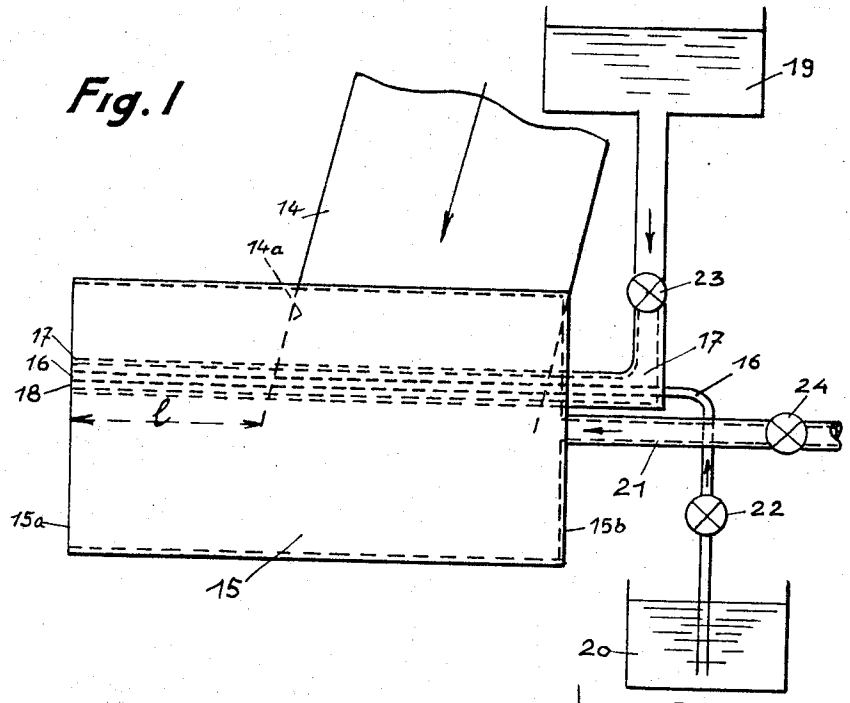
Sept. 5, 1967 R. C. M. GUETET 3,339,846

APPARATUS FOR BLOWING COMMINUTED TREATING MATERIAL ONTO PLANTS AND THE LIKE

Filed April 12, 1966 2 Sheets-Sheet 1

Fig. 1



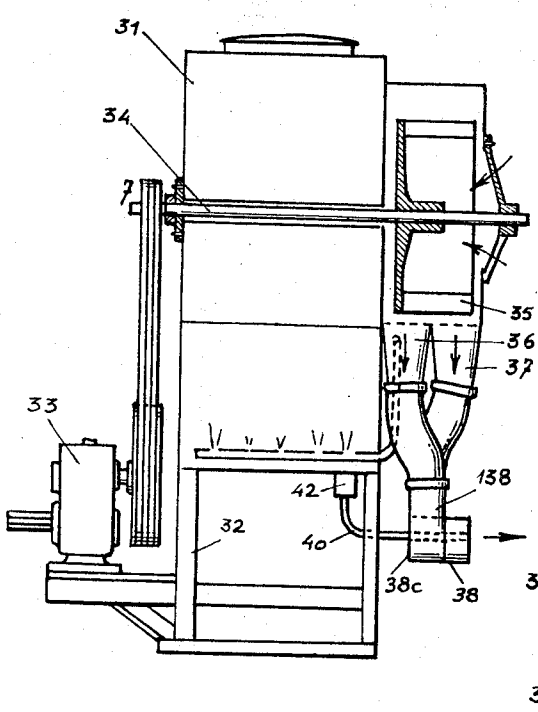


Fig. 3

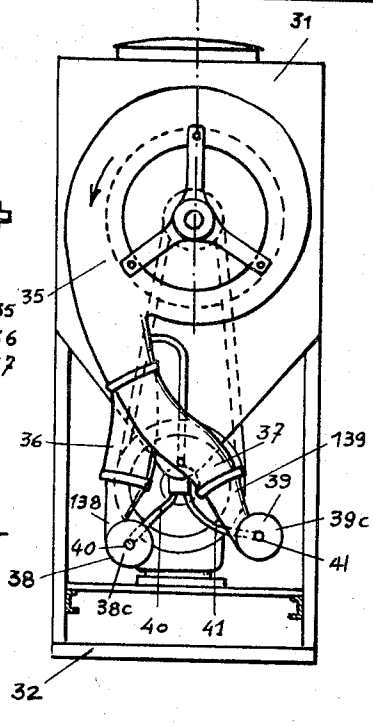


Fig. 2

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APPARATUS FOR BLOWING COMMINUTED TREATING MATERIAL ONTO PLANTS AND THE LIKE

