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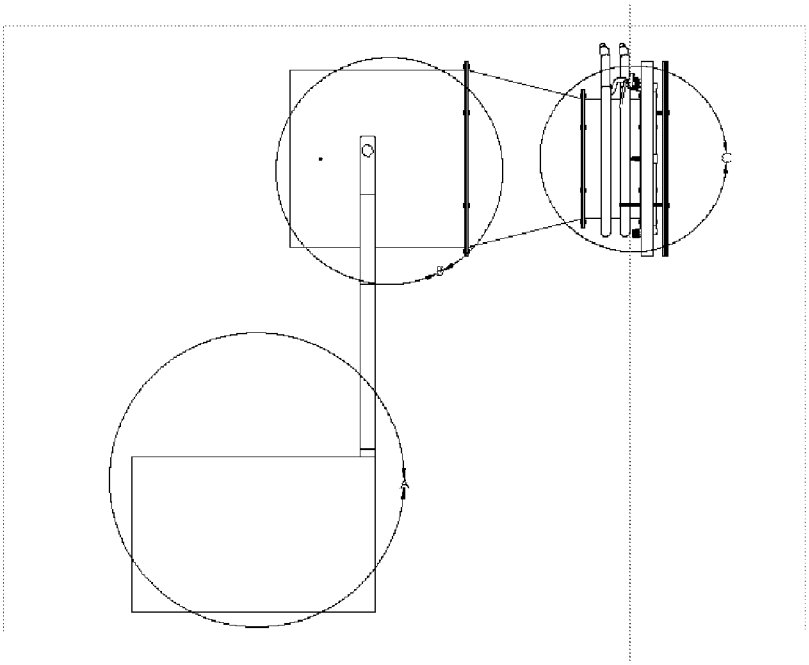

Fig. 1

(57) Abstract: The present invention and utility model discloses a multipurpose air-induced air-assisted high range electrostatic spraying system based on induction charging principle for dust mitigation and environment protection. The air-induced air-assisted high range electrostatic spraying system comprises variable number of air-assisted nozzle, charging mechanism based on induction principle, high voltage generation unit with an automated controlling and protection device to avoid the damage, an axial fan to propel/transport the charged droplets onto the target, an air compressor for air supply and a liquid tank. The electrostatic spraying system can be placed on a movable mini-truck or manually hand driven trolley. The droplets are charged sufficiently so that the system can be used efficiently for high range spraying. The present invention has the advantages of cost effective manufacturing and multipurpose usage.

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INDUCTION CHARGING BASED ELECTROSTATIC SPRAYING DEVICE

FIELD OF THE INVENTION

The present invention particularly relates to an induction charging based multipurpose air-assisted high range electrostatic spraying device in the field of dust suppression and environment protection of a type having an arrangement for charging liquid sprays. Charged droplets are more capable of suppressing small and respirable dust particles entrained in the air. This electrostatic spraying device helps to take control of dust while improving effectiveness and efficiency. This electrostatic spraying device has the utility/application in the field of dust mitigation and environment protection as a charged liquid fogger/dust destroyer. This electrostatic spraying device can also be used for agriculture spraying of crops and orchards, especially for shelter trees and high range spraying with enhanced level of performance and efficiency.

BACKGROUND OF THE INVENTION

It is a very common practice to suppress dust and sand particles in the working areas of coal mines, cement enterprises and demolition areas by using conventional spraying systems such as jet sprayers, mist foggers described in patent number US 4487615, US 4487615 A, CN 201760208 U, US 4650598 A and US 20140008469 A1. The conventional spraying systems having the problem of less efficiency, off-target losses, uneven distribution of droplet size and the droplet size is bigger than expected, creates a gravitational losses. An electrostatic method of spraying reduces off-target drift, environmental pollution and human health risks and increases the mass transfer efficiency onto the targets with uniform deposition. Another advantage of charged particles generated from electrostatic spraying nozzle is that they recombines with foreign particles present in the naturally occurring environment and settle down very efficiently more particularly to novel, useful method and technology for eradicating undesirable foreign material entrained in the air. So far the pressure based system designed and developed for high range spraying have used corona charging mechanism as stated in patent number CN 104646204 A, CN 204544524 and CN 104588227 A. The corona charging uses a very high voltage in the range of 15-20 kV and requires current controlling mechanism, creates a complexity as stated in US patent number US 20160008829 A1.

Dust is a ubiquitous problem while working and handling many fragile, dusty and bulk materials such as coal, cement *etc*. The dust can be seen at coal mines, cement enterprises and plants, dusty atmosphere near the sea ports, interfering with all phases of task which reduces the staff efficiency. Dust and small respirable particle suppression systems help to take control of dust while improving effectiveness and efficiency. There are numerous reasons for suppressing dust vary for particular industries; however, the main arguments are: environmental problems and health hazard, loss of valuable material, reduced visibility due to dusty environment, explosion/oxidation, machine maintenance *etc*. The methods used for such kind of dust suppression are wet dust suppression systems such as handheld sprayers, high pressure swirl nozzle, air-assisted nozzle *etc*. The problems associated with these techniques are bigger sized droplets, usually in the range of 300 to 600µm, are not effective on respirable dust. The air-assisted electrostatic spraying method produces the droplets in less than 100µm which is more favorable to respirable dust particles and hence more effective and efficient.

Electrostatic force field application for charging of liquid sprays is known from late 1980s. US patent number's US3630441 and US3698635A describe electrostatic spraying apparatuses that have been developed for spraying. The electric charging of liquid droplets was already known from the 19th century; however, the actual application of charged liquid droplets came into existence only at the end of the 19th century. Reference to charged liquid droplets and their application can be found in Electrostatics and its Applications, Moore, A.D., Ed., Wiley and Sons, 1973. A US patent number US 7913938 B2 granted to Steven C. Cooper describes an electrostatic spray nozzle with adjustable fluid tip and interchangeable components. Further, numerous patents such as US 6,003,794; US 6,276,617; US 6,138,922 and US 6,227,466 also describes electrostatic nozzles. Use of an induction based charging of liquid sprays and twin fluid geometry arrangement, i.e., air and liquid that are similar to the above-mentioned patents by Law, Cooper and Sickles. Patent numbers US 5,765,761; US 5,052,628 also describe the same principle.

