NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

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REPLY TO
ATTN OF: GP

TO: KSI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for
Patent Matters

SUBJECT: Announcement of NASA-Owned U.S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code KSI, the attached NASA-owned U.S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No.	: 3,741,001
Government or Corporate Employee	: Litton Systems, Inc. Minneapolis, MN
Supplementary Corporate Source (if applicable)	:
NASA Patent Case No.	: HQN-10037-1

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:
Yes [X] No [ ]

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of column No. 1 of the Specification, following the words ". . . with respect to an invention of . . ."

Elizabeth A. Carter

Elizabeth A. Carter
Enclosure
Copy of Patent cited above

(NASA-Case-HQN-10037-1) APPARATUS FOR SAMPLING PARTICULATES IN GASES Patent (Litton Systems, Inc.) 8 p CSCL 14B
N73-27376
Unclas
00/14 09032

United States Patent [19]
Fletcher et al.

[11] **3,741,001**
[45] **June 26, 1973**

[54] **APPARATUS FOR SAMPLING PARTICULATES IN GASES**

[76] Inventors: **James C. Fletcher,** Administrator of the National Aeronautics and Space Administration with respect of an invention; **Rex C. Wood,** 1958 Cedar Drive, New Brighton, Minn. 55112

[22] Filed: **Mar. 20, 1972**

[21] Appl. No.: **235,957**

[52] U.S. Cl. **73/28**
[51] **Int. Cl.** **G01n 15/06**
[58] **Field of Search** .... 73/28, 170, 421.5 R

[56] **References Cited**

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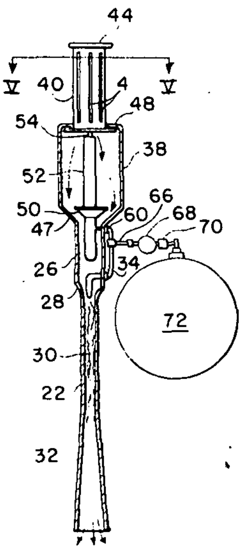
Primary Examiner—S. Clement Swisher
Attorney—John R. Manning et al.

[57] **ABSTRACT**

Improved apparatus for sampling particulatematerial in gases of the type comprising the combination of a slit impactor and air ejector pump. The apparatus disclosed comprises an air ejector pump, a primary nozzle in the air ejector pump, a source of compressed gas which compressed gas is supplied to the primary nozzle through a valved supply line, a collection cylinder having a plurality of slit impactors at the cylindrical surface thereof. The slit impactors are parallel to the longitudinal axis of the collection cylinder. The collection cylinder is normally stowed within a cylindrical storage casing, one end of which is in communication with the inlet of the air ejector pump. The second end of the casing has a circular opening with a diameter larger than the diameter of the collection cylinder. The apparatus has a pneumatic actuator which is operated by compressed gas fed to the actuator from the same valved supply line which supplies the ejector pump. The actuator is connected to the collection cylinder in such a manner that when the compressed gas is fed to the actuator the collection cylinder will be moved outside of the storage casing. The actuator has a spring to bias the collection cylinder to the stowed position when the actuator is not being supplied with pressurized gas. When the collection cylinder is stowed in the storage casing, sampling surfaces are isolated from outside atmosphere to prevent contamination of the sampled particulates.