Filed April 12, 1966 2 Sheets-Sheet 2

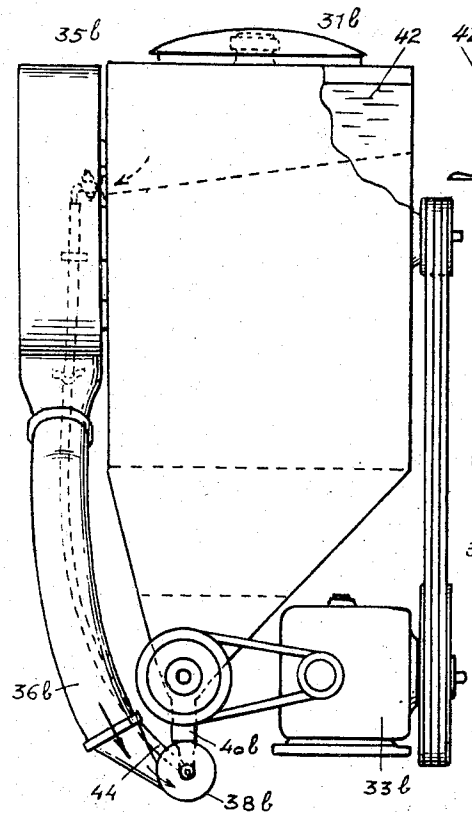


Fig. 6

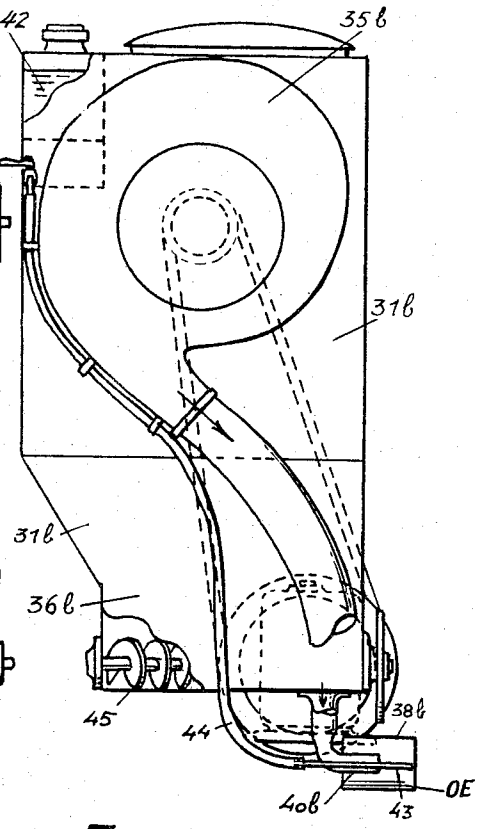


Fig. 5

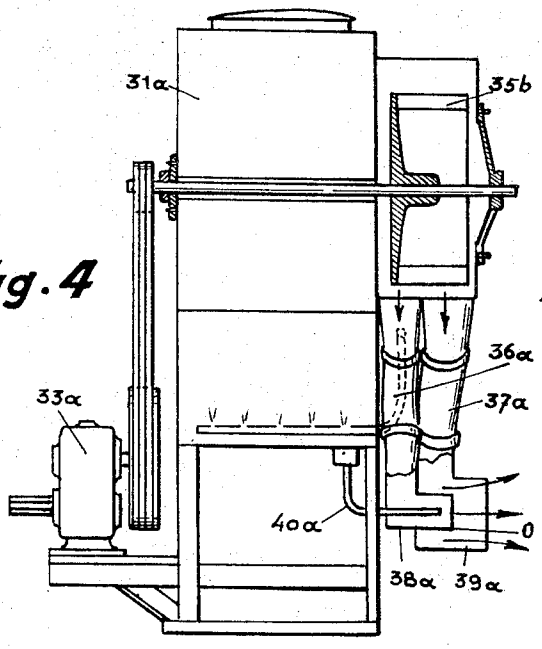


Fig. 4

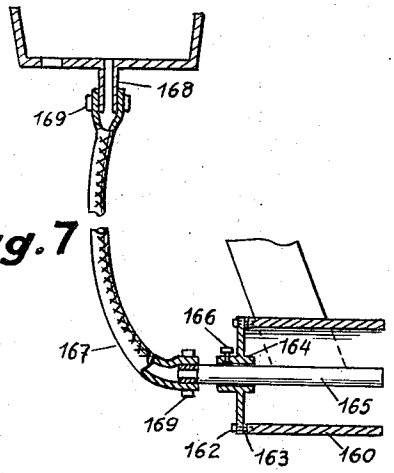


Fig. 7

United States Patent Office

3,339,846

Patented Sept. 5, 1967

3,339,846

APPARATUS FOR BLOWING COMMINUTED TREATING MATERIAL ONTO PLANTS AND THE LIKE

Robert Charles Marie Guetet, 39 Ave. de Friedland, Paris, France

Filed Apr. 12, 1966, Ser. No. 542,059
Claims priority, application France, Oct. 24, 1962, 913,260, Patent 1,455,762
6 Claims. (Cl. 239—304)

This application is a continuation-in-part application of the U.S. patent application Ser. No. 318,374, now abandoned, filed by the same inventor on Oct. 23, 1963.

The present invention relates to the problem of projecting in a continuous manner at a certain distance through the atmosphere or through another similar gaseous medium a gaseous material, the path of which forms a jet charged with either liquid, gaseous or solid particles of another material or of a number of other materials. The invention is more especially although not exclusively concerned with the formation of such a jet having a range of several meters and a substantial diameter, say of more than one foot, preferably of several feet.

Accordingly, the object of the present invention is to produce an appliance for generating such a jet which is additionally endowed with rotational motion. Therefor the invention makes use of a free spiral vortex flow.

It is known that a "free spiral vortex" flow pattern results from the superposition of two types of flow, one being known as a "radial flow" and the other being known as a "spiral vortex," both having a velocity potential. A fact which has been brought out by mathematical study is that the radial velocity of a