OBJECTIVES OF THE INVENTION

1. The main object of the present invention is to provide a method for multipurpose usage such as dust suppression and environment protection, high range orchards,

shelter trees spraying, more particularly for high range spraying based on induction charging of liquid sprays.

2. Another object of the invention is to provide a method for charging of liquid sprays based on induction charging principle for multiple nozzles with individual charging electrode placed near the air-assisted nozzle.

3. Yet another object of the invention is to provide a method for suppressing the airborne contaminant dust particles engendered from the coal mines, cement enterprises and demolition of buildings by the distribution of charged particles throughout the contaminant region.

4. Yet another object of the present invention is to provide a solution for improved transport of the charged particles in the size range of respirable dusts to intended target or polluted zone.

5. Yet another object of the present invention is to provide exact aerodynamic conditions to transport the finely divided particulate matter to the target through the help of air assistance.

6. Yet another object of the invention is to provide a mechanism to provide air assistance to charged droplets for high range spraying with the help of axial fan which provides a trust to propel the droplets to intended target.

7. Yet another object of the invention is to make a provision of variable number of air-assisted electrostatic nozzle in the boom structure depending upon the application and desired liquid flow rate of the liquid.

8. Yet another object of the invention is to generate the high voltage for charging of the liquid sprays.

9. Yet another object of the invention is to provide a variable liquid flow rate by changing the number of air-assisted electrostatic nozzles into the nozzle holder.

10. Yet another object of the invention is to provide a short circuit protection and controlling mechanism.

With the above objects in view, the present invention consists of the combination and arrangement of parts hereinafter the details of this invention is described and illustrated in the accompanying drawings and more particularly pointed out in the appended claims. By considering the points mentioned, it being understood that changes

may be made if required without disturbing /changing the basic principles and spirit of the invention or sacrificing any of the advantages of the invention.

In the present invention and utility model, induction charging has been used for charging of liquid sprays along with novel and unique design features of an air-assisted electrostatic nozzle for dust suppression and environment protection. The present invention has the advantages of cost-effective manufacturing and multipurpose usage.

This present invention is in the field of electrostatic spraying for multipurpose usages such as dust mitigation/suppression, that is generated while handling the bulk material such as coal, cement, demolition of buildings, and environment protection device and relates to the removal of potentially damaging airborne respirable dust particles through electrostatic spraying apparatus of the type having an induction charging arrangement of liquid sprays for the high range targets, applicable in transient conditions such as the presence of high wind, incorporated in the body of the sprayer. It can also be used for agricultural insecticides applications especially for high range orchards, forests and shelter trees.

SUMMARY OF THE INVENTION

An electrostatic spraying is one of most efficient methods to apply/spray liquids and it is gaining more popularity and usage worldwide. It has various applications such as agricultural pesticides spraying, thin film deposition, edible coatings of biomaterials to perishable foods and fruits, medical devices and industrial applications. Recent application is respirable dust suppression/mitigation through electrostatic spraying, though the suppression of dust was long known and addressed by conventional methods such as foggers, jet sprayers *etc*. The introduction of the electrostatic spraying method has made this job more efficient and economic since it produces the droplets in the range of respirable dust and hence more efficient and also uses less natural resources such as water and other ingredients. The electrostatic spraying can majorly be divided into three sections: (i) Hydrodynamics, (ii) Electrodynamics and (iii) Aerodynamics. Once the fine droplets are formed and charged to a significant net electrical charge, electrostatic forces which mainly decide the trajectory of charged particle, the main consideration is aerodynamic activity in the electrostatic spraying, including other minor, undesired, and unwanted forces. The conversion of liquid stream into droplets takes place at the droplet formation zone which is inside a hollow passage of a housing made of an electrically

insulating material. The high velocity air stream is the main kinetic energy source, for the atomization and thrust provided to finely divide particulate matter, against frictional force and air resistance in open environment. The size of the droplets in the electrostatic spraying is in the order of few microns and hence it recombines with the respirable dust particles and settles down very effectively. Therefore, it increases the nozzle efficiency and will cover a longer distance of the target canopy, and applicable in the transient and harsh agro-climatic conditions i.e. in the presence of high wind.

Accordingly, the present invention provides a multipurpose dust suppression and environment protection device, more particularly for high range spraying. The device comprises: an air accelerating frustum comprising a rear part adapted to receive an axial fan coaxially at a center of the rear part; and a nozzle holder comprising one or more air-induced air-assisted nozzles, the nozzle holder being connected to: a front part of the air-accelerating frustum; and an electrode holder adapted to hold one or more charging electrodes.

In accordance with an embodiment of the present invention, the multipurpose induction charging based air-induced air-assisted high range electrostatic spraying device further comprises: a sprayer base body having a high voltage generation unit having a controlling mechanism; an air compressor to supply an air to the one or more air-induced air-assisted nozzles; and a liquid tank to supply a liquid or a mixture of liquids.

In accordance with another embodiment of the present invention, the air-induced air-assisted nozzles may vary in number depending upon the required flow rate and target applications.

In accordance with another embodiment of the present invention, the air-accelerating frustum further comprises: a middle part having an air flow accelerator; wherein the front part of the air-accelerating frustum comprises one or more air induced air-assisted electrostatic nozzle with the support of the nozzle holder, and wherein the rear part of the air-accelerating frustum is adapted to be held by a U-shaped holding unit attached to the base body of the device which can rotate vertically as well as horizontally.

In accordance with another embodiment of the present invention, a number of one or more charging electrodes is equal to a number of one or more air-induced air-assisted nozzles, wherein the electrode holder is placed at a predetermined distance from

the air-induced air-assisted nozzle holder, and wherein the charging electrode is a charging ring electrode.

In accordance with another embodiment of the present invention, the air-induced air-assisted electrostatic nozzle comprises a nozzle head, an outer cap, a very high resistance for protection and safety, and water and air inlet conduits connected to the nozzle head.

In accordance with another embodiment of the present invention, an air stream supplied to the air-induced air-assisted nozzle forms an air path around the charging ring electrode, that is, a means between the liquid jet and the charging ring electrode to avoid a wetting of the charging electrode.

