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3,313,487

CLOUD SEEDING APPARATUS

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FIG. I

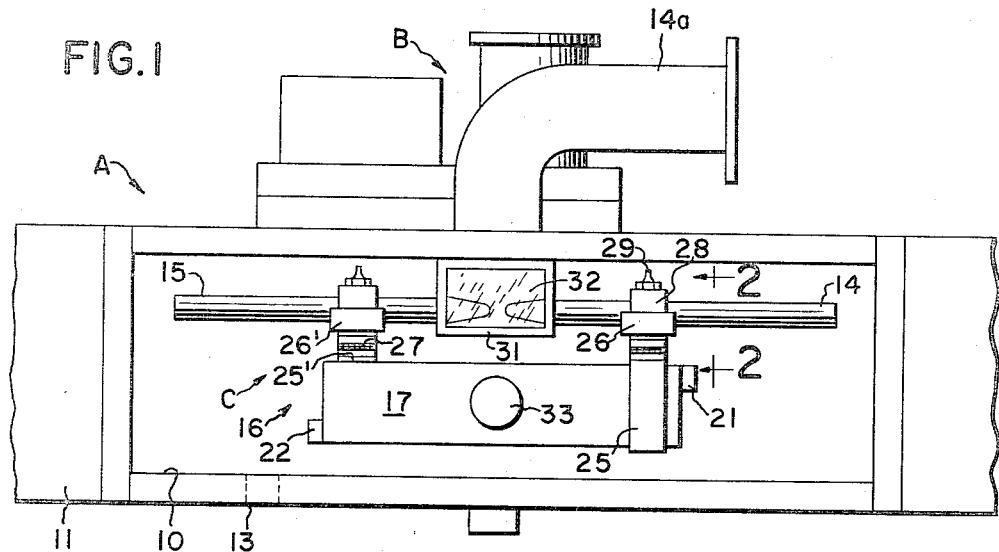


FIG. 2

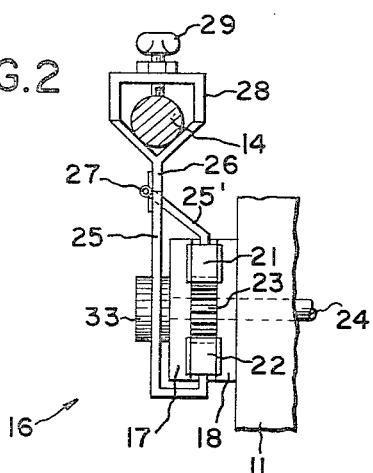
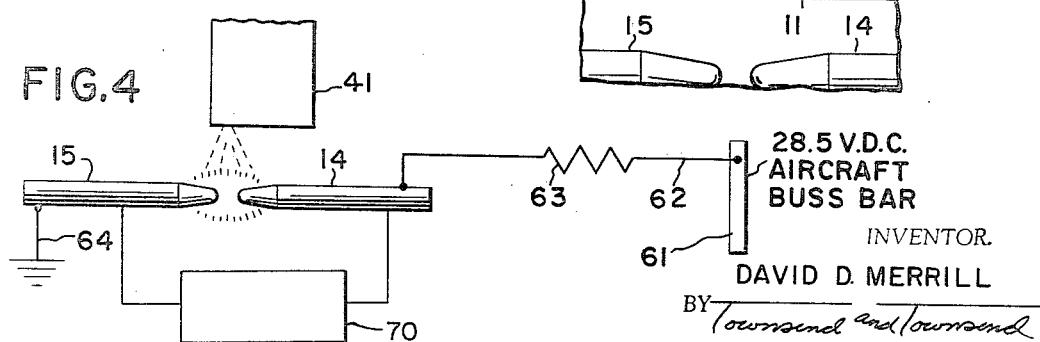


FIG. 4



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CLOUD SEEDING APPARATUS
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The present invention relates in general to cloud seeding apparatus and more particularly to an airborne cloud seeding device adapted for the producing of gamma-type silver iodide crystals to be dispensed in clouds for inducing rain.

Broadly stated, the present invention is directed to apparatus for producing nucleating agents such as silver iodide crystals and especially adaptable for airborne operation including means for mounting and driving a pair of electrodes for production of the arc and with the electrode mounting arms segmented and spring biased in operational position so that the electrodes can conveniently be replaced when substantially consumed by moving the spring biased segments of the arms to place the electrodes in reachable position. With this construction it is possible easily to replace the arc electrodes in the cloud seeding apparatus while airborne without utilizing an excessive amount of flying time.

