

[54] **RANDOM FLOW COUNTER**

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**235/92 V, 235/98 C, 221/278**

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[58] Field of Search..... **235/92 PK, 92 V,**  
**235/92 PC, 92 TC, 98 C; 221/278, 254;**  
**222/193, 394**

[56] **References Cited**

**UNITED STATES PATENTS**

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[57]

**ABSTRACT**

A highly accurate counting technique for large numbers of randomly flowing, discrete solid particular sample materials such as capsules utilizing a feeder-sensor assembly and associated circuitry is described. The feeder-sensor assembly employs a pressure gradient along the sample passageway induced by a high-velocity air jet below the sensing element to effectuate proper spacing of the sample so that the sensing element can register individual passage of the samples. A secondary air flow which assists in sample separation is provided by employing an air space between the sample input cavity and the sensor element position of the feeder sensor assembly. In a preferred embodiment the output of a plurality of feeder-sensor assemblies is fed to discrete channels into a counter circuit distinguished in having the memory latch reset controlled by a delayed multiplexer pulse synchronized to the address counter output. Thus, a reset pulse is supplied to the memory latch only if it were previously set.

**6 Claims, 3 Drawing Figures**

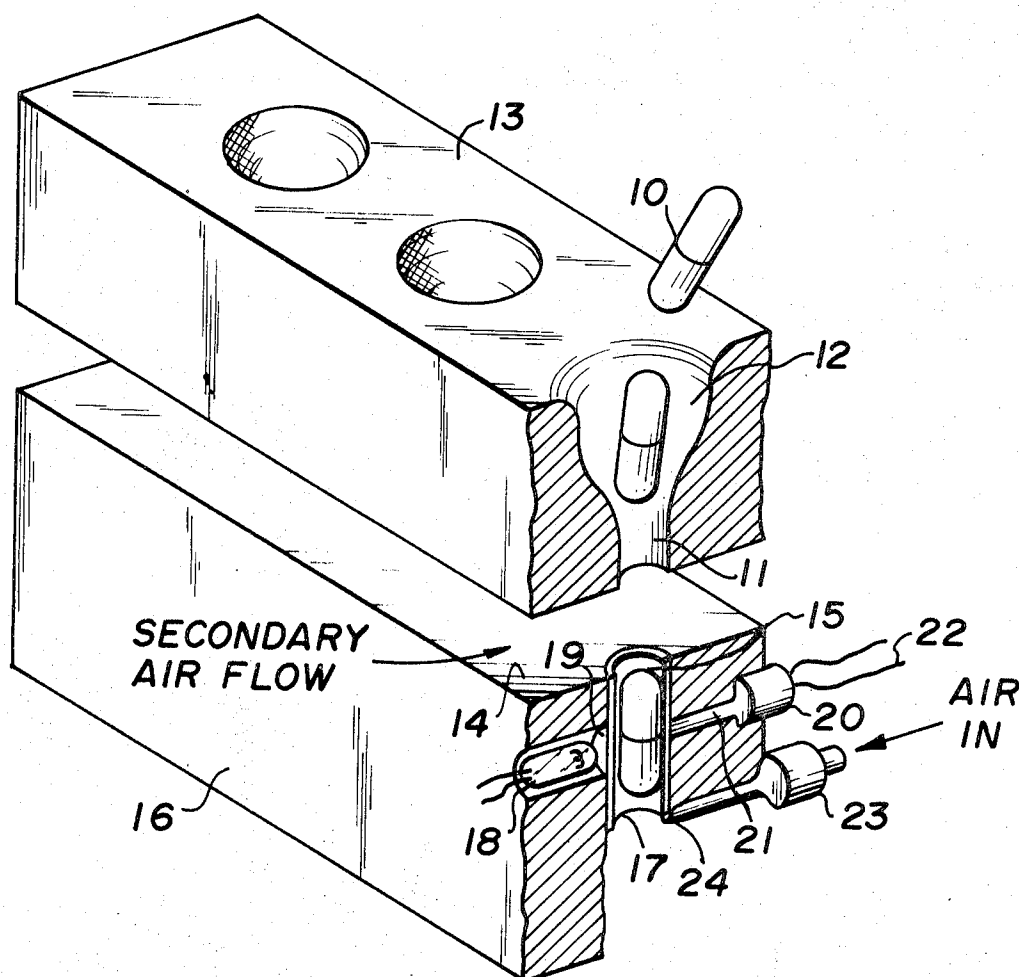


**FIG. 1**

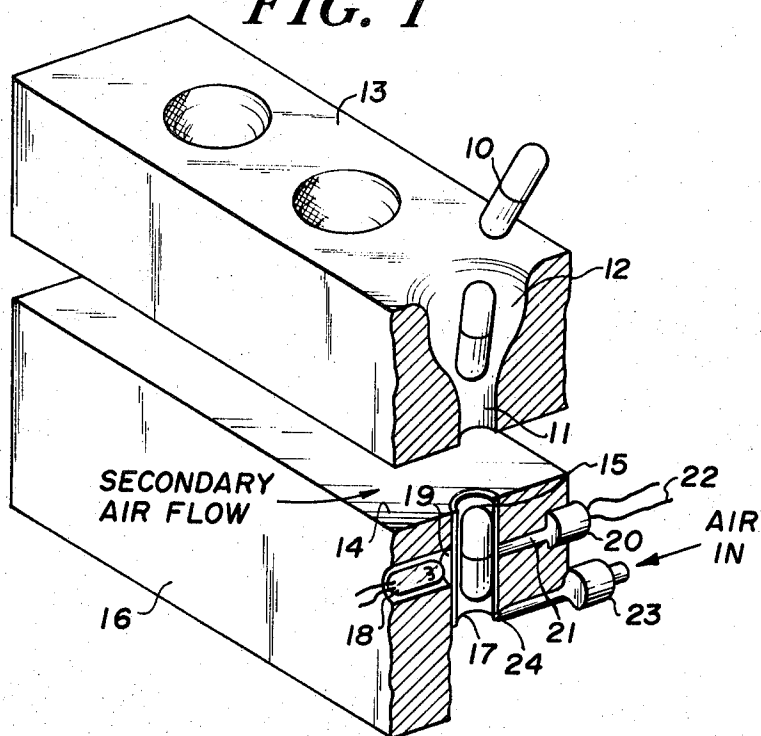
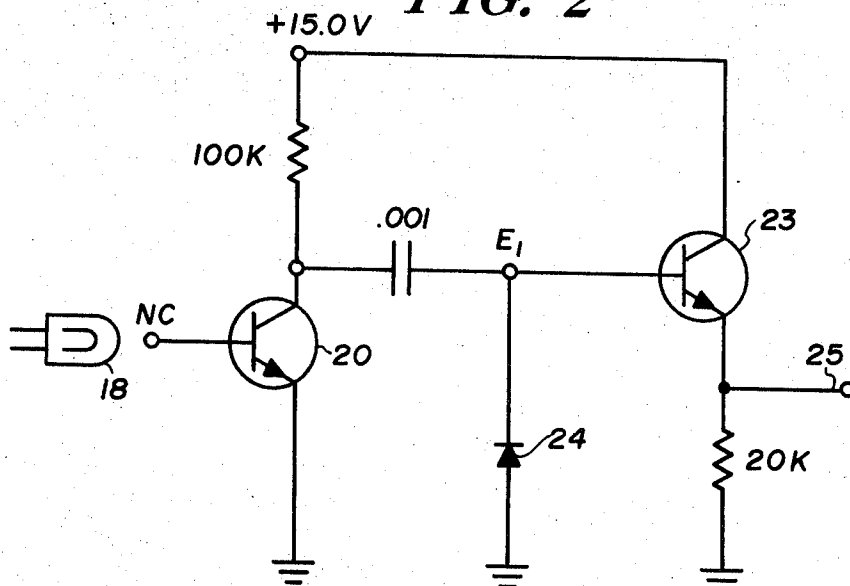


