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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : G01G 11/08	A1	(11) International Publication Number: WO 92/14126
		(43) International Publication Date: 20 August 1992 (20.08.92)

(21) International Application Number: PCT/GB92/00215

(22) International Filing Date: 5 February 1992 (05.02.92)

(30) Priority data:
9102476.0 5 February 1991 (05.02.91) GB

(71) Applicant *(for all designated States except US):* MATCON LIMITED [GB/GB]; Matcon House, London Road, Moreton-in-Marsh, Gloucestershire GL56 0HJ (GB).

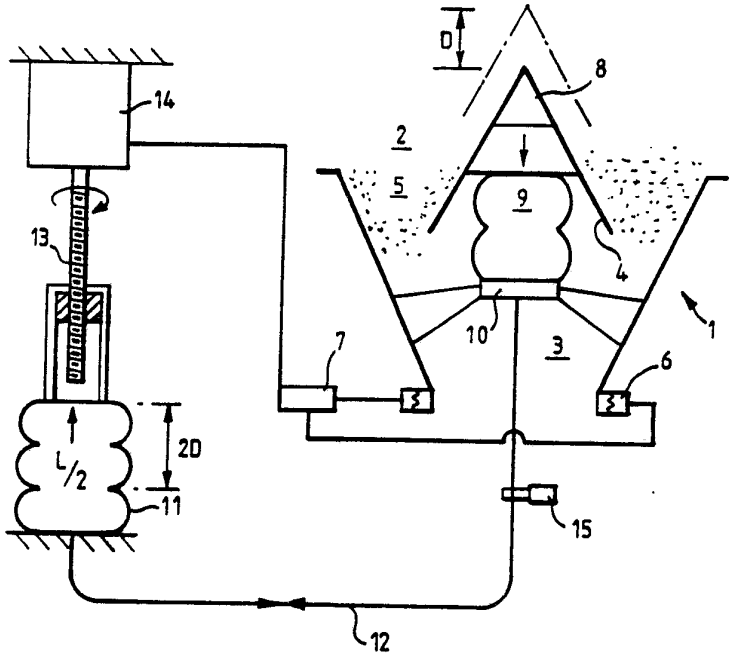
(72) Inventor; and
(75) Inventor/Applicant *(for US only) :* SEMENENKO, Ivan [GB/GB]; Matcon House, London Road, Moreton-in-Marsh, Gloucestershire GL56 0HJ (GB).

(74) Agent: JOHNSON, Terence, Leslie; Edward Evans & Co., Chancery House, 53-64 Chancery Lane, London WC2A 1SD (GB).

(81) Designated States: AT, AT (European patent), AU, BB, BE (European patent), BF (OAPI patent), BG, BJ (OAPI patent), BR, CA, CF (OAPI patent), CG (OAPI patent), CH, CH (European patent), CI (OAPI patent), CM (OAPI patent), CS, DE, DE (European patent), DK, DK (European patent), ES, ES (European patent), FI, FR (European patent), GA (OAPI patent), GB, GB (European patent), GN (OAPI patent), GR (European patent), HU, IT (European patent), JP, KP, KR, LK, LU, LU (European patent), MC (European patent), MG, ML (OAPI patent), MR (OAPI patent), MW, NL, NL (European patent), NO, PL, RO, RU, SD, SE, SE (European patent), SN (OAPI patent), TD (OAPI patent), TG (OAPI patent), US.

Published
With international search report.

(54) Title: CONTROL SYSTEM



(57) Abstract

The invention relates to apparatus (1) for controlling substantially vertical discharge of flowable material such as a powder or other particulate or granular material (2), comprising a discharge opening (3) near a lower end (in use and as shown) thereof, flow control means (4) adapted to be mounted internally of the discharge opening (3) for the flowable material (2) and to form with that opening (3) a flow path (5) for material through the opening (3), a load cell (6) adapted to monitor the weight of material, and an electronic controller (7) connected electronically with the load cell (6), the arrangement being such that a signal from the load cell (6) is interpreted by the controller (7) to control the flow control means (4) and to maintain a desired discharge for a batch of material to be discharged through the opening (3).