15 Claims, 7 Drawing Figures



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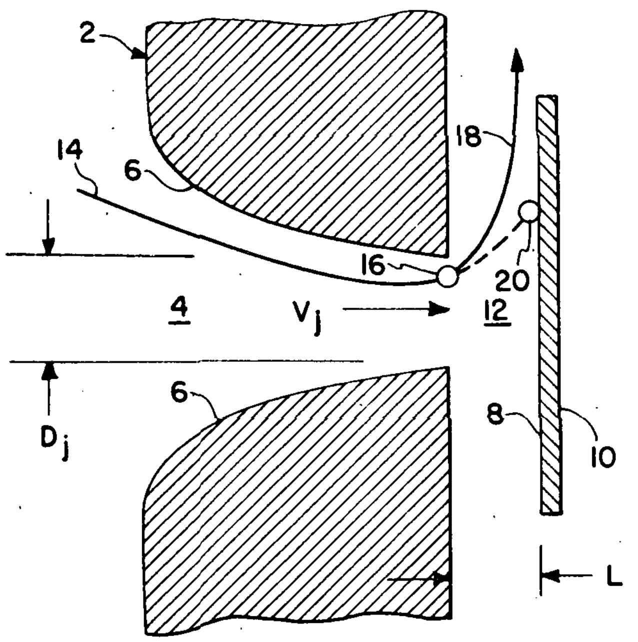
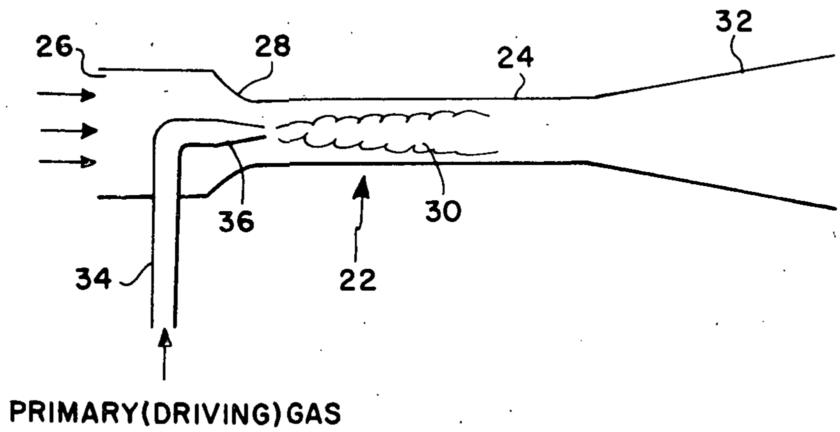

2
14
6
18
16
20
4
V_j
12
6
8
10
D_j
L

FIG. 1


26
28
24
32
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PRIMARY (DRIVING) GAS

