner venturi, the lower end being angled as shown. However, the use of such a nipple is usually not necessary, the device being entirely satisfactory if the material flows directly from the passage 77 into the throat 73. Regardless of whether or not the nipple 87 is utilized, it will be clear that the material moving through the passage 77 is picked up by the stream of gas moving through the inner venturi and is subdivided or atomized, the atomized material being delivered by the forward-diverging passage 74 to the inner orifice means 70. In the embodiment illustrated this atomized material is discharged toward a surface 88 in the form of an inner cone bounded by dotted lines 89.

In spraying certain materials it has been found very desirable to separate the atomized or subdivided material from the atmosphere. This may be desirable to prevent either physical or chemical changes in the material being sprayed or to hold the spray more intact. If paraffin is being sprayed, it is essential that the liquid paraffin particles in this spray be maintained in liquid state until they reach the surface 88. If these particles are allowed to cool, either by contact with a cool atmosphere or by excessive expansion of the gases discharged from the inner orifice means 70, solidification thereof will take place and it will be impossible to spray the paraffin in liquid state onto the surface 88. Such solidification can be avoided by applying heat to the atomized material after it is discharged from the spraying device, or by separating the atomized material from the atmosphere by a heat-insulating stream of gas which is usually itself heated, or by both of these expedients. In the embodiment shown in Fig. 1, both expedients are utilized, though it will be clear that these expedients can be separately utilized. In this connection it will be noted that the annular orifice means 71 discharges an annular stream of gas which is concentric with the stream of atomized material, the outer boundaries of this stream of gas being indicated by the dotted lines 90 of Fig. 1. This stream of gas tends to heat-insulate the stream of atomized material from the surrounding atmosphere. Further, in the embodiment shown in Fig. 1 this annular stream of gas is heated, thus further tending to prevent cooling of the atomized material. It is sometimes preferable to maintain this stream of gas at a temperature somewhat above the temperature of the atomized material, thus actually heating the atomized material further during its passage from the spraying device to the surface 88. In this connection it will be clear that while the temperature of the gas entering the inner venturi is the same as the gas moving through the annular space between the tube 68 and the walls of the opening 64, the atomized material moving from the inner orifice means 70 is somewhat cooler due to the addition of the somewhat cooler material to be atomized and due to any expansion which takes place in the forward-diverging passage 74. Thus, the temperature of the annular stream of gas discharged from the outer orifice means 71 is considerably higher, and by proper design the temperature of the surrounding conical stream of air can be maintained above the temperature of the atomized material moving toward the surface 88 so as to impart heat to this atomized material as it moves toward the surface to be coated.

In the spraying of paraffin or certain other materials, the problem of expansion in or beyond the forward-diverging passage 74 is an important one. I have found that in spraying such materials it is impossible to secure good results if the pressure of the pump means 43 is too high. Heretofore all spraying processes with which I am familiar have utilized pressures of from 20 to 100 lbs./sq. in. or more. While such pressures can be sometimes utilized in my spraying device in spraying certain materials, these pressures are entirely ineffectual to produce best results when spraying other materials such as paraffin, or other materials which solidify upon exposure to the atmosphere. With such materials I have found it desirable to utilize much lower pressures, using, in fact, as low a pressure as possible and still secure the desired atomizing action. With such materials best results are secured if the pressure in the main passage does not exceed a few pounds per square inch, with one or two exceptions pressures of not to exceed three pounds per square inch have been entirely satisfactory. In spraying paraffin and certain other materials I prefer to utilize as low a pressure as possible, the pressure being only sufficient to insure that the atomized material will move to the surface to be coated. Entirely satisfactory results have been obtained by utilizing pressures of twelve inches of water or less. One factor in this connection is, of course, the direction of movement of the sprayed material. If the spray is directed vertically upward, it is usually necessary to use pressures of between eight and twelve inches of water. When the spray is directed horizontally or vertically downward, pressures as low as four inches of water are very satisfactory.