In accordance with another embodiment of the present invention, the very high resistance is connected to the air-induced air-assisted nozzle to eliminate the effects of stray current by maintaining a zero potential through a ground electrode connected to a liquid stream.

In accordance with another embodiment of the present invention, the one or more charging electrodes are induction charging electrodes placed coaxially in front end of the one or more air-induced air-assisted nozzle separately at a selected position from a nozzle tip using the electrode holder.

In accordance with another embodiment of the present invention, the air-assisted electrostatic nozzle is having a liquid and air inlet passages along with a liquid and air filter respectively connected to the nozzle head through a connecting liquid and air coupler.

In accordance with another embodiment of the present invention, the high voltage generation unit comprises an oscillator unit, a high voltage conversion unit, a short circuit protection, the controlling and feedback mechanism to avoid any damage to the device.

The air-induced air-assisted nozzles may vary in number depending upon the required flow rate and applications. The air-induced air-assisted nozzles are connected to the front part of the air-accelerating frustum. The device further comprises a high voltage generation unit along with a controlling and protection mechanism, an automated switching (ON/OFF) device for a high voltage power supply, a rechargeable battery, an air compressor and a liquid tank, a conductive liquid supply pipe connector with a liquid filter and a compressed air supply pipe connector with an air filter. The designed device

provides a means to spray the liquids more effectively and efficiently, having higher target and coverage distance, reduced off-target losses and applicable in harsh atmospheric conditions such as in the presence of wind current.

BRIEF DESCRIPTION OF THE DRAWING

The invention will be further described by way of some set of examples in addition to the accompanying drawings, in which:

Figure 1 represents a multipurpose induction charging based high range electrostatic spraying device, having a combination of a base body (A), an air accelerating frustum (B) and air-induced air-assistive electrostatic nozzles holder (C).

Figure 2 shows a sprayer base body (A) which consists of an air compressor 1, liquid tank 2 and high voltage generation unit 3.

Figure 3 shows an air accelerator (B) which is called frustum. The frustum consists of an axial fan to provide thrust for transportation of the charged particulate matter.

Figure 4 shows a nozzle holder (C) having a variable number of nozzle depending upon the target application and liquid flow rate.

Figure 5 shows a holder for charging electrodes; charging electrodes may vary in number equal to the air-induced air-assisted nozzles.

Figure 6 shows an air-induced air-assisted spraying nozzle which has two inputs liquid and air.

Figure 7 is a high voltage generation device along with controlling and protection unit, device is placed in the base body of spraying system.

DETAILED DESCRIPTION OF THE INVENTION

Referring to Figure 1, a multipurpose induction charging based high range electrostatic spraying device has been presented. The multipurpose induction charging based high range electrostatic spraying device is a multipurpose air-induced air-assisted high range electrostatic spraying device. The multipurpose induction charging based high range electrostatic spraying device includes a sprayer base body (A), an air accelerating frustum (B) and air-induced air-assistive electrostatic nozzles holder (C). In the design of the present invention, the air-induced air-assistive electrostatic nozzles holder comprises

two segments: an air-induced air-assistive nozzles holder and a holder for holding charging electrodes.

Considering the Figure 2, the sprayer base body (A) comprises an air compressor 1 to supply the compressed air to an air-induced air-assisted electrostatic nozzle, a liquid tank 2 for the supply of liquid/liquid solution to nozzles and a high voltage generation unit 3 for charging liquid sprays. The base body of the spraying device is connected to a supporting structure 4 which is further connected to a U-shaped movable connector 5. The U-shaped movable connector connects the air-accelerating frustum (B) of the spraying device through nuts 6 and bolts 7 such that the air-accelerating frustum can rotate around the connector. The air-accelerating frustum of the spraying device can move and rotate horizontally as well as vertically to cover the wide range of spraying targets in all possible directions.

Referring to Figure 3 it shows an air-accelerating frustum for air accelerator and axial fan holder. The air-accelerating frustum (B) of the spraying device has three segments. A first segment 8 of the air-accelerating frustum is the mail carrier for an axial fan and the first segment 8 is connected to the U-shaped movable structure. The first segment 8 of the air-accelerating frustum is connected to a second segment 9 of the air-accelerating frustum (B). The first segment 8 has a bigger diameter than the second segment 9. The second segment is an angled frustum 9 that converges the compressed air to provide a higher velocity and air pressure to a front part i.e. a third segment 10 of the air-accelerating frustum. The diameter of third segment 10 is smaller than the diameter of the second segment 9. The smaller diameter frustum further provides the higher velocity and desired air pressure to transport droplets to a higher target distance and canopy coverage. The smaller diameter frustum 10 comprises a water supply pipe 11 and an air supply pipe 12 which is the main input for the air-induced air-assistive nozzles. The front part of the frustum 10 is connected to the nozzle holder with the help of screws and nuts 13. The air enters to the air-induced air-assisted nozzle from a T connector 14 since the air-induced air-assisted nozzle has two symmetrical entrances for the air. The T connector is an extension of an air supply pipe 15. The air enters to the air supply pipe from an air compressor through an air filter 16. The liquid is fed to the air-induced air-assisted nozzle from a liquid supply pipe 17 which is supplied by a liquid tank to a liquid filter 18. A back side of the frustum (B) comprises an axial fan 19 which provides an air thrust to transport the spray droplets onto the high range targets. The axial fan is driven

by a motor 20 which is supported by a combination of four blades 21. The axial fan is connected to the frustum with the help of screws 22.

Referring to Figure 4, it shows an air-induced air-assisted electrostatic nozzle holder (C) having two segments. The first segment is air-induced air-assistive nozzles holder 23 and the second segment is charging electrodes holder 24 which are connected with the help of screws 25. The three views of an air-induced air-assisted electrostatic nozzle holder have been shown as rear (a) side (b) and the front (c). The air-induced air-assisted electrostatic nozzle holder is connected to the charging electrodes holder with the help of screws 26. The front view shows nozzle holder grooves 27 and connectors 28. The air-induced air-assisted electrostatic nozzle holder has six grooves 30 to hold the air-induced air-assisted nozzles. The nozzle grooves may vary with the variation of the air-induced air-assistive nozzles and the nozzle grooves in number is equal to the air-induced air-assistive nozzles. The air-induced air-assisted electrostatic nozzle holder is connected to the air-accelerating frustum (B) with the help of nuts and bolts 31. All the connections are air tight as O-rings are provided at the connections to avoid any kind of air leakages.