radial flow as well as the tangential velocity of rotation of a spiral vortex increase in inverse ratio to the distance from the center and that at the same time, each increase in velocity is accompanied by a pressure drop, the partial vacuum thereby created consequently becoming very strong in the vicinity of the vortical axis. The pressure gradient also increases progressively towards the axis. Finally, both the theoretical study and experimental study of said "free spiral vortex" flow pattern in three-dimensional space bring out the fact that the axial velocity of flow increases to a considerable extent from the periphery to the axis. The foregoing properties taken as a whole result in the formation of a rotational cyclonic jet which is endowed with special characteristics. The velocity of translation of the jet as well as the tangential velocity of rotation thereof decrease from the center to the periphery of said jet, and this characteristic feature permits novel results to be obtained which are of particular interest and value in the case of certain applications which will be specified below. Furthermore, the partial vacuum which is created by the formation of said flow makes it possible to distribute within the vortical stream forming the jet any particles desired, whether gaseous, solid or liquid particles, and even makes it possible as a result of its action alone to atomize therein in a very finely divided state either one or a number of liquids. Among the possible uses of an appliance according to the invention, there can be mentioned as examples: the industrial sand-blasting of surfaces to be cleaned, burred, scoured, engraved, etc., the fire-fighting by a jet charged with antioxygen particles or other particles having an extinguishing action such as particles of carbonate of lime, for example, or both.

