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

JAN 29 1971

REPLY TO
ATTN OF: GP/43026

TO: USI/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 USI, 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. : 3,472,372

Government or Corporate Employee : Electro-Optical Systems, Inc. Pasadena, California

Supplementary Corporate Source (if applicable) : JPL

NASA Patent Case No. : XNP-09770

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:

Yes ☒ 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. . . "

Dorothy J. Jackson

Dorothy J. Jackson
Enclosure
Copy of Patent cited above

XNP-09770

Oct. 14, 1969 JAMES E. WEBB 3,472,372

ADMINISTRATOR OF THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SOIL PARTICLES SEPARATOR, COLLECTOR AND VIEWER

Filed Jan. 24, 1968 2 Sheets-Sheet 1

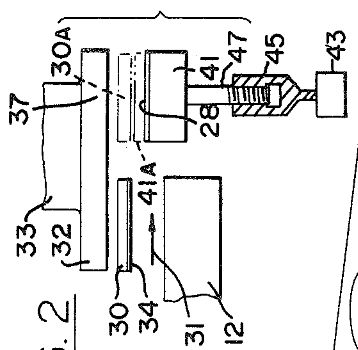

FIG. 2

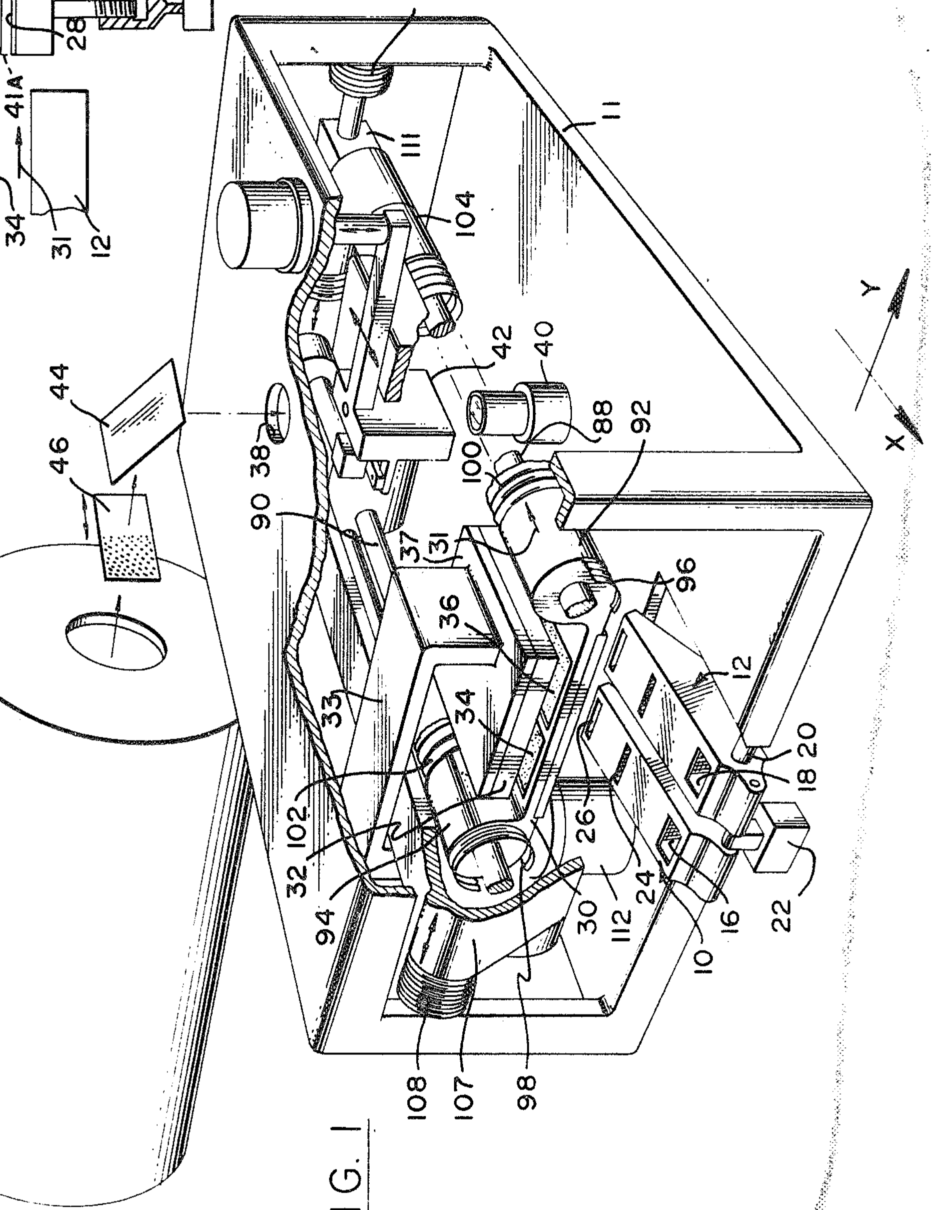

FIG. 1

N71-20440 40%

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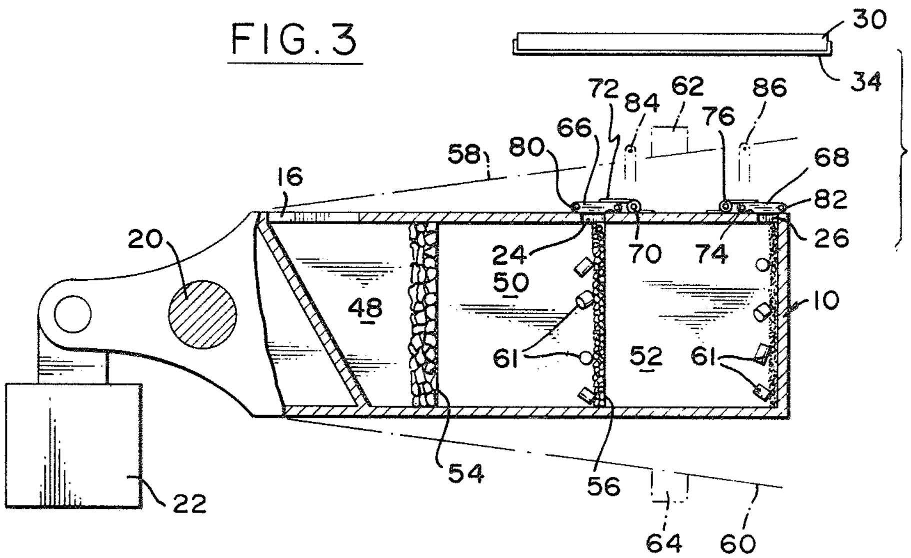
FIG. 3



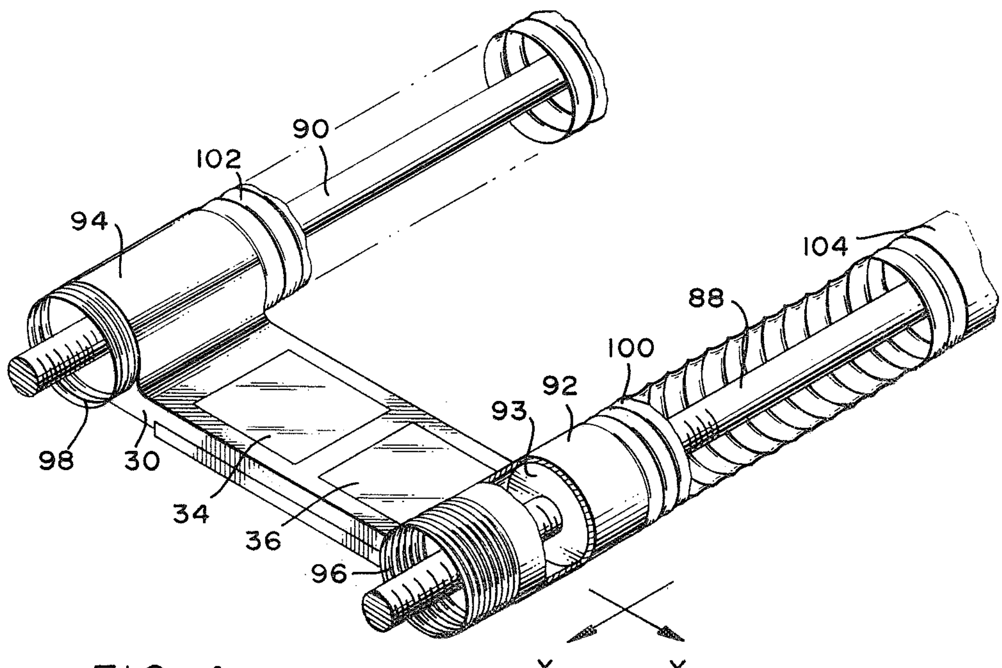


FIG. 4

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United States Patent Office

3,472,372

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3,472,372

SOIL PARTICLES SEPARATOR, COLLECTOR AND VIEWER

James E. Webb, Administrator of the National Aeronautics and Space Administration, with respect to an invention of Douglas G. Ritchie, Pasadena, Calif.