**FIG. 2**



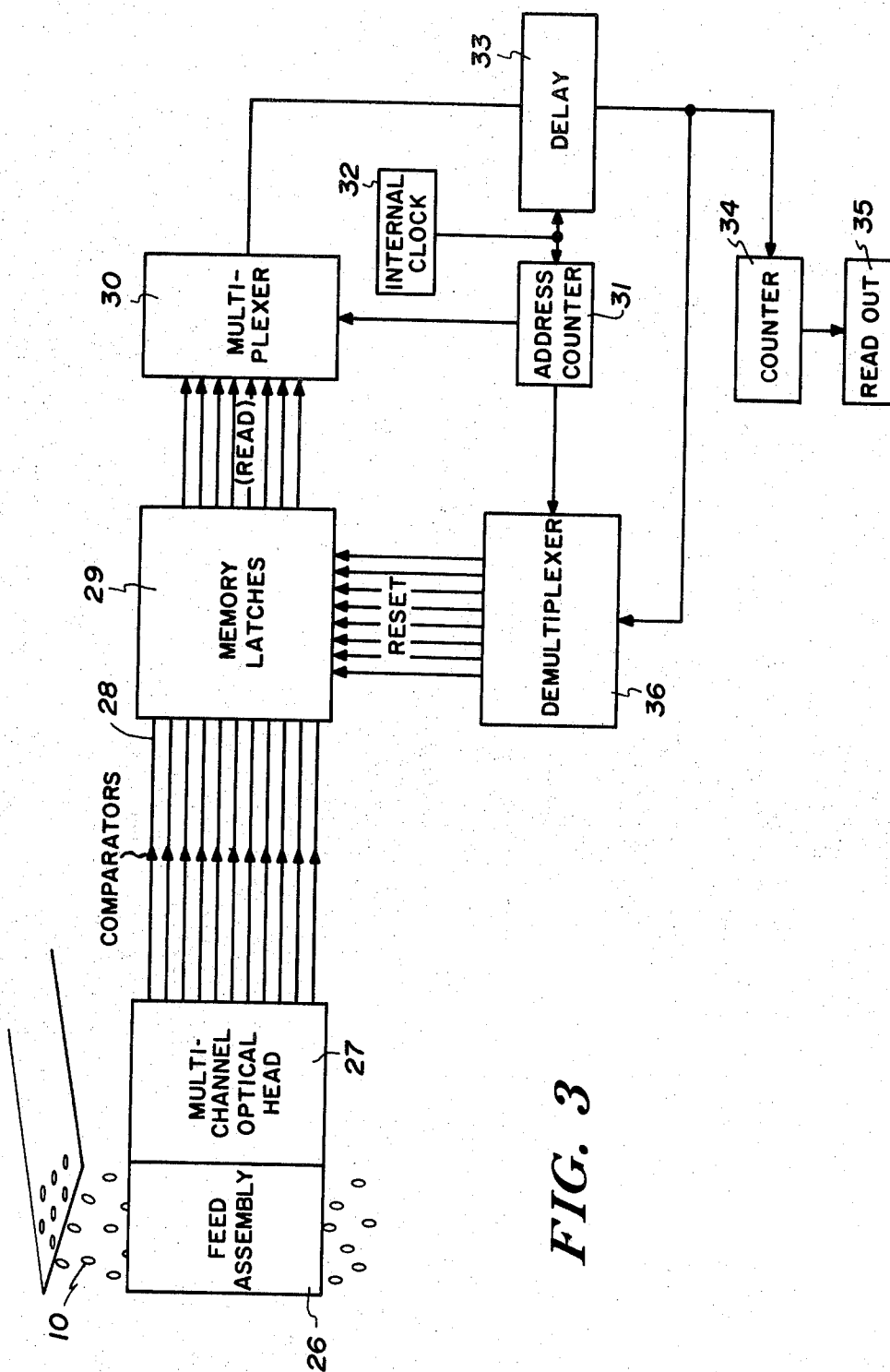


FIG. 3

## RANDOM FLOW COUNTER

## BACKGROUND OF THE INVENTION

High speed feeding and counting of large numbers of discrete, solid objects has long presented a problem of counting accuracy to the art. The basic method utilized in the art for counting employs a photoelectric light beam disposed across the path of the object and directed towards a sensing means. Each passage of an object across the light beam results in interruption of the beam causing a unique signal to be produced in the sensing means which is used to trigger an appropriate type of counter.