There are several reasons for my utilization of low pressures in the preferred embodiments of my invention. In the first place, it is very desirable that the atomized particles be not impinged upon the surface 88 at such high velocity that they will rebound therefrom. This factor is especially important if the atomized stream is in the form of a cone, for if the velocity of the atomized particles is too high these particles will rebound from the surface 88 outward toward the surrounding stream of gas and sometimes therethrough so as to contaminate the surrounding atmosphere or be prematurely deposited in solid form on surfaces which are to be later coated.

In the second place, it is important to maintain the atomized paraffin particles in liquid state during passage from the spraying device to the surface 88. In this connection it is important to prevent cooling of these atomized particles to any great degree. If high-pressure gas is utilized for formation of the spray of atomized material, this gas excessively expands upon being discharged from the inner orifice means, thus necessarily cooling the atomized particles. As an example of this, I have found that if the temperature of the atomized stream of paraffin is 600° F. at the forward end of the nozzle 62, the temperature one-half inch in front of this position will be 590° F., and the temperature one inch in front of the first-named position will be 580° F. Thus, if the nozzle is one inch from the surface 88 (a spacing which will give entirely satisfactory results), the temperature drop will be approximately 20° F. On the other hand, with a similar spacing and utilizing high pressures, the temperature of the atomized material as it leaves the spraying device may be 800° F., dropping to 300° F. by the time that the atomized material reaches the surface, a drop in temperature of 400° F. This excessive drop in temperature is caused primarily by the greater expansion of the gas in the atomized spray, but is influenced also by the higher velocity of the outer stream of gas which tends to suck in a portion of the surrounding atmosphere, thereby cooling this stream of gas.

In the third place, higher pressures result in higher velocities of the concentric streams. As to the surrounding stream of gas, such higher velocities are detrimental in that excessive turbulence is set up when this stream contacts the surface 88. If lower velocities are utilized, this surrounding stream will flare outward adjacent the surface 88, creeping therealong rather than rebounding therefrom or creating excessive turbulence. This creeping action of the outer stream of gas is indicated by the dotted lines 90 of Fig. 1. Such a slower-moving stream of surrounding gas also offers greater resistance to spreading of the atomized stream when it contacts the surface 88.

In the fourth place, it is desirable that this surrounding stream of gas transmit to the surface 88 as many of the heat units per unit of time as possible. If high pressures are used, excessive expansion will result to defeat this purpose. By decreasing this expansion by the use of lower pressures this excessive cooling is eliminated and substantially all of the heat units in the gas are received by the surface in the preheating and post-heating steps. In this connection I prefer to use a relatively large quantity of heated gas moving toward the surface 88, thus more effectively heating same as will be hereinafter pointed out, rather than a lower quantity of gas moving at higher velocity and thus incapable of transmitting to the surface 88 the desired quantity of heat units. This expedient also avoids the excessive over-heating of the gas resulting if a high velocity stream is used and if the temperature at the point of impingement with the surface is controlled to be at or above a predetermined amount. Such over-heating of the gas will often detrimentally affect the material to be sprayed, many of these materials losing their effectiveness if heated to too great a degree preparatory to application to a surface.

I usually find it desirable to provide on or adjacent the spraying device a heat-responsive means either in the form of a simple thermometer or in the form of a thermostat so connected as to regulate the temperature of the gas. In the embodiment shown in Fig. 1, I position such a heat-responsive means in the path of flow of the gas as it moves from the intermediate passage 28 to the passage 50, being thus responsive to the final temperature of the gas delivered to this main passage. As shown, this heat-responsive means includes a coil of bi-metallic material 95 secured at one end through a pin 96 to a dial 97 of a heat-indicating means 98. This means is suitably encased in a shell 99 closed by a glass 100, the shell 99 being retained in a cavity of the rear head 21 in the preferred embodiment of the invention. The other end of the bi-metallic strip is secured to a pin 101 which carries a hand or pointer 102 moving across suitable graduations on the dial 97. Such a heat-responsive means will indicate to the operator the temperature of the gas entering the main passage 50.