Another application of appliances for producing cyclone jets in accordance with the invention is the use thereof as flame-throwers, especially in appliances for clearing undergrowth by fire, the jet being in that case charged with fuel particles which are either solid, liquid or gaseous. By additionally incorporating smoke-producing particles with said jet, the appliance thus becomes a fumingator which is effective for the protection of crops against frost.

However the main application is the use of said appliances for processes which are already known per se and which involve the treatment of plants and crops by means of jets of suitable products. In this application, the special properties of the cyclonic jet which is generated by a free spiral vortex flow produces novel effects. It accordingly follows that the rotational flow motion of the jet facilitates the penetration thereof within the interior of even the most dense foliage, with the result that the treatment is also applied to the underface of each leaf. The foliage is thus veritably immersed and agitated within the interior of the full rotational jet which is formed and is subsequently treated from all angles on both faces of the leaves. The distribution of the treatment product over plants is accordingly characterized by exceptional uniformity and prevents excessive local applications which are liable to result in damage to the parent plant as well as insufficient local applications. In addition, on account of the difference in axial velocities, the penetration in the foliage is selective or in other words is of maximum value along the axis or center-line of the jet whereas the peripheral portions of the jet which have a lower penetrating power mainly treat the superficial layers of foliage. This distribution is rational inasmuch as those surfaces of the foliage which are to be treated are larger and more widespread when located at a distance away from the stem or trunk than those which are located in the immediate vicinity of this latter. The shape of the jet also offers a very special feature inasmuch as the jet expands to a substantial extent as soon as it emerges from the device and is flared out at an angle which can reach 70° over a short distance of the order of one meter. This enlarged portion is then sharply narrowed so as to reduce the angle of divergence to only a few degrees. Moreover, the velocity of longitudinal flow as well as the velocity of rotation of the jet decrease to a very considerable extent as soon as the jet is discharged so as to be scarcely higher than 3 to 4 meters per second at a distance of one meter from the orifice whereas in the interior of the discharge orifice itself, these velocities reach nearly a hundred meters per second in the vicinity of the axis. The result thereby achieved is a very gentle action on plants and affords the possibility of carrying out the treatment at a very short distance on tender shoots or on fruit-tree blossom. In spite of this very marked deceleration, the overall kinetic energy of the jet is not reduced inasmuch as the mass of this latter is increased by a substantial influx of air which is derived from the ambient air and which penetrates in a forward direction into the central portion of the jet, namely into the zone of substantially reduced pressure, thereby producing the expansion and deceleration which have been noted above, said influx of air being in turn accelerated at the expense of the jet which is discharged at high velocity from the orifice of the generator body. There finally results from this assembly as a whole a better treatment, a substantial economy of means and of motive power as well as a lower consumption of treatment material. In fact, systematic experiments carried out (by the research station at Fernhurst, Sussex, England) have proved that a few drops of product per leaf are sufficient. The essential requirement in practice is to obtain atomized droplets of the order of 30 to 100 microns since in that case, for a same flow rate, the number of droplets produced is sufficient to carry out a treatment with small quantities of water (for example between thirty and sixty liters of water per hectare (2½ acres) instead of the usual two or three hundred liters), either by increasing the concentration of the treatment

product or even by retaining the ordinary concentration of the treatment product. The saving of water can reach 60 to 80% (article by Professor Lacombe published June 15, 1958, in the French magazine called "Progres Agricole"), which is of substantial interest in areas which do not have an abundant water supply and, in all cases, achieves an appreciable saving in time since the apparatus needs to be replenished with treatment liquid at much less frequent intervals.

A more specific object of the invention hence is to provide an apparatus by means of which it will be possible to spray and/or powder plants of any kind, blossoms and the like at very short distance without damaging them in any way by the flow impact.

