The Hogan Vibratory Bin Discharger

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Summary

The discharge of powders stored in bulk has always been a problem, and there are many devices, schemes and designs to ensure that material once in a silo will flow out again. The subsequent control of that flowing material is considered a separate problem. This paper discusses the mechanical make-up and practical application of a device that not only promotes flow but also controls it.

1. Introduction

The Hogan Bin Discharge/Feeder was first introduced into the British market in 1974 as alternative equipment to the well-established 'Bin Activator'. Since then the Hogan has established itself equally as capable as the alternative, handling small discharge and bagging problems right through to the discharge of large 600 ton silos, with over 300 machines operational throughout the world.

The construction and use of the Hogan leads to some significant process and capital cost advantages, some of its typical applications are illustrated below.

2. Construction of Discharger

These advantages are best illustrated by considering the mechanical make-up of the unit, as shown in Fig. 1.

The overall unit is either square or rectangular and has a top flange section (1). This is used to attach the machine to a hopper or silo outlet. Suspended underneath, by means of a number of anti-vibration suspension links (7) (the number increases with machine size), is the main vibrating body (2). Bridging the gap between the top flange and the main body is a rubber sleeve (8). This is a one piece moulded silicone rubber section that acts as an integral gasket between the top flange and the silo outlet flange. The bottom end of this sleeve is clamped onto the main vibrating body, see Fig. 2. The gap between the top flange and the main vibrating body is, at the most, 10 mm. Otherwise the sleeve is well protected and they usually last three to four years for the majority of materials. The sleeve can be further protected by the fitting of a metal sleeve attached to the top flange but not connected to the main body. For installation where tramp metal or explosions are a major consideration, this sleeve protector is useful.

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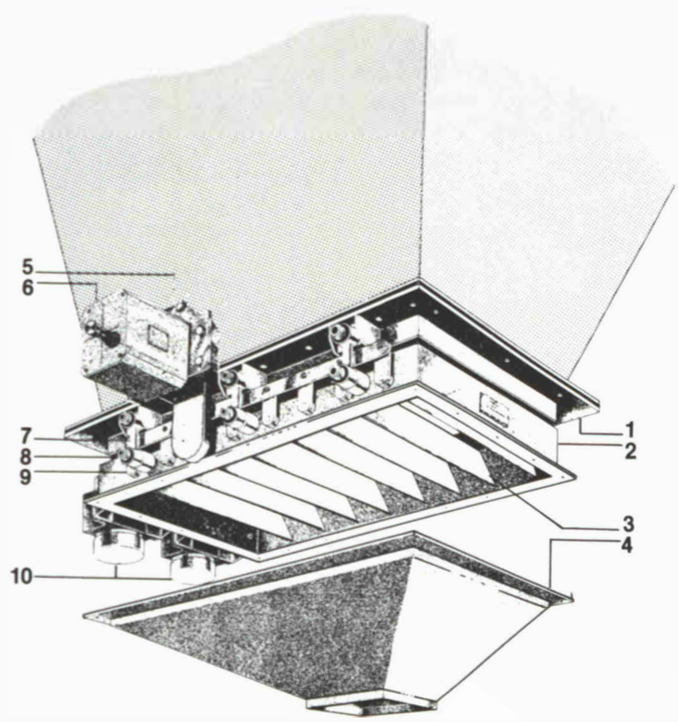
The main vibrating body contains within it a number of blades (3) which are free to rotate through 90° from the horizontal (closed position) to the vertical (open position).

The blades are built with bosses at each end, into which stub shafts fit, the bosses have keyways and the stub shafts keys, so that there are no nuts, bolts, pins, or similar that can come loose inside the discharger and contaminate the process powder. The stub shafts rotate in bearings set in the outer wall, these bearings are made from any suitable bearing material, generally either P.T.F.E. or oil impregnated phosphor bronze. An 'O' ring seal is positioned at the front of each bearing, so improving bearing life and eliminating leakage and loss of the process powder.

The stub shafts and bearings can be removed, if necessary, extremely quickly, using a simple slide-hammer style maintenance tool. This can be accomplished with the discharger in position.

