May 13, 1969 P. R. EBERT 3,443,362

PRECIPITATOR

Filed July 13, 1965 Sheet 1 of 2

Fig. 1

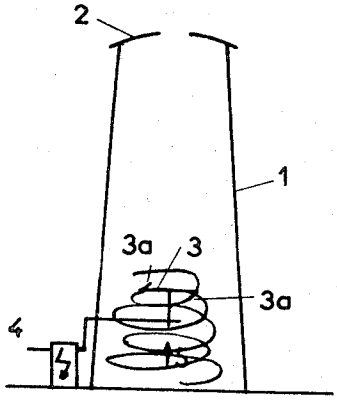

Fig. 2

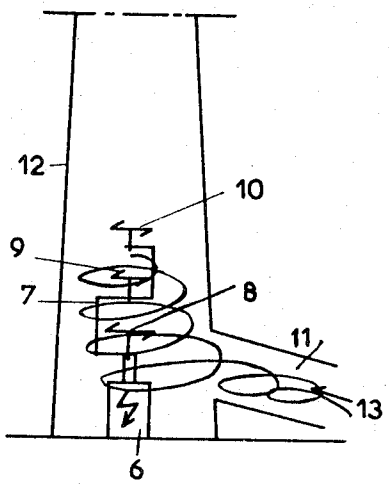

Fig. 8

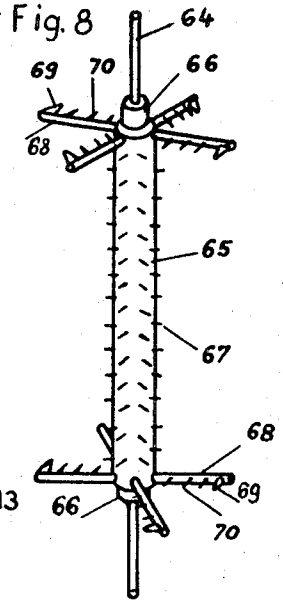

Fig. 3

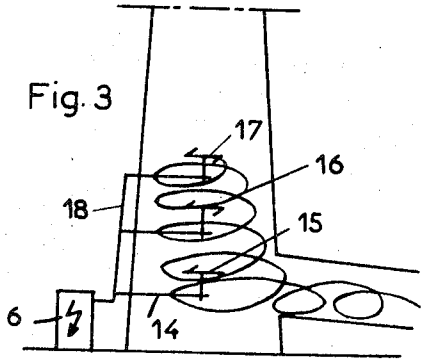

Fig. 4

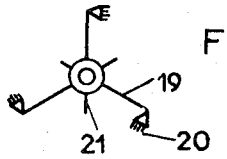

Fig. 5

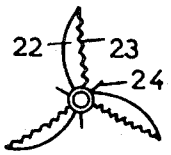

Fig. 10

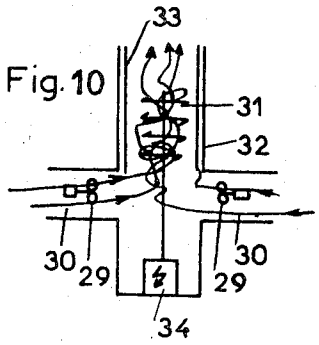

Fig. 6

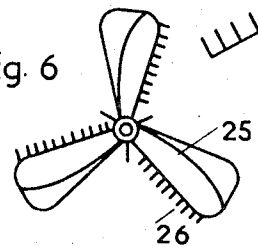

Fig. 7

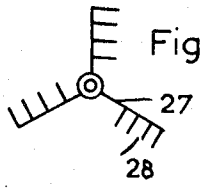

Fig. 11

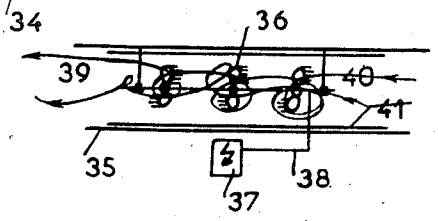

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Fig.12

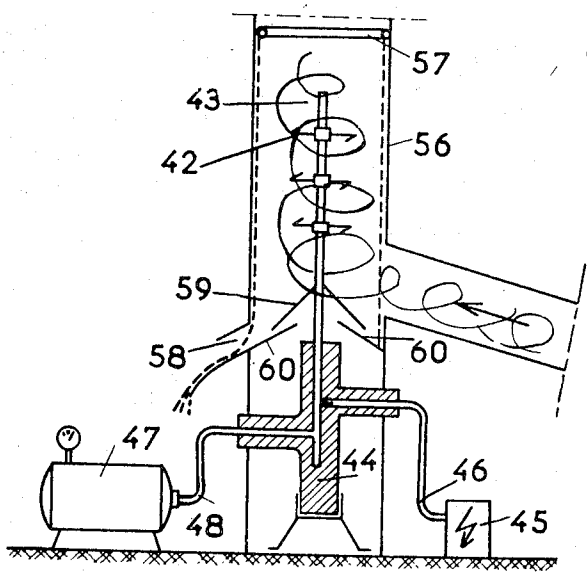


Fig.9

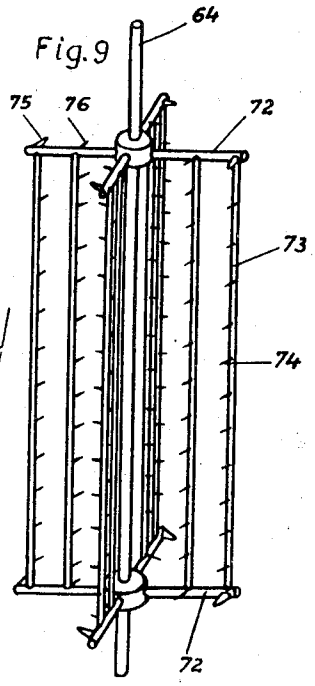


Fig.13

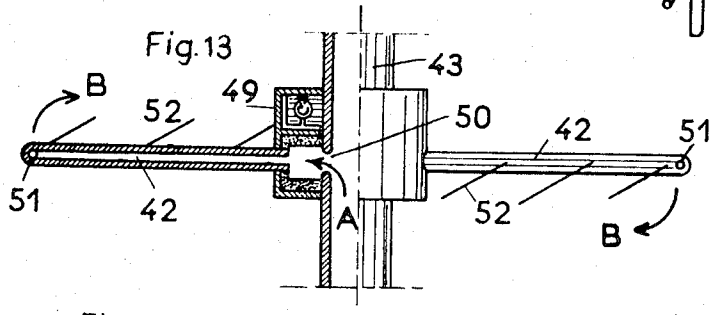


Fig.15

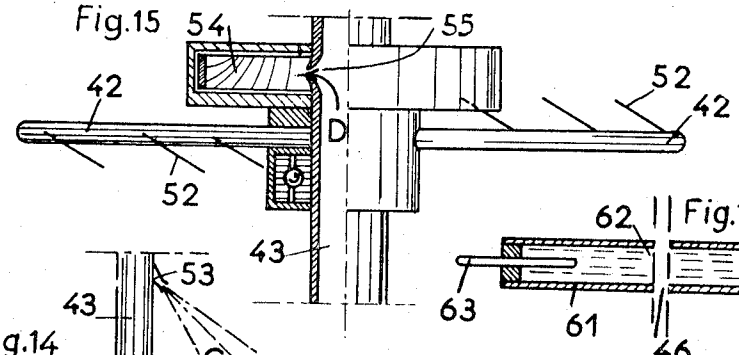
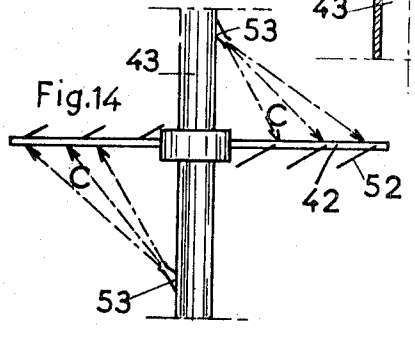


Fig.16

Fig.14



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PRECIPITATOR

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Claims priority, application France, July 15, 1964, 981,967, Patent 1,406,733; Jan. 7, 1965, 1,203, Patent 87,149; Apr. 30, 1965, 15,481, Patent 87,986
Int. Cl. B03c 3/78, 3/41
U.S. Cl. 55—117 4 Claims

ABSTRACT OF THE DISCLOSURE

An electric precipitator having a plurality of vertically spaced elements mounted for independent rotation on a common shaft. The shaft is in turn axially contained within a walled conduit through which gas flows continuously. The elements are each provided with relatively sharp projections extending laterally in a direction opposite to the direction of element rotation. A D.C. current generator is connected to the elements in order to produce an electric potential between the elements and the conduit wall. The magnitude of the potential is such that ions are caused to escape from the sharp projections. The reaction of the escaping ions causes the elements to rotate, and any particles contacted by the ions are propelled against the interior conduit wall, which is continuously being washed by a downward flow of water.