Various forms of embodiment of appliances designed in accordance with the invention have been illustrated in the accompanying drawings which are given solely by way of example and not in any limiting sense, and in which:

FIG. 1 illustrates diagrammatically a jet discharging nozzle to be used according to the invention in an apparatus for delivering into the atmosphere a jet of air carrying comminuted material;

FIGS. 2 and 3 show respectively in profile and in front view an apparatus which is applicable in particular to the protection of crops and which is provided with jet discharging nozzles adapted to operate as the nozzle illustrated in FIG. 1;

FIG. 4 is similar to FIG. 2 and illustrates an appliance of the same type as that shown in FIG. 2 but wherein the elements for generating the rotational jet have been slightly modified;

FIGS. 5 and 6 are views, respectively similar to FIGS. 2 and 3, illustrating an appliance of the same type but which is adapted for the projection and even simultaneous projection of particles of two different products, more especially of a product in powdered form and a product in liquid form; and

FIG. 7 is a fragmentary view illustrating a nozzle body having a detachable end portion and an axially adjustable feed tube associated therewith.

In the form of embodiment which is illustrated in FIG. 1, the jet discharging nozzle comprises a body or nozzle which is generally designated by the reference **15** and which is cylindrical from one end to the other, one end **15***a* being open while the other end **15***b* is closed. The body **15** is provided over a portion of its length starting from the closed end with an intake conduit **14** which has its opening **14***a* tangentially to the cylindrical wall of said body.

The operation is as follows:

When a stream of fluid which is fed in any suitable manner penetrates inside the body **15** through the tangential orifice **14** and emerges from said body through the circular orifice **15***a* which is located opposite to the closed end, the flow pattern obtained is of the free spiral vortex type. It is known that the flow pattern which is referred to in fluid mechanics as a free spiral vortex results from the addition of two potentials φ_1 and φ_2, one of which is:

$$\varphi_1 = U \text{ arc } \tan \frac{y}{x}$$

which defines a free vortex, x and y being the co-ordinates of a point of the flow and U being a parameter; and the other,

$$\varphi_2 = \frac{Q}{2\pi} \log \frac{r}{a}$$

being a radial flow pattern in which Q is the rate of flow, r the distance from a point of the flow to a fixed point or center, and a is a parameter.

In the case of the first, the stream lines are circles; in the case of the second, the stream lines are half-straight

lines which converge towards the center. The flow velocity in the first case is

$$V_1 = \frac{U}{\sqrt{x^2+y_2}} = \frac{U}{r}$$

and is therefore inversely proportional to the radius, in other words the kinetic moment $V_1 r$ is constant; in the second case, the flow velocity is

$$V_2 = \frac{Q}{2\pi r}$$

therefore also inversely proportional to the radius.

The addition of the two potentials $\varphi_1 + \varphi_2$ gives a resultant flow such that the stream lines thereof are logarithmic spirals having the same angle.

Since the flow is irrotational, there is no exchange of energy within the stream, with the result that the conservation of the kinetic moment on the one hand and the radial acceleration on the other make it necessary, in order to ensure that the energy of the fluid does not change, that there should take place a conversion of the potential energy of the fluid into kinetic energy, in particular a conversion of fluid pressure to fluid velocity when said fluid is considered as being subject to practically no variation in volume during its motion. At a point located at a distance r from the axis, this pressure drop dp has the form

$$dp = \frac{dr}{r_3}$$

The pressure gradient is therefore particularly high in the vicinity of the center.

No consideration has been given in the foregoing to a three-dimensional flow, the flow pattern of the radial type being a plane flow which presupposes a disappearance of the fluid at the central point referred-to as the "well." In practice, the fluid disappears when flowing through said circular orifice; this transformation of a plane flow into a flow along an axis at right angles to said plane flow entails a progressive incurvation of the radial velocity at each point of the flow. The stream filaments of fluid which penetrate inside the body **15** at the end of the intake conduit **14** which is most distant from the closed end are deflected towards the outlet orifice as soon as they pass into the body **15** and flow along the cylindrical surface thereof. Those stream filaments which are located a little further away from the intake conduit **14** are deflected above the filaments previously mentioned, therefore within slightly closer proximity to the axis of the orifice, that is to say after having acquired a higher radial velocity which subsequently endows said filaments with a higher axial velocity as a result of said deflection, this progression thus continuing from point to point up to those stream filaments which pass into the apparatus in the vicinity of the closed end opposite to the outlet orifice, these latter stream filaments being the most central components of the spiral vortex which flows out through the orifice of the body **15**. The fact noted above has been confirmed by experiment. Accordingly, not only do the tangential velocities of rotation of this flow in three-dimensional space increase from the periphery to the axis with a correlative reduction in pressure of the fluid, but the axial velocities of flow also increase from the periphery to the axis.