FIG. 2

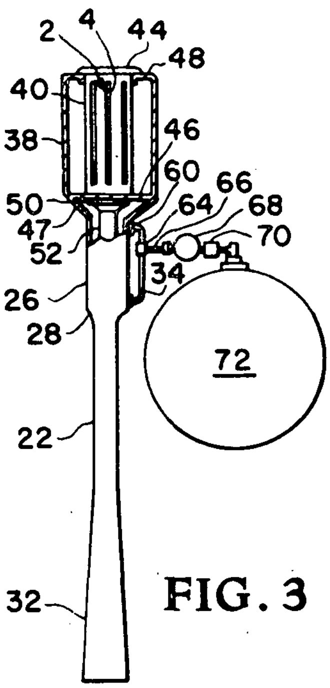

FIG. 3

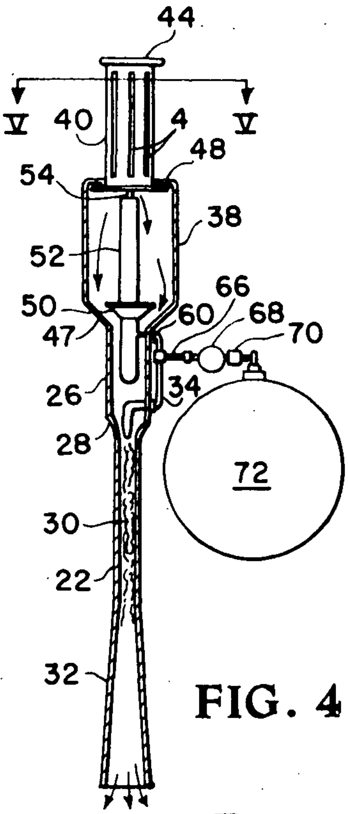

FIG. 4

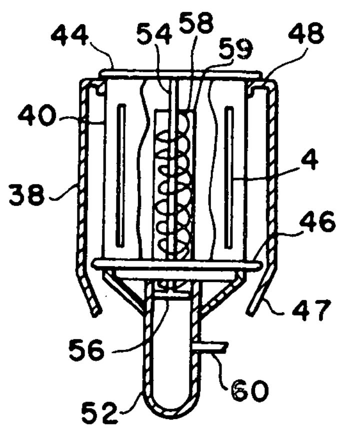

FIG. 6

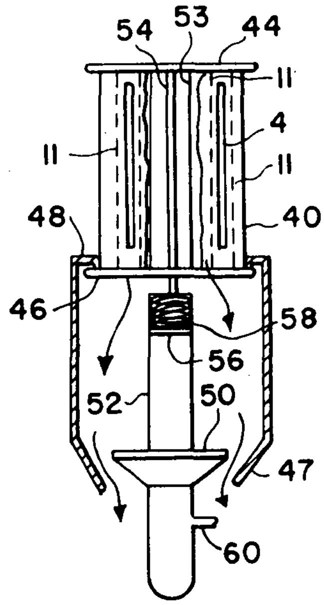

FIG. 7

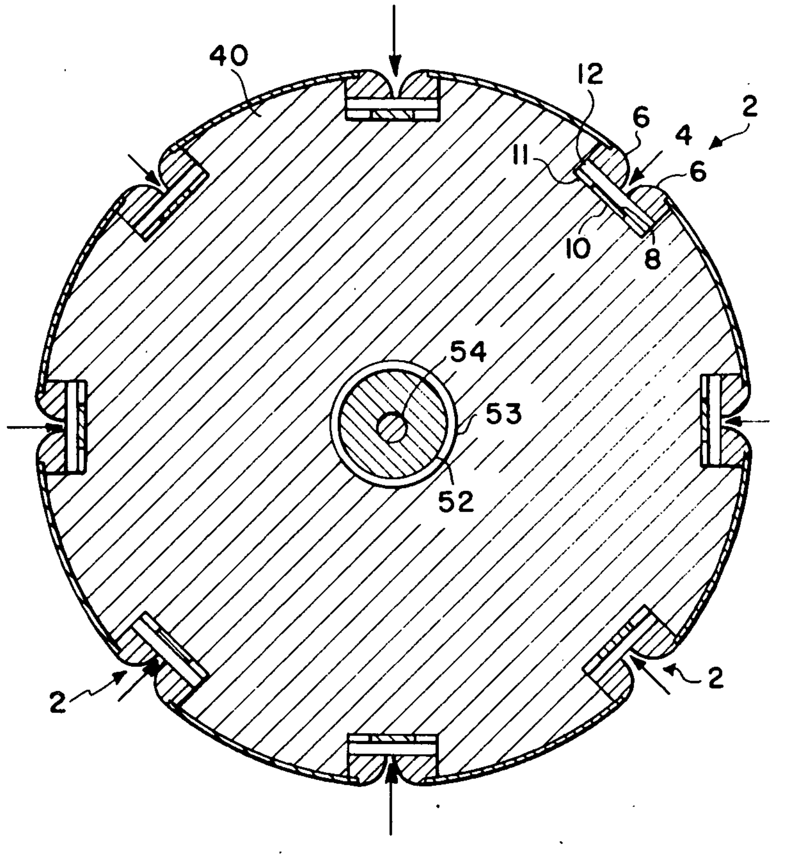

FIG. 5

APPARATUS FOR SAMPLING PARTICULATES IN GASES

ORIGIN OF THE INVENTION

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 Stat. 435; 42 U.S.C. 2457).

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to the collection of samples of extra-terrestrial particles and more particularly to apparatus used for the collection of such samples.

2. Description of the Prior Art

Over the past few years scientific interest in obtaining samples of small solid particles from the atmosphere, especially the upper regions thereof, has increased significantly. Many different techniques have been employed with varying degrees of success.

The primary problem to the present time has been the lack of a relatively simple sample collection system which was capable of collecting sample particles at a specific height without the samples becoming contaminated by exposure to the atmosphere at different heights during descent of the collection device or by the presence of contaminants accumulated on the collection surface during ascent of the collection device to the height under investigation.

Because of the extremely small size of the particles to be sampled, common well known techniques for sampling solids in gases are not satisfactory.