Considering the Figure 5, the electrode holder 32 has six grooves 33 coaxially with nozzle holder grooves 27 and electrode holder grooves are equal in number to air-induced air-assistive nozzles. The electrode holder grooves may vary in the number as the nozzle holder grooves 27 varies. The electrode holder has a high voltage wire carrier space 34 on a periphery which supplies the high voltage to the air-induced air-assistive nozzles; the high voltage wire is passing through holes 35. The electrode holder is connected to the nozzle holder with the help of nuts and bolts 36.

Figure 6 represents an air-induced air-assistive nozzle which consists of an outer cap 37, a nozzle head 38. The back side of the nozzle head has two input supplies through the input supply conduits. The first input supply is air supply conduit 39 and the second input supply is of liquid supply conduit 40. The air and liquid input supply conduits are connected to the air compressor and the liquid tank through the air and liquid supply pipes respectively. A nozzle tip 41 inside the outer cap 37 is at selected distance which gives a unique feature to this design called air-induced air-assisted nozzle which does not require any motor to pump the liquid.

Referring to Figure 7, the high voltage generation system 3 for charging of liquid sprays has been divided into three sections: a pulse generator unit a, a voltage multiplier unit b and a protection and controlling unit c. The high voltage generation unit comprises a source 42, which is a rechargeable battery. The DC voltage from the rechargeable battery is fed to a DC to AC conversion section which comprises a voltage regulator 43, a PWM generator 44, a frequency selector 45 and a power MOSFET 46 which finally goes to primary windings of a Fly-Back transformer 47. The voltage from secondary windings is fed to a voltage multiplier and a rectifier 48 which produces the desired high voltage for the charging of liquid sprays. The voltage multiplier unit has short circuit protection arrangement 49 to avoid any kind of failure leaving to the damage of high voltage generation unit. The output voltage is taken from output voltage ports 50. The protection and controlling unit c includes a bridge rectifier 51, a voltage divider 52, an A/D converter 53 and a duty cycle selector 54. The designed power supply is application specific and developed for the charging of liquid sprays based on induction charging principles.

EXAMPLES

The following example is given by way of illustration of the working of the invention in actual practice and should not be construed to limit the scope of the present invention in any way.

A multipurpose electrostatic spraying device has been designed and developed, relates to an induction charging based an air-assisted high range spraying system especially in the field of dust suppression and environment protection. It can also be used for high range spraying such as orchards, shelter trees etc. For highly conductive liquids such as water, the induction charging among all techniques has proved to be satisfactory methods. In the induction charging, a grounded liquid passed through a positively charged ring electrode placed at a calculated distance from a nozzle tip. Here, the charged ring electrode acts as an anode and continuity of a liquid sheet acts as a cathode. At an outer surface of the liquid sheet which is very near to the charged ring electrode, a high electric field in the range of $10^6 - 10^7\, V/m$ is developed between the liquid sheet and the charged ring electrode. Surface densities of free electrons is of the order of $10^8/mm^2$ are typical to charge the spray droplet to a significant level of charge in the

order of $0.5 - 1.5 \times 10^6$ electronic charge for a volume median diameter of $50\,\mu m$ droplet.

When the liquid droplets are being separated from the liquid sheet which is having absolutely neutral charge and moving towards the positive electrode, by the effect of induction or attraction between opposite charges, negative charge is pulled onto the droplets. At the same time, the positive charge of droplets is pushed back to the liquid sheet and hence to ground. Finally, it results the negatively charged fine spray. The voltage has been supplied from the high voltage power supply system, which is generated from the 9.0 dc battery with the help of dc to dc convertor raised to several kilovolts in the range of $1.2 - 2.0\,kV$. The designed system covers all the conductive liquid sprays within the range of $10^{-1} - 10^4\,\Omega - m$. Once the charged droplets come out of the nozzle in aerodynamic region, they try to repel and make a fountain like path. An axial fan provides a thrust to charged droplets to reach a higher target distance. The charged droplets generated from electrostatic spraying device recombines with foreign particles such as respirable dust present in the naturally occurring environment and settle down very efficiently more particularly to novel, useful method and technology for eradicating undesirable foreign material entrained in the air.

ADVANTAGES

The present invention in the field of dust suppression and environment protection has many advantages over the available technologies and methods for spraying the liquids to suppress the respirable dust continuously generated from the coal mines, cement enterprises and demolition areas. It can also be also for high range orchards and tree spraying and other agro-based industrial usage. The advantage of Induction charging based multipurpose air-assisted high range electrostatic spraying system: dust mitigation and environment protection device are:

- The spray droplet has been charged to a significant level of net electrical charge, therefore the trajectory of the charged particle can be controlled.
- Since the spray is charged, therefore, it is producing a small and uniform droplet size, after the effect of Rayleigh limit, which is more effective in suppressing the respirable dust.

- Reducing the effect of gravitational force and hence deducing the weight of the droplet. In this case, the losses due to gravitational forces can be minimized. As the droplet size reduces the electrostatic forces are dominating over gravitational force.
- Effective spraying solution will provide a means to conserve the natural resources such as water, agricultural and protective chemicals etc.
- It will cover a longer target distance especially in suppressing the dust in coal mines and demolition areas and also for high range orchards and tree spraying.

Claims:

1. A multipurpose induction charging based air-induced air-assisted high range electrostatic spraying device, wherein the device comprises:

an air accelerating frustum comprising a rear part adapted to receive an axial fan coaxially at a center of the rear part; and

a nozzle holder comprising one or more air-induced air-assisted nozzles, the nozzle holder being connected to:

a front part of the air-accelerating frustum;

an electrode holder adapted to hold one or more charging electrodes.