It is the spiral vortex noted above which emerges from the open end of the nozzle body **15** which forms as a result of its motion the requisite rotational jet having the characteristic properties hereinabove set forth.

A particular arrangement which is of interest in certain cases is to make the base or closed end of the vortex-generating body readily detachable, or at least a portion of said body which is traversed by the means for supplying the material to be distributed within the main stream, and to support said means by the detachable base or by said detachable portion of the base, for instance by a plate

securable to said body by screws. It is thus extremely easy to modify a device to permit of its use for various purposes such as the dispersion of a powder, atomization of a liquid, simultaneous dispersion and wetting of a powder, etc.

FIG. 7 shows an arrangement in which the nozzle body **160** has an end plate **161** detachably secured thereto. This end plate is held in place by screws **162**. A suitable washer **163** is interposed between the periphery of the end plate and the nozzle body. The end plate is provided with a tubular boss structure **164** through which is slidably fit a supply tube portion **165**. As is conventional, a set screw **166** secures this tube **165** in an axially adjustable position within the nozzle body. The feed of the material is effected through a flexible hose **167** which is secured at one end to a depending nipple **168** on a feed tank and at the other end to one end of the tube **165** by conventional means such as C-clamps denoted diagrammatically at **169**.

As shown in FIG. 1, the body **15** is traversed from end to end in the direction of the eccentric axis of the spiral vortex which is generated by said body **15** by two concentric tubes **16** and **17** which form relatively to each other an annular passage **18**. As indicated in the figure, these tubes are laterally offset from the axis *l* of the body **15** which, as stated, is cylindrical. Said two tubes terminate substantially at the level of the jet discharge orifice, open end **15***a*, and pass in fluid-tight manner through the opposite base or closed end **15***b* of the tubular body. The outer tube **17** communicates with a feed tank **19** located so as to provide a small pressure head on the orifice or outlet of said tube **17** at the outlet end **15***a* of the body **15** while the inner tube **16** passes through the wall of the outer tube **17** and extends down into a feed tank **20** which is located at a lower level than the discharge orifice of the tube **16** at the open outlet end **15***a* of the body **15**. These two feed tanks **19** and **20** are each intended to contain either liquid, powdered or gaseous material. A third inlet tube **21** communicates with the interior of the body **15** through closed end **15***b* in the immedaite vicinity of the tubes **16** and **17** and terminates at the other end thereof in communication with a feed tank, not shown, which also contains a substance to be fed into the gas stream. Valves **22**, **23** and **24** are fitted in the tubes **16**, **17** and **21**.

The operation is as follows:

A field of reduced pressures having different values at all points within the body **15** is associated with the formation of the rotational jet as hereinbefore described. Accordingly, in respect of a valve of alpha=15°, an internal diameter of tube of 46 millimeters, a length *l*=60 millimeters (FIG. 1) and a tangential inlet orifice having a length of 110 millimeters and a width of 16 millimeters, there has been obtained near the axis of the spiral vortex by means of a fan producing a pressure of 530 millimeters of water a reduced pressure of 1,520 millimeters in the vicinity of the base or closed end and of 620 millimeters at the outlet. The reduced pressure which is thus exerted on the orifices of the tubes **16**, **17** and **21** causes the material contained in the feed tanks to which said tubes are connected to flow through these latter. As said material passes into the gas stream in the central region thereof which is endowed with a very high rotational velocity, said material is powerfully centrifugalized and distributed throughout the vortex.

When the material is a liquid, this latter as it passes out of the tube through which it is delivered disintegrates into extremely fine particles which are immediately centrifugalized; this atomization by disintegration which is already very thorough is increased even further by the constricting action to which said particles are subjected during their centrifugal motion as a result of differences in the rotational velocities and axial velocities of the layers of the vortex through which they pass successively on their centrifugal path. When it proves necessary to prevent the centrifugalized particles of an atomized liquid from coalescing against the walls, conduits are accordingly employed for the purpose of conveying said liquid, such as the tubes **16**, **17** which terminate in the outlet orifice of the body **15**. When the above-mentioned coalescing process does not constitute a disadvantage, a conduit can accordingly be employed such as the tube **21** or any other conduit which terminates at an intermediate point of the length of the body **15**.