This invention relates to gas cleaning apparatus and more particularly to an improved electrical precipitator.

It is well known that the chimneys of industrial installations and heating systems of all kinds often emit large quantities of gas containing contaminative particles. These gases, which mingle with the atmosphere, are both injurious to the health of human beings and animals as well as being harmful to vegetation and crops.

In certain industrial regions, the atmosphere becomes so saturated with impurities that it is almost impossible to bring fresh clean air from the exterior to the interior of buildings, whether it be done by simply opening windows or through use of commercial ventilation devices. This situation is especially critical at certain periods, such as in the case of fog.

In spite of the steps taken up to the present time to meet this problem, air pollution continues to assume ever more alarming proportions, this fact being attributable not only to the chimneys of factories, but also to those of private homes.

Systems have already been conceived for the purpose of cleaning industrial gaseous emanations. These systems, which operate either electrically or mechanically, all have serious drawbacks which have impeded their general use. For example, they are all extremely costly to install and maintain. In addition, these existing systems are not effective under any and all conditions.

In the past, attempts have been made by ionization to eliminate certain particles contained in the exhaust gases by means of electrode type separators of different concepts and constructions. But serious difficulties arise with this type of equipment, particularly where rapid cleaning of large quantities of exhaust gas or smoke is required, since the noxious elements of these emanations require, according to their nature or origin, a long period to become sufficiently ionized for separation. Moreover, according to the volume of gas being processed, the ionization zone of influence and the trajectory along which separation will take place may assume considerable proportions. Furthermore, there is a persistant risk that particles which have already been separated may be picked up again and mixed with the atmosphere. Finally, the

cleaning of this type of filtering system is particularly tedious and burdensome since it requires periodic washing, vibration and/or beating.

The present invention is distinguishable from the known systems mentioned above in that ionization of the exhaust gases and smoke and particularly of the particles that they contain, is intensified to such a degree that a reduced trajectory and a reduced time are sufficient for the realization of the desired effect. By providing a rapid and effective ion bombardment, the impurities are immediately projected against the interior walls of the smoke stack or ventilation duct. This is achieved with the aid of negatively charged rotatable vanes or porpellers having ends sharpened into a point where the ions appear. As they depart from these points, the ions impart a rapid rotation to the vanes which in turn vigorously stir the gases to be treated, thus notably increasing the precipitation effect.

In addition, by providing a cap with a variable and adjustable opening on the duct or chimney, precipitation is accelerated by increasing the pressure within the conduit.

A further intensification of the purifying effect may also be obtained on the one hand by accelerating vane rotation with the aid of compressed air, steam, oxygen, and other appropriate gaseous substances, and on the other hand by utilizing a spray of absorbent or neutralizing liquids or powders. A flow of water or of gas-absorbent liquids may also be provided on the separating surfaces in the exhaust conduit or in the chimney, as well as a blower device.

The invention includes in addition, for supplying the vanes with electric current, a high voltage generator which first produces electrons, and as the voltage increases, ions, as well as its special supply cable constituted of a sheath of plastic material filled with a conductive fluid of a variable resistance.

The present system may be installed at small expense on any existing conduit, without requiring a special emplacement. The high voltage generator, which may be of known construction, is connected in a manner which precludes short-circuit hazards and presents no danger of electrocution. The vanes and propellers, from which the ions emerge, are applicable unconditionally for any gas purification operation, are not expensive, and may be mounted even in small chimneys.

