

Jan. 23, 1962

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3,018,399

CHARGED PARTICLE EJECTION MEANS

Filed Feb. 1, 1960

2 Sheets-Sheet 1

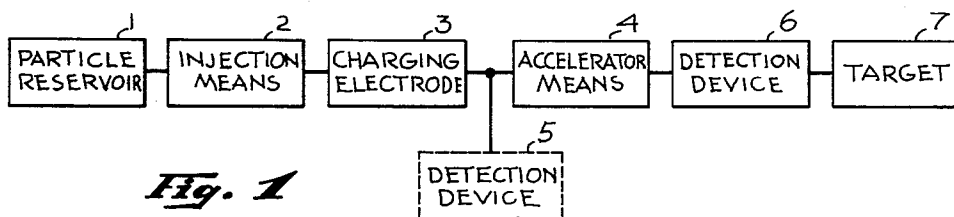


Fig. 1

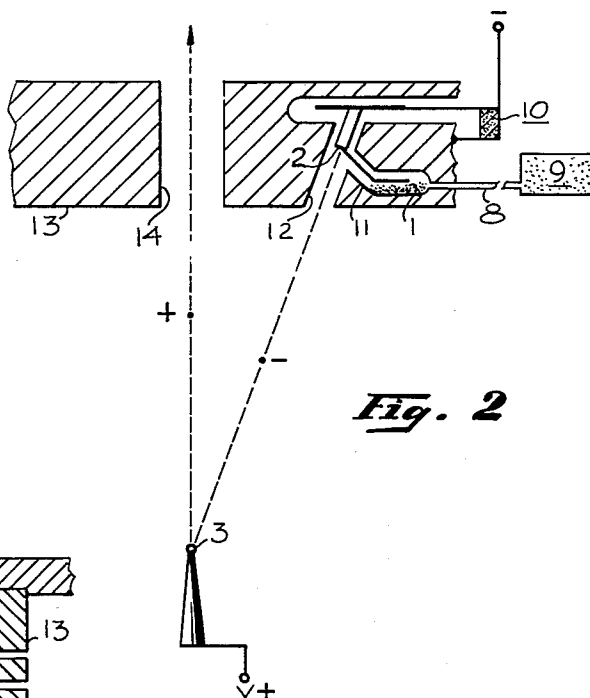


Fig. 2

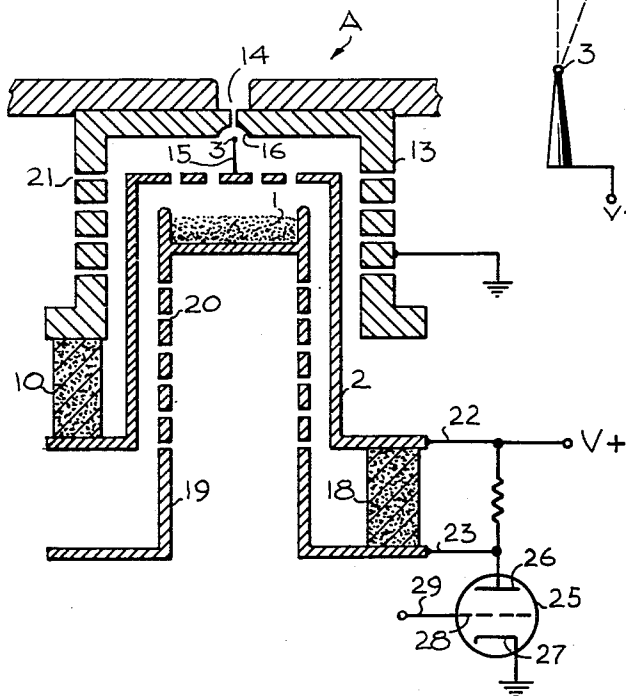


Fig. 3

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2 Sheets-Sheet 2

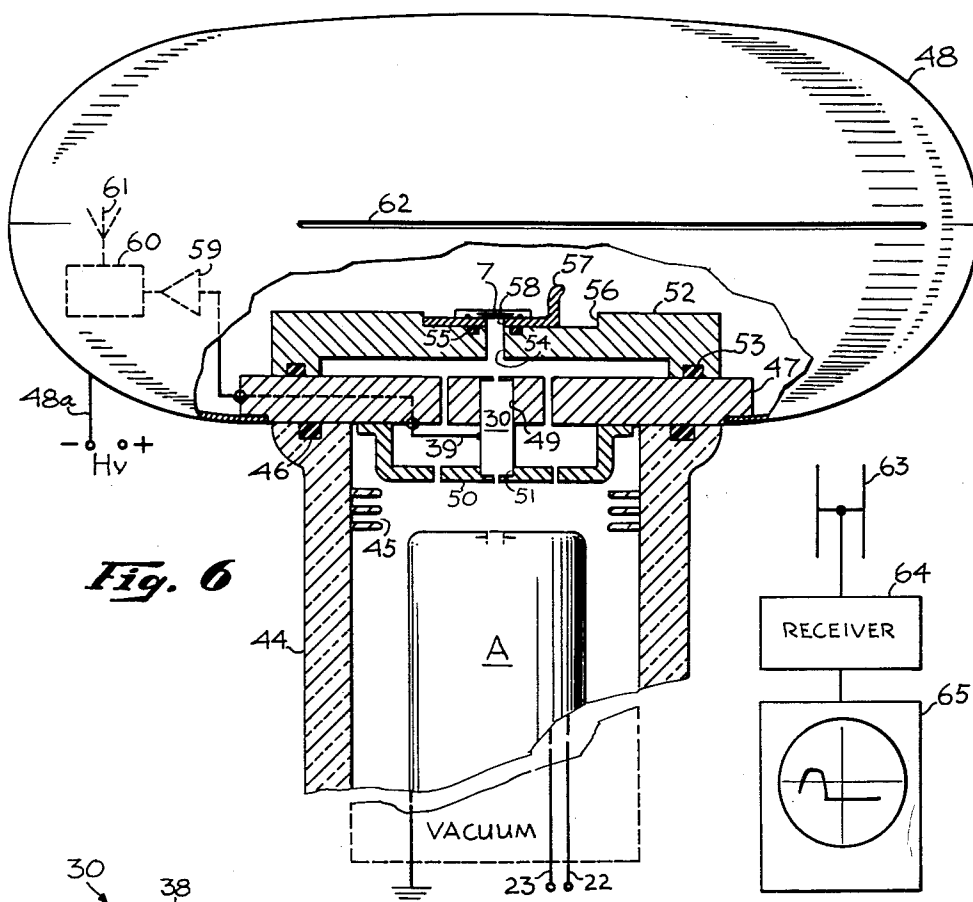


Fig. 6

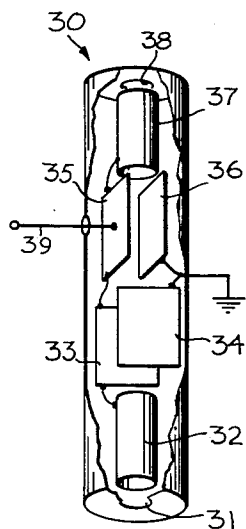


Fig. 4

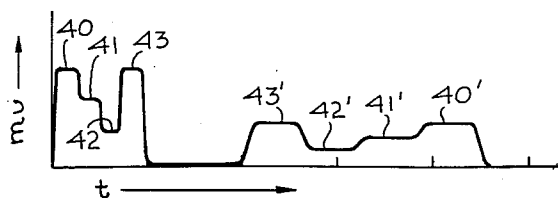


Fig. 5

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CHARGED PARTICLE EJECTION MEANS

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The present invention relates to a charged particle ejection means and in particular to a means for electrostatically charging particles and accelerating these particles in a predetermined direction at very high velocities.

In the area of high velocity collision of one object with another very little information has been available. It is believed that the reaction of a surface to the impact of high velocity micron particles may provide information as to the reaction of larger particles striking a surface. It can be seen, therefore, that by providing a means of studying the collision of micron size particles with a surface more information about other size particles can be obtained. In addition, the velocities obtained by the structure of this invention can be used to simulate the study of meteors or vehicles moving through space, as well as providing a means of forming holes in a solid surface.