In addition, it is sometimes desirable to utilize the heat-responsive means 98 as a thermostat to regulate the temperature of this stream of gas. In the embodiment shown this is accomplished by extending the hand 102 below the pin 101 to form a movable contact 104, which engages a stationary spring contact 105 when the temperature increases to or exceeds the desired degree, remaining out of contact therewith at temperatures between atmospheric temperature and the desired temperature to be maintained. These contacts are respectively connected to conductors 106 and 107 extending to corresponding terminals of the socket 35 and forming a part of a control circuit, the plug 36 containing correspondingly positioned terminals connected to conductors 108 and 109 of the cable 37, the latter conductors terminating in an auxiliary plug 110. A corresponding auxiliary socket 111 indicated by dotted lines continues the control circuit to include the secondary winding 112 of a step-down transformer 113, the primary winding of this transformer being connected across conductors 114 and 115 connected to a conventional plug 116. Also included in the control circuit in series with the secondary 112 is a winding of a relay 117, this winding being indicated by the numeral 118.

The conductors 39 and 38 carrying the main current to the heating unit 20 terminate in a main plug 120 adapted to fit in a main socket 121 from which extend conductors 122 and 123 corresponding to the conductors 39 and 38. The conductor 122 is connected to the conductor 114. The conductor 123 is connected to a contact 125 of the relay 117 through an impedance shown as comprising a resistor 127, and is also directly connected to a contact 126 of this relay. A movable contact member 130 of the relay 117 is normally retained in engagement with the contact 126 as by a spring 131. However, energization of the winding 118 of this relay moves this contact member 130 into engagement with the contact 125. A conductor 133 connects the contact member 130 to the conductor 115.

Assuming that the temperature is below the desired degree, the winding 118 will not be energized, and the contact member 130 will engage the contact 126. At this time current will flow from the conductor 115 through the contact member 130, thence through the contact 125, the conductors 123, 38, and 31 to the heating unit 20, returning through the conductors 32, 39, and 122 to the conductor 14, thus energizing the heating unit to a maximum degree.

As soon as the temperature reaches or exceeds the desired value, the contacts 104 and 105 close, thus completing the control circuit. At this time current flows through this control circuit from the lower terminal of the secondary 112, and successively through the relay winding 118, conductors 109 and 107, and thence through the contacts 105 and 104, returning to the secondary winding 112 through conductors 106 and 108. This will energize the winding 118 to move the contact member 130 into engagement with the contact 125. The effect of this change in position of the contact member 130 is to somewhat decrease the current flowing through the heating unit due to the fact that the resistance 127 is now in the main heating circuit. While it is sometimes possible to completely cut off the heating current when the temperature has reached the desired degree, it is usually preferable to merely decrease this current to a value insufficient to maintain the desired temperature. Such a system requires operation of the relay 117 at less frequent intervals.

It will, of course, be understood that the thermostatic system disclosed is only one of a number of control systems which can be utilized for controlling the temperature of the gas moving through the main passage 50. Furthermore, if it is not desired to automatically control the temperature, the control circuit can be rendered inoperative by merely disconnecting the auxiliary plug 110 and the auxiliary socket 111.

Various means may be utilized for driving the pumping means 43. In the preferred embodiment, I utilize an electric motor 140 in this capacity, connecting this motor across the conductors 114 and 115.

The superior penetrating properties of my method cannot be accounted for by any high velocity of the atomized particles, for when low pressures are used the impact of these atomized particles is not sufficient to force these particles any material distance into the surface. However, my process has been definitely shown to produce a deeper-penetrating coating than existing processes. Thus, for instance, in spraying paraffin on brick I have been able to secure penetrations of approximately two inches. In spraying ordinary concrete the penetration by use of my process will be from $\frac{1}{32}''$ to $\frac{1}{2}''$. With blown concrete this penetration will be even greater. Thus with my process it is possible to obtain penetrations far greater than with other processes, these greater penetrations being more than double or triple the penetration possible, for instance, by the use of a paraffin-coating process in which a single application of the paraffin is applied with a brush or in solution form.