2. The device as claimed in claim 1 further comprising:

a sprayer base body having:

a high voltage generation unit having a controlling mechanism;

an air compressor to supply an air to the one or more air-induced air-assisted nozzles; and

a liquid tank to supply a liquid or a mixture of liquids.

3. The device as claimed in claim 1, wherein the air-induced air assisted nozzles may vary in number depending upon the required flow rate and target applications.

4. The device as claimed in claim 1, wherein the air-accelerating frustum further comprises:

a middle part having an air flow accelerator;

wherein the front part of the air-accelerating frustum comprises one or more air induced air-assisted electrostatic nozzle with the support of the nozzle holder, and

wherein the rear part of the air-accelerating frustum is adapted to be held by a U-shaped holding unit attached to the base body of the device which can rotate vertically as well as horizontally.

5. The device as claimed in claim 1, wherein a number of one or more charging electrodes is equal to a number of one or more air-induced air-assisted nozzles, wherein

the electrode holder is placed at a predetermined distance from the air-induced air-assisted nozzle holder, and wherein the charging electrode is a charging ring electrode.

6. The device as claimed in claim 1, wherein the air-induced air-assisted electrostatic nozzle comprises a nozzle head, an outer cap, a very high resistance for protection and safety, and water and air inlet conduits connected to the nozzle head.

7. The device as claimed in claim 1, wherein an air stream supplied to the air-induced air-assisted nozzle forms an air path around the charging ring electrode, that is, a means between the liquid jet and the charging ring electrode to avoid a wetting of the charging electrode.

8. A device as claimed in claim 1, wherein the very high resistance is connected to the air-induced air-assisted nozzle to eliminate the effects of stray current by maintaining a zero potential through a ground electrode connected to a liquid stream.

9. The device as claimed in claim 1, wherein the one or more charging electrodes are induction charging electrodes placed coaxially in front end of the one or more air-induced air-assisted nozzle separately at a selected position from a nozzle tip using the electrode holder.

10. The device as claimed in claim 1, wherein the air-assisted electrostatic nozzle is having a liquid and air inlet passages along with a liquid and air filter respectively connected to the nozzle head through a connecting liquid and air coupler.

11. The device as claimed in claim 1, wherein the high voltage generation unit comprises an oscillator unit, a high voltage conversion unit, a short circuit protection, the controlling and feedback mechanism to avoid any damage to the device.