It is, therefore, an object of the present invention to provide a reliable particle ejection device operable to eject charged particles at high velocities.

It is another object of the present invention to provide a reliable arrangement for detecting the velocities and positions of the charged particles immediately prior to impact or other study.

It is another object of this invention to provide a particle ejection device that is relatively free from malfunction due to insulator breakdown.

Other objects, purposes and characteristic features will become obvious as the description of the invention progresses.

According to one embodiment of the present invention involving the basic principles, a reservoir of particles such as dust particles, or extremely fine metallic powder, preferably smooth and spherical, is subjected to an electric field to disturb the particles and cause them to move into the region of a positively charged electrode. Upon contact of the positively charged electrode by one of the disturbed particles, the electrons are given off to the electrode, and the particle becomes positively charged. Upon becoming positively charged, the particle is attracted rapidly towards a target by a suitable accelerating electrode. The velocity obtained by the particle is equal to the square root of two times the charge to mass ratio multiplied by the accelerating voltage.

FIGURE 1 shows a block diagram illustrating the main components of the present invention.

FIGURE 2 shows a schematic cross-sectional view of one device for producing a charged particle.

FIGURE 3 shows a schematic representation of another embodiment of a device for producing a charged particle.

FIGURE 4 shows a particle detection device capable of particle velocity and position detection.

FIGURE 5 is a curve representing the passage of a particle through the detection device of FIGURE 4, and

FIGURE 6 shows a schematic representation of a complete charged particle accelerating device utilizing the charged particle producing device of FIGURE 3.

In the figures of the drawings, like numerals indicate similar parts.

In the block diagram illustration of FIGURE 1, there is shown a particle producing device or source A comprising a reservoir 1, an injection means 2, and a charging electrode means 3. Any particle ejected by the source A

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passes into the region of an accelerating means 4 for providing acceleration motion to the charged particle from the source A. Under circumstances where the accelerator of the device is long, it may be desirable to provide a first detecting means 5 near the charging electrode 3 and before the accelerating means 4 for determining the velocity of the particle prior to reaching the accelerator means 4 area.

After leaving the accelerator means 4 the particle velocity is again measured by a second particle detection means 6, prior to collision with the target 7.

In FIGURE 2, one embodiment of the injection means involving the ejection device A of FIGURE 1 is shown. In this embodiment the reservoir of particles 1 is shown as provided with a feed pipe 8 from suitable main reservoir 9 capable of periodically replenishing the particles in the small reservoir 1 through any suitable conveying means (not shown). The reservoir 1 is normally maintained at ground potential and is provided with an injector electrode 2 supported on an insulator 10 remote from the reservoir 1. The injector electrode 2 is provided with a negative input potential capable of causing the particles in the reservoir 1 to be disturbed and deflected out through the passage 11 to a contoured deflected surface 12 capable of directing the particles into the vicinity of the charging electrode 3. The injector electrode 2 is brought into the reservoir 1 through the passage 11 and serves to keep the passage free from particle stoppage.

The charging electrode 3 is provided with a positive source of potential V (not shown) and the electrode is in the form of a sphere to provide for maximum strength at the time of particle contact. It should be understood, however, that other shapes such as a point may be used.

The electrode sphere 3 utilizing a high charge density along its surface is also preferably formed of an extremely hard material such as tungsten in order to prevent its destruction upon contact by a negatively charged particle from the reservoir 1. The particles from the reservoir 1 are preferably of micron diameter but may be of a different size. The tungsten electrode sphere 3 should be at least several diameters larger, for example, 25 microns in diameter.

With this type of size relationship the small particle from the reservoir 1 launched into the vicinity of the sphere 3 can be attracted thereto and provided with the positive charge density as related to a surface electric field intensity of about 25 million volts per centimeter.