These and other objects and advantages of the present invention will become more apparent as the description proceeds with reference to the accompanying drawings in which:

FIGURE 1 is a schematic illustration of one embodiment of the present invention adapted for use with a chimney having a single flue;

FIGURE 2 is a view similar to FIGURE 1, modified to include several rotatable vanes, and with the high voltage generator positioned in the interior of the chimney;

FIGURE 3 relates to the same basic arrangement as that shown in FIGURE 2, but with the high voltage generator positioned exterior of the chimney;

FIGURES 4–9 illustrate alternate embodiments of the rotatable propellers or vanes;

FIGURES 10 and 11 are schematic illustrations showing alternate embodiments of the invention adapted for purification of air being drawn into buildings;

FIGURE 12 is a schematic illustration of still another embodiment of the invention;

FIGURE 13 is an enlarged schematic view, partially in section of a rotor having supplemental pneumatic propulsion means which also serves for the cleaning or purging of the device;

FIGURE 14 shows another means of supplemental rotor propulsion by compressed air;

FIGURE 15 relates to a means of supplemental rotor propoulsion with the aid of a turbine; and

FIGURE 16 shows a high-voltage current-feed conductor with conditioned resistance in the form of a fluid filled cable.

Referring initially to FIGURE 1 wherein are best shown general features of one embodiment of the invention, a chimney or exhaust conduit **1** is shown provided with a cap **2** having an adjustable opening open to the atmosphere. A vane **3** is rotatably mounted within the conduit **1** and connected to a conventional high voltage D.C. generator **4**. The cap **2** sets up a supplemental pressure in conduit **1**, without adversely affecting draft. Tests have confirmed the fact that in many cases, better and more rapid separation of impurities from gases passing through the conduit is capable of being achieved with such a supplemental pressure.

When high voltage current is applied to vane **3**, ions escape through oppositely directed points indicated typically by the reference numeral *3a* and bombard the interior wall of conduit **1**. Through the reaction which is produced, a rapid rotative movement is imparted to vane **3**. Because of this, the evacuated gases coming from the direction indicated diagrammatically by the arrow **5**, are vigorously stirred so that they are contacted in a substantially uniform manner by the ions.

In the form of the invention shown in FIGURE 2, the high voltage generator **6** is placed at the very bottom of the chimney and combined with a support **7** carrying several vanes or propellers **8**, **9** and **10**. The smoke or gases are drawn by natural draft from the lateral conduit **11** into the chimney **12** in the direction indicated diagrammatically by arrow **13**.

The high voltage current coming from generator **6** is preferably negative. Moreover, to obtain a rapid and complete separation of particles from the gas, it is usually preferable to utilize metal conduits, or in the alternative non-metallic conduits provided with a grounded metal lining. In certain cases, the chimney or lining may be positively charged. All of these arrangements facilitate cleaning because of the layer of particles being deposited on the inner surface of the chimney will eventually become detached due to its own weight, thereafter falling to the base of the chimney where it can be easily removed. The same is of course true of liquid deposits.

The embodiment of the invention shown in FIGURE 3 is distinguishable from that shown in FIGURE 2 only by the placing of the high voltage generator **6** on the exterior of the conduit, the supports **14** for carrying the vanes or propellers **15**, **16**, **17** passing through the wall of the conduit, as well as the power supply being carried by an external supply cable **18**.

As is evident from FIGURES 4–9 the vanes or propellers may assume any number of varied form. For example, in FIGURE 4, the vane has three arms **19**, with multiple points **20** arranged adjacent the end of each arm in the form of a fringe. In addition, the vane is further provided with supplemental points **21** located on the hub. The propeller in FIGURE 5 has blades **22**, the trailing edge of each being notched to form points **23** from which the ions can escape. Here also, supplemental points **24** are provided on the hub. In FIGURE 6, blade **25** of the propeller is equipped with inserted points **26**. In FIGURE 7, the vane is provided arms **27** equipped with points **28** in the manner of a comb. FIGURE 8 shows a vane assembly in which there is mounted on a vertically disposed supporting shaft **64** a roller **65** held against axial movement by bearings **66**. Roller **65** is equipped with points **67** and flanked at the ends with hollow radially disposed arms **68** equipped with nozzles **69** which likewise terminate in points.

In FIGURE 9, a vane assembly is shown comprising two vertically spaced casings **71** forming bearings mounted on the shaft **64**. Each casing **71** is in turn provided with radially disposed arms **72** connected by vertical rods **73** equipped with points **74**. The arms **72** may be hollow and may be provided with nozzles **75** and points **76**.

Depending on the quantity of gas or air to be purified, several vanes may be superimposed, and their speed of rotation and their emission rate of ions regulated at will for the purpose of obtaining a steady separation at a constant voltage.