The main body is manufactured from a number of pressings welded together. This gives clean flat surfaces on the inside



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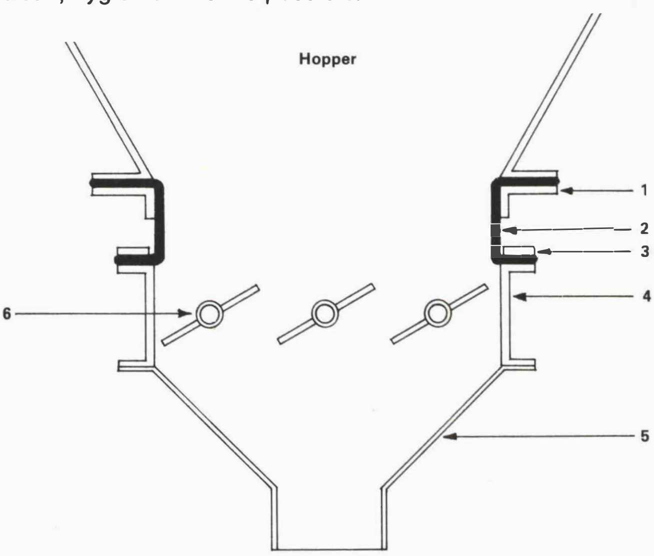
of the vibrating body, surfaces which are in contact with the process powder. This means that there are no dead spots where powder may lie and in the case of machines made for the food industry, particularly from stainless steel, a very clean, hygienic finish is possible.



1. Top flange for bolting to bin outlet flange
2. Flexible sleeve
3. Clamp for flexible sleeve
4. Main vibratory body
5. Under hopper
6. Bearings

Fig. 2: Diagrammatic section through the Hogan Bin Discharger

Using a flexible sleeve made from pure silicone rubber means that the whole unit is suitable for the most stringent of food applications and has, in fact, proved itself on baby foods where hygiene standards are the highest in the powder handling business.

The blades fit into the main body so that the blades butt onto one another. When dealing with fine powders the gap (9) between blades in the closed position is less than 1 mm, see Fig. 3, the gap between the blade ends and the wall is of similar size, see Fig. 4.

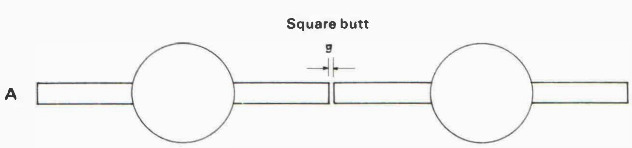


Fig. 3: Butted blade configuration, in closed position

The advantage of the butt bladed system is that the system acts like a guillotine and material cannot either build up on the blades or particles lodge in such a way that the blades are prevented from closing completely, as could happen with overlapping blades (Fig. 5).

If an almost gas-tight fit is required then the blades can be covered with an elastomer so that there is an interference fit.

However, experience has shown that even with the machine vibrating, only the finest of powders trickle through the standard gap, and even that ceases when the vibration stops. By the use of suitable control mechanisms, the machine can be set up so that when the vibrator motors stop, the blades close instantaneously. This system is used extensively for accurate bag filling systems so that there is no outflow of material between each bag fill.

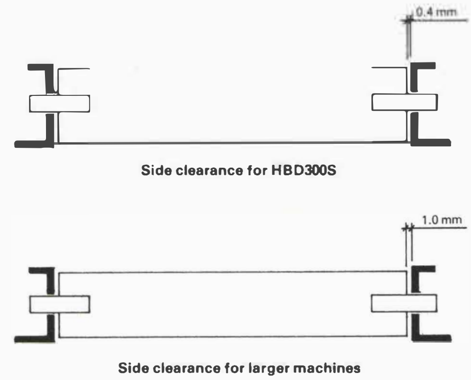


Fig. 4: Blade side clearances

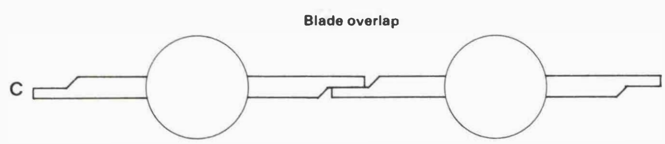


Fig. 5: Overlapping blade configuration

For coarse material, say 10 mm upwards, a deliberate gap is left between the blades, generally the gap is approximately half the mean particle diameter.

However, should a discharger installed for fine powder need to handle coarser material then the blades can be set so that they never close and the system relies on the bridging of the particles to stop flow (see Fig. 6).

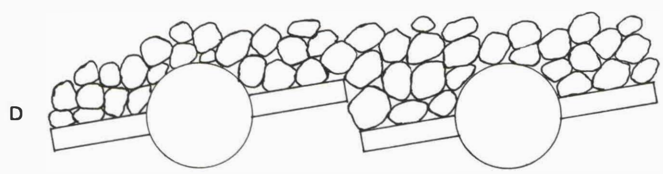


Fig. 6: Bridging of coarse particles in partially open position

The blades are all connected externally by means of a linkage system (9). This then allows a variety of mechanical devices (6) to be attached to the machine to give a range of operational standards starting at simple hand lever control up to (integrated) closed-loop feed back positioning.