If so desired, it is possible to regulate the pressures which are exerted in the tanks containing materials to be fed into the gas stream, or to adjust the difference in height between the free surface of the material in a feed tank and the outlet of the corresponding feed pipe (namely the head on said outlet) in such manner that no flow of said material can take place within the conduit when there is no reduced pressure or partial vacuum in the generator body, consequently when there is no circulation of a gas stream.

In the application of the invention to the projection of particulate treatment products on crops by means of appliances which are designed for this purpose, different forms of embodiments are shown by way of example in FIGS. 2 to 6. All said forms of embodiment essentially consist of at least one body for generating a rotational jet of the type hereinabove defined, a fan for the purpose of maintaining an air-flow within said body, at least one feed tank containing a treatment product to be introduced and distributed within the rotational jet, said feed tank being in communication with a reduced-pressure zone in the interior of said jet-generating body, and a carrying structure supporting all said elements.

In FIGS. 2 and 3, a feed tank **31** containing liquid treatment product is supported on a frame or carrying structure **32** which is constructed of structural steel members and on which is also mounted a step-up gear unit **33** which is intended to be coupled either to a motor or to the power take-off of a tractor and which is coupled by drive-belt to a horizontal shaft **34** which passes straight through the feed tank **31** and drives a fan or blower **35** which is located on the other side of the tank **31** relatively to the speed-change unit **33** and which is supported on the tank. Two conduits or connecting-ducts **36** and **37** for delivery of air extend downwards from the fan **35** and terminate respectively in communication with two tangentially disposed conduit portions **138**, **139** of nozzles or bodies **38** and **39** for generating a rotational jet. These inlet conduit portions are similar in function to the inlet or tangential orifice **14** of FIG. 1. Feed conduits **40** and **41** for supplying the treatment product are passed respectively through the closed ends **38***c*, **39***c* of said bodies **38** and **39** which as shown are disposed in parallel relation with each other at the bottom of the apparatus, said conduits **40**, **41** extend from a common filter **42** which is secured beneath the feed tank **31** and supplied from this latter.

The apparatus which is illustrated in FIG. 4 differs from the previous example in that the two jet-generating nozzles or bodies **38***a* and **39***a* are disposed coaxially with respect to each other, with the result that the rotational jet which is produced by the body **39***a* into which the body **38***a* is adapted to penetrate is of annular configuration and surrounds the rotational jet which is discharged from the body **38***a*, said body **38***a* accordingly comprising only one supply conduit **40***a* for the supply of treatment product from the tank **31**. The body **39***a* thus exerts a suction on the orifice or outlet end O of the body **38***a*, thereby accelerating the flow velocity of the jet which is discharged therefrom and accordingly increases the range of this latter. Furthermore, by designing the body **39***a* in such a manner that the jet generated by this latter rotates in the direction opposite to that of the jet which is discharged from the body **38***a*, the result thereby achieved is that the peripheral velocity of the boundary layers of the two jets in the vicinity of the contact surfaces or boundaries of said jets is progressively reduced with a consequent re-

duction of centrifugal force and of the expansion of both jets considered as a whole, thereby increasing the range of the combined jet. A similar effect can be obtained without any need for the outer jet to be rotational. The body **39***a* can in that case have an axial inlet. Whether the outer jet is rotational or not, it can prove advantageous to make said outer jet slightly convergent towards the downstream end by means of a slightly conical outlet of the body **39***a*. The body **39***a* can also be open in free air at both ends thereof instead of being connected to the fan, in which case it is the jet which passes out of the body **38***a* which induces the flow through the body **39***a*, the combined assembly accordingly working in the manner of a combining-tube.