One type apparatus for sampling extraterrestrial dust which has been developed recently comprises what is known as a slit impactor which is coupled to an air ejector pump. In this apparatus, particle laden air is pulled through a specially designed slit orifice. Located downstream of the slit orifice is an impactor plate having a collection surface for the particles to be sampled. The air streams drawn through the slit are caused to bend sharply at the impactor plate. The inertia of the particles tends to keep them moving in a straight line to the collection surface on the impactor plate where they are collected.

The air drawn in through the slit past the impactor plate is drawn by a device known as an air ejector pump. In an air ejector pump a jet of relatively high velocity primary gas is injected into the upstream section of a venturi like mixing tube and expands to entrain the surrounding secondary air, or air that is drawn in through the slit. The momentum of the driving or primary air mixed with the driven or secondary air causes a reduction in pressure in mixing tube and a net flow through the system.

The collection efficiency of such jet impaction system is characterized by the value of an inertial parameter K where

$$K = (C\, P_p V_j D_p{}^2)/(18\, \mu_j\, D_j) \qquad (1)$$

and,

C = Cunningham's slip correction,
P_p = Particle density,
V_j = Jet air velocity,
Dp = Particle diameter,
μj = Jet air viscosity,
Dj = Jet (slit) width.

Other variables which must also be considered are the Jet Reynolds number, Re_j; the jet clearance, L, and the inlet shape. The collection efficiency, η, in functional notation, neglecting the shape factor, is then expressed by:

$$\eta = (K,\ Re_j,\ L/D_j). \qquad (2)$$

Theoretical solutions for this equation have been developed by a number of investigators (Ranz and Wong, 1952; Davies and Aylward, 1951). In general, however, experimental methods have been employed to obtain data from which performance characteristics may be accurately predicted. Prior collection devices of the type described have generally been limited to a single collection surface, and most importantly, no practical device which assured that the collection surface and collected sample were maintained free of contaminants or unwanted particles has been developed.

SUMMARY OF THE INVENTION

The present invention overcomes many of the foregoing problems by providing an air-borne particle sampler for use in collecting samples of extraterrestrial dust which assures that the samples collected are protected from contamination by unwanted particles and provides a compact arrangement of multiple collection surfaces. The device of this invention also utilizes a common source of gas pressure providing the primary or driving gas of an air ejector pump, and for driving an actuator exposing the normally enclosed collection surfaces during the sampling period.

The apparatus of the present invention broadly comprises a sample collection cylinder having a plurality of slit impactors running longitudinally on the outer cylindrical surface of the cylinder and terminating just short of each end of the cylinder, in combination with an air ejector pump.

Spaced inwardly from and aligned with each impactor slit is a collection surface. Behind the impactor slits and between the impactor slits and collection surfaces are longitudinal air-flow channels running from the top to the bottom of the cylinder. The bottom of the air-flow channels are in communication with the upstream end of the air ejector pump. As indicated, the air ejector pump is operated by a primary driving gas.

The collection cylinder is carried on a pneumatic actuator. When sampling is not taking place, the collection cylinder is contained within a cylindrical storage compartment which is upstream of the air ejector pump. During the sampling period when the primary driving gas is turned on, the sampling cylinder is extended outside of the storage cylinder by a pneumatic actuator which is operated from a common source of compressed gas which supplies the air ejector pump. The air flow channels are in communication through the storage cylinder with the upstream end of the air collection pump. When the source of driving gas is exhausted or valved off, the air ejector pump ceases to function, and spring means associated with the pneumatic actuator return the collection cylinder to stowed position within the storage cylinder, and seal off the collection surfaces from the atmosphere.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawing:

FIG. 1 is a schematic diagram of an air impactor collection system showing a particle to be sampled impinging against the collection surface.

FIG. 2 is a schematic diagram of an air ejector pump of the type utilized in the apparatus of this invention.

FIG. 3 is a side view partially in section of the apparatus according to this invention with the collection cylinder shown in the retracted or stowed position.

