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Automatic Control System for Dispensing Precise Amounts of Finely Divided Solids

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MOUND LABORATORY
Miamisburg, Ohio
operated by
MONSANTO RESEARCH CORPORATION
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for the
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Monsanto

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AUTOMATIC CONTROL SYSTEM FOR DISPENSING PRECISE AMOUNTS OF FINELY DIVIDED SOLIDS

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I. ABSTRACT

A device for automatic dispensing of precise amounts of finely divided solids has been developed. Precision is a function of dispensing time. Smaller than gram quantities may be dispensed at a rate of about 1/3 g/min with a precision corresponding to a weight range of about 0.001 g for a series. The process consists in moving the material with the effect of the vibratory motion of a miniature air-powered vibrator. Operation is automatically controlled by the electronic system of the weighing unit interfaced to the pneumatic dispensing device via a combination fluidic and pneumatic control system.

II. INTRODUCTION

An automated system for dispensing precise amounts of finely divided solids has been developed. Dispensing, in this instance, consists in moving material from a supply source to a weighing mechanism. Dispensing of the desired amount is automatically controlled by interfacial electronic, fluidic, and pneumatic devices. The system is shown in Fig. 1.

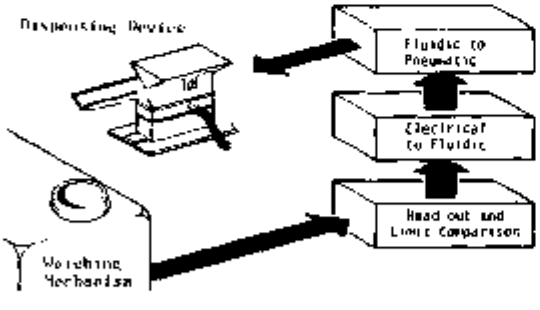

Fig. 1. Closed Loop Automatic Controlled Dispensing System

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Although the system is intended for smaller-than-gram quantities, a limited extent of scale-up may be feasible without loss of the advantages of speed and precision.

III. AUTOMATED SYSTEM

The system consists of three major parts: (1) dispensing device, (2) weighing mechanism, and (3) automatic controls. These are described below in detail.

DISPENSING DEVICE

Finely divided solids are moved from a supply hopper onto and along a trough by the vibratory motion of a miniature air powered vibrator*. Mass particles** move in a flow that permits cutoff after delivery of the desired amount. The dispensing device is shown in Fig. 2.

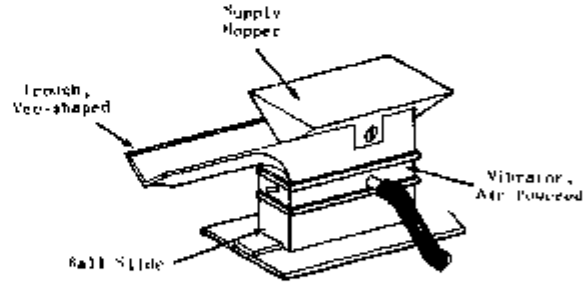

Fig. 2. Dispensing Device

*A list of components and manufacturers is attached.

**Mass particles are those seen by the unaided eye and consist of clusters of individual particles of microscopic size.

It is comprised of three major parts. These are:

- Vibrating part
- Flexible connection
- Base support

• The vibrating part consists of the vibrator itself, a frame for holding the vibrator, and a hopper and a dispensing trough. The trough is machined from aluminum and has a groove in the underside that causes particles traveling over the edge to fall off rather than to build up. The hopper is fabricated of brass shim stock. A small vee-shaped opening at the bottom of the front end of the hopper provides for controlled flow out onto the trough.

• The vibrating part is moored to a stationary base by a flexible connection consisting of a ball slide and a rubber pad 1/8 in. thick. The ball slide is mounted so as to permit movement parallel with the length of the trough.

• The assembly is mounted on a supporting arm of a support base and stand.