In the apparatus which is illustrated in FIGS. 5 and 6 and which is designed for either dry-dusting or wet-dusting of crops, the feed tank **31***b* is intended to contain a treatment product in the form of a powder but is provided at the top portion thereof with a compartment **42** for the purpose of holding a liquid. The fan **35***b* which is arranged and driven as shown in FIGURE 1 only delivers through a single connecting-duct or coduit **36***b* for the purpose of generating a rotational jet. There opens into the interior of the nozzle **38***b* a conduit **40***b* which extends from the bottom of the tank **31***b* and which delivers into the nozzle body the powder which is contained in the feed tank **31***b*. The conduit **40***b* is traversed longitudinally by a tube **43** having a smaller diameter, said tube being intended to project downstream of the conduit **40***b* and extends up to the outlet orifice or open end OE of the nozzle body **38***b*. At the opposite end thereof, the tube **43** is connected through a flexible conduit **44** which communicates with the compartment **42**. A wormscrew or rotating spiral **45** which conveys the powder in a uniform manner to the inlet end of conduit **40***b* is disposed horizontally in the bottom of the feed tank **31***b*, the base of which is in the form of a hopper. The screw conveyor **45** is belt driven from the step-up gear unit **33***b* which operates the fan **35***b*.

Although the appliances which have been described in the foregoing have been designed primarily for the purpose of projecting treatment products on crops, said appliances are suitable for a large number of uses. They can in particular be employed for the purpose of projecting insecticides, especially against mosquitoes. By utilizing as product which is fed into the rotational jet a material which is either combustible, solid or liquid, or even a solid material and a liquid material in the case of the apparatus which is represented in FIGS. 5 and 6, these latter are transformed into flame-throwers which are suitable for use in clearing undergrowth and into fumigators for protection against frost if smoke-producing materials are mixed with the jet. The use of water as a liquid to be atomized in the rotational jet and similarly, the use of antioxygen products or products which are capable of carrying out in any other manner a fire-extinguishing action or flame-smothering action, accordingly transforms said appliances into wet mist sprayers for the purpose of fighting forest fires.

What I claim is:

1. An apparatus for delivering into the atmosphere a jet of air carrying comminuted plant treatment material, thereby to direct a blast through the atmosphere onto plants and the like, comprising a carrying structure, a blower secured to said structure, at least one tank carried by said structure and adapted to contain such material to be discharged in comminuted condition, and means including a nozzle body of circular cross-section, said nozzle body having a closed end, an inlet conduit means connected to said blower, said body having its opposite end opened to constitute a discharge end communicating with the atmosphere, said means further including a tube connected to said tank and having a discharge orifice into said nozzle to discharge said material in comminuted condition into the central region of the air flow from said blower through the nozzle whereby an air jet carrying said comminuted material is discharged from the nozzle into the atmosphere, wherein said nozzle inlet conduit means communicates with the nozzle body in substantially tangential relation thereto and the nozzle body constitutes a means for causing said air flow from the blower to be formed in the nozzle body into a free spiral vortex, whereby the jet discharged into the atmosphere is a rotating jet and the pressures prevailing therein are lower than the atmospheric pressure.

2. An apparatus as in claim **1**, wherein said nozzle body has a substantially straight axis and said tube extends through the closed end of said nozzle body longitudinally of the nozzle body at a distance from the axis thereof so as to be in substantially coaxial relation with the vortex axis, which is laterally offset with respect to the first mentioned axis, and said tube extending substantially up to said nozzle body open discharge end.

3. An apparatus as in claim **2**, further comprising a second tank, a second tube disposed concentrically to said first tube and defining therewith an annular free space, said second tube being connected to said second tank and having an annular discharge orifice located adjacent said nozzle body closed end to discharge into said nozzle body the material contained in said second tank.

4. An apparatus as in claim **1**, wherein said tube has its discharge orifice located close to the nozzle body closed end.

5. An apparatus as in claim **1**, wherein said tube extends movably through said closed end of the nozzle and its connection with the tank is flexible, whereby it is longitudinally adjustable within the nozzle.

6. An apparatus as in claim **1**, wherein said nozzle closed end includes a detachably secured closing part carrying said tube and readily detachable connecting means are included in the connection between said tube and said tank.

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