FIG. 4 is a side view of the apparatus of this invention shown partially in section and with the collection cylinder in the exposed position and the air ejector pump in operation.

FIG. 5 is a cross sectional view of the collection cylinder taken along line V—V of FIG. 4.

FIG. 6 is an enlarged sectional view of the storage cylinder and collection cylinder with the collection cylinder in the retracted position.

FIG. 7 is an enlarged sectional view of the storage cylinder and collection cylinder with the collection cylinder in the exposed position.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring to FIGS. 1 and 2 of the accompanying drawing, a slit impactor is shown generally at **2**. The slit orifice or intake opening **4** is formed by the curved inlet surfaces **6**. Behind the slit orifice **4** is the collection surface **8** which is mounted on an aluminum backing strip **10**. The air flow channel **12** is in communication with the air ejector pump **22** which causes the outside particle laden air to be drawn through the slit orifice **4** as shown by the air stream line **14**. The air carries with it the particle shown at position **16**. As the air approaches the impact surface behind the slit orifice **4** it is curved sharply away from the slit orifice **4** because it must flow away from the surface **8**. The inertia of the particle causes the particle to tend to maintain its direction towards the surface **8** and it falls out of the air stream and impinges upon the collection surface **8** as shown at position **20**. The dimension of the jet slit referred to by the "J" in the formula above is indicated in FIG. 1 as well as the jet air velocity "V_j" and the jet clearance "L".

In FIG. 2 the air ejector pump is shown generally at **22** and comprises a tube **24** comprising an upstream inlet **26** and a secondary nozzle **28** for the driven or secondary air from the impact slit and a mixing portion of the tube **24** shown at **30**. The downstream end of the tube **24** has an outwardly extending diffusing portion **32**. The primary driving gas is supplied through a supply line **34** to the primary nozzle **36** which is positioned centrally of the secondary nozzle **28** in the tube **24**.

As shown in FIGS. 3 through 7 of the drawing the sampling apparatus of the present invention comprises a collection cylinder **40** for supporting a plurality of slit impactors **2** arranged parallel to the longitudinal axis of the cylinder **40** on the outside surface of the cylinder. The cylinder **40** is stored within a cylindrical storage casing or housing **38**. The casing **38** is connected at its lower end to an extension of the inlet **26** of the tube **24** of the air ejector pump **22**.

Collection cylinder **40** is extended upward outside of the storage casing **38** during the sampling operation as shown in FIGS. 4 and 7. Backing plates **10** are located at the back of the longitudinal channels **11** which extend in each case from the top to the bottom of the cylinder **40**. A removeable top cover plate **44** seals the open ends of the channels **11** at the top of the cylinder **40**. The backing plates **10** with the impact surfaces **8** may be removed through the top of the cylinder by removing the cover **44**. The plates **10** are dimensioned so that they slide snugly into the channels **11**. The slit orifices **4** terminate as shown in FIGS. 3 and 4 a slight distance from the top and bottom of the cylinder **40**. The channels **11** open into the bottom of the cylinder **40** but are not covered by the base plate **46** which extends outwardly from the base of the cylinder **40**. When the cylinder **40** is in the stowed position as shown in FIGS. 3 and 6 the edges of the plate **46** rest in sealing engagement with the side wall **47** of the casing **38**. The bottom ends of the channels **11** are then closed by the pedestal **50** of the pneumatic actuator **52**. The top plate **44** of the cylinder forms a seal with the flanges **48** of the casing **38**.

When the collection cylinder **40** is extended for sampling as shown in FIGS. 4 and 7 the top surface of the base plate **46** comes in contact with the undersides of flanges **48** at the top of the casing **38**.

The pneumatic actuator **52** extends the collection cylinder **40** outside of the cylindrical casing **38** for sampling and automatically returns the collection cylinder to the position shown in FIG. 3 within the casing **38** when the sampling is complete. The collection cylinder **40** has a circular passage **53** running longitudinally from the top of the bottom of the cylinder and having a diameter slightly larger than the outside diameter of the pneumatic actuator **52**. The top plate **44** of the cylinder **40** is connected at the center of the lower surface thereof to the connecting rod **54** of the actuator **52**. This is shown best in FIGS. 5, 6, and 7. The connecting rod has a piston **56** at the bottom thereof. A compression spring **58** located between the top **59** of the actuator and the piston **56** normally biases the piston **56** towards the lower end of the actuator cylinder **59**, and thus, in absence of stronger pressure on the lower side of the piston **56**, will cause the collection cylinder **40** to remain within the cylindrical casing **38**.

