12-13-2005

Method of measuring flow rate of flowable material under continuous flow conditions, and an in-line continuous flow meter

Yuh Yuan Shyy
Iowa State University, yshyy@iastate.edu

Manjit K. Misra
Iowa State University, mkmisra@iastate.edu

Method of measuring flow rate of flowable material under continuous flow conditions, and an in-line continuous flow meter

Abstract
A method of determining the rate of flow of a flowable material, particulate or liquid, through a flowable material passageway, comprising causing the material passing through the passageway to move downwardly by gravity slowing the downward movement of material as compared to free falling gravitational movement measuring the weight of material passing slowly downwardly with respect to the passageway; causing an electronic signal to be generated in response to the magnitude of the weight measuring; and connecting the electronic signal to a read out display to reflect the flow rate of material with respect to units of weight with respect to units of time.

Keywords
Agricultural and Biosystems Engineering

Disciplines
Agriculture | Bioresource and Agricultural Engineering

US006973843B2

(12) **United States Patent**
Shyy et al.

(10) **Patent No.: US 6,973,843 B2**
(45) **Date of Patent: Dec. 13, 2005**

(54) **METHOD OF MEASURING FLOW RATE OF FLOWABLE MATERIAL UNDER CONTINUOUS FLOW CONDITIONS, AND AN IN-LINE CONTINUOUS FLOW METER**

(75) Inventors: **Yuh-Yuan Shyy**, Ames, IA (US); **Manjit K. Misra**, Ames, IA (US)

(73) Assignee: **Iowa State University Research Foundation, Inc.**, Ames, IA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/883,289**

(22) Filed: **Jul. 1, 2004**

(65) **Prior Publication Data**

US 2004/0255692 A1 Dec. 23, 2004

Related U.S. Application Data

(63) Continuation-in-part of application No. 10/336,256, filed on Jan. 3, 2003, now Pat. No. 6,805,014.

(60) Provisional application No. 60/346,588, filed on Jan. 8, 2002.

(51) **Int. Cl.**[7] **G01F 1/30**
(52) **U.S. Cl.** **73/861.73**
(58) **Field of Search** 73/861.74, 861.73

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,056,293	A	10/1962	Ofner	
3,640,136	A	2/1972	Nolte	
3,945,532	A	3/1976	Marks	
4,067,238	A	1/1978	Oetiker	
4,157,661	A	6/1979	Schindel	
4,397,423	A *	8/1983	Beaver et al.	239/684
4,440,029	A	4/1984	Tomiyasu et al.	
4,637,262	A	1/1987	Vesa	
4,765,190	A	8/1988	Strubbe	
4,788,930	A	12/1988	Matteau	
5,335,554	A	8/1994	Kempf et al.	
5,343,761	A	9/1994	Myers	
5,423,456	A	6/1995	Arendonk et al.	
5,561,250	A	10/1996	Myers	
5,895,865	A	4/1999	Ozawa	
6,805,014	B1 *	10/2004	Shyy et al.	73/861.73

OTHER PUBLICATIONS

Feedpro—A Step Up to Better Pork Production Through Improved Feed Blenging, Pella Electronics, Inc., Pella, Iow, USA.

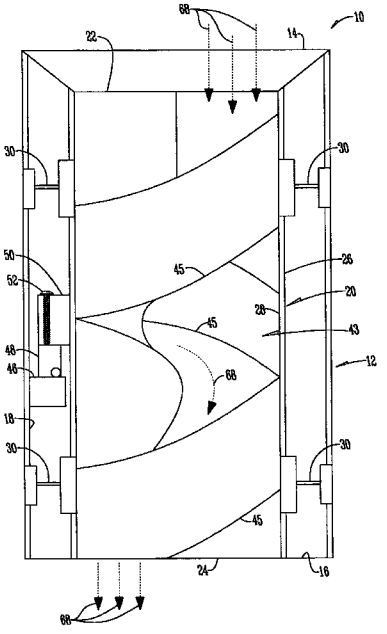
* cited by examiner

Primary Examiner—Harshad Patel

(57) **ABSTRACT**

A method of determining the rate of flow of a flowable material, particulate or liquid, through a flowable material passageway, comprising causing the material passing through the passageway to move downwardly by gravity slowing the downward movement of material as compared to free falling gravitational movement measuring the weight of material passing slowly downwardly with respect to the passageway; causing an electronic signal to be generated in response to the magnitude of the weight measuring; and connecting the electronic signal to a read out display to reflect the flow rate of material with respect to units of weight with respect to units of time.