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CONTROL SYSTEM

The invention relates to a control system, particularly for the discharge of flowable material such as powders.

According to the invention there is provided apparatus for controlling substantially vertical discharge of flowable material, comprising a discharge opening near a lower (in use) end thereof, flow control means adapted to be mounted internally of the discharge opening for flowable material and to form with that opening a flow path for material through the opening, a load cell adapted to monitor weight of material, and an electronic controller connected with the load cell, the arrangement being such that a signal from the load cell is interpreted by the controller to control the flow control means and maintain a desired discharge for a batch of material to be discharged through the opening.

The apparatus may comprise a silo or a container in an intermediate bulk container (I.B.C.) system, and the load cell may support the apparatus.

Alternatively, the apparatus may comprise a hopper adapted to receive flowable material from the opening, and the hopper may be mounted on the load cell.

There may be a plurality of load cells, for example two.

The apparatus may be used in a continuous system, that is one where material is continuously discharged in use through the opening. There may be bellows means for moving the closure device substantially vertically relative to the opening between a position in which the

opening is fully closed against flow of material through the opening and a position in which the opening is open for flow of the material therethrough, the bellows means being activated by a liquid medium.

The liquid medium may be water. This provides an activating medium which is virtually incompressible.

The bellows means may be activated by an additional bellows means which is in turn activated by an electromechanical activator device, the two bellows means being connected together by a conduit for water. This provides a sealed system and for accurate control of operation of the first-mentioned bellows means which is not susceptible to variation in headload.

The electromechanical activator may be a motor driven screw jack device. This arrangement allows the lift height of the closure device to be calculated accurately as the lift height or retraction of the screw jack is proportional to the discharge rate; this lift height is also proportional to the time the motor is switched on (= time x revolution x pitch). The controller may then be adapted constantly to reverse the motor so as continuously to adjust the height of the closure device so as to maintain an accurate desired discharge rate.

The conduit may be flexible.

There may be in the conduit a valve such as a diverter valve for relatively rapid exhaust of the water at the end of the discharge of a batch.

The closure device may comprise a control or frusto-

conical closure device positioned in the opening.

There may be a vibrator adjacent to or mounted on the closure device for vibrating same to assist passage of material through the opening in the open position of the discharge device.

According to a second aspect of the invention there is provided a method for controlling substantially vertical discharge of flowable material from apparatus as hereinbefore defined, comprising the step of providing a load cell adapted to monitor the weight of material, providing an electronic controller connected with the load cell, and controlling the flow control means to maintain a desired discharge for a batch of material through the opening.

Using the invention in a pulse mode the controller looks at the trend over the previous pulses to ascertain whether the system is going towards instability or towards over-damping, and adjusts the pulse size multiply limits accordingly. Moreover the controller remembers moving average pulse time through a batch and uses this average for its starting point on the next batch for that particular material, or any other material. Thus the controller automatically caters for any material and also for any change in characteristics of each material.

The controller also automatically calculates the maximum weight check delay time it can have by working out the cycle time from one pulse to the next and waiting for a time just short of that - the backstop minimum may be 1.5 seconds. Thus the controller is always working with

the best possible input signal while at the same time allowing the maximum possible discharge rate.

Another feature is the optional continuous mode of operation whereby a continuous voltage signal is sent to an E/P converter (basically an electrically driven pressure regulator) constantly to adjust the pressure so as to maintain the cone at a lift height that will give the required discharge rate. This lift height will vary for a particular set discharge rate depending on various material conditions, the height of material in the bin, and other factors.

The controller samples the discharge rate every fraction of a second and increases or decreases the voltage and therefore the pressure and lift height accordingly so as to maintain an accurate average discharge rate. As for pulse control, the continuous mode also has automatic self learning and self correcting logic.

Apparatus embodying the invention is hereinafter described, by way of example, with reference to the accompanying drawing.