In accordance with another aspect of the present invention, the arc electrodes for producing the nucleating agents are connected in direct circuit with the positive bus bar of the aircraft electrical system through a high wattage, low resistance bias resistor for supplying direct current from the aircraft electrical system to the electrodes of the seeding apparatus. This construction avoids the problem of operating through a relatively inefficient inverter and step up transformer system which in the past has required as much as 60 amps of current from the aircraft's electrical system to operate the cloud seeding apparatus. With the present invention the required current for the cloud seeding apparatus can be lowered by approximately 15 amps which current is often required when flying under the hazardous weather conditions existent when cloud seeding must take place.

Another of the problems typically encountered with cloud seeding apparatus utilized in the past has been the clogging and caking of the silver iodide material in the feeding container to the arc generating assembly with the result that practically it has only been possible to provide a small amount of silver iodide in the feeding container which supply has had to be replenished at frequent intervals. Naturally, in order to replenish the supply of material fed into the machine, at frequent intervals it is necessary to shut off the seeding apparatus and have a passenger in the aircraft open the container and add a small amount of crystals.

In accordance with another aspect of the present invention, a feed mechanism is provided including a driven shaft positioned within the container of nucleating material and having at least a pair of wings projecting therefrom at an angle thereto so as to meet the base of the container at an acute angle whereby when the shaft is driven in a direction of closing the acute angle, material is continuously forced into the feeding aperture in the bottom of the container. Additionally, an agitating rod is positioned on the top of each of said wings for agitating material lying above the surfaces of the wings to continuously feed material to the wings and prevent caking of the material within the container.

Other objects and advantages of this invention will become apparent when reading the following description and referring to the accompanying drawings in which similar characters of reference represent corresponding parts in each of the several views.

In the drawings:

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FIG. 1 is a side view schematically illustrating a cloud seeding apparatus in accordance with the present invention with the cover door removed therefrom;

5 FIG. 2 is an elevational view partially in section of a portion of the structure shown in FIG. 1 taken along line 2—2 in the direction of the arrows;

10 FIG. 3 is an elevational sectional view of another portion of the apparatus illustrated in FIG. 1 taken along line 3—3 in the direction of the arrows; and

15 FIG. 4 is a view schematically illustrating the electrical connection between the electrodes of the cloud seeding apparatus and the aircraft electrical system.

20 Referring now to the drawings with particular reference to FIG. 1, a nucleating agent generator A in accordance with the present invention for utilization in an aircraft includes a feeding assembly B for feeding the nucleating agent to an arc generating assembly C at which a high temperature arc is established for releasing crystals of the nucleating agent such as, for example, gamma-type 25 crystals of silver iodide. The generator is illustrated in FIG. 1 with the cover door removed leaving an access aperture 10 open for maintenance.

25 The apparatus includes a main housing 11 with an air inlet 12 for drawing air through the housing 13 to pick up the nucleating agents generated therein and exhaust through an air outlet 14a and a discharge tube (not shown) through the fuselage of the aircraft. The air stream passing over the open end of the discharge tube effectively draws the air through housing 11 from the 30 inlet 13 to the outlet 14a picking up the nucleating crystals on its passage therethrough. Inside the housing a pair of arc generating rods 14 and 15 such as, for example, carbon are positioned by a support and drive assembly 35 generally designated 16 for generating the arc which produces the desired nucleating agents therein.

35 With reference to FIG. 2, the rod support and drive assembly 16 includes a forward and rear plate 17 and 18 held in spaced apart relation and each slotted near its top and bottom surface facing the other plate to slidably 40 support top and bottom rack members 21 and 22, respectively. These rack members are driven by a pinion 23 rotatably mounted in the assembly 16 and driven by a drive shaft 24 by means of an actuating assembly shown 45 schematically in FIG. 4.

45 The arc electrodes 14 and 15 are respectively supported in axial alignment with one another for easy replacement and for movement toward and away from one another during consumption of the electrodes by lower and upper arm members 25 and 26 and 25' and 26', respectively. One end of the members of each pair of 50 arms 25 and 26 and 25' and 26' are joined together by a spring biased hinge 27 which normally holds the arms rigid and coplanar, and a yoke 28 provided with a set screw 29 is connected to the other end of the upper arm members 26 and 26' and adapted to rigidly hold the electrode when the screw is tightened.

55 The lower arm members 25 and 25' are respectively connected to the rack members 22 and 21, arm 25 projecting out of the bottom of the drive assembly 16 and upwardly in front of the forward plate 17 while the arm 25' projects upwardly out of the drive assembly 16 and angularly forwardly of the plate 17 so that the upper arms 26 and 26' are coplanar to position the electrodes 14 and 15 coaxially.

60 The lower arm members 25 and 25' are respectively connected to the rack members 22 and 21, arm 25 projecting out of the bottom of the drive assembly 16 and upwardly in front of the forward plate 17 while the arm 25' projects upwardly out of the drive assembly 16 and angularly forwardly of the plate 17 so that the upper arms 26 and 26' are coplanar to position the electrodes 14 and 15 coaxially.