At one end of the main vibrating body two electric rotary out-of-balance vibrator motors are bolted on. Two motors are used, each rotating in the opposite direction to one another to produce a linear vibrational movement. This linear vibration is of high frequency (3,000 rpm) with small amplitudes, approximately 0.5 mm peak to peak. These motors are the energy source for promoting flow. For hazardous areas flame-proof motors are supplied or, where the supply of compressed air is plentiful, a single pneumatic piston type vibrator is used. Used in conjunction with a pneumatic actuator it means that the whole system is air operated and thus most suitable for hazardous operations.

Attached to the main vibrating body is an underhopper, this connects the discharge to the next stage of the process via a flexible connecting sleeve. Since the underhopper vibrates there is little likelihood of material blocking in this section even though the outlet may, in some cases, be much smaller than the discharger.

Even for the largest of the machines made, the overall depth, excluding the underhopper, is as little as 200 mm, thus there are some important space and height savings to be made by using the Hogan, in that large buffer hoppers are not needed and also that the Hogan generally takes up less head room than alternative methods.

3. Operation of Discharger

The sequence of events in operating a Hogan is that at the start the hopper is full with powder resting on the blades. The vibrator motors are switched on with the blades in the horizontal position. In this position they are in the same plane as the direction of vibration, and so little vibration passes into the powder. This is important since it enables the equipment to be left vibrating without causing significant compaction of the stored powder.

As the blades open, an increasing amount of vibrational movement is imparted into the stored powder inducing flow. Recent tests have detected this vibration 15 m above the discharger at the top of the coal stored in a 70 ton silo.

The powder flows out until at maximum opening high discharge rates are achieved. Once a sufficient volume of powder has been discharged then the blades are closed, (using a pneumatic actuator this can be less than 1 second) the powder flow then stops and the silo/hopper is sealed. Alternatively the blades open to some intermediate position and discharge is continuous at a steady consistent rate (± 5%) by volume) for a period of time.

The Hogan Vibratory Bin Discharger thus achieves three functions in the one piece of equipment:

1. Promotes and maintains continuous flow of stored particulate materials.
2. Acts as a variable area discharge gate capable of accepting sophisticated control systems.
3. Does the same job as a slide gate in that it stops flow (but over the whole discharge area at the same time) and seals the hopper outlet.

Thus for process applications where there is a requirement to do more than just promote flow, and this is generally the case in most applications, the use of the Hogan offers significant cost savings over the use of a flow promotor, a separate slide gate and a flow control device such as a screw feeder.

4. Blade Actuator System

The major development over the years has been the systems builtup around the blade actuator. In this context, the Hogan can be considered as any other type of control valve, and so downstream process signals can be used to control the discharge rate.

4.1 Electric Actuators

The simplest of these developments is the use of the electric actuator shown in Fig. 7. The electric actuator is simply an electrically powered rotary gearbox. The switch for energising the actuator can be positioned at any convenient point, say in a control room, and by connecting a potentiometer to the main shaft of the actuator, the degree of the rotation of the blades is indicated on the meter, also seen on the right in Fig. 7. This can be calibrated to indicate the discharge rate giving the process operator remote contol of the discharge operation.

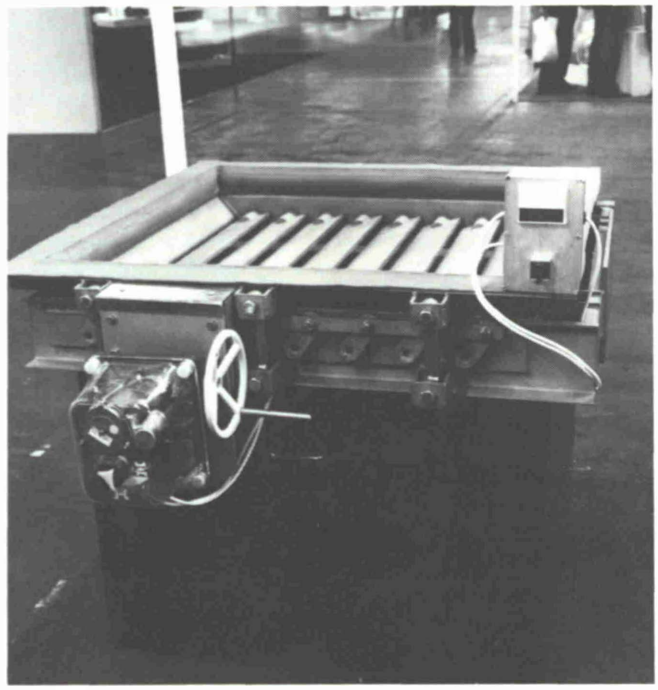


Fig. 7: Electric actuator

4.2 Pneumatic Positioner

By using a pneumatic actuator with a positioner such as that by Moore, a 3—15 psi air signal can be used to position the setting of the vibrating blades. By using solenoid operated valves on three air lines preset by regulators to various air pressures, say 3 psi, 6 psi, and 15 psi, the blades can be made to open fully, close to a small opening, and close completely, in sequence. This system is extremely useful, for example, in bag filling, small batch outloading or filling loss in weight feeders.