The reservoir 1 and injector electrode 2 are supported within a grounded frame member 13 which is provided with an opening 14 of relatively large size compared to the particle passing therethrough. The opening 14 is used to provide a restriction to limit the direction in which a particle can be launched for use. The particle after passing through the opening 14 eventually passes an accelerator of high voltage and strikes a target, each of which is not shown.

The embodiment of FIGURE 3 illustrates a different form of ejector device A in which the reservoir 1 is positioned within a recess formed by the injector electrode 2 upon which the charging sphere 3 is supported. The charging sphere 3 is supported upon a rod 15 secured to the injector 2 and positioned within a substantially half domed shaped recess 16 within the frame 13 also provided with an ejection hole 14. The injector electrode 2 is supported on suitable insulators 10 and the reservoir 1 is supported from the injector electrode 2 on a suitable insulator 18. In this embodiment the reservoir 1 is provided with a base portion 19 having openings 20 therein for allowing misdirected particles to be directed outwardly through to the bottom of the base portion 19 without coming into contact with the insulators 10 or 18. In ad-

dition, the supporting base member 13 is provided with openings 21 also for the purpose of directing misguided particles outwardly away from the insulators 10 or 18 to prevent breakdown of the insulating structure.

The injector electrode 2 is connected through a suitable conductor 22 to a suitable source of potential V, preferably in the potential range of 10 to 20 kilovolts. The reservoir 1 is connected through a conductor 23 and a suitable resistor 24 to the 10 to 20 kilovolts source so that during no current flow through the resistor 24, the reservoir 1 and injector electrode 2 are at the same potential.

In order to cause the reservoir 1 and injector electrode 2 to have a difference in potential, a suitable high voltage tube 25 is provided with its anode 26 connected to the resistor 24, its cathode 27 connected to ground and its grid 28 connected to a conductor 29 capable of receiving control pulses from a control pulse source (not shown), to cause conduction of the tube 25 and thus a voltage drop across the resistor 24. This action results in a voltage difference between injector electrode 2 and the reservoir 1 with the injector electrode 2 at the 10 to 20 kilovolt potential level and the reservoir 1 going negative therefrom by a value determined by the current flow through the resistor 24. Since the electrode 2 supported sphere 3 is connected to the injector electrode 2 its potential is also from 10 to 20 kilovolts with respect to the supporting frame 13. It can be seen, therefore, that any particle launched by the input pulse to the grid 28 of the tube 25 and caused to eventually strike the electrode 3 is provided with a charged density proportional to the charged density of the electrode 3. It has been found that the small micron size particles upon contact with the electrode 3 when the electrode 3 is provided with a high density charge on its surface will actually obtain a charge density of 1.65 times the charge density on the electrode 3. It can be seen, therefore, that if the charge density on the sphere 3 is in the vicinity of 15 to 18 million volts per centimeter, the particle contacting the sphere 3 will have a charge density in the region of 25 to 30 million volts per centimeter.

FIGURE 4 shows a detection device for any particle launched from the sphere 3 with the detection device positioned prior to the target. The detection device 30 may be described as a cylinder having an end opening 31 positioned to receive a particle from the sphere 3. Positioned adjacent to the opening 31, along the path of the particle, is a cylinder 32 capable of being increased in potential level by the field established by the positive charge on the particle passing therethrough. After passing through the cylinder 32 the particle then passes between a pair of horizontally displaced plates 33 and 34 with the plate 33 connected to the cylinder 32 and the plate 34 connected to ground. As the particle progresses further through the detector 30 it then passes through a pair of vertical displaced plates 35 and 36 with the plate 35 connected to the plate 33 and the plate 36 connected to ground. Further movement of the particle passed the plates 35 and 36 causes the particle to enter another cylinder 37 also connected to the plate 35 and also capable of detecting the field of the charge on the particle as it passes therethrough. The particle then finally passes through an opening 38 in the cylinder of the detector 30. In order to detect the particle as it passes through each of the cylinders and through each of the pairs of plates a conductor 39 is provided. The conductor 39 is connected to the plate 35 and capable of reading the potential level of each of the elements 32, 33, 35 and 37 connected thereto. The action of a particle passing through the detector will now be described. If we plot a curve (see FIG. 5) with the detector output in millivolts along the ordinate and the particle passage time through the detector as illustrated in microseconds along the abscissa, it can be seen that as the particle passes through the cylinder 32 an output occurs on the conductor 39. During the period of traverse time of the cylinder 32 an output voltage lobe 40 occurs. The actual velocity of the particle can be detected by the