The supply line **60** is provided for the supplying of compressed gas to the actuator cylinder **59** below the piston **56** in order to force the piston **56** upwardly in the cylinder as shown in FIG. 7 thereby moving the collection cylinder **40** outside of the casing **38**. The supply line **34** for the primary nozzle **28** is joined with the supply line **60** for the pneumatic actuator at the T **64** which leads to a common supply line **66** having a pressure regulator **68** and a valve **70** in order to regulate the flow of compressed gas from the storage tank **72**.

In operation the collection sampler apparatus is carried aloft to the desired sampling altitude by balloon or other means. When it is desired to commence sampling, automatic control means (not shown) open the valve **70** to permit the flow of compressed gas through lines **66**, **60** and **34**. Simultaneously the air ejector pump **22** starts to operate in the manner described above to draw air through the impactor slits **4** and the collection cylinder **40** is extended outside of the casing **38** by the action of the compressed gas on the lower surface of the piston **56** of the pneumatic actuator **52** which forces the piston **56** and rod **54** connected to it upward, thereby extending the collection cylinder **40** upward until the top surface of the base plate **46** contacts the lower surface of the flanges **48**.

Since, as indicated, the channels **11** are open at the base of the collection cylinder **40**, they are placed in communication with the air being drawn by the air ejector pump 22. The air to be sampled is thereby drawn into the impactor slits 4.

When the compressed gas in the tank 72 is exhausted or when the valve 70 is closed, the operation of the air ejector pump 22 ceases, pressure is removed from the base of the piston 56 and the action of the spring 58 returns the collection cylinder 40 to inside the casing 38.

The collection surfaces 8 are thereby isolated from exposure to contaminants in the atmosphere by the sealing of plate 44 on the flanges 38, the sealing of channels 11 by the pedestal 52, and the sealing of the plate 46 on the walls 47.

In the apparatus shown in the accompanying drawings, the collection cylinder 40 is approximately 6 inches in diameter and the apparatus had the following characteristics:

Sampling rate	$30 m^3/min$
Particle size cutoff, diameter*	0.1 micron
Impactor slit width	3 mm
Impactor slit length	400 mm
Number of impactor slits	8
Total area, particle deposit	$96 cm^2$
Compressed nitrogen gas	50 lb at 3000 p.s.i.
System weight at launch **	350 lb
Altitude of sample	40 km

* Lower limit at which collection efficiency becomes 50% for spherical particles of unit density.
** Includes peripheral instrumentation, ballast, suspension cable.

While the invention has been explained by detailed description of certain specific embodiments, it is understood that various modifications and substitutions can be made in any of them within the scope of the appended claims which are intended also to include equivalents of such embodiments.

What is claimed is:

1. Apparatus for sampling particulate material in gases comprising, an air ejector pump, a primary nozzle in said air ejector pump, a source of compressed gas, a valved supply line from said source of compressed gas to said primary nozzle, a collection cylinder, a plurality of slit impactors at the cylindrical surface of said collection cylinder and parallel to the longitudinal axis of said collection cylinder, a cylindrical storage casing, one end of said casing in communication with the inlet of said air ejector pump, the second end of said casing having a circular opening with a diameter larger than the diameter of said collection cylinder, a pneumatic actuator, said actuator operated by compressed gas fed to said actuator from said valved supply line, connecting means operably connecting said actuator to said collection cylinder, said actuator having biasing means to bias said collection cylinder to a stowed position within said storage casing, said collection cylinder being moved outward of said storage casing by said actuator when said compressed gas is fed to said actuator at a pressure sufficient to overcome said biasing means, air channels of said slit impactors being placed in communication with air drawn by said ejector pump when said pump is operated.