The drawings shows a schematic side elevation of apparatus according to the invention for discharge of flowable material such as powder from a silo, hopper or I.B.C. container.

Referring to the drawing, there is shown apparatus 1 for controlling substantially vertical discharge of flowable material such as a powder or other particulate or granular material 2, comprising a discharge opening 3 near a lower end (in use and as shown) thereof, flow

control means 4 adapted to be mounted internally of the discharge opening 3 for the flowable material 2 and to form with that opening 3 a flow path 5 for material through the opening 3, a load cell 6 adapted to monitor the weight of material, and an electronic controller 7 connected electronically with the load cell 6, the arrangement being such that a signal from the load cell 6 is interpreted by the controller 7 to control the flow control means 4 and to maintain a desired discharge for a batch of material to be discharged through the opening 3.

The flow control means 4 comprises a cone which is vibratable by a vibrator 8 which is between the cone and a bellows means 9 which contains a virtually incompressible medium such as water.

The bellows means 9 is internally of the discharge opening 3 mounted on a support such as a beam 10. Externally of the discharge opening 3, there is additional bellows means 11, connected with the first mentioned bellow means 9 by a flexible conduit 12. The two bellows means 9 and 11 thus form a closed system.

The bellows means 11 is of less diameter than the bellows means 9 to provide a mechanical advantage together with an increased lift height.

The bellows means 11 is activated by an electromechanical activator in the form of a screw jack 13 driven by a motor 14. As this jack 13 moves up and down (as viewed) it bears physically on the bellows means 11 to move same up and down. This in turn moves the bellows means 9 up and down as water in the conduit

12 is transferred between the two bellows means 9 and 11. This in turn varies the position of the cone 4, so in turn controlling the size of the discharge opening 5 and hence the flow of material. The load cell 6 responds to the varying weight to cause the controller 7 to activate the control to the motor 14, and hence the two bellows means 9 and 11, so as continuously to adjust the height of the cone 4, to provide an accurate discharge rate. This applies to a "pulse" or batch discharge or a "continuous discharge".

The conduit 12 has a valve 15 for diverting water for quick exhaust at the end of a batch discharge.

The height 'D' moved by the cone 4 may be twice the extension of the bellows 11.

The invention may be applied to apparatus similar to that sold under the Registered Trade Mark MATCON.

The controller will receive an analogue input from a load cell amplifier/junction box and will use this weight data together with the input variables to calculate the signal duration and time between signals to an external air solenoid valve which sequentially allows air to a MATCON Discharger or IBC station to operate the MATCON in a 'pulse' mode. Thus, under this control the MATCON discharges incremental small pulses of material at defined time intervals to process so as to maintain an overall accurate discharging rate, and a consistent pulse size.

The controller logic programme will calculate each sequential pulse 'on' time signal to the solenoid valve

comparing the actual last pulse weight to the required pulse weight and adjusting the pulse 'on' time accordingly - within the multiplier limits as set out. The controller will calculate the time from the start of one pulse to the start of the next pulse by dividing the last actual pulse weight by the required discharge rate to give the exact cycle time. This is in the pulse mode.

In the continuous mode, the controller will receive the analogue signal and input variables to calculate the continuous signal output to an external converter so as to set the operating pressure of the MATCON, and thus the continuous discharge rate.

The input signal is used at preset times to recalculate and resend the output signal, and so adjust and maintain the process, and thus the discharge rate.

IN both modes, near the end of the batch, both systems go to a 'top-up' mode, where the remainder weight is calculated and a proportional and progressively reducing pulse is discharged to top up to the required batch. The time interval between pulses is calculated so as to maintain the required rate.

The controller will carry out the above calculation(s) sequentially until either the required batch size is achieved or the total cycle time is achieved.

There is an additional single output to a second solenoid valve to operate external air vibrators fixed to the bulk hopper or container to operate at a certain time during the sequence as outlined below.