WEIGHING MECHANISM

The goal of automated dispensing of powdered solids is rapid dispensing with high precision at low cost. Rapid precise dispensing is dependent not only on the movement of material but also on the capability of the weighing mechanism. At the time this work was initiated, the only available fast acting weighing mechanism with automatic control features was a Voland Model 160-BT Automatic Netweigh Balance. This balance, a prototype of a top loading weighing device with automatic features, has a capacity of 100 g and an accuracy of 0.0008 g. It is equipped with a taring system which reduces the effective weight of the weighing dish, with or without a proposed load, to zero. Electrical output signals (adjustable set point controls) are provided at 80, 95, and 100% of a preselected weight for interfacing with external controls.

AUTOMATIC CONTROLS

Fluidic components are interfaced to the Voland electrical controls for automatic control of dispensing, see Fig. 3. The electrical balance signals operate electric transducer valves for a fluidic system which in turn controls the air powering the dispensing device. With this innovation, operator manipulations

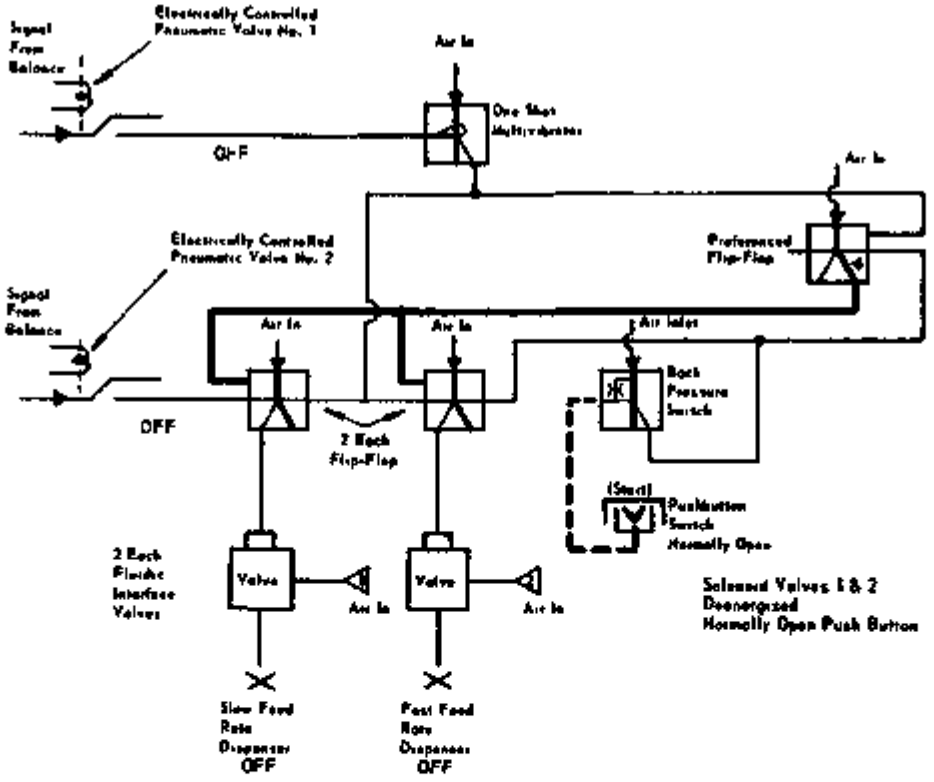

Fig. 3. Fluidic Control For Dispensing Precise Amounts In Start Position

are reduced to placing the weighing dish on the balance, taring the balance, and pressing the START button to set the system in operation. The fluidic signal from the start button actuates the fluidic control to send a regulated air stream to the vibrator for dispensing at a fast rate, see Fig. 4. As the amount of material on the balance reaches 80% of the programmed amount, or another preset fractional amount, an electrical signal from the balance causes the fluidic control to cut off the stream of air regulated to power the vibrator at a fast rate and to turn on a stream regulated to a lower pressure, for finishing the dispensing at a slow rate, see Fig. 5. When the amount of material on the balance reaches the programmed amount, an electrical signal from the balance actuates a fluidic control which stops the flow of air to the vibrator and thus completes the dispensing sequence, see Fig. 6. The digital display on the balance shows the quantity dispensed. The balance also produces a binary-coded decimal output suitable for automated data printing or recording for later statistical evaluation of the data.