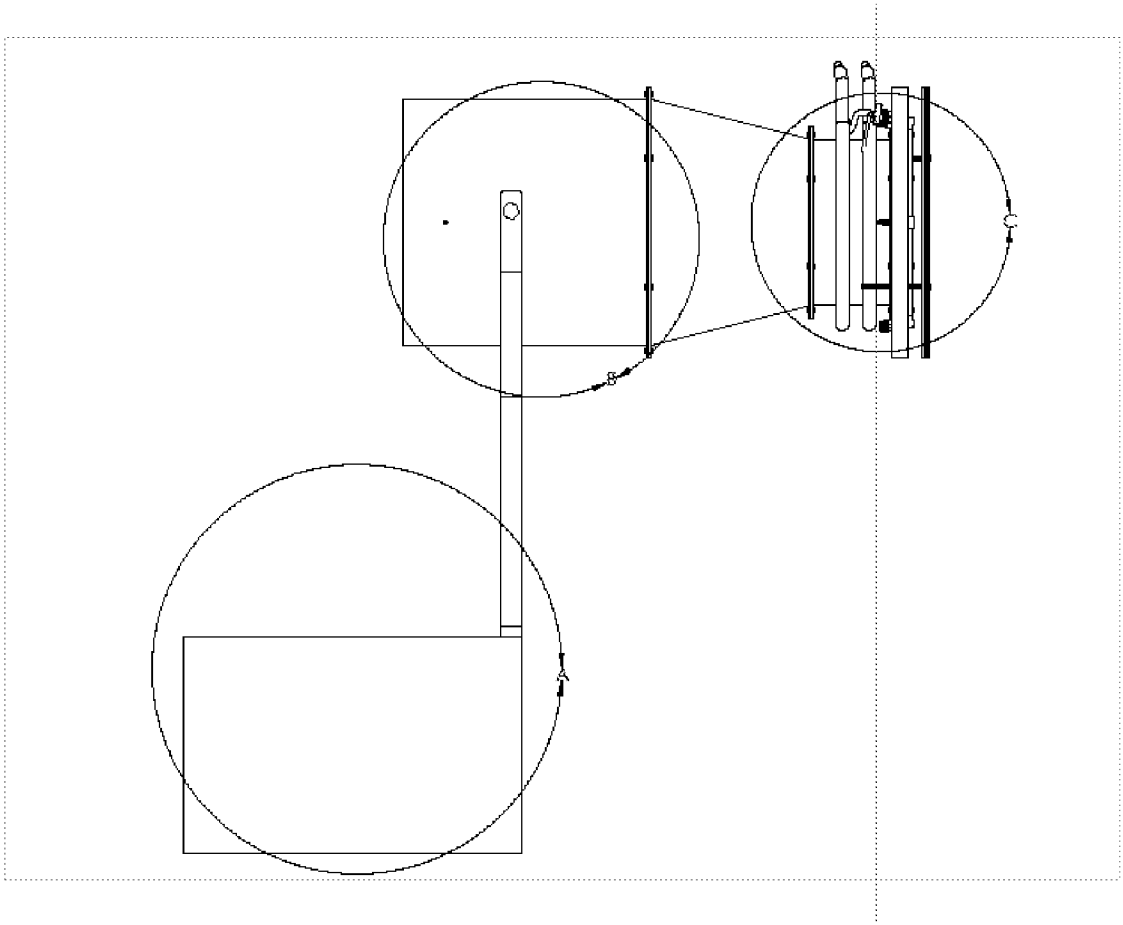

Fig. 1

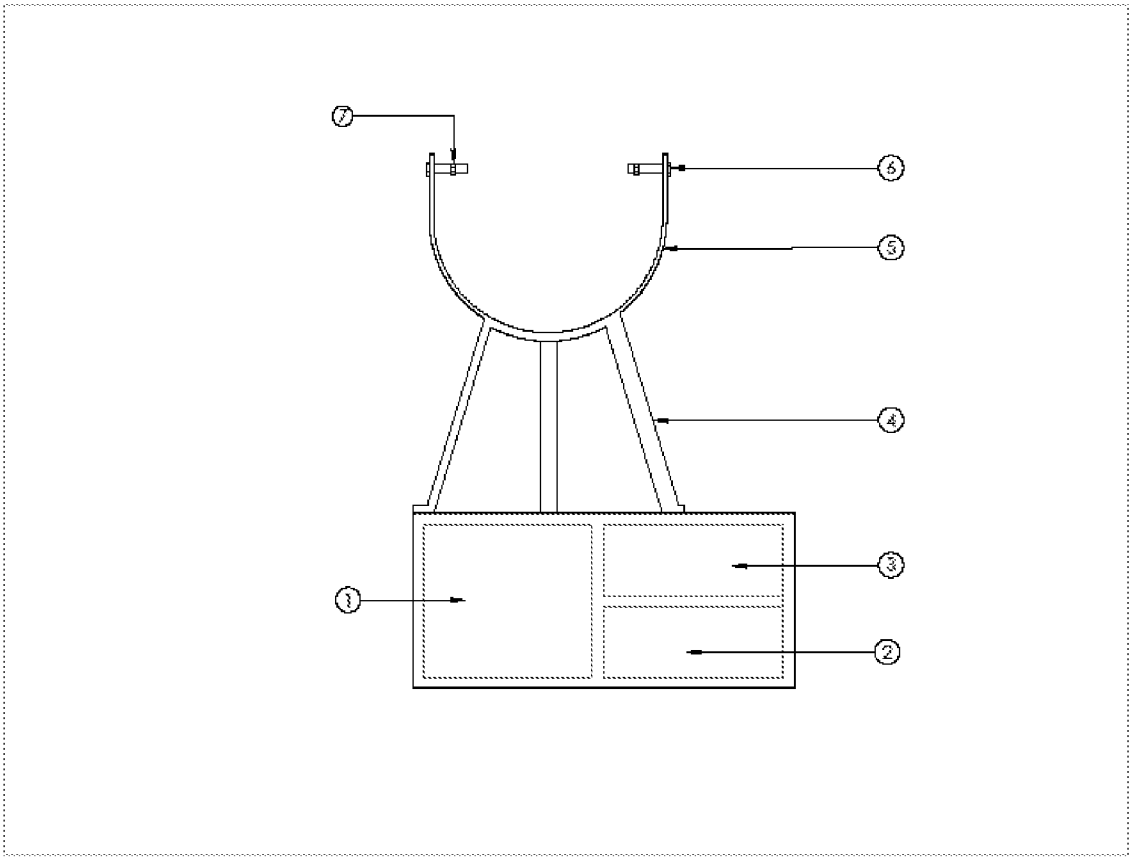

Fig. 2

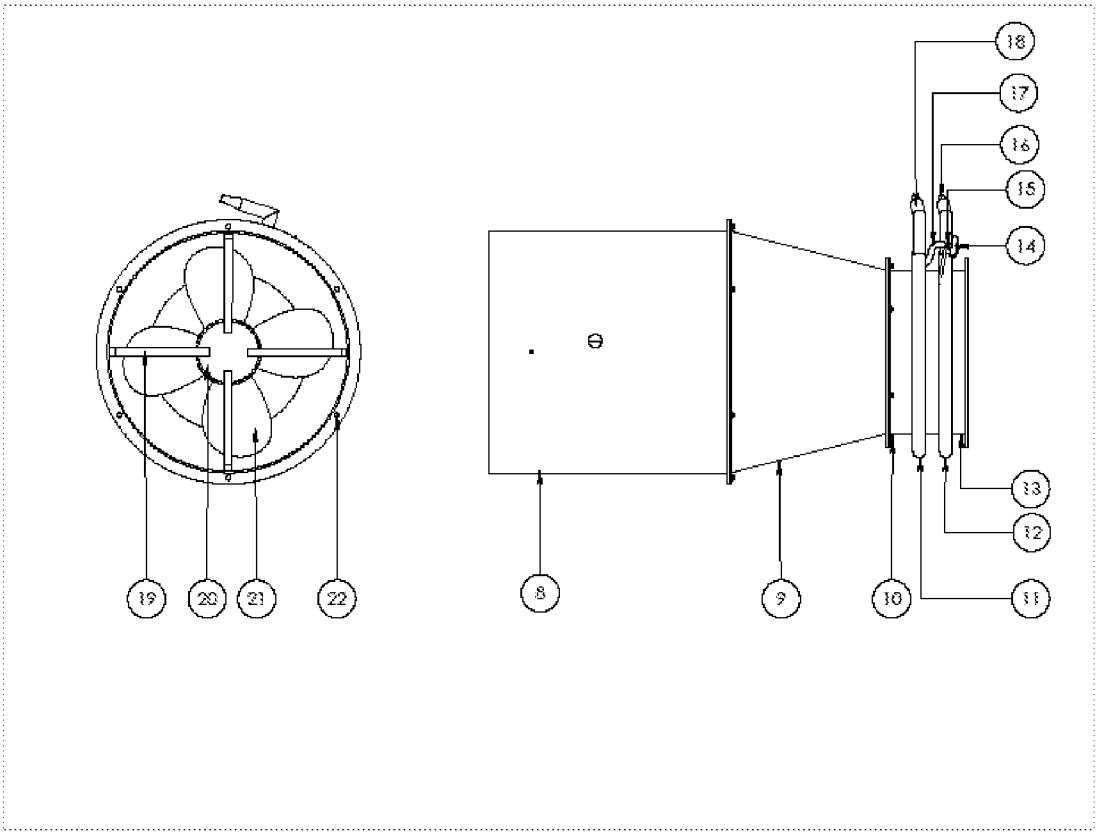

Fig. 3

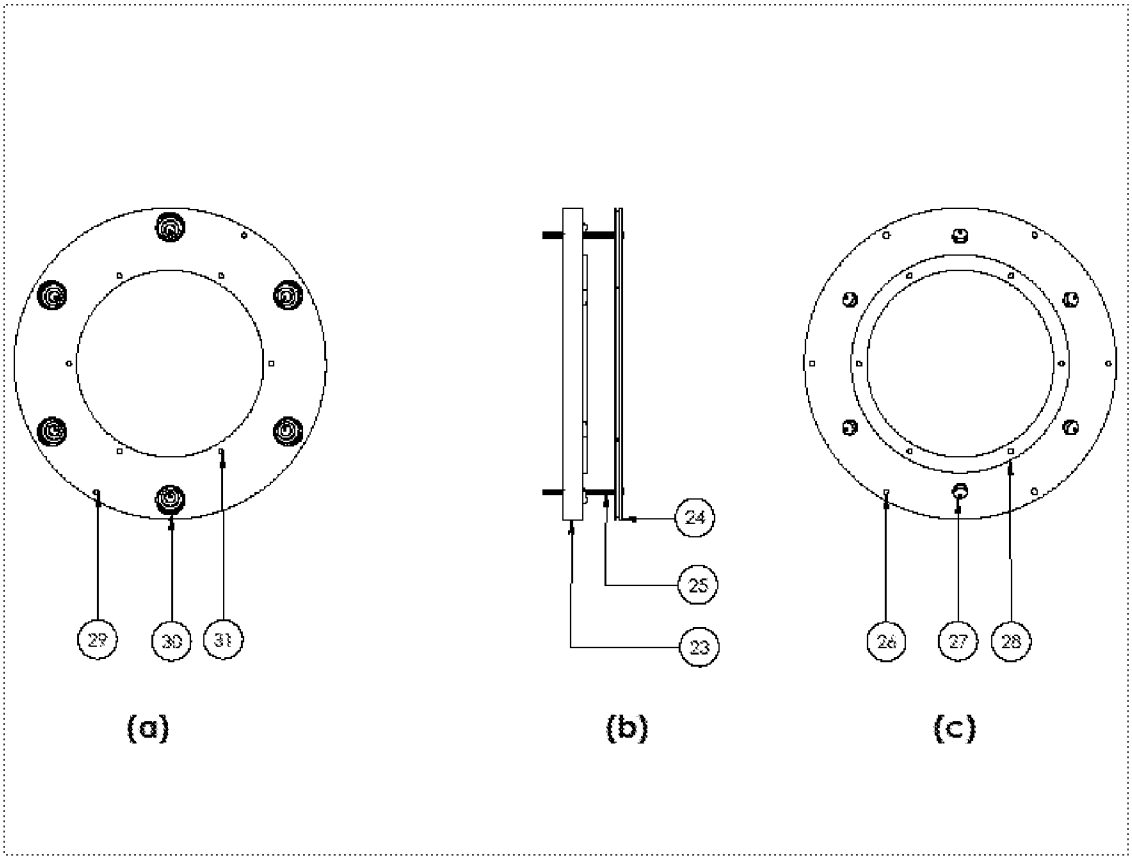

Fig 4

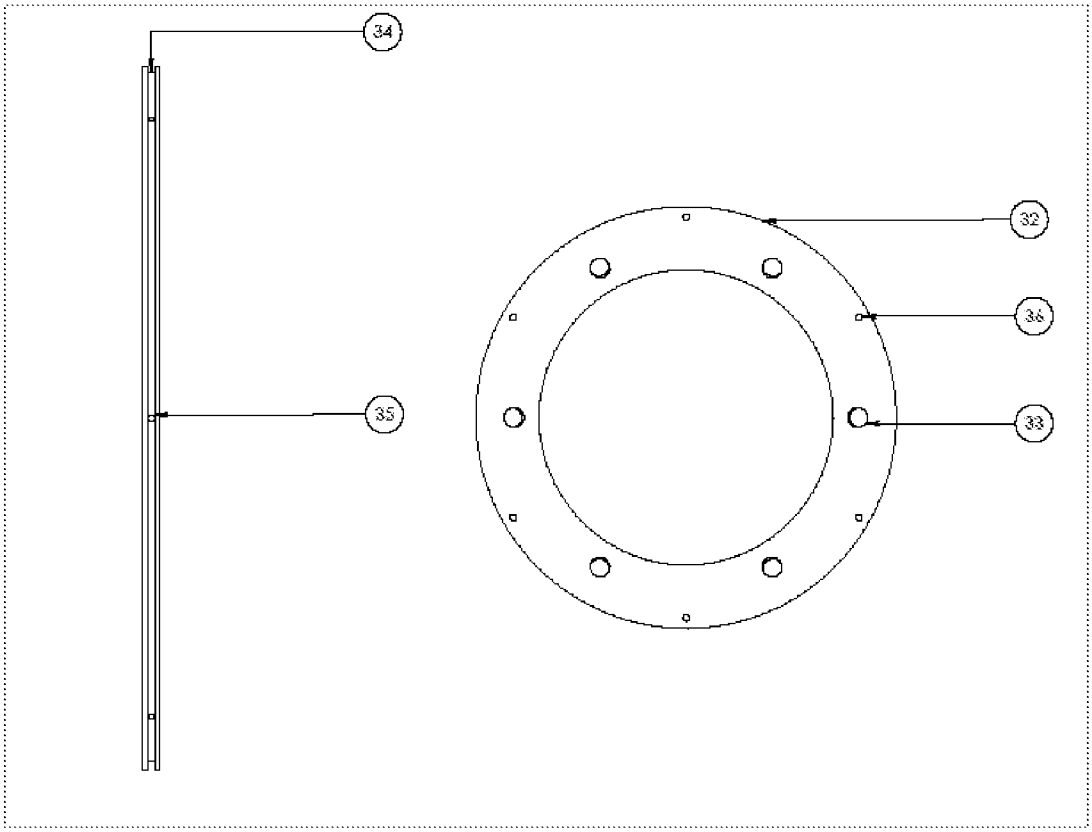

Fig. 5

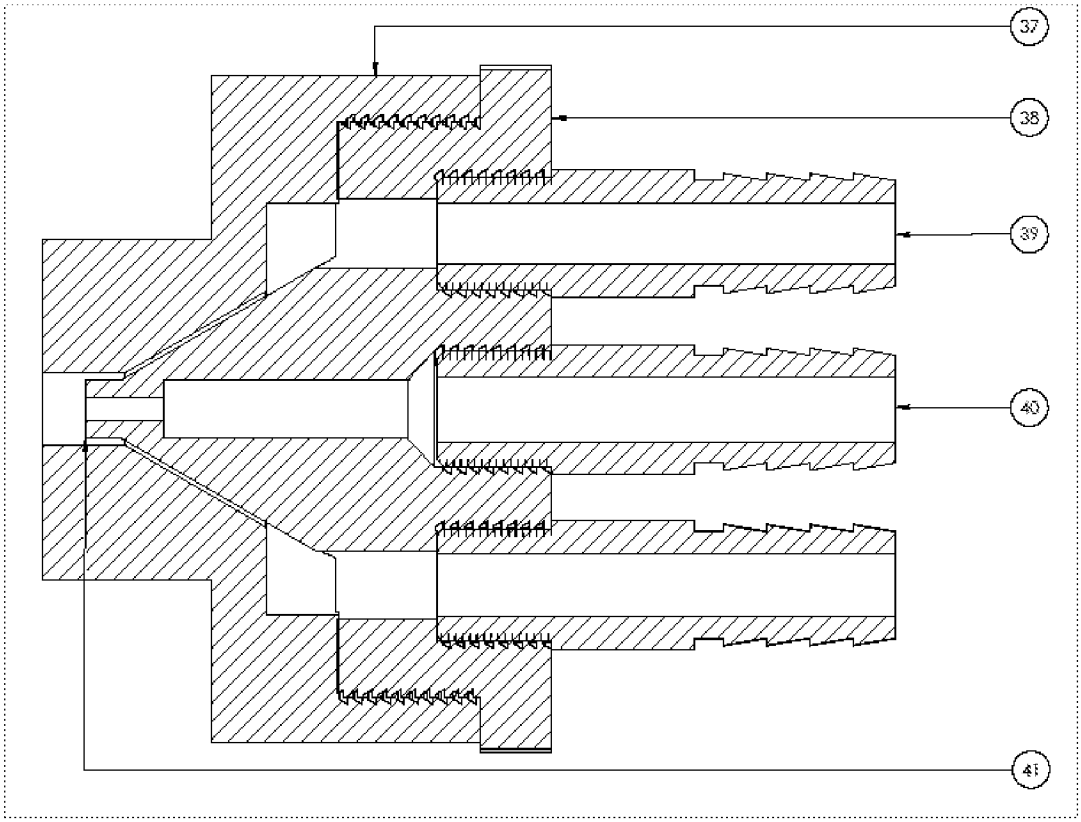

Fig. 6

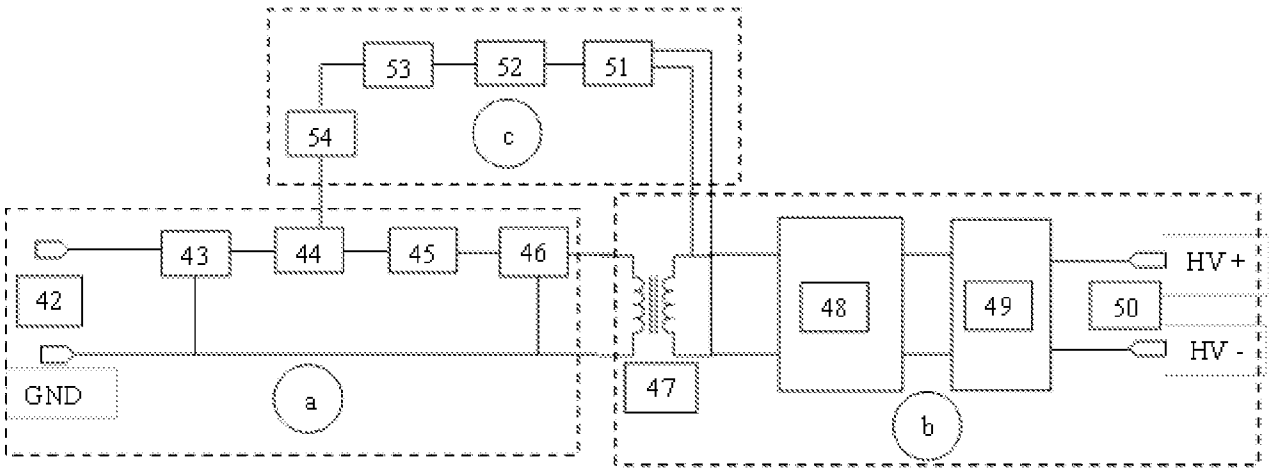

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IN2018/050122

A. CLASSIFICATION OF SUBJECT MATTER
B05B5/043,B05B5/053,B05B5/16 Version=2018.01

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