It should also be understood that when large quantities of smoke or gas are to be treated at an accelerated rate, rotation of the vanes or blades under the sole influence of the escaping ions may be inadequate to assure a sufficiently high speed for the latter. Under such conditions, it may be necessary to rely on an auxiliary means for rotating the vanes.

In the embodiment of the invention shown in FIGURE 10, which is intended more particularly for the purification of air in buildings, the air is drawn in by intake fans **29** mounted in shafts **30** towards the vane **31** disposed for example in series in conduit **32** which is lined with a metallic tube **33**. The latter is made detachable to permit removing it periodically for cleaning the deposits which adhere to it. A high voltage generator is designated by the reference numeral **34** located in a pit beneath the junction of conduit **32** with shafts **30**.

In FIGURE 11 a plurality of vanes are aligned in a horizontally disposed conduit **35**. Each vane has a pair of blades **36** equipped with needles, of the type for example shown in FIGURE 6. The vanes are each connected electrically to the high voltage generator **37** by a conduit **38** which is in turn connected to a fixed central shaft **39** mounted with the aid of appropriate supports **40**. Here a removable metallic lining **41** is likewise provided to facilitate cleaning. The blades **36** in turning under the effect of the ions, draw in and stir the gases, as well as providing an ionization means to precipitate particles from the gas.

According to the installation depicted in FIGURE 12, the vanes or propellers **42** are mounted on a hollow shaft **43** held on a pedestal base **44** of insulating material. The shaft **43** is energized by the high voltage generator **45** to which it is connected by the cable **46**. In addition, the interior of shaft **43** is filled with a gas such as air under pressure, coming from a compressor **47** to which the shaft is connected by pipe **48**.

The vanes or propellers **42**, preferably mounted on shaft **43** by means of ball bearings **49** (FIG. 13) have hollow arms **42**. The air or other gas under pressure from compressor **47** will pass upwardly through the interior of shaft **43**, through openings **50** (as indicated by the arrow A) into the hollow arms, thereafter escaping through orifices **51** as indicated by the arrow B. Several significant advantages are gained through this arrangement. For example, the flow of pressurized air will provide a cooling effect for the shaft **43**, bearings **49** as well as the hollow arms **42** extending radially therefrom. The air pressure will also aid in excluding contaminants from the bearings and, if oil is entrained with the air, the bearings may be continuously lubricated.

In addition to the above, it should be noted that the thrust created by air escaping under pressure from nozzles **51** will aid considerably in rotating the vanes about shaft **43**. This additional thrust will provide a supplement to the reactive propulsion provided by the ions escaping from the electrodes **52**. It should of course be understood that additional orifices may be located along the lengths of the arms **42** where still greater increases in propulsion are required.

The above-described auxiliary gas propulsion may also be provided, as shown in FIG. 14, by nozzles **53** on shaft **43** in communication with the interior thereof. Air escaping under pressure from nozzle **53** will travel along lines indicated diagrammatically by the arrows C, to impinge upon the arms **42**, thereby providing a supplementary propulsion means as well as means for cleaning the

surfaces of the arms. Finally, according to the embodiment shown in FIGURE 15, there may be associated with the vanes **42** a turbine **54** fed by the gases under pressure through nozzles **55** in shaft **43** along the arrows D.

In the upper part of the chimney or the gas evacuation pipe **56** (See FIGURE 12) there may be provided a washing device **57** which produces a flow of liquid over the inner surfaces of the chimney wall. For this purpose, water or liquids susceptible of absorbing the gases or of entering into chemical combinations with them may be employed; this operation may take place either under normal pressure, or under increased pressure obtained for example with the aid of a rotary pump. The particles adhering to the walls are detached and carried by the flow of liquid to the exterior of the chimney through openings **58**, after having been collected by the chutes **59** and **60**. In the case of gases which can be ionized only with difficulty, a liquid such as for example carbon monoxide with a solution of copper chloride may be utilized. The vapors which are released under the effect of high temperatures are very beneficial from the point of view of the ionization and the separation action which it exerts. When the temperature of the conduit is insufficient for vaporization, the liquid may be preheated.