This increased penetration is of great value in three respects. In the first place, paraffin deteriorates when subjected to ultra-violet rays such as are present in sunlight. The depth of penetration effected by my process prevents any action on the deeper-embedded paraffin through the action of ultra-violet rays, for these rays cannot penetrate sufficiently to affect such deeply embedded paraffin.

In the second place, the effectiveness of the coating is increased in proportion to the depth of penetration. For instance, if a water-proofing coating is applied by my process, the deeper penetration available makes possible the formation of an impervious coating which will allow no water whatsoever to move therethrough over an indefinite length of time. In this connection I have found my method of coating to be very effective in retaining moisture in a body of concrete by applying to the exposed surfaces of the concrete, shortly after the forms have been removed, a penetrating coating of paraffin or similar material. After this is done I have found that the concrete contracts materially less than would be the case if the surfaces thereof were allowed to remain in contact with the atmosphere. Furthermore, I have found that the contraction in such instance when utilizing my process is only one-fifth of the linear contraction which takes place if the best coating process now commercially available is utilized. I have furthermore found that by thus coating the surfaces of concrete after the forms have been removed the compression strength of the concrete is increased from 14% to 18%, and that the minute air-cracks ordinarily formed if the concrete is allowed to remain exposed to the atmosphere are entirely eliminated. These new results are due to the fact that my process is particularly effective in preventing escape of any of the moisture which still remains in the concrete, allowing all of this moisture to be equally distributed throughout the cross-section of the concrete, and permitting all of this moisture to be used for hydration. In conventional processes moisture distribution is not uniform due to the evaporation which takes place at the exposed surfaces of the concrete.

In the third place, I have found that my process produces a penetrating coating capable of withstanding high pressures. Thus, if paraffin is sprayed onto concrete by my process, utilizing only small quantities of paraffin (from 1/3 to 1/2 oz. per square foot), the resulting coating will withstand pressures exerted on the face of the coating of 360 pounds per square inch or more. Furthermore, if pressure is applied to the rear of the concrete, thus tending to force the paraffin from the coated surface, the coating applied by my process will withstand pressures in excess of 100 pounds per square inch without leakage or removal from the surface.

One factor in securing this increased penetration is the fact that the paraffin particles are all maintained in liquid state until they reach the surface, as distinct from other processes of applying hot paraffin in which a portion of the paraffin may prematurely solidify when applied with a brush or other applying means. Fundamentally, however, the deeper penetration effected by my process is caused by a novel preheating and post-heating effected by the enveloping hot stream of gas and can best be understood by reference to Fig. 6. Here I have indicated a portion of a surface 144 to be coated, this surface being of a porous character such as brick, concrete, etc. The sinuous dotted line formed by transverse lines 145 to 148, and the arrows adjacent this sinuous line, indicate the path of movement of the central axis of the spray of atomized material as the spraying device is moved to and fro in advancing relationship across the surface 144. I have indicated a given instantaneous position of this axis by the numeral 152. When in this given position the atomized stream will cover an area inside a circle 153, while the stream of heated gas will impinge against the surface in a surrounding area defined between the circles 153 and 154.

Considering the action which takes place in a zone 156 as the spraying device is moved to the right along the dotted line 146, it will be clear that this zone will be first pre-heated by contact with the upper quadrant of the stream of heated gas. When the spray is subsequently moved leftward axially along the dotted line 147, this zone will be additionally pre-heated by the side quadrant of the annular stream of gas. Further leftward movement along the line 147 will bring the zone 156 in the atomized spray, so that after two pre-heating steps the paraffin, for instance, is applied to the zone 156, without permitting any cooling between the second pre-heating step and the application of paraffin. As the spray is moved leftward a further distance along the dotted line 147, the zone 156 will be post-heated by the other side quadrant of the stream of gas. So also, when, at a later period of time, the spray is being moved rightward along the dotted line 148, the zone 156 will again be post-heated by the lower quadrant of the heated stream of gas.