10 Claims, 4 Drawing Sheets



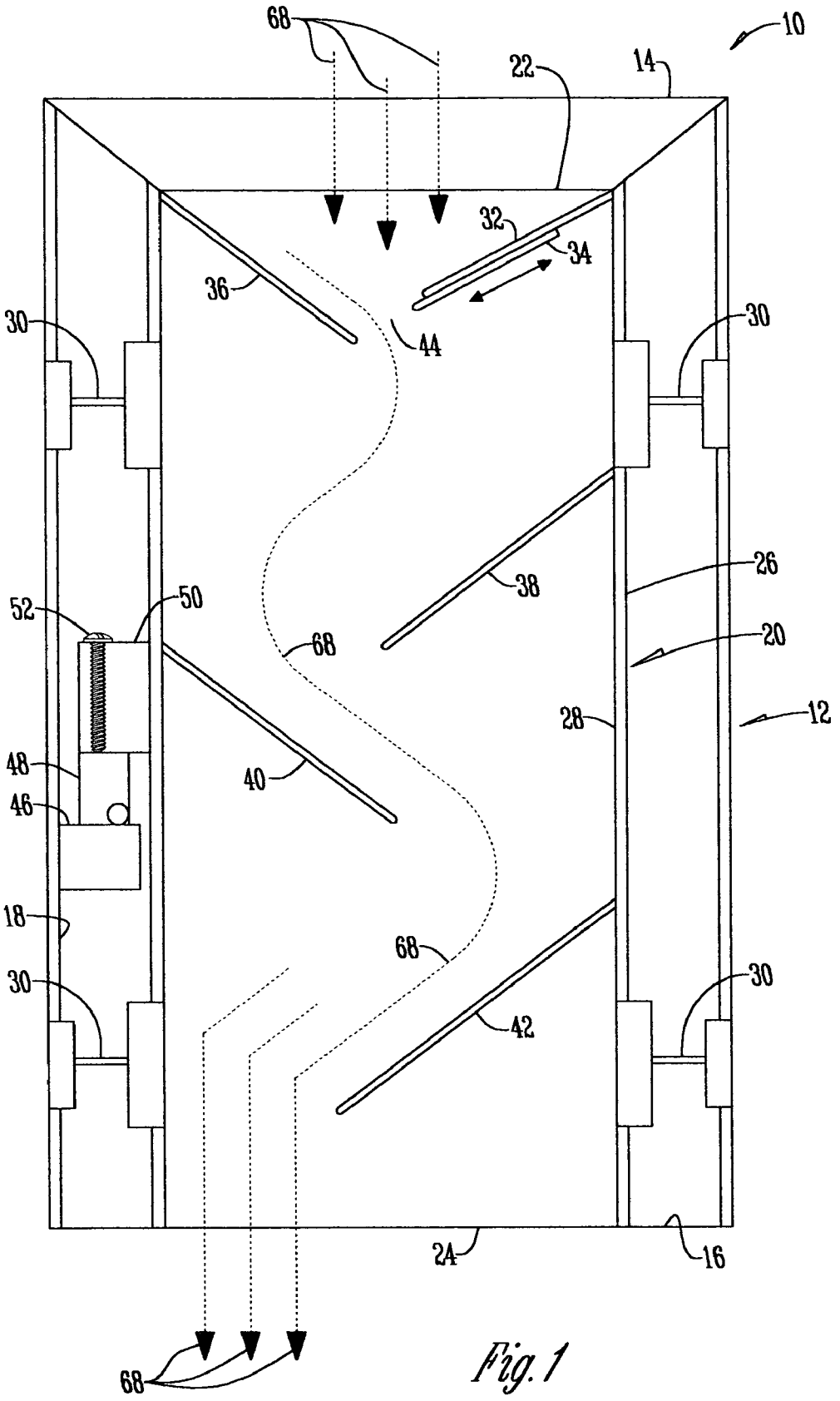

68
10
22
14
32
34
36
30
44
30
26
38
52
50
68
20
28
12
48
40
46
18
68
30
42
30
24
16
68