length of the lobe 40, however, greater accuracy can be provided if the traverse time taken by the particle through the entire detector is used as will be explained hereinafter. As the particle moves into the area between the plates 33 and 34, a second potential level 41 occurs which may be at any position between the maximum potential 40 and zero depending upon whether the particle strikes the plate 33 or is positioned between the plates 33 and 34 or strikes the plate 34. The representative potential level illustrated by the plateau 41 indicates that the particle is passing closer to the plate 33 than the plate 34. As the particle passes on into the zones between the plates 35 and 36 another plateau 42 occurs, again depending upon the position of the particle with respect to the plates 35 and 36. As shown in the illustration of FIGURE 5, this particle is passing approximately midway between the plates 35 and 36. Movement of the particle into the final cylinder 37 causes the next plateau 43 which should be at exactly the same potential level as the plateau 40 and as the particle passes out of the cylinder 37, the length of time of the entire micron particle passage through the detector 30 can provide a means of determining the velocity of the particle. If we assume that the particle strikes a target at some point beyond the detector and instead of being absorbed in the target the particle is actually bounced back, the second portion of the curve of FIGURE 5 would occur. In this case as a particle returns back through the cylinder 37, the plateau 43' of much longer length due to the slower velocity of the particle and lesser voltage height due to the loss of charge will occur. As the particle continues its return passage the plates 35 and 36 would cause the plateau 42' to occur, the plates 33 and 34 would cause the plateau 41' to occur and the cylinder 32 would cause the plateau 40' to occur.

The use of two cylinders 32 and 37 in the detector provides a means of always indicating that the particle has completely traversed the detector 30.

Referring now to FIGURE 6, a complete illustration of one complete system is provided. In this figure the ejector A of FIGURE 3 and the detector 30 of FIGURE 4 are utilized and thus will not be further described. In this figure a suitable hollow glass cylinder 44 is provided capable of allowing the area therewithin to be evacuated by a pump not shown. The cylinder 44 is provided with arcing arrester ridges 45 for preventing high voltage arcing within the interior of the evacuated glass cylinder 44. At the top of the glass cylinder there is positioned an O-ring seal 46 for providing a complete seal between the glass cylinder 44 and the base plate 47 of a high voltage dome 48 positioned on top thereof. The base plate 47 is provided with an opening 49 for supporting the detector 30 therein with the detector 30 having a shield 50 enclosing the detector to provide smooth edges for reducing the possibility of arcing. The shield 50 is also provided with an opening 51 for the detector to receive particles therethrough. The base plate 47 has positioned thereabove a container forming member 52 provided with an O-ring seal 53 therebetween. The container member 52 is provided with an opening 54 for allowing the passage of the launched particle therethrough. Positioned about the opening 54 is an O-ring seal 55 and a suitable recess 56. Within the recess 56 and in contact with the O-ring seal 55, there is provided an air lock slide member 57 capable of supporting the target 7 thereon for displacement to one side while the target is being removed and replaced. The action of the air lock 57 is as follows: With the air lock in one extreme position covering the opening 54, the target is placed over an opening 58 therein. With the target now in place over the opening 58, the air lock is moved to its other extreme position positioning the opening 58 and target 7 in alignment with the opening 54. With this arrangement, the vacuum within the device is maintained with the high voltage dome 48 at normal air pressure level. The dome 48 is provided with a negative

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high accelerating voltage over the conductor 48a from a source Hv (not shown). With a negative voltage of 2 million volts and a one micron diameter particle a velocity of 10 km./sec. can be obtained.