The apparatus also caters for various alarm and default conditions as set out below:

- Bin Nearly Empty
- Bin Empty
- System Blockage
- System Flush
- Bin Off Station
- Manual Pause, Reset or Restart

The apparatus may be either a loss-in-weight or a gain-in-weight system. A loss-in-weight system is one whereby the bulk container or silo is on the load cells and thus the operating logic substracts the continuously reducing total weight from the previous total weight to calculate each increment discharged.

In a gain-in-weight system a downstream process vessel or weight hopper is on load cells and the control logic substracts the previous wieght from the present total weight to arrive at the actual weight discharged.

The system is configured to calculate many of the required parameters and to accommodate for widely different material characteristics so that the invention is self learning and self correcting.

CLAIMS

1. Apparatus for controlling substantially vertical discharge of flowable material, comprising a discharge opening near a lower (in use) end thereof, flow control means adapted to be mounted internally of the discharge opening for flowable material and to form with that opening a flow path for material through the opening, a load cell adapted to monitor weight of material, and an alectronic controller connected with the load cell, the arrangement being such that a signal from the load cell is interpreted by the controller to control the flow control means and maintain a desired discharge for a batch of material to be discharged through the opening.

2. Apparatus according to Claim 1, comprising a silo, or a container in an intermediate bulk container (I.B.C.) system.

3. Apparatus according to Claim 2, the silo or container being mounted on the load cell.

4. Apparatus according to Claim 1, comprising a hopper adapted to receive flowable material from the opening, and a load cell on which the hopper is supported.

5. Apparatus according to Claim 3 or Claim 4, there being a plurality of load cells.

6. Apparatus according to any preceding claim, comprising bellows means for moving the closure device substantially vertically relative to the opening between a position in which the opening is fully closed against flow of material through the opening and a position in

which the opening is open for flow of the material therethrough.

7. Apparatus according to Claim 6, the bellows means being activated by a liquid medium.

8. Apparatus according to Claim 7, the liquid medium being water.

9. Apparatus according to Claim 8, the bellows means being activated by an additional bellows means which is in turn activated by an electromechanical activator device, the two bellows means being connected together by a conduit for water.

10. Apparatus according to Claim 9, the electromechanical activator device comprising a motor driven screw jack device.

11. Apparatus according to Claim 10, the controller and motor being operatively interconnected whereby constantly to reverse the motor so as continuously to adjust the height of the closure device so as to maintain an accurate desired discharge rate.