Pre-heating this zone 156 causes expansion of the gases near the surface of the porous surface, thus expelling a portion of these gases. If the paraffin is immediately sprayed onto such a preheated surface, it reaches this surface at such time as a portion of the air has thus been expelled from the pores. So also, the paraffin does not immediately solidify in view of the fact that the pre-heated surface is sufficiently hot to prevent quick solidification, and due to the fact that after this application of paraffin the post-heating step prevents such solidification. By post-heating the zone 156, the paraffin is maintained in liquid form and is forced deeper into the pores. As soon as the post-heating has been completed, the heated air in the pores rapidly cools by heat conduction. Primarily the heat flows to the deeper-embedded portions of the concrete, and secondarily heat flows to the surrounding atmosphere. The result is that the cooling air contracts before the paraffin has solidified, this contraction drawing the paraffin into the pores and thus effecting a much deeper penetration than has heretofore been obtainable. Successive post-heating is desirable in that it tends to further increase this depth of penetration.

While the temperature of the gas entering the main passage can vary over wide limits with most materials, I have found it desirable to utilize rather high temperatures in the spraying of materials such as paraffin. I prefer to utilize a very high-grade paraffin such, for instance, as Borneo paraffin, utilizing temperatures of from 550° F. to 660° F., the temperature of 600° F. being found very satisfactory in spraying paraffin. However, no fixed temperature can be set forth for all materials. Thus, in spraying asphalt it is possible to utilize somewhat lower temperatures, while in spraying sulphur-silica temperatures between 250° F. and 280° F. may be utilized, though best results are obtained with temperatures from 265° F. to 275° F. In spraying the more critical materials, such as sulphur-silica, it is very desirable to use a thermostatic means. Regardless of the material being sprayed, the temperatures utilized should not exceed the flash-point of such material.

Alternative spraying devices capable of forming the concentric streams are disclosed in Figs. 3, 4, and 5. Referring particularly to Fig. 3, I have illustrated a modified form of head structure detachably connected to the plate 12 in place of the head 81. This embodiment utilizes a tubular construction including a head member 200 spaced from a forward member 201 by an outer sleeve 202, an inner sleeve 203 also extending between these members and cooperating with the outer sleeve 202 and defining an annular space 204. The main stream of gas is conducted from the inner tubular member 16 to the inner sleeve 203 so that the main passage in this form of the invention is formed by both of these elements, this main passage being indicated by the numeral 205.

Positioned in this main passage is a tube 206 shown as being in the form of an inner venturi similar to the structure shown in Fig. 1 and being supported by an arm 207 of the forward member 20. The nozzle 208 is detachably connected to the forward member 201 and forms a passage 209, this nozzle preferably comprising an outer venturi, the throat of which receives the atomized material discharged from an inner orifice 210 defined by the inner venturi. Similarly, an outer orifice 211 is provided to form the annular stream of gas.

In this embodiment of the invention the material to be sprayed is introduced through a passage means 215 of the head member 20, the flow being controlled by a valve 216. The passage means 215 communicates with a pipe means 217 disposed in heat-transferring relationship with the gas moving through the main passage 205. A preferable mode of effecting this result is to form the pipe means 217 in the form of a helix extended in the annular space 204. The forward end of this pipe means communicates with the throat of the inner orifice means through a suitable valve 218. This valve may be used alternatively with the valve 216. Usually, however, it is sufficient if the valve 218 acts as a regulating means to control the maximum flow of the material introduced into the inner venturi. Material may be supplied to the passage means 215 from the receptacle 80 in which event a dual heating of the material will be effected, the material being preliminarily heated in the receptacle and being further heated in the pipe means 217. In other instances, the passage means 215 can communicate with a pipe or hose 220 acting to supply the material to the pipe means 217 to be heated therein before atomization.

The type of head structure shown in Fig. 3 can be used with various materials. However, it is particularly applicable to the spraying of such heavy liquids as tarry substances, for instance, asphalt. However, paraffin and various other coating materials can be successfully sprayed with this type of construction.