Since the dome 48 is at high voltage potential and the detector 30 is also at the same potential, the problem exists in obtaining information from the detector in a safe manner. For this purpose, a suitable amplifier 59 is connected to the detector conductor 39 to amplify the detector signal. The amplified signal is then fed into a suitable transmitter 60 and radiated through the antenna 61 and the half wavelength slot 62 in the dome 48 to be picked up on a suitable receiver antenna 63. The signal received by the antenna 63 is amplified by a suitable receiver 64 and displayed on a suitable oscilloscope 65.

The ejector and accelerating device of this invention impart a velocity set forth by the following equation:

$$V_p = \sqrt{2\left(\frac{q}{m}\right)V_a}$$

where:

V_p =velocity of the particle

q =particle charge

m =particle mass

V_a =accelerating voltage

While there has been described what is at present considered a preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A high velocity particle ejection device comprising: a particle reservoir means; a plurality of particles in said reservoir; positively charged electrode means; injector means for providing an electric field for charging said particles to cause random displacement of a portion of said particles into an area adjacent said electrode means; an accelerator means for providing an accelerating potential for positively charged particles; each of said particles being positively charged on contact with said positively charged electrode.

2. A high velocity particle ejection device comprising: a particle reservoir means; a plurality of particles in said reservoir; positively charged electrode means; injector means for providing an electric field for charging said particles to cause random displacement of a portion of said particles into an area adjacent said electrode means; accelerator means for providing an accelerating potential for positively charged particles; each of said particles being positively charged on contact with said positively charged electrode; said injector means having a negatively charged electrode provided with a surface for directing displaced particles into the area adjacent said positively charged electrode.

3. A high velocity particle ejection device comprising: a particle reservoir means; a plurality of particles in said reservoir; positively charged electrode means; injector means for providing an electric field for charging said particles to cause random displacement of a portion of said particles into an area adjacent said electrode means; an accelerator means for providing an accelerating potential for positively charged particles; each of said particles being positively charged on contact with said positively charged electrode means; control means for providing a difference in potential between said reservoir means and said injector means.

4. A high velocity particle ejection device comprising: a particle reservoir means; a plurality of particles in said reservoir; positively charged electrode means; injector means for providing an electric field for charging said particles to cause random displacement of a portion of said particles into an area adjacent said electrode means;

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an accelerator means for providing an accelerating potential for positively charged particles; each of said particles being positively charged on contact with said positively charged electrode means; control means for providing a difference in potential between said reservoir means and said ejector means; said positively charged electrode means being mounted upon said injector means and at the same potential level; said control means causing said reservoir to change potential with respect to said injector means.

5. A high velocity particle ejection device comprising: a particle reservoir means; a plurality of particles in said reservoir; positively charged electrode means; injector means for providing an electric field for charging said particles to cause random displacement of a portion of said particles into an area adjacent said electrode means; an accelerator means for providing an accelerating potential for positively charged particles; each of said particles being positively charged on contact with said positively charged electrode means; control means for providing a difference in potential between said reservoir means and said injector means; said control means comprising a pulse controlled electron tube having a resistor connected between said injector means and said reservoir means for providing potential difference therebetween during said electron tube conduction.

6. A high velocity particle ejection device comprising: a particle reservoir means; a plurality of particles in said reservoir; positively charged electrode means; injector means for providing an electric field for charging said particles to cause random displacement of a portion of said particles into an area adjacent said electrode means; accelerator means for providing an accelerating potential for positively charged particles; each of said particles being positively charged on contact with said positively charged electrode means; said positively charged electrode means including a hard tungsten sphere.

7. A high velocity particle ejection device comprising: a particle reservoir means; a plurality of particles in said reservoir; positively charged electrode means; injector means for providing an electric field for charging said particles to cause random displacement of a portion of said particles into an area adjacent said electrode means; accelerator means for providing an accelerating potential for positively charged particles; each of said particles being positively charged on contact with said positively charged electrode means; said positively charged electrode means including a sphere; said sphere being at least several times the diameter of each of said particles.