Fig. 1

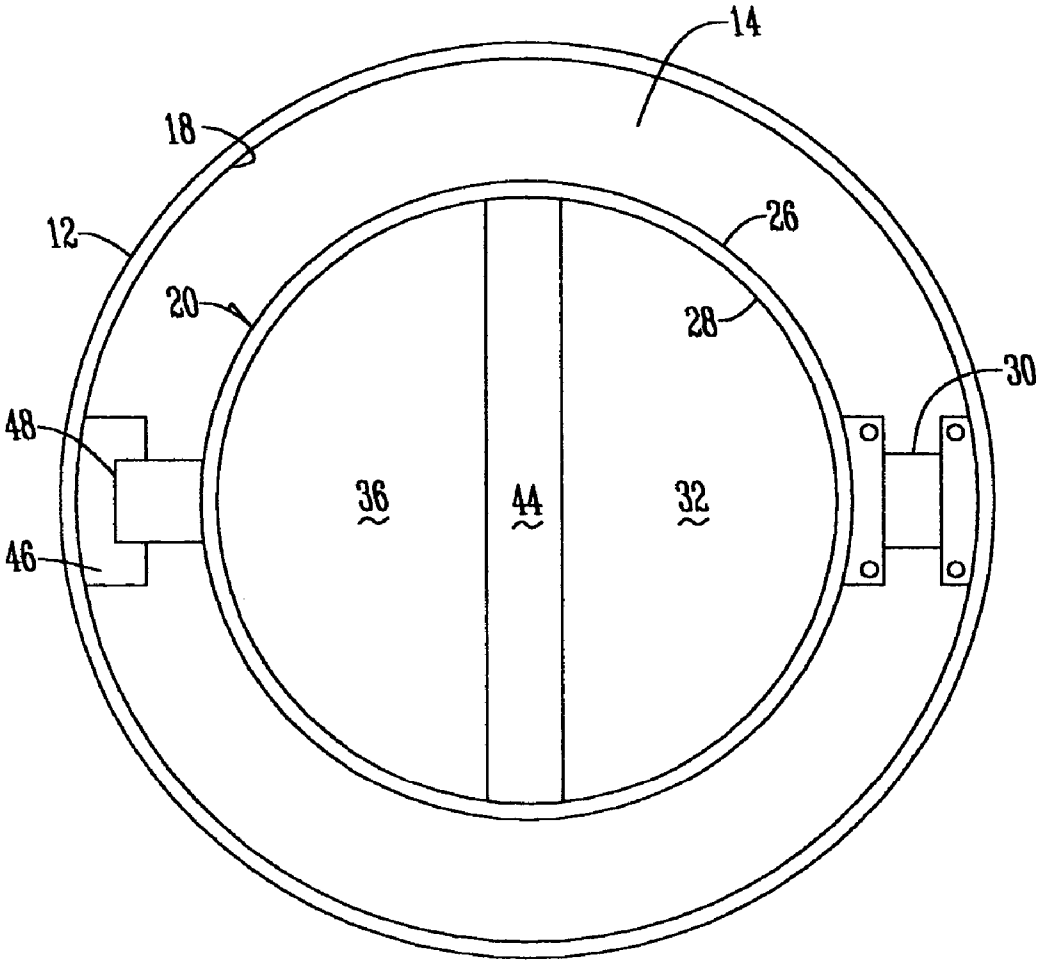


Fig. 2

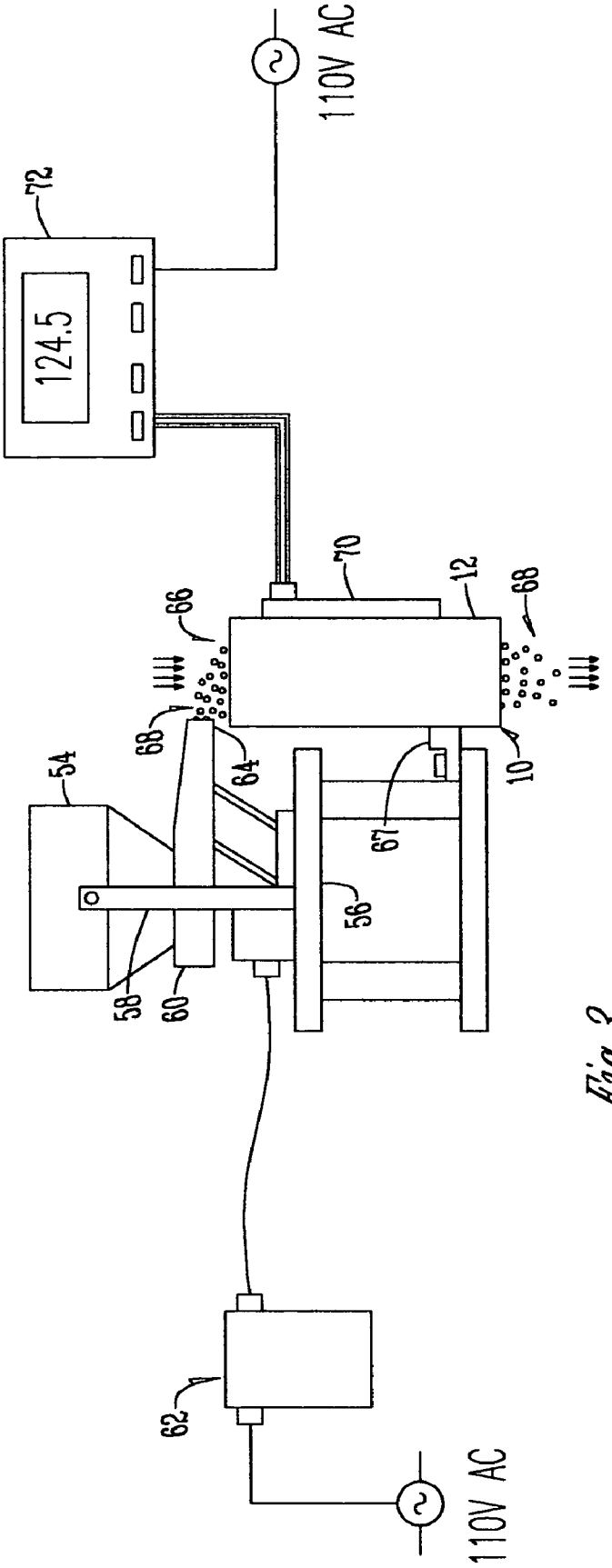


Fig. 3

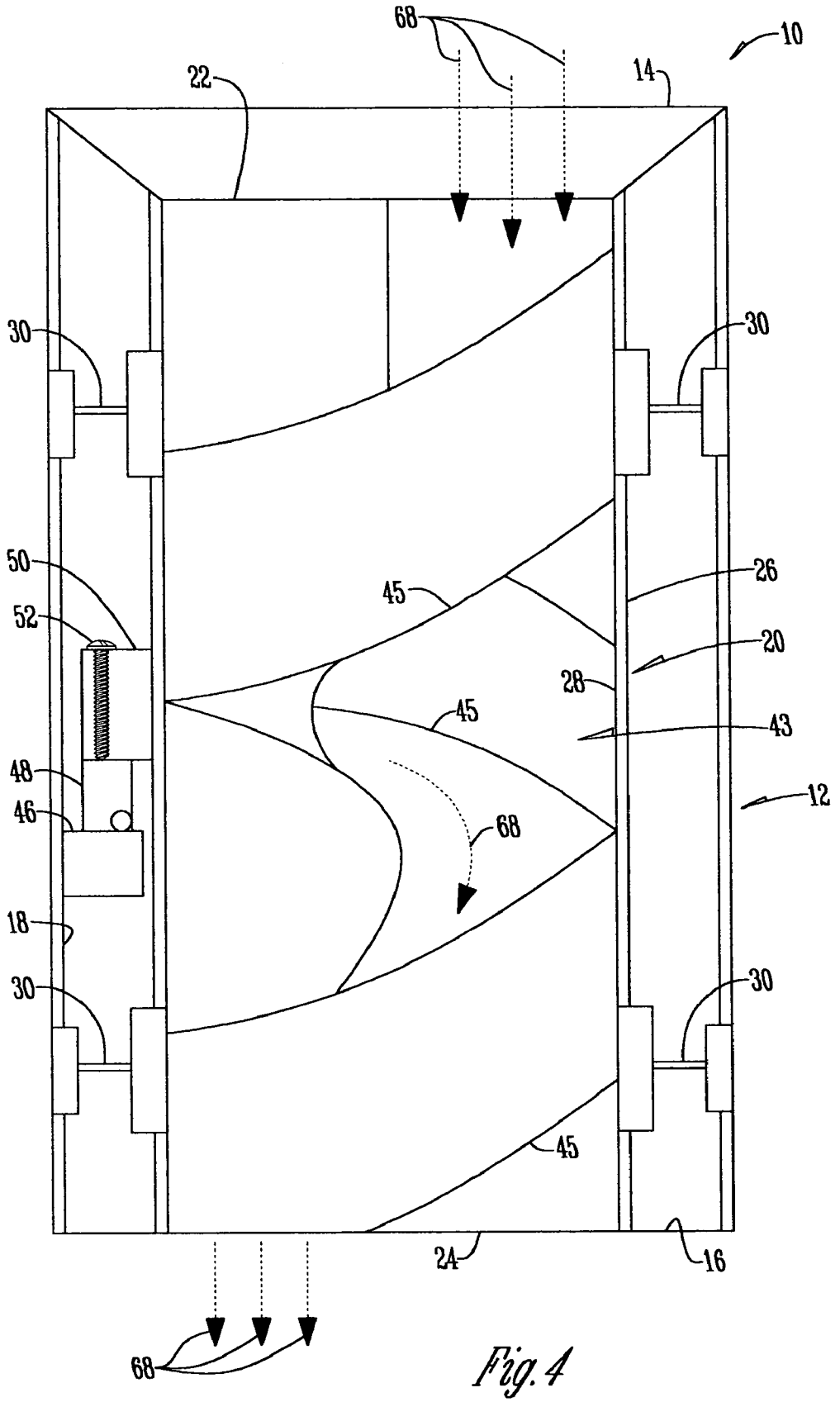

68
10
22
14
30
30
50
45
26
52
20
28
45
43
48
12
46
68
18
30
30
45
24
16
68

Fig. 4

METHOD OF MEASURING FLOW RATE OF FLOWABLE MATERIAL UNDER CONTINUOUS FLOW CONDITIONS, AND AN IN-LINE CONTINUOUS FLOW METER

CROSS REFERENCE TO A RELATED APPLICATION

This application is a continuation-in-part of application Ser. No. 10/336,256 filed Jan. 3, 2003, which claims the benefit of Provisional Patent Application Ser. No. 60/346,588 filed Jan. 8, 2002.

BACKGROUND OF THE INVENTION

Monitoring and managing material flow through a passageway at different check points in the passageway in real time for conditioning of seeds, for example, can increase operating efficiency and can improve profitability. However, no seed meter is available that meets the criteria of minimum damage to seeds, accuracy of measurement, cost effectiveness, and the feasibility of physical installation for retrofitting the flow meter in existing operations.

Existing devices have limitations in many areas, e.g., they draw a sample from the flow and measure the flow rate according to the weight per unit of time; or they employ a moving mechanism (belt or auger) to move the product and weigh the moving device with the product loaded thereon. U.S. Pat. Nos. 5,423,456; 4,788,930; and 4,765,190 are illustrative of this method. Other devices measure the pressure, displacement or impact due to the force generated by the product flow (U.S. Pat. Nos. 4,157,661; 4,440,029; 5,335,554, and 4,637,262). Similar problems arise if the flowable material is a liquid.

Therefore, it is a principal object of this invention to provide a method of measuring flow rate of flowable material, including particulate material or liquids under continuous flow conditions, and an in-line continuous flow meter which is accurate, non-damaging to the material, easily adaptable to existing flow ways, cost effective, and gravity operated without moving mechanisms.