Filed Jan. 24, 1968, Ser. No. 700,120

Int. Cl. B04b 3/08, 3/00

U.S. Cl. 209—10 6 Claims

ABSTRACT OF THE DISCLOSURE

A mechanism useful in an unmanned spacecraft for screening a soil sample to obtain particles for television viewing. The mechanism comprises a bin for receiving the soil sample, apparatus for rapidly oscillating the bin about a pivot to create centrifugal forces pushing the soil particles through coarse and fine screens, a heated plastic sheet for receiving particles thrown out of the bin, and a translating mechanism for carrying the plastic to a vidicon tube for television observation of the particles. The translating mechanism includes slides which move along rods, each rod hermetically enclosed within a bellows to prevent the evaporation of lubricants when operated in a vacuum environment such as exists on the moon.

Origin of 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 USC 2457).

Background of the invention

This invention relates to apparatus for separating particles by passage through screens.

One important phase in the exploration of the moon and of other planets by unmanned spacecraft involves the identification of soil compositions. Mechanisms for gathering up a soil sample are easily designed, but the separation of the sample into particles for observation is difficult. While the sample could be sifted through screens, gravity is insufficient on the moon, and some planets, to force the sample through the screen. Moreover, in a vacuum environment the particles have a tendency to stick together and to a screen. In addition to the problems of separating out the particles, difficulties are encountered in the gathering of separated particles so that they can be readily viewed by a television camera or the like.

Objects and summary of the invention

Accordingly, one object of the present invention is to provide apparatus for enabling the viewing of particles in a sample of material, which operates in a vacuum and low-gravity environment.

Another object is to provide apparatus for separating and screening particles which provides high forces tending to separate the particles and tending to push the particles through a screen.

Yet another object is to provide apparatus for encapsulating particles for television viewing.

Still another object is to provide a mechanism for enabling the sliding of a stage while maintaining the sliding mechanism in a sealed atmosphere.

The present invention provides a mechanism for separating soil samples by unmanned spacecraft, including a bin for receiving soil samples and a mechanism for pivotally oscillating the bin so that particles pass through coarse and fine screens into various bin chambers. The oscillation of the bin occurs about an axis to set up

centrifugal forces pushing the particles through the screens. Bumpers are provided for suddenly stopping the bin at its extremes of pivoting to provide tangential shocks that separate the particles and prevent their adhesion in a vacuum environment. In addition, large pellets are included in the bin chambers to keep the particles "stirred up." After several minutes of vibrations, slots in the bin chambers are opened and the bin is oscillated to cause the coarse and fine particles to be thrown out of the bin.

The particles thrown out of the bin through the slots are captured by a preheated plastic sheet placed near the slots. After sufficient particles have been deposited on the plastic sheet, another sheet is pressed against the deposited particles to securely encapsulate them. The capsule is then moved under a vidicon tube for enabling television viewing of the coarse and fine particles, which lie on different parts of the plastic sheet.

The stage which holds the plastic sheets slides a considerable distance from the position above the bins to a position under the vidicon tubes. The sliding mechanism must be protected against the vacuum environment yet must allow the stage to slide a considerable distance. To protect the sliding mechanism, two bellows are provided which seal the sliding mechanism against the ambient atmosphere. One bellows extends between the vidicon camera position and the stage and is collapsed as the stage moves toward the vidicon camera, while the other bellows extends between the bin positions and the stage for expanding as the stage moves toward the vidicon camera.

A more complete understanding of the invention may be had by considering the following specification and claims when taken in conjunction with the accompanying drawings.