8. A high velocity particle ejection device comprising: a particle reservoir means; a plurality of particles in said reservoir; positively charged electrode means; injector means for providing an electric field for charging said particles to cause random displacement of a portion of said particles into an area adjacent said electrode means; an accelerator means for providing an accelerating potential for positively charged particles; each of said particles being positively charged on contact with said positively charged electrode means; said acceleration means providing a field potential capable of causing

$$\text{positively charged particle velocities} = \sqrt{2\left(\frac{q}{m}\right)V_a}$$

where: q =the charge on the particle; m =mass of the particle; and V_a is the accelerator voltage.

9. A high velocity particle ejection device comprising: means for ejecting particles into an area; electrode means in said area for positively charging said particles contacting said electrode means; accelerating means for providing particle acceleration to a selected velocity; and detector means for detecting the velocity and position of particles passing through said detector means.

10. A high velocity particle ejection device comprising: means for ejecting particles into an area; electrode means in said area for positively charging said particles contact-

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ing said electrode means; accelerating means for providing particle acceleration to a selected velocity; and detector means for detecting the velocity and position of particles passing through said detector means; said detector having a velocity sensing means and direction sensing means.

11. A high velocity particle ejection device comprising: means for ejecting particles into an area; electrode means in said area for positively charging said particles contacting said electrode means; accelerating means for providing particle acceleration along a path to a selected velocity; and detector means for detecting the velocity and position of particles passing through said detector means; said detector means having a velocity sensing means and direction sensing means; said velocity sensing means including a cylinder surrounding the path of passing particles accelerated away from said electrode means.

12. A high velocity particle ejection device comprising: means for ejecting particles into an area; electrode means in said area for positively charging said particles contacting said electrode means; accelerating means for providing particle acceleration along a path to a selected velocity; and detector means for detecting the velocity and position of particles passing through said detector means; said detector means having a velocity sensing means and direction sensing means; said direction sensing means including two pairs of detection plates; one of said pairs of detection plates being positioned to detect particle movement in one plane and the other of said pairs of detection plates being positioned to detect particle movement in a plane 90° thereto.

13. A high velocity particle ejection device comprising: means for ejecting particles into an area; electrode means in said area for positively charging said particles contacting said electrode means; accelerating means for providing particle acceleration along a path to a selected velocity; and detector means for detecting the velocity and position of particles passing through said detector; said detector means having a velocity sensing means and a direction sensing means; said direction sensing means including two pairs of detection plates; one of said pairs of detection

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plates being positioned to detect particle movement in one plane and the other of said pairs of detection plates being positioned to detect particle movement in a plane 90° thereto; each of the plates of each of said pairs of detection plates being positioned in spaced apart relationship on opposing sides of said particle path with one plate of each pair being retained at detector means potential during particle passage.

14. In a high velocity particle ejection device a detector means comprising: first and second spaced apart velocity sensing means; first and second direction sensing means; said first and second velocity sensing means including cylinders surrounding a path for high velocity positively charged particles for sensing the positive field established about one of said particles as it passes therethrough; said direction sensing means including field strength measuring spaced part plates positioned to determine the relative particle field strength with respect to said plates during the particle traverse period; and output means for providing remote indication of detector velocity and direction sensing.

15. In a high velocity particle ejection device a detector means comprising: first and second spaced part velocity sensing means; first and second direction sensing means; said first and second velocity sensing means including cylinders surrounding a path for high velocity positively charged particles for sensing the positive field established about one of said particles as it passes therethrough; said direction sensing means including field strength measuring spaced apart plates positioned to determine the relative particle field strength with respect to said plates during the particle traverse period; output means for providing remote indication of detector velocity and direction sensing; said output means combining the detection of said first and second velocity sensing means and said first and second direction sensing means into a single output for display in event time sequence.

References Cited in the file of this patent UNITED STATES PATENTS

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,018,399

January 23, 1962

Haywood Shelton

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 8, lines 17 and 23, for "part", each occurrence, read -- apart --.

Signed and sealed this 5th day of June 1962.

(SEAL)

Attest:

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Commissioner of Patents