TotalPatent One, patents.google.com

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO2013161476 A1 (HOCHIKI CORPORATION) 31 October 2013 (31.10.2013) Para [0047]-[0053], [0082]-[0083], Figure 1-3, 5	1-6, 8-9
Y	Para [0047]-[0053], [0082]-[0083], Figure 1-3, 5	7, 10-11
Y	US4343433 A (PPG INDUSTRIES INC) 10 August 1982 (10.08.1982) Column 5; line 23-61, Figure 2-3	7, 10
Y	US5685482 A (TARZIERS JAMIE) 11 November 1997 (11.11.1997) Column 12; line 59-64, Column 19; line 60-67	11

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23-05-2018	23-05-2018
Name and mailing address of the ISA/ Indian Patent Office Plot No.32, Sector 14,Dwarka,New Delhi-110075 Facsimile No.	Authorized officer Seetha Raman A Telephone No. +91-1125300200

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IN2018/050122

Citation	Pub.Date	Family	Pub.Date
WO 2013161476 A1	31-10-2013	JP 2013227806 A	07-11-2013
		TW 201348662 A	01-12-2013
US 5685482 A	11-11-1997	AU 7406094 A	28-02-1995
		CA 2168223 A1	16-02-1995
		EP 0713427 A1	29-05-1996
		JP H09502647 A	18-03-1997
		WO 9504604 A1	16-02-1995