These and other objects will be apparent to those skilled in the art.

SUMMARY OF THE INVENTION

A method of determining the rate of flow of a continuously flowing material through a passageway involves causing the material to move continuously downwardly by gravity in the passageway; placing baffle means in the path of the material to slow its downward movement and to create some dwell time on the baffle means of the material as it passes over the baffle means; intermittently determining the weight of the material passing over the baffle means with respect to increments of time; intermittently averaging data as to the weight collected from the preceding step, producing electronic signals from the values resulting from the averaging data; and converting the electronic signals to a flow rate of units of weight of material with respect to units of time.

The flow meter that measures the material flow in the passageway includes an inner housing resiliently suspended in spaced relation within an outer housing. The inner housing has an inlet upper end, and an outlet lower end. At least one baffle extends downwardly and inwardly from an inner surface of the inner housing within the path of the material to slow the downward flow of material.

A load cell on the inner surface of the outer cell measures the weight of the material on the baffle, preferably on an intermittent basis, and sends an electronic signal corresponding to the weighed material which transforms the signal to a flow rate with respect to units of time.

The flowing material may be either particulate material or liquids.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a vertical sectional view taken through an embodiment of the flow meter;

FIG. **2** is a top plan view thereof;

FIG. **3** is a schematic view of the flow meter imposed in a material flow way; and

FIG. **4** is a vertical sectional view taken through another embodiment of the flow meter.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The description of the invention hereafter will refer primarily to particulate material. It should be understood that this invention is applicable to flowable material whether it be particulate material or liquid material. As such, statements made in regard to particulate material will be equally applicable to liquid material. With reference to FIG. **1**, a flow meter **10** includes an outer cylinder or housing **12** which has a top **14**, a bottom **16**, on an inner surface **18**. An inner cylinder or housing **20** is located within housing **12** in spaced relation thereto, and has a top **22**, a bottom **24**, an outer surface **26** and an inner surface **28**. The inner housing **20** is resiliently suspended with housing **12** by leaf spring assemblies **30** which extend between the inner surface **18** of housing **12** and the outer surface **26** of housing **20**.

A diagonal semi-circular plate **32** extends downwardly and inwardly into inner housing **20** from its upper end and has a lower edge that terminates short of the vertical axis of the housing **20**. A conventional adjustable valve plate **34** (FIG. **1**) is secured in any convenient fashion to regulate flow of particulate material down through meter **10** as will be discussed below.

Similarly, semi-circular plates **36**, **38**, **40** and **42** are secured within housing **20** to extend downwardly and inwardly into the housing at progressively different levels (FIG. **1**). The plates **38** and **42** are wider than plates **32** so that their respective lower edges interrupt any straight vertical flow of particulate material downwardly through housing **20** so as to create an alternately oblique pattern of flow of particulate material downwardly through the meter **10**. (The circuitous flow of material within housing **20** is depicted by the dotted line adjacent the numeral **68** in FIG. **1**). This phenomenon serves to slow down the vertical movement of material through the meter as the material engages each plate. The throat **44** (FIGS. **1** and **2**) can be selectively adjusted in width by the plate **34** (FIG. **1**).

In an alternative embodiment, meter **10** uses a channel **43** in place of plates **36–42**, as shown in FIG. **4**. Specifically, a channel **43** is secured within housing **20**. Channel **43** spirals downwardly with curves **45** secured to the inner surface **28** of the housing **20**. The curves **45** serve to slow down the vertical movement of the particulate material **68** through the meter as the material engages the curves **45**.

A load cell base **46** is secured to the inner surface **18** of outer housing **12** and supports conventional load cell **48** which in turn engages block **50** secured to the outer surface **26** of inner housing **20**. This arrangement imparts the weight

of housing **20** and the particulate material moving over plates **36–42** or through curves **45** of channel **43** onto the load cell **48**. An adjustment screw **52** on block **50** is used to cause the load cell to factor out of its sensitivity the dead load of the housing itself, so that the load cell is registering only the weight of material that experiences movable dwell time on the plates **36–42** or through curves **45** of channel **43**.