In Fig. 4 the head structure includes a head member 230 with a sleeve 231 extending forward therefrom and cooperating in forming the main gas passage. A forward member 232 provides a cavity into which this sleeve extends and provides an opening 233 which converges forwardly. In this embodiment the tube, such as the tube 68 or 206 previously described, it is not in the form of a venturi but comprises a relatively long tube 235 bounding an inner orifice means 236 at its forward end and cooperating with the opening 233 in defining an outer orifice means 237 of annular shape. This tube 235 is closed at its rear end by any suitable means, such as a central member 238, which may serve to support this tube, being in turn supported by an arm 239 of the head member 230.

The passage means delivering the material includes in this embodiment an inner tube 241 carried by the central member 238 and extending forward in the tube 235 to a position beyond one or more openings 242 formed in the tube 235.

In this embodiment the main stream of gas is divided into two streams, one being an annular stream and being discharged through the outer orifice means 237, and the other being a stream formed inside the pipe 235 when a portion of the gas moves through the openings 242 and forward through the annular space between the tubes 235 and 241. The latter stream of gas forcibly withdraws the material from the inner pipe 241 and thus from the passage means, acting to atomize this material as soon as it is discharged from this inner tube. In this embodiment I have not found it necessary to utlize venturis for purposes of atomization or for producing the concentric streams.

In Fig. 5 is shown a modified head structure including a head member 250 secured to the plate 12 and providing a nozzle 251 which may be formed integrally therewith. This nozzle provides an opening 252 which is preferably, though not necessarily, of Venturi shape. The central member 238 and its supporting arm 239 are substantially the same as indicated in Fig. 4, supporting the tube 235 and the inner tube 241. However, the openings 242 in this embodiment are positioned in the intake passage of the venturi so that a portion of the main stream of gas moves through these openings into the annular space between the tubes 235 and 241. The remaining gas from this main stream is discharged through an outer orifice means 255 between the tube 235 and the walls of the opening 252. Preferably both of the tubes 235 and 241 terminate near the throat of the venturi, very satisfactory results having been obtained by extending the inner tube 241 a slight distance beyond the forward end of the tube 235. The atomizing action is such that an inner stream of subdivided material is projected, being enveloped by a moving stream of hot gas as previously described, atomization taking place at the forward ends of the tubes 235 and 241. The action of this construction can sometimes be improved by using helically disposed vane means 260 in the main passage.

The head structures shown in Figs. 4 and 5 can be used for various materials, including the materials previously suggested. They are particularly adapted for spraying such materials as sulphur-silica.

The spraying devices herein described can be used at various spacings from the surface to be coated. On the smaller units herein described this distance is usually less than 6 inches, though larger spacings can be used. This spacing depends in part upon the temperature of the surrounding atmosphere and the surface to be coated. Usually on hot days or when the surface is already warm the larger spacings can be used to best advantage, while on cooler days or when the surface is rather cool the smaller spacings are more desirable.

It will be clear that my invention is not limited to the particular embodiments herein disclosed, finding utility in various capacities wherein it is desirable to coat a surface for waterproofing, protecting, or other purposes. While I have particularly described the spraying of liquids by atomization or subdivision thereof, my invention can also be used to spray various other materials in powder or granular form, the surrounding stream of gas serving to separate the sprayed material from the surrounding atmosphere. Nor is it necessary to the utility of my invention that coatings of a penetrating nature be always applied. For instance, the sulphur-silica previously mentioned will not materially penetrate but will bond very effectively to various surfaces.

I claim as my invention:

1. In a spraying device of the character described, the combination of: a head structure providing an opening therein; a tube disposed in said opening and bounding an inner orifice means, said tube being smaller than said opening in said head structure to provide an annular orifice means surrounding said inner orifice means; a tubular member extending rearward from said head structure in axial alignment with said opening of said head structure; heating means surrounding said tubular member; means for flowing a stream of gas through said tubular member, said stream being heated by said heating means, a portion of said stream of heated gas flowing through said tube and another portion of

said heated gas flowing around said tube and through said annular orifice means; and means delivering the material to be sprayed to said tube whereby said material is picked up by said stream of heated gas moving through said tube and is discharged from said inner orifice means, the heated gas flowing through said annular orifice means being discharged in enveloping relationship with said material.