2. Apparatus as claimed in claim 1 wherein air channels of said slit impactors are closed at the top end of said collection cylinder by a circular cover plate having a diameter greater than the diameter of the opening of the second end of said storage casing, and wherein said air channels are open at the bottom end of said collection cylinder.

3. Apparatus as claimed in claim 2 wherein said collection cylinder has a circular passage along the longitudinal axis thereof, and wherein said connecting means is a rod which passes through said passage and is connected to the center of the lower surface of said cover plate on the top of said collection cylinder.

4. Apparatus as claimed in claim 3 wherein said actuator is located in said storage casing, the longitudinal axis of said actuator being coincident with the longitudinal axis of said casing and of said collection cylinder.

5. Apparatus as claimed in claim 4 wherein said collection cylinder has a circular bottom plate, the periphery of said bottom plate forming a seal with the lower sides of said casing when said collection cylinder is in the stowed position, the diameter of said bottom plate being greater than the diameter of the circular opening at the second end of said casing, said bottom plate having openings therein corresponding to the air flow channels of said collection cylinder, and the circular passage of said collection cylinder.

6. Apparatus as claimed in claim 5 wherein said actuator has a circular pedestal on the lower portion thereof, said pedestal being of sufficient diameter to cover said air flow channels when said collection cylinder is in the stowed position.

7. Apparatus for collecting sample particles disposed in a fluid environment, said apparatus comprising:

means for defining a tubular opening;

valve means for directing selectively a jet of a fluid derived from a fluid supply through said opening;

support means for defining an intake opening receiving the particles disposed in the fluid environment and for supporting a collection surface aligned with and spaced from said intake opening for collecting the particles;

housing means for receiving said support means and having an opening through which said support means may be disposed, and

actuator means selectively connected to said fluid supply for moving said support means from a first position within said housing means through said housing opening to a second position exposed to the fluid environment whereby the particles disposed in the fluid environment are directed under the influence of the fluid jet, through the intake opening onto said collection surface.

8. Apparatus as claimed in claim 7, wherein said support means comprises a tubular member having a plurality of said intake openings disposed about its periphery.

9. Apparatus as claimed in claim 7 wherein said support means in the first position is disposed in fluid tight relation with said housing means to substantially isolate said collection surface from the fluid environment.

10. Apparatus for sampling particulate material in gases comprising:

an ejector pump having a primary nozzle;

a source of compressed gas in selective communication with said pump;

particulate collection means being selectively moved from a stowed inactive position to an active collecting position; and

actuator means operable by compressed gas received from said source of compressed gas through said ejection pump to move said particulate collection means from the stowed inactive position to the active collecting position.

11. Apparatus as in claim 10 wherein said ejector pump is tubular in form and having an inlet chamber disposed at one end and said primary nozzle disposed at the other end thereof, said particulate collection means being stowed in a housing extending from said inlet chamber and wherein means are provided for dividing the flow of gas from said source of compressed gas into a first flow leading through a secondary nozzle, disposed within said pump, to a primary nozzle and a secondary flow causing said actuator means to move said particulate collection means from the stowed inactive position to the active collecting position.

12. Apparatus as in claim 11 wherein said particulate collection means is perforated and in fluid communication with said ejection pump when in the active collecting position and hermetically sealed from said ejection pump when in the stowed inactive position.

13. Apparatus as in claim 12 wherein the perforations in said particulate collection means are in the form of a plurality of longitudinal slits extending along a portion of the length thereof and wherein means are provided to collect solid particles in the gas received through said slits within said particulate collection means without impeding the flow of gas therethrough.

14. Apparatus as in claim 13 including means for moving said particulate collection means from the active collecting position to the inactive stowed position when the flow of compressed gas from said source ceases.

15. Apparatus as in claim 13 wherein the perforations in said particulate collection means are in fluid communication with said ejector pump when said particulate collection means is in the active collecting position and wherein the flow of compressed gas through said secondary and said primary nozzles create a force to draw gas through said particulate collection means into said ejection pump for exiting at said primary nozzle.

* * * * *