Brief description of the drawings

FIGURE 1 is a broken isometric view of the particle separator constructed in accordance with the invention;

FIGURE 2 is a partial side elevation view of the encapsulating mechanism of the particle separator of FIGURE 1;

FIGURE 3 is a side elevation view of a bin of the particle separator of FIGURE 1; and

FIGURE 4 is a partial pictorial view of the translation mechanism of the particle separator of FIGURE 1.

Description of the preferred embodiments

FIGURE 1 illustrates one embodiment of the invention for receiving soil samples in bins **10** and **12** and enabling the viewing of particles of the samples by a vidicon camera **14**. The apparatus is generally a portion of a spacecraft landed on an extraterrestrial body, such as the moon, and the soil samples are provided by a mechanical arm (not shown) which scoops up some of the ground area and deposits it in one of the bins through an opening **16** or **18** therein. The bins are pivotally mounted on a separator housing **11** by a flexure support **20** and are vibrated about this support by a vibrator solenoid **22**. The vibration about the flexure support **20** causes particles in the soil sample to pass through screens in the bin. After a sample has been deposited in one of the bins, such as bin **10**, and the bins have been vibrated for several minutes to separate the particles, covers (shown in FIGURE 3) over slots **24** and **26** are opened. The bins are then vibrated for a short period of time to throw out the particles through the slots **24** and **26** onto a heated plastic receiving sheet **34** which captures the particles.

The plastic receiving sheet **34** is positioned on the bottom of a slide stage **30**. The slide stage **30** is initially positioned below a heating plate **32**, which is held on a clamp **33**. The heating plate **32** heats the sheet **34** to a tacky consistency immediately prior to removal of covers on the slots **24** and **26**. The sheet **34** is positioned to receive the particles emerging from the slots, and these particles stick to the heated plastic. After particles have been thus deposited on the sheet, the slide stage **30** is moved in the direction of the arrow **31** until it is beneath the end portion **37** of the clamp **33**. At this position, an encapsulating sheet is applied to the receiving sheet **34**.

FIGURE 2 is a partial view of the mechanism of FIGURE 1, showing the apparatus for encapsulating particles held on the receiving sheet **34**. After the sheet receives the particles, the slide stage **30** on which the sheet is held is moved to the position shown at **30***a*. A lower clamp **41** which holds an encapsulating sheet **28**, is located below the slide stage in its position at 30A. The lower clamp **41** includes a heater for heating the encapsulating sheet **28** to a tacky consistency. After the sheet **28** has been thus heated, the lower clamp **41** is moved upwardly toward the slide stage **30A** by conventional means such as a motor **43** that rotates a nut **45** on its shaft to advance a screw **47** fixed to the clamp **41**. In the position at 41A, the lower clamp holds the heated encapsulating sheet **28** against the receiving sheet **34** to encapsulate the particles held thereon. The lower clamp **41** is then moved down again. Thereafter, the slide stage **30** is moved in the direction of the arrow **31** toward a viewing station **38**, shown in FIGURE 1.

At the viewing station **38**, the capsule formed by a portion of the plastic encapsulating sheet **28** and the sheet **34** is brought between an illuminator **40** and a lens system **42**. Light passing from the illuminator **40** through the capsule and the lens assembly **42** passes through a hole at the viewing station **38**, is deflected by a mirror **44**, passes through an analyzer/neutral density filter **46** and enters an opening in the vidicon camera **14**. An image of the particles is converted to electrical signals by the vidicon camera **14**, delivered to a transmitter, and transmitted to receiving stations on the earth.

FIGURE 3 is a side sectional view of the bin **10** of FIGURE 1. The bin comprises an elongated chamber separated into a first compartment **48** for receiving soil samples through the opening **16**, a second chamber **50** for receiving coarse particles of less than a predetermined size from the first chamber **48**, and a third chamber **52** for receiving fine particles from the second chamber **50**. A coarse screen **54** separates the first and second chambers and a fine screen **56** separates the second and third chambers. The bin is pivotally mounted at **20** by reason of attachment to a flexure support at **20**. Slots **24** and **26**, located on a side of each screen **54** and **56** which is opposite to the pivot point **20**, enable the exhaustion of particles.