2. In a spraying device of the class described, the combination of: inner and outer tubular members spaced from each other to define an annular space; means closing one end of said annular space; annular heating means extending into the other end of said annular space to form same into a tortuous passage one end of which communicates with said inner tubular member; means for delivering a stream of gas through said tortuous passage to be heated by said annular heating means, said heated gas discharging from said tortuous passage into said inner tubular member; orifice means receiving the heated gas from said inner tubular member; and passage means for delivering a material to be sprayed to said heated gas.

3. In a spraying device of the class described, the combination of: a body structure providing a chamber; a rearward-extending tubular member attached to said body structure and extending rearward in said chamber; an annular heating unit around and spaced from said tubular member; means for flowing a stream of gas between said heating unit and said tubular member and thence into said tubular member; an atomizing means associated with said body structure and receiving at least a portion of said heated gas; and means for delivering the material to be sprayed to said atomizing means.

4. A combination as defined in claim 3 including a heat-responsive means in the path of flow of said hot gas as it moves from the space between said heating unit and said tubular member and into said tubular member.

5. In a paraffin spraying device of the character described, the combination of: walls defining an inner orifice means and an annular orifice means therearound; means for flowing simultaneously through said orifice means relatively large-quantity but low-pressure streams of heated air, said means including a blower, a heating means for said air and means delivering a portion of the heated air to each of said orifice means; and means for delivering molten paraffin to said inner orifice means whereby the inner stream of air carries particles of molten paraffin to the surface to be coated and the stream of heated air moving through said annular orifice means forms a protecting envelope for said inner stream during its passage to said surface.

6. A method of applying to a surface a coating of paraffin, which method includes the steps of: heating said paraffin until it is molten; spraying said paraffin onto said surface in molten condition and in atomized state by moving toward said surface an inner stream of low velocity hot air containing atomized paraffin; and protecting said stream of atomized paraffin from contact with the atmosphere by surrounding said stream with a moving annular envelope of heated gas flowing toward said surface in concentric relation with said inner stream of atomized paraffin.

7. A method of applying to a surface a coating of paraffin, which method includes the steps of: heating said paraffin until it is molten; atomizing said molten paraffin; moving said atomized paraffin while dispersed in a stream of heated air toward said surface from a position spaced therefrom; and applying heat to said stream of atomized paraffin as it flows through space from said position spaced from said surface toward said surface to insure that the atomized paraffin will reach and be deposited on said surface in molten condition.

8. A method of applying to a surface a coating of paraffin, which method includes the steps of: moving a relatively low-velocity stream of heated gas through and from a passage toward said surface, the impelling pressure in said passage being not in excess of twelve inches of water to eliminate excessive cooling of said stream of gas such as would be caused by excessive expansion after leaving said passage when utilizing higher impelling pressures; entraining in said stream of heated gas molten particles of paraffin which are carried to said surface by said stream of heated gas, any expansion of said stream of heated gas taking place after discharge from said passage being minimized by said low impelling pressure; and surrounding said stream of heated gas with a low-velocity concentric stream of hot gas moving concurrently and in contact therewith and of a temperature above the melting point of paraffin.

9. A method of applying to a surface a coating of material, which method includes the steps of: heating a flowing stream of gas; dividing said stream of heated gas into two concentric inner and outer streams flowing concurrently toward said surface; and introducing into and entraining in said inner stream particles of the material to be sprayed, which particles are at a temperature slightly below the temperature of said heated gas, whereby said inner stream is slightly cooled to allow said outer stream of gas to be somewhat warmer, thereby supplying heat to said inner stream of gas during movement toward said surface.

10. A method of applying to a surface a coating of paraffin, which method includes the steps of: flowing from a position spaced from said surface a moving annular stream of heated but non-burning gas; moving toward said surface and inside said annular stream of heated gas molten particles of paraffin, the inner stream of air occupying the entire space inside the annular stream, the temperature of said annular stream of heated gas being above the melting point of said paraffin; and applying said annular stream of heated gas and the molten particles of paraffin to successive areas of said surface by moving said stream and said molten particles relative to said surface during application of said molten particles to said surface, whereby a given area of said surface is first pre-heated by said heated gas on one side of said annular stream, then immediately receives a deposit of said paraffin particles, and is then post-heated by said heating gas on the other side of said annular stream, after which said given area is cooled by contact with the atmosphere.