65 The free ends of the electrodes 14 and 15 project through apertures in the side walls of an inner housing member 31 so that the arc is produced thereinside and an eye shield 32 is provided over the front end of the housing 31 so that the arc can be observed without damage to the observer's eye. The rack and pinion assembly 70 drive the arc electrodes toward one another as

the electrodes are consumed and a hand adjustment knob 33 is provided in front of the drive assembly and connected to the pinion 23 so that the racks 21 and 22 can be manually operated to withdraw the electrodes 14 and 15 from the inner housing 31. With the electrodes withdrawn, the upper arms 26 and 26' can be swung down against the spring bias for loosening the thumb screw 29 for convenient replacement of the electrodes.

When the arc is established between the electrodes 14 and 15, a nucleating agent such as, for example, silver iodide is fed into the arc for burning and production of crystals that will nucleate supercooled clouds.

With reference to FIG. 3, the feeding assembly B includes a hollow cylindrical container 41 supported above the housing 11 by means (not shown) and with a tube 42 providing communication from an aperture 43 in the bottom of the container 41 through an aperture in the top surface of the housing 11 directly above the gap between the arc electrodes 14 and 15.

A rotating wheel 44 with a peripheral groove of desired dimension is rotatably positioned in the aperture 43 for moving a desired amount of silver iodide from the container 41 into the tube 42. Due to the atmospheric conditions typically encountered during seeding operations in supercooled clouds, a cleaning wheel 46 with teeth 47 projecting from the periphery thereof is rotatably mounted below the wheel 44 for clearing the silver iodide from the groove 45 whereby the silver iodide material is then dropped down the tube 42 into the arc region inside the housing 11. The wheels 44 and 46 are driven at a desired speed by a gear assembly (not shown) which is adjustable for changing the amount of nucleating agent fed into the arc region.

A drive shaft 51 is rotatably mounted in the lower wall of the container 41 axially thereof and driven by a gear train including gears 52 and 53. A pair of wings 54 and 55 are secured on the drive shaft 51 and positioned at an angle with respect to the axis of the drive shaft 51 and engaging the bottom surface of the container 41 at an acute angle D to force nucleating material into the aperture 43 upon rotation of the drive shaft 51 in a direction of closing the acute angle D between the wings 54 and 55 and the bottom surface of the container 41. An agitating rod 56 is provided on each of the wings 54 and 55, respectively, and projecting upwardly therefrom to stir the nucleating material contained in the container 41 above the rotating wings 54 and 55 so that the nucleating material does not cake above the wings 54 and 55 and thereby prevent feeding nucleating material to the wings 54 and 55 for compaction in the peripheral groove 45 of the rotating wheel 44. This construction assures a uniform flow of nucleating material from a substantial supply of such material to the arc even in environmental conditions conducive to clogging and caking of the nucleating material.

As still another aspect of the present invention as illustrated in FIG. 4, the arc electrodes 14 and 15 are connected in direct circuit with the bus bar 61 of the aircraft electrical system. As illustrated in FIG. 4, one of arc electrodes is connected via a conductor 62 through a high wattage, low resistance element 63 to the aircraft bus bar 61 and the other of the electrodes is connected via ground back to the aircraft electrical system. This electrical connection avoids the inverter and step up transducer utilized in previous systems and at the same time reduces the current drawn by the cloud seeding apparatus by on the order of 15 amps. With reference to FIG. 4, conventional means well-known in the arc generating art and shown as block 76 are provided for initiation and maintenance of the arc between the ends of the electrodes.

Although the foregoing invention has been described in some detail by way of illustration and example for purposes of clarity of understanding, it is understood that certain changes and modifications may be practiced

within the spirit of the invention as limited only by the scope of the appended claims.

What is claimed is:

1. Apparatus for producing nucleating agents for nucleating clouds comprising: a housing; a pair of electrodes; means for establishing and maintaining a high temperature arc between said electrodes within said housing, including means for supporting each of said electrodes with an end of said electrode spaced from the end of said other electrode for establishing an arc therebetween and driving at least one of said electrodes toward said other electrode; means for feeding a substance into said arc; means for conveying nucleating agents produced in said arc out of said housing to the region to be nucleated; said support and driving means including a pair of electrode holding members, a pair of arm members associated with each of said holding members, support means associated with each pair of arm members, each pair of arm members being secured together at their one end in a spring biased manner with the other end of one of said arm members secured to said support means and the other end of the other of said arm members secured to one of said electrode holding members; circuit means for generating an arc between said electrode members, and electrical means associated with said circuit means for controlling the movement of said one of said electrodes for initiation and maintenance of the arc between the ends of said electrodes.