However, as higher and higher flow rates are utilized, difficulty is experienced in accurately sensing the objects to be counted due to the inability of the device to separate the objects in the flow streams. For example, when capsules of the type used in the pharmaceutical industry are to be counted and are introduced in free-fall through a counting channel at high flow rates (5-10 capsules per second), the capsules tend to touch one another. This results in a situation wherein a unique signature pulse is not obtained for each individual capsule. It appears that in such circumstance the probability of erroneous signatures occurring is approximately 0.002. This level is unacceptable under new standards of accountability of pharmaceutical products which require a counting error of less than 1 part in  $10^4$ .

The problem of producing a proper separation in objects to be counted or fed into a high speed operation is not new to the art. For example, U.S. Pat. No. 3,130,863, issued April 28, 1964 to Batchelder, describes a feeder apparatus which employs a rotary disc brush and a jet of compressed air directed along the path of motion of the jamb nut objects to effectuate separation prior to counting of the nuts by interruption of a photoelectric head beam. In the disclosed embodiment the air is introduced at an oblique angle to the feed channel to produce the air flow in the general direction of the flow of the object nuts.

The use of an oblique air inlet to produce an air stream essentially parallel to the flow path of moving objects to effect a degree of separation between them is also shown in a feeding mechanism described in U.S. Pat. No. 3,324,697, issued June 13, 1967 to Reiley. Both patents discussed above are seen to employ positive air flow directly on the moving objects to effect some spacing. However, it has been observed that this procedure does not produce a counting accuracy at the required level.

## BRIEF DESCRIPTION OF THE INVENTION

The present invention relates to an improved counting system comprising a feeder-sensor assembly and associated circuitry which system is particularly adapted to count with a low degree of error (0.0001) a high rate of randomly flowing discrete, solid particular material. In particular, the counting system of the present invention is adapted to count solid materials having a longitudinal axis substantially greater than their horizontal axis such as, for example, pharmaceutical capsule dosage forms.

The feeder-sensor assembly achieves the ultra high counting accuracy by means of several novel structural features. Spacing of the randomly flowing objects is obtained by subjecting each object to a slight pressure gradient as it approaches the sensing means in a mea-

suring channel. In contrast to the procedure employed by the prior art, the pressure gradient is developed by providing a source of air at ambient pressure at a point in the channel above the sensing means and by introducing a high velocity, low flow rate stream of air transversely across the channel perpendicular to the flow path of the objects to be counted at a point below the sensing means. As the air stream impinges on the far wall of the channel it converts to turbulent flow producing a zone of pressure lower than ambient. The resultant is the production of a slight pressure gradient between the ambient air inlet and the high velocity air inlet which causes each object in the channel to accelerate from the object behind it thereby providing sufficient space between each object for a unique signature to be generated when passing through the sensing means.

The counting system of the present invention will be more clearly understood by reference to the accompanying drawings.

FIG. 1 is a longitudinal cross-sectional view of the feeder-sensor assembly,

FIG. 2 is a circuit diagram of the detector circuit assembly and

FIG. 3 is a block schematic diagram of the counting system of the present invention.

Turning first to FIG. 1, objects to be counted 10, e.g., capsules, are introduced from a suitable storage and transport means (not shown) which can be a hopper, moving belt, vibrating tray, etc. The objects 10 are in a state of random flow, free fall and enter flow channel 11 through the enlarged diameter of entrance cavity 12. Flow channel 11 and entrance cavity 12 are formed by drilling holes of desired size through feeding block 13. It is desirable that the diameter of the flow channel 11 be about 0.25 cm. larger than the diameter of the objects to be counted. Obviously, the diameter of the entrance cavity 12 is larger to facilitate proper entry and flow of the objects 10.