With respect to the high voltage generator **45**, it may be of the cascade potential type and is combined with a high frequency transformer. Due to the fact that it is thus possible to increase the frequency of normal current, it is possible to obtain an increased output from a given high voltage generator. In other words, the high voltage generator may, in spite of its high output, be held to small dimensions resulting in a lowering of the installation cost and also that of possible repairs. In addition, this device permits providing a reserve of power which, with the aid of an appropriate regulator, may be drawn on according to the need. A single high voltage generator may serve for the supply of several installations.

The cable **46** utilized for bringing the high voltage current from the generator to the electrodes is preferably of the type consisting of a sleeve **61** (FIGURE 16) of an appropriate plastic material, such as polyvinyl chloride or other, filled with a conductive fluid **62** of variable resistance. The plugs at the two ends are metallic and are formed into contractors **63**.The construction of such a cable filled with fluid is much less costly than the price of a regular cable. By use of such an arrangement, the diameter of the cable may be reduced substantially while increasing safety, due to the fact that in case of damage, the absence of the conductive liquid due to its escape, cuts off the current immediately. Such a cable has only a slight electrical capacitance and its electrical resistance may, because of the fluid that it contains, be modified at will.

The principal advantage of this fluid type cable consists in the fact that the installations are protected against dangerous transistory surges, and in addition, the risks of fire and explosions are considerably reduced.

In view of the above, it can now be seen that numerous advantages are obtainable over the prior art devices through use of the present invention. For example, with reference to the simpler embodiments disclosed in FIGures 1–3, the rotative elements in these embodiments are driven solely by a reactive force produced by the escaping ions. Because the elements rotate as they continuously emit ions, more particles will be precipitated from moving gas. In addition, the rotating elements will disturb the otherwise smooth flow of gas in the conduit, thus temporarily retarding the gas in the operative range of the ion-emitting elements. These factors will combine to provide a more efficient gas cleaning operation which is capable of handling greater gas volumes without a corresponding increase in the size or cost of the apparatus.

In the embodiments disclosed in FIGURES 12–14, an auxiliary force is provided to insure rotation of the elements at the desired speed. This force is provided by compressed gas which may be fed to nozzles on the support shaft and/or rotating element, or to small turbine devices connected to the elements. Where the gas impinges directly on the elements, it will in addition to providing additional rotative force, also clean and cool the elements. The same is true where the gas is passed through hollow extensions on the elements to thereafter exit through nozzles which provide a jet action tending to accelerate element rotation. In addition, use of a compressed gas protects the various bearings from overheating and contamination by the particles being precipitated.

I claim:

1. A vertically extending walled conduit having gas flowing axially therethrough, an electric precipitator means within said conduit for removing suspended particles from said gas comprising in combination: a plurality of vertically spaced apart elements, each of said elements being independently rotatably mounted within said conduit for rotation independent of each other in one direction about a stationary shaft which is parallel to the flow of gas through said conduit and the longitudinal axis of said conduit; a plurality of relatively sharp projections on each said elements, said projections being arranged to extend laterally from said elements in a direction opposite to the direction of rotation thereof; means for producing an electric potential between said elements and the wall of said conduit, said potential being of a magnitude suffiicient to cause ions to escape from said projections towards the wall of said conduit, whereby the particles contacted by said ions will be propelled towards the wall of said conduit to accumulate thereagainst, and the said elements will be rotated by the reaction of the ions escaping therefrom; and means for continuously washing the interior surfaces of said conduit in order to remove the particles being deposited thereagainst.

2. The apparatus as claimed in claim **1** further characterized by an adjustable outlet at the upper end of said conduit for controlling the pressure of the gas flowing therethrough.

3. The apparatus as claimed in claim **2** wherein said cleaning device is comprised of means at the upper end of said conduit for radially directing water against the interior wall of said conduit; and a collecting trough extending inwardly from said wall at the lower end of said conduit, the said trough being positioned to receive the water and particles flowing downwardly along the interior surface of said wall.

4. The apparatus as set forth in claim **1** further characterized by said elements being mounted for rotation about a hollow stationary shaft, each said elements having axial passageways in communication at one end with the interior of said shaft and at the other end with nozzles carried by said elements, and a source of pressurized gas connected to said hollow shaft, whereby the reaction produced by gas flowing through said shaft and passageways to escape from said nozzles will supplement the reaction of ions escaping from the projections on said elements, thus accelerating rotation of said elements about said shaft.

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U.S. Cl. X.R.

55—127, 128, 149, 152, 154; 60—200; 266—15; 310—2