IV. DEVELOPMENT OF THE DISPENSING PROCESS

The original concept of the dispensing device incorporated manual control. Manually controlled trials demonstrated that the device had promising capability for dispensing precise amounts. A double control system provided for operating the device at two speeds and offered the advantage of dispensing the majority of the material at a fast rate and the remainder at a slow rate.

The immediate objectives to be attained in the automatic dispensing process are precision and speed. Precision is a function of speed. Speed is controlled by the vibration rate, and fast and slow rates are employed as appropriate. Speed is also controlled by the size of the train of material in the trough. A heavy train of material provides rapid delivery and a narrow train of material provides slow delivery. On the other hand, precise control cannot be achieved with a heavy train as it can with a narrow train. Although these conditions of speed and precision are opposite to one another, each can be employed advantageously with

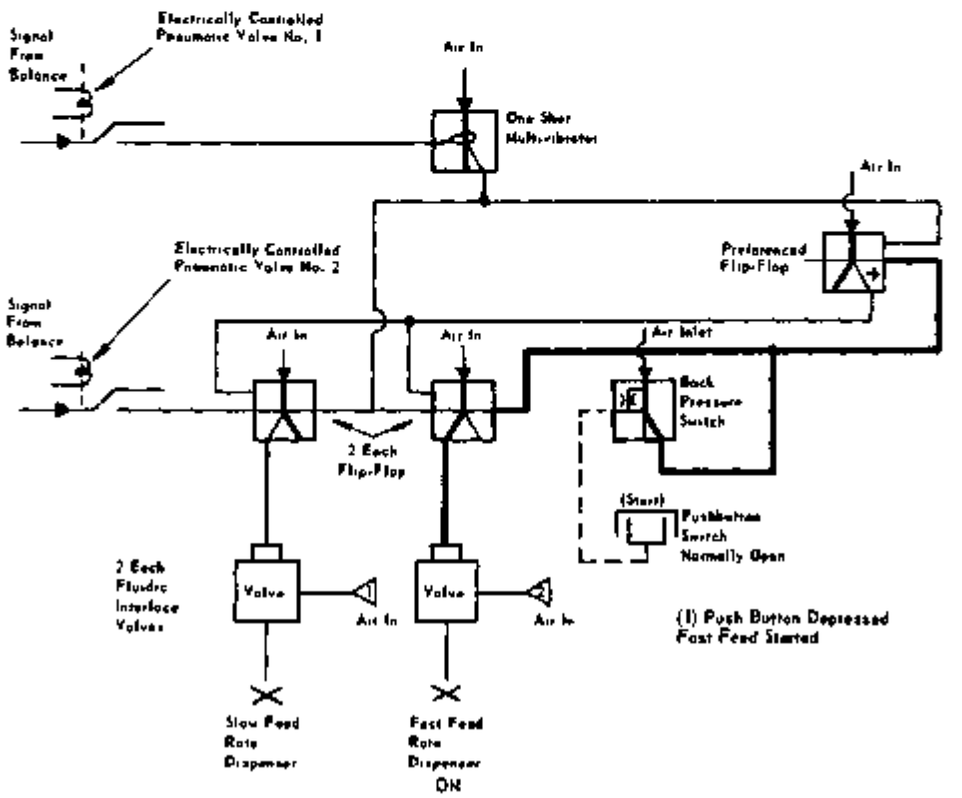

Fig. 4. Fluidic Control For Dispensing Precise Amounts In Fast Feed Position

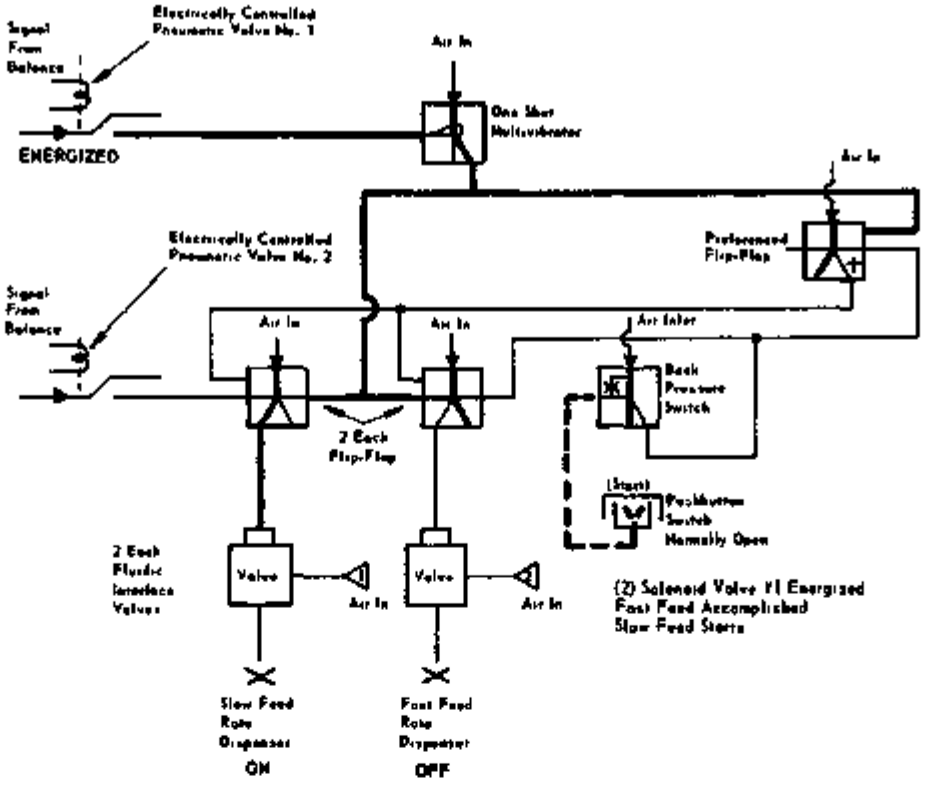

Fig. 5. Fluidic Control For Dispensing Precise Amounts In Slow Feed Position

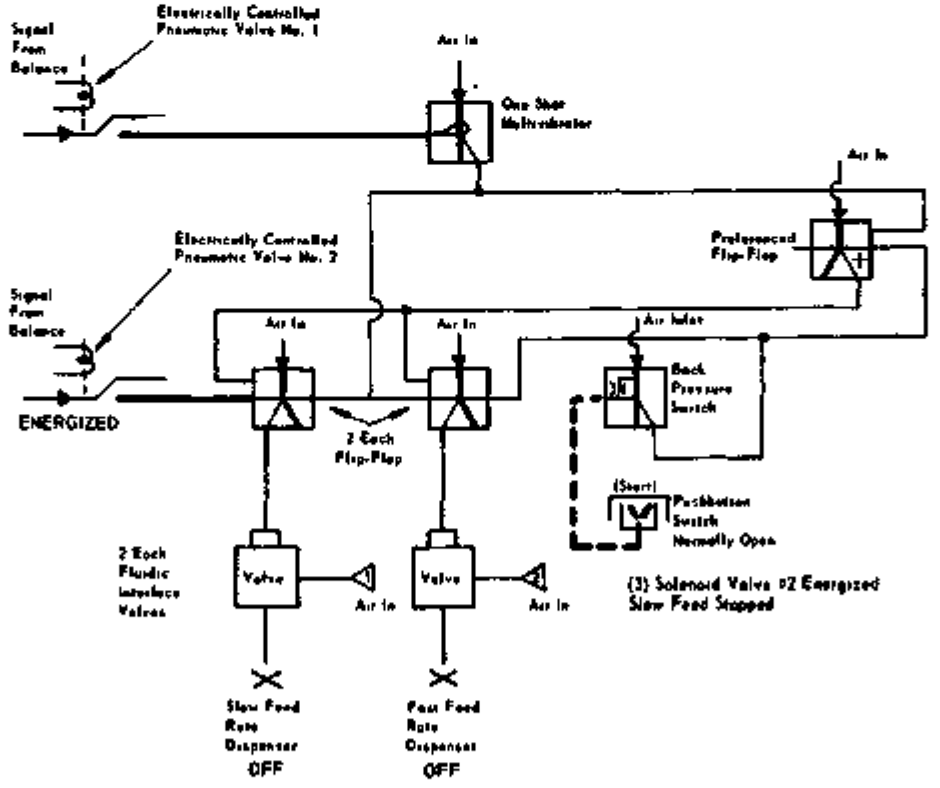

Fig. 6. Fluidic Control For Dispensing Precise Amounts With Cycle Completed

a separate dispensing device. Therefore, the automatically controlled operation was changed from one dispensing device operated at two dispensing rates to two dispensing devices operated at individual rates, see Fig. 7. One with a heavy