After dropping across opening 14, objects 10 enter into sensor channel 15 which is formed within sensor block 16 by appropriate means such as by drilling a hole of desired size therein. Opening 14 provides access for ambient air to enter sensor channel 15. It can readily be provided by spacing feeding block 13 from sensor block 16 by utilizing appropriate support means (not shown). The spacing between the two blocks is not critical but preferably is in the order of about 19 mm.

Sensor channel 15 will preferably be provided with a lining 17 which is transparent to the electromagnetic radiation employed to detect the passage of objects 10. Generally, this lining will take the form of a glass tubing since visible light is the most practical form of electromagnetic radiation to be employed in the sensor for the practice of the present invention. Electromagnetic radiation means 18 is provided in access channel 19 which is oriented perpendicular to the flow path of objects 10. In a preferred embodiment a lamp is employed to generate light energy in the form of an optical beam across channel 15.

Diametrically opposed to electromagnetic radiation means 18 there is provided an electromagnetic radiation sensing means 20, preferably a phototransistor, which is oriented with regard to access channel 21 so as to provide a direct pathway for said optical beam to the sensing element of said sensing means 20. The elec-

tromagnetic radiation sensing means 20 is linked to the counting circuit through conducting means 22.

Downstream of the sensing elements there is provided high velocity air inlet means 23 which is oriented in a manner to provide entry of a stream of high velocity air at low flow rates into channel 15 through aspirator nozzle 24. This air stream is produced in a direction essentially perpendicular to the flow path of objects 10. Generally, the air pressure utilized in air inlet means 23 will be in the range of from about 15 to 40 psig, most preferably about 20 psig. The pressurized air may be provided from any conventional source not shown. It is desirable that aspirator nozzle 24 be located in channel 15 at a distance roughly equivalent to the length of object 10 below the bottom of opening 14.

The feeder-sensor assembly operates as follows. A flow of objects 10 enter channel 11 through entrance cavity 12 in end-to-end relationship. As the objects respectively reach the entrance to channel 15 they are separated from the other objects in higher position by the effect of a pressure gradient imposed along the length of channel 15. This pressure gradient is caused by a zone of air at a pressure below ambient occasioned by the flow of high velocity air from aspirator nozzle 24. The result is to produce a secondary air flow from the exterior of the apparatus through opening 14 into channel 15 which accelerates the objects 10 as they enter that channel.

As each object 10 passes through the optical beam it breaks the beam which causes sensing means 20 to become non-conducting. A narrow, positive-voltage pulse is produced in the circuitry associated with the sensing means 20 and the pulse is transmitted to the counting system of the present invention.

In FIG. 2, the circuit utilized in the sensor assembly of the present invention is depicted utilizing the specific embodiment employing a lamp and phototransistor as described above. When the optical beam produced by lamp 18 is broken, phototransistor 20 becomes non-conducting and results in a narrow positive voltage pulse at  $E_1$ . The output of the emitter follower 23 follows this positive pulse. Negative pulses at  $E_1$  are prevented by diode 24. This output (one pulse per object) is transmitted to the counting system by means of output 25.

FIG. 3 is a schematic representation of the feeding and counting systems of the present inventions. Objects 10 are seen being conveyed to Feed Assembly 26 which contains a plurality of the flow and sensor channels described in FIG. 1. A plurality of the sensor assemblies described in FIG. 2 form a multi-channel optical head 27. The output signal from each of the emitter-followers 23 in the sensor assembly is fed to the input of a corresponding comparator or Schmidt trigger (one per channel) 28. The comparator output is "high" (logic level "1") when this signal voltage exceeds the comparison voltage and "low" (logic level "0") otherwise. The comparator output is inverted and passed to the input of memory latch means 29 which in preferred embodiments may consist of a simple memory circuit such as two appropriately connected "NAND" gates. The appearance of an "0" at the memory latch means input results in the output of "1". Once the output is "1" it remains at that level until a reset pulse is supplied.