12. Apparatus according to any of Claims 9 to 11, the conduit being flexible.

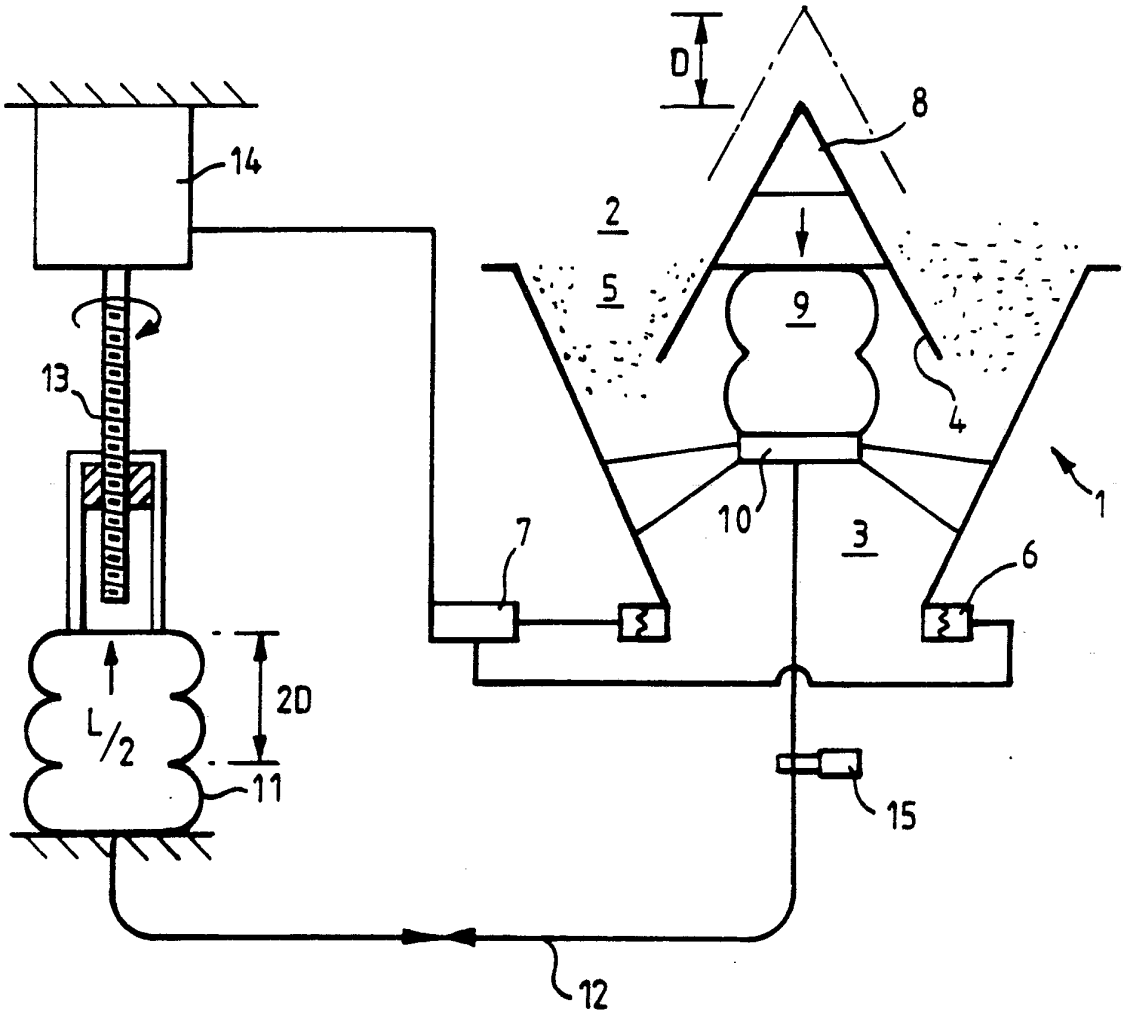
13. Apparatus according to Claim 12, comprising, in the conduit, a valve for relatively rapid exhaust of the water at the end of the discharge of a batch.

14. Apparatus according to any preceding claim, the closure device comprising a control or frusto-conical

closure device positioned in the opening.

15. Apparatus according to Claim 14, comprising a vibrator adjacent to or mounted on the closure device for vibrating same to assist passage of material through the opening in the open position of the discharge device.

16. A method for controlling substantially vertical discharge of flowable material from apparatus according to any preceding claim, comprising the steps of providing a load cell adapted to monitor the weight of material, providing an electronic controller connected with the load cell, and controlling the flow control means to maintain a desired discharge for a batch of material through the opening.


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INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 92/00215

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 G01G11/08

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	G01G

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
A	WO,A,8 605 875 (G. BÜHLER AG) 9 October 1986 see page 10, line 21 - page 11, line 28; figure 1 ---	1,2,16
A	DE,A,3 617 595 (W. FREDE) 26 November 1987 see column 3, line 52 - line 58 see column 4, line 10 - line 21; figures 4,5 ---	1,16
A	EP,A,0 290 999 (FUJI PHOTO FILM CO. LTD) 17 November 1988 see page 6, line 8 - line 16; figure 2 ---	1,16
A	ENGINEERING. (INCL. MACHINE SHOP MAGAZINE) vol. 223, no. 10, October 1983, LONDON GB page 792; 'Electronically controlled hopper copes with sticky materials' see the whole document ---	1,16

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
13 MAY 1992	04. 06. 92
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	GANCI P.A.

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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GB 9200215 SA 56193

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 13/05/92
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		DE-U- 8528992	02-04-87
		WO-A- 8605874	09-10-86
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