When the bin is vibrated by the vibrator solenoid **22**, it oscillates about the flexure support **20** by plus and minus 8° from its center position, taking the extreme position defined by the lines **58** and **60**. Bumpers **62** and **64** attached to the separator housing limit movement of the bin between these extreme positions, and also serve to stop the bin abruptly at its extreme positions, by contacting the upper and lower walls of the bin. The rapid oscillations about flexure support **20**, such as 20 cycles per second for a bin **10** which is three inches long, with a maximum arc of ¾ inch, provides a centrifugal force which peaks at 7 g. This force causes particles to move through the coarse and fine screens **54** and **56** with considerable impetus. Additionally, the abrupt stopping of the pivoting by the bumpers **62** and **64** results in large tangential accelerations, resulting in the particles moving violently back and forth across the screen and facilitating their separation in spite of bonding action which often occurs in a vacuum environment.

In order to further facilitate particle separation, pellets **61** are initially included in both chambers **50** and **52**. The pellets **61** are included to stir up the particles in each bin to prevent their sticking together, and to dislodge particles which stick to a screen to keep the screens cleared. The pellets are short cylinders constructed of the same plastic used for the receiving sheets **34** and **36** and for the encapsulating sheet **28**. Thus, any dust from the pellets does not contaminate the particles, since such dust melts into the heated plastic sheets. The pellets **61** are large enough so that they do not move through the screen **56** or the slots **24** and **26** in the bin.

During the first period of vibration of the bin **10**, after deposition of a particle sample in the first chamber **48**, covers **66** and **68** disposed over the slots **24** and **26** are closed. The cover **66** is pivotally attached at **70** to a hinge fixed to the bin **10**. A spring **72** having one end attached to the bin **10** and the other end attached to the cover **66**, tends to spring open the cover **66** to uncover the slot. Similarly, cover **68** is pivoted at **74** and spring-biased toward an open position by spring **76**. Pins **80** and **82** hold the covers to protuberances on the bin, to keep the covers closed. A solenoid (not shown) pulls the pins **80** and **82** to release the covers **66** and **68** and allow them to spring to an open position shown by dotted lines at **84** and **86**. Hinged covers are shown to maintain a minimum of friction in springing open, but slidable covers could be used instead.

After the sample has been deposited into first chamber **48**, and the bin **10** has been vibrated for a sufficient time, such as several minutes, to allow particles to sift through the coarse and fine screens, the solenoid operating the pins **80** and **82** is operated. Thereupon, the covers **66** and **68** fly open. Further vibration of the bin by the solenoid **22** causes the coarse and fine particles to be projected out of the openings **24** and **26** in the bin. The plastic film **34** positioned above the bin, receives the particles, and, due to its tacky nature from heating by the heating plate **32**, holds the particles. The slide stage **30** can then be moved to the end position **37** of the clamp assembly for encapsulation.

The translation of the slide stage between the heating plate **32** and viewing station **38** involves considerable movement. The slide stage **30** is guided by guide shafts **88** and **90** which extend between guide shaft supports **107** and **111**. The guide shafts **88** and **90** are positioned within slide bearings **92** and **94**, and the bearings are attached to the slide stage **30**. In order to facilitate movement of the slide bearings **92** and **94** along the guide shafts **88** and **90**, lubrication is provided between them. In a vacuum environment such lubrication is likely to evaporate and the slide bearings are likely to seize on the guide shaft and not move. To prevent this, a hermetically sealed environment is provided about the guide shafts **88** and **90**.

The area about the guide shafts **88** and **90** is hermetically sealed by means of bellows. Two bellows **96** and **98** extend between the slide bearings **92** and **94** and the guide shaft support **107** nearest the bins. Another pair of bellows **100** and **102** extends between the slide bearings **92** and **94** and the guide shaft support **111** adjacent to the viewing station **38**. When the slide stage **30** is under the heating plate **32**, the bellows **96** and **98** are in their fully collapsed position, while the bellows **100** and **102** are fully extended. When the slide stage **30** is at the viewing station **38**, the bellows **96** and **98** are fully extended and the bellows **100** and **102** are fully collapsed. In all positions, the bellows reliably seal the area about the guide shafts **88** and **90**, which they cover. This sealing is reliable inasmuch as it does not depend upon sliding seals which readily develop leaks.