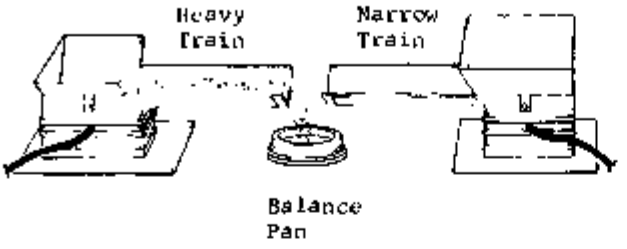

Fig. 7. Two Devices In Position For Dispensing Materials Onto The Voland Balance

train was operated at a fast vibration rate for dispensing 80% of the programmed amount. The other with a narrow train was operated at a slow rate for dispensing the remaindor of the amount. With the automatic features of the Voland balance, it was necessary only to push the START button. Fast dispensing was cut off at the proper point and slow dispensing proceeded to a precise endpoint. This system gave best performance in both precision and speed. Smaller-than-gram quantities were automatically dispensed at a rate of 1/3 g/min with a precision corresponding to a weight range of about 0.001 g for a series.

V. SUMMARY

An automated system was developed for dispensing precise amounts of finely divided solids and its capability was demonstrated. Precision is a function of dispensing speed. Smaller-than-gram quantities may be dispensed at a rate of 1/3 g min with a precision corresponding to a weight range of about 0.001 g for a series.

The process consists in moving material with the effect of the vibratory motion of a miniature pneumatic vibrator. Material from a hopper moves along a trough and drops onto a weighing balance. The air powering the vibrator is controlled automatically with a combination of fluidic and pneumatic devices interfaced with the weighing unit. The electrical balance signals operate electric-to-fluidic transducer valves for a fluidic system which in turn controls the air powering the dispensing device. With this innovation, operator manipulations are reduced to placing the weighing dish on the balance, taring the balance, and pressing the START button to set the system in operation. Thus, dispensing of a designated weight of material may be accomplished without the variations resulting from the human factor.

VI. APPENDIX - COMPONENTS AND MANUFACTURERS

DISPENSING DEVICE

Vibrator - Model VM-25 vibrator,
The Cleveland Vibrator Company,
2828 Clinton Avenue,
Cleveland, Ohio 44113.

Ball-slide - Series J Ball-slide,
Automation Gages, Inc.,
100 Seneca Avenue,
Rochester, N. Y. 14621.

BALANCE

Voland Model 160-BT Automatic Netweigh Balance,
Voland Corporation,
27 Centre Avenue,
New Rochelle, N. Y. 10802.

PNEUMATIC CONTROLS

Pressure Regulators - Mini-Regulator, Model 70B, 0-60 psi for fast and slow feed rate and 0-15 psi for fluidic control,
Fairchild Hiller, Industrial Products Division, Winston Salem, N. C.

Valve Fluidic Interface - Fluidamp Model 2010-LP 5 to 40 psig,
Northeast Fluidics Inc., Amity Road,
Bethany, Connecticut 06525.

Corning Preferenced Flip-Flop 191926
Corning Flip-Flop 191454
Corning Back Pressure Switch 191491
Corning One Shot Multivibrator 191458
Microswitch Pushbutton 192496
Corning Glass Works, Fluidic Product Dept., Corning, N. Y. 14830.

ELECTRIC TO FLUIDIC TRANSDUCER VALVES

Interface, Electrically Controlled Pneumatic Valve; Model LIF 180D 3A 12,
The Lee Company,
Pettipaugh Road,
Westbrock, Connecticut 06498.