2. Apparatus for producing nucleating agents for nucleating clouds comprising: a housing; a pair of electrodes; means for establishing and maintaining a high temperature arc between said electrodes within said housing including means for supporting each of said electrodes with an end of said electrode spaced from the end of said other electrode for establishing an arc therebetween and for driving said electrodes; means for feeding a substance into said arc; means for conveying nucleating agents produced in said arc out of said housing to the region to be nucleated; said driving means including a pair of electrode holding members, a pair of rack members, a pinion for driving said rack members, a pair of arm members associated with each of said racks; each pair of arm members being secured together at their one end in a spring biased manner with the other end of one of said arm members secured to one of said racks and the other end of the other of said arm members secured to one of said electrode holding members; circuit means for generating an arc between said electrode members; and electrical means associated with said circuit means for controlling the rotation of said pinion for initiation and maintenance of the arc between the ends of said electrodes.

3. Apparatus for producing nucleating agents for nucleating clouds from an aircraft having an electrical system with a bus bar comprising: a housing; a pair of electrodes; means for establishing and maintaining a high temperature arc between said electrodes within said housing including means for supporting each of said electrodes with an end of said electrode spaced from the end of said other electrode for establishing an arc therebetween and driving at least one of said electrodes toward said other electrode; means for feeding a substance into said arc; means for conveying nucleating agents produced in said arc out of said housing to the region to be nucleated; and circuit means for generating an arc between said electrode members including a high wattage low resistance, a conductor connecting the bus bar of the aircraft electrical system through said low resistance to one of said electrodes, a second conductor connecting the other of said electrodes back to said aircraft electrical system, and electrical means associated with said circuit means for controlling the movement of said one of said electrodes for initiation and maintenance of the arc between the ends of said electrodes.

4. Apparatus for producing nucleating agents for nu-

cleating clouds comprising: a housing; a pair of electrodes; means for establishing and maintaining a high temperature arc between said electrodes within said housing including means for supporting each of said electrodes with an end of one of said electrodes spaced from the end of the other of said electrodes for establishing an arc therebetween and driving at least one of said electrodes toward said other electrode; means for feeding a substance into said arc including a container for holding a supply of said substance, said container having an aperture in the bottom for passing said substance from said container, means for controlling the amount of said substance passing through said aperture; a drive shaft extending into said container, a pair of oppositely directed wing members secured on said drive shaft at an angle with respect to the axis of said drive shaft and engaging the bottom surface of said container at an acute angle, and means for rotating said drive shaft in a direction of closing said acute angle whereby said substance is continuously fed into said aperture by said rotating wing members; means for conveying nucleating agents produced in said arc out of said housing to the region to be nucleated; said support and driving means including a pair of electrode holding members, a pair of arm members associated with each of said holding members, support means associated with each pair of arm members, each pair of arm members being secured together at their one end in a spring biased manner with the other end of one of said arm members secured to said support means and the other end of the other of said members secured to one of said electrode holding members; and circuit means for generating an arc between said electrode members including a high wattage low resistance, a conductor connecting the bus bar of the aircraft electrical system through said low resistance to one of said electrodes, a second conductor connecting the other of said electrodes back to said aircraft electrical system, and electrical means associated with said circuit means for controlling the movement of said one of said electrodes for initiation and maintenance of the arc between the ends of said electrodes.

5. Apparatus for producing nucleating agents for nucleating clouds from an aircraft having an electrical system with a bus bar comprising: a housing; a pair of electrodes; means for establishing and maintaining a high temperature arc between said electrodes within said housing including means for supporting each of said electrodes with an end of one of said electrodes spaced from the end of the other of each electrode for establishing an arc therebetween and driving at least one of said electrodes toward said other electrode; means for feeding a substance into said arc including a container for holding a supply of said substance, said container having an aperture in the bottom for passing said substance from said

10 15 20 25 30

container, means for controlling the amount of said substance passing through said aperture, a drive shaft extending into said container, a pair of oppositely directed wing members secured on said drive shaft at an angle with respect to the axis of said drive shaft and engaging the bottom surface of said container at an acute angle, and means for rotating said drive shaft in a direction of closing said acute angle whereby said substance is continuously fed into said aperture by said rotating wing members; means for conveying nucleating agents produced in said arc out of said housing to the region to be nucleated; said support and driving means including a pair of electrode holding members, a pair of arm members associated with each of said holding members, support means associated with each pair of arm members, each pair of arm members being secured together at their one end in a spring biased manner with the other end of one of said arm members secured to said support means and the other end of the other of said members secured to one of said electrode holding members; and circuit means for generating an arc between said electrode members including a high wattage low resistance, a conductor connecting the bus bar of the aircraft electrical system through said low resistance to one of said electrodes, a second conductor connecting the other of said electrodes back to said aircraft electrical system, and electrical means associated with said circuit means for controlling the movement of said one of said electrodes for initiation and maintenance of the arc between the ends of said electrodes.

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