A better view of the guide shafts **88** and **90** and the four bellows disposed thereabout is provided in FIGURE 4. The slide stage **30** is moved by a drive motor **104** which turns the guide shaft **88**. Threads on the guide shaft **88** allow it to function as a lead screw. A ball bearing nut **93** on the slide bearing **92** engages the threads on the shaft **88** so that the slide stage moves as the motor turns. Thus, the housing **11** defines three stations, located at the area near the bins, the area at the vidicon camera, and the intermediate area where encapsulation occurs. The rods **88** and **90** serve as means for guiding the slide between the stations. The bellows, including one pair extending between the vidicon station area of the housing and the slide, and the other extending between the station near the bins and the slide stage, hermetically seal the area about the rods.

In addition to movement between a location under the heating plate **32** and the viewing station **38**, the slide stage **30** is required to move laterally to enable the bringing of many portions of the capsule in line with the field of view of the vidicon camera **14**.

In the particle separator shown in FIGURE 1, two bins are provided to enable the viewing of two separate soil samples. Each of the bins **10** and **12** may be filled with a soil sample, both of the bins vibrated, particles thrown from both bins onto the plastic sheets **34** and **36** at the same time, and the two sheets encapsulated by an encapsulating film **28** at the same time.

The sequence of operations can be controlled by a set of cams that are rotated by a timing motor to close switches that operate the solenoid **22** for the screening operation, the drive motor **104** for moving the slide stage, the motor **43** for operating the clamp, and so forth. Such timing motors are well known in the art, being used extensively in operating automatic washing machines and other household and industrial items. Alternatively, a human operator can send signals to a receiver at the particle separator to close switches that control energization of solenoids and motors, to thereby control the sequence of operations.

While a particular embodiment of the invention has been illustrated and described, it should be understood that many modifications and variations may be resorted to by those skilled in the art, and the scope of the invention is limited only by a just interpretation of the following claims.

What is claimed is:

1. A particle separator comprising:
bin means for receiving a sample;
means defining a pivot point coupled to said bin means;
oscillating means coupled to said bin for pivoting said bin means back and forth about said pivot point;
screen means within said bin means for regulating the passage of particles therethrough;
walls defining an opening in said bin means on a side of said screen means opposite said pivot point for enabling the ejection of particles therefrom;
particle-gathering means disposed adjacent to said bin means for holding particles ejected from said opening; and
moving means for shifting the position of said particle-gathering means, said moving means comprising stage means for holding said particle-gathering means, bearing means for supporting said stage means, elongated guide means engaged with said bearing means for guiding its movement therealong, and bellows means disposed about said guide means, said bellows means having a first end sealed to said bearing means and a second end in sealing relationship to an end of said guide means.

2. The particle separator described in claim **1** wherein said particle gathering means comprises a sheet-like piece of material composed of a substance which has a tacky consistency when heated, and means for heating said sheet-like piece of material.

3. The particle separator described in claim **1** including bumper means for abruptly halting the pivoting of said bin means, whereby to impart tangential forces to particles in said bin means.

4. An oscillating particle separator comprising:
a bin for receiving particle samples, said bin having at least one screen dividing said bin into a first chamber for initially receiving said particle samples and a second chamber for receiving particles from said first chamber which are smaller than a predetermined size, and including an opening formed in the walls of said bin at said second chamber for exhausting particles;
means for pivoting said bin to create centrifugal forces tending to move particles through said screen from said first chamber to said second chamber;
gathering means for receiving particles exhausted through said opening;
a slide stage for carrying said gathering means;
bearing means attached to said slide stage for supporting it;
a viewing station for viewing particles gathered by said particle-gathering means;
shaft means having an end portion disposed adjacent to said viewing station, for carrying said bearing means to said viewing station; and
bellows means disposed about said shaft means, said bellows means having a first end in sealing engagement with said bearing means and a second end in sealing engagement with said end portion of said shaft means adjacent to said viewing station.

5. The oscillating particle separator described in claim **4** wherein said bin includes a third chamber, and a second screen dividing said second and third chambers to permit only particles smaller than a second predetermined size to pass into said third chamber, and an opening formed in the walls of said bin at said third chamber for exhausting particles.

6. The oscillating particle separator described in claim **4** including second bellows means disposed about said shaft means, said second bellows means having a first end in sealing engagement with said bearing means and a second end in sealing engagement with an end portion of said shaft opposite said viewing station.

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FRANK W. LUTTER, Primary Examiner

U.S. Cl. X.R.

209—237, 258, 360, 381; 214—1; 308—3.5; 356—38