Passage of an object 10 through a sensor channel 15 will cause the output of the corresponding memory cir-

cuit in memory latch means 29 to remain in the "1" position until it is read by the multiplexer 30.

The sampling of the complete set of channels in the multiplexer 30 is controlled by programmed pulses from address counter 31 which is driven by internal clock means 32 and is accomplished in less time than the minimum theoretical time between two objects falling through each sensor channel. Thus when pharmaceutical capsule dosage forms are used as objects 10 then each channel would be sampled about every 20 milliseconds.

At the output of multiplexer 30 pulses will appear as the outputs of the various memory circuits are sampled. These output pulses are delayed by circuit delay means 33 such as, for example, a set of JK flip-flops. The delayed pulses are used to drive decimal counter means 34 and, if desired, the counter information can be transferred and displayed by read out means 35. Obviously, each delayed pulse counted corresponds to the passage of one object through a sensor channel.

The delayed pulses also are passed to the demultiplexer 36 which is controlled by address counter means 31. Arrival of these pulses at demultiplexer 36 occurs at the exact time that the reset input for that particular channel is addressed. Thus, a delayed reset pulse is supplied to the memory circuit for a particular channel in memory latch means 29 only if a "1" has been read by the multiplexer 30 for that channel. This technique of read/delayed-reset serves to eliminate problems of missed or double counts which could arise if other approaches are used.

I claim:

1. A feeder-sensor assembly comprising in combination:

1. object inlet means;
2. flow channel;
3. sensor channel which is so arranged and constructed as to be in direct flow path relation to said flow channel;
4. opening means providing a space between said flow channel and said sensor channel, said opening means providing access to ambient air for said sensor channel;
5. electromagnetic radiation means which radiates electromagnetic energy across said sensor channel;
6. electromagnetic radiation sensing means which is in diametrically opposed position to said electromagnetic radiation means across said sensor channel; and,
7. high velocity air inlet means so arranged and constructed as to provide a high velocity air stream perpendicular to the longitudinal axis, of said sensor channel at a point below said electromagnetic radiation means.

2. A feeder-sensor assembly of claim 1 wherein said electromagnetic radiation means comprises a lamp and said electromagnetic radiation sensing means comprises a phototransistor.

3. The feeder-sensor assembly of claim 2 wherein said sensor channel contains a glass lining transparent to visible light.

4. The feeder-sensor assembly of claim 1 wherein said air inlet means comprises an aspirator nozzle.

5. An improved system for high velocity counting of randomly flowing, discrete solid particular materials which system comprises:

1. at least one feeder-sensor assembly of claim 1;

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- 2. multichannel optical head means;
- 3. comparator means;
- 4. memory latch means;
- 5. multiplexer means;
- 6. circuit delay means;
- 7. address counter means;
- 8. internal clock means;
- 9. counter means; and,
- 10. demultiplexer means;

wherein a pulse generated by the passage of an object 10  
through said feeder-sensor assembly is conducted from  
said optical head means to set said memory latch means  
through said comparator means, said memory latch  
means being read by said multiplexer means which is  
driven by said address counter means which is controlled 15  
by said internal clock means, a resultant multi-  
plex pulse obtained when said memory latch means is  
set is passed through said delay means and the delayed  
pulse is passed through said counter means and said de-

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multiplexer means, said demultiplexer means being  
driven by said address means and resets said memory  
latch means only if said memory latch means had been  
previously set by a pulse from said optical head means.

5 6. In a system for counting randomly flowing objects  
through a complimentary shaped flow channel having  
a sensor station positioned for counting the objects as  
they flow past the station, comprising:

means for introducing a flow of air at ambient pres-  
sure in an area defining a break in the flow channel  
above said sensor station; and,

means for introducing a second air flow of high ve-  
locity and low flow rate transversely across said  
sensor channel below the sensing station to define  
in combination with said ambient air flow a pres-  
sure gradient for enhancing separation of the par-  
ticular objects prior to passage through the sensor  
station.

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