The use of the flow meter **10** is schematically shown in FIG. **3**. A material hopper **54** is supported on stand **56** mounted on a supporting surface by legs **58**. A conventional vibrator feeder tray **60** is supported on legs **58** underneath hopper **54**. The feeder tray **60** is conventionally controlled by feeder controller **62** which has a discharge end **64**. The numeral **66** generally designates a flow way indicating the gravitational flow of material **68** from the hopper **54** and feeder **60** to the discharge end **64** of the feeder **60**. If the flowable material is liquid material, the vibrator feed tray may not be necessary, depending on the viscosity of the liquid material.

The meter **10** is imposed into the flow way **66** by means of bracket **67** secured to stand **56**. The particulate material **68** (e.g., corn or soybean seeds) proceeds downwardly through the sensor **10** in the manner described above along the circuitous path shown by the dotted lines in housing **20** in FIG. **1**. The weight of the material impinging on plates **36–42** or through curves **45** of channel **43** is transferred to the load cell **48** in the manner described above, whereupon the conventional load cell delivers an electronic output signal through signal output harness **70** to a conventional digital display **72**. Preferably, the load cell senses the weight of the material every 15 seconds or so, and a plurality of such readings are averaged to permit the digital display to show the flow rate of the material through the meter **10** in units of weight with respect to units of time.

It is therefore seen that the flow rate of this invention can measure flow rates accurately, without damaging the material, and which can be adapted to existing flow ways, and which can measure flow rates continuously by gravity feeding for both particulate and liquid material, thus achieving all of its stated objectives.

We claim:

1. A method of determining the rate of flow of a flowable material through a material passageway, comprising,

causing the flowable material to move continuously downwardly by gravity in the passageway;

placing a curved channel in the path of the flowable material to slow the downward movement of the flowable material and to create some dwell time on the curved channel of the flowable material as the flowable material passes through the channel;

intermittently determining the weight of the flowable material passing through the channel with respect to increments of time;

intermittently averaging data as to the weight collected from the preceding step,

producing electronic signals from the values resulting from the averaging data;

and converting the electronic signals to a flow rate of units of weight of material with respect to units of time.

2. The method of claim **1** wherein the passageway through which the flowable material passes includes an inner cylinder resiliently suspended in spaced relation within an outer cylinder, and the curved channel is positioned within the inner cylinder, and the weight of the flowable material passing through the inner cylinder is determined by a load cell affixed to an outer surface of the inner cylinder.

3. The method of claim **1** wherein the flowable material is a particulate material.

4. The method of claim **1** wherein the flowable material is a liquid material.

5. A method of determining the rate of flow of a flowable material through a flowable material passageway, comprising,

causing the material passing through the passageway to move downwardly by gravity,

slowing the downward movement of material as compared to free falling gravitational movement by passing the material through a curved channel,

measuring the weight of material passing slowly downwardly with respect to the passageway,

causing an electronic signal to be generated in response to the magnitude of the weight measuring, and

connecting the electronic signal to a read out means to reflect the flow rate of material with respect to units of weight with respect to units of time.

6. The method of claim **5** wherein the passageway through which the flowable material passes includes an inner cylinder resiliently suspended in spaced relation within an outer cylinder, and the curved channel is positioned within the inner cylinder, and the weight of the flowable material passing through the inner cylinder is determined by a load cell affixed to an outer surface of the inner cylinder.

7. The method of claim **5** wherein the flowable material is a particulate material.

8. The method of claim **5** wherein the flowable material is a liquid material.

9. A flow meter for determining the flow rate of flowable material flowing continuously by gravity through a passageway, comprising,

an inner housing resiliently suspended in spaced condition from an outer housing,

the inner housing having an inlet upper end, and an outlet lower end,

a curved channel extending downwardly and inwardly from an inner surface of the inner housing to slow the flowable material flowing downwardly through the inner housing, and to provide dwell time of flowable material passing there through,

a load cell on the inner surface of the outer housing to measure intermittently the weight of the flowable material within the channel, and to send an electronic signal corresponding to the magnitude of the weight,

and means to receive and convert the electronic signal to a flow rate of units of weight with respect to units of time.

10. The flow meter of claim **9** wherein leaf springs connect the inner housing to the outer housing.

* * * * *