11. A method of spraying a surface with paraffin which includes the steps of: flowing an annular stream of non-burning gas heated to a temperature above the melting temperature of paraffin toward the surface to be sprayed, and moving molten paraffin particles toward and into contact with said surface inside said annular stream of gas by means of a stream of hot air and in heat transferring relationship therewith

whereby said particles are heated during such movement.

12. In a spraying device of the character described, the combination of: a head structure having an opening therein; means for delivering a stream of low pressure non-combustible gas to said opening; means in said opening for dividing said stream of gas into inner and outer substantially concentric streams, said means including a tube disposed in said opening, said tube having an annular edge adapted to pierce said stream, whereby said inner stream may flow through said tube and said outer stream may flow through the space between said tube and the walls of said opening; passage means communicating with the interior of said tube; and means for delivering to said passage means, and thus to said inner stream of gas moving through said tube, the material to be sprayed, whereby said material may be picked up by said gas constituting said inner stream and discharged inside said outer stream of gas and against a surface to be coated, the low pressure of said gas preventing such spreading or mixing of said streams as would prevent a smooth flow of concentric streams from said head to a surface to be coated.

13. A combination as defined in claim 12, including means for heating the stream of gas before it reaches the annular edge of the tube.

14. A combination as defined in claim 12, in which the pressure of the stream of gas is not in excess of twelve inches of water.

15. A combination as defined in claim 12, including means for heating the stream of gas before it reaches the annular edge of the tube, and in which the pressure of said stream of gas is not in excess of twelve inches of water.

16. A combination as defined in claim 12, in which the tube is a Venturi tube.

17. A combination as defined in claim 12, in which the means for delivering the stream of low pressure gas to the opening includes a blower.

18. In a spraying device of the character described, the combination of: a head structure providing an opening therein; a tube disposed in said opening and bounding an inner orifice means, said tube being smaller than said opening in said head structure to provide an annular orifice means surrounding said inner orifice means; a tubular member extending from said head structure in axial alignment with said opening of said structure; means for flowing a stream of gas through said tubular member, a portion of said stream of gas flowing through said tube and another portion of said stream of gas flowing around said tube and through said annular orifice means; heating means adjacent said tubular member for heating said gas before it enters said tubular member; and means delivering the material to be sprayed to said tube, whereby said material is picked up by said stream of heated gas moving through said tube and is discharged from said inner orifice means, the heated gas flowing through said annular orifice means being discharged in enveloping relationship with said material.

19. In a spraying device of the class described, the combination of: a body structure providing a chamber; a tubular member attached to said body structure and extending within said chamber; an annular heating unit around and spaced from said tubular member; means for flowing a stream of gas between said heating unit and said tubular member and thence into said tubular member; an atomizing means associated with said body structure and receiving at least a portion of said heated gas; and means for delivering the material to be sprayed to said atomizing means.

20. A combination as defined in claim 19, including a heat responsive means in the path of flow of said hot gas as it moves from the space between said heating unit and said tubular member and into said tubular member.

21. In a device for spraying material upon a surface, the combination of: an outer venturi providing a throat and a flared portion extending from said throat toward the surface to be sprayed; an inner Venturi tube providing a throat and bounding an inner orifice means at one end, said outer venturi opening directly to the atmosphere and said inner Venturi tube being within the outer venturi, said inner orifice means being disposed adjacent the throat of said outer venturi, said inner Venturi tube being smaller than said outer venturi and cooperating therewith in forming an annular orifice means; means for flowing gas through and from said inner and said annular orifice means to form concentric streams moving through the atmosphere to the surface to be sprayed; and means for introducing the material to be sprayed into said throat of said inner Venturi tube to be picked up by said gas flowing therethrough and discharged from said inner orifice means inside the annular stream of gas discharged from said annular orifice means.

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