In filling sacks, (Fig. 8) the signal from an electronic weigh scale triggers off the various sequences, for instance in fil-

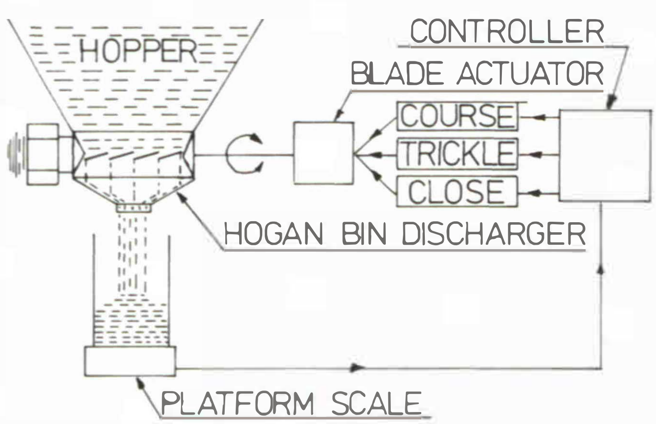


Fig. 8: Pneumatic positioner used in weighing system

ling 20 kg sacks, the blade after being fully opened giving maximum discharge rates, closes to a 10° opening, giving a trickle discharge when the scale indicates that the sack has reached 19 kg. At 19.9 kg a final signal closes the blades, stops flow and the inflight material brings the sack up to 20.1 kg at most. With most fine powders down to 100 micron size, the mere closing of the blades, even with the vibrators running, is sufficient to stop flow. Even with finer powders, the vibrator motors can be wired to stop instantaneously on closing of the blades and this ensures that the finest or most fluidised of powders are held back.

This latter system is used to feed loss in weight feeders which can be made to perform better by having the Hogan act as a fast filling device, giving consistent slugs of powders in a short period of time. This allows a loss in weight feeder to operate for longer periods in the stable condition, so improving the accuracy of its output.

4.3 Continuous Accurate Systems

For continuous consistent mass discharge systems there is a closed-loop measuring and control system available (Fig. 9).

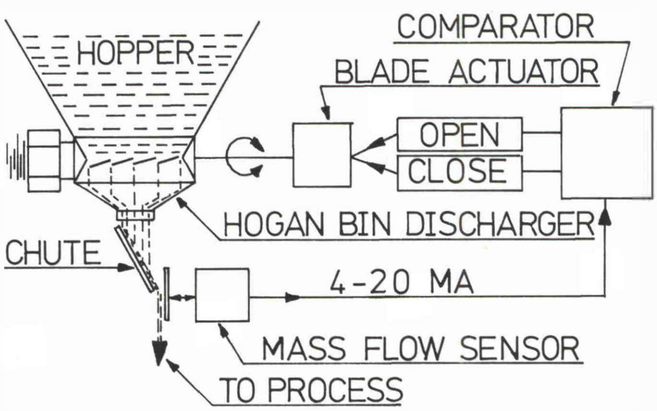


Fig. 9: Closed-loop measuring and control system in a mass flow system

Here a device such as a mass flow meter or a weigh belt can be used to detect changes from a set point. Any deviation is detected and a signal is passed to the Hogan which is fitted with an electro-pneumatic positioner and actuator. The positioner responds to a 4—20 milliamp signal generated by the downstream detector.

An increase in flow rate due to a change in powder density or the onset of flooding is detected and the signal from the impact plate causes the blades to close to a degree sufficient to counteract the surge. In the event of a density increase the blades settle to a new lower opening to maintain the required mass flow rate. Accuracy with this system can be ± 1—1/2 % by weight.

Obviously, if the density of the stored powder decreases, say, because of the fresh filling of the silo, then the opposite occurs.

Fig. 10 shows an electro-pneumatic positioner and actuator fitted to a HBD600S.

There are numerous extensions of this idea. In the water treatment business, lime is added for pH control, in this instance the pH meter can be connected to the Hogan and the pH used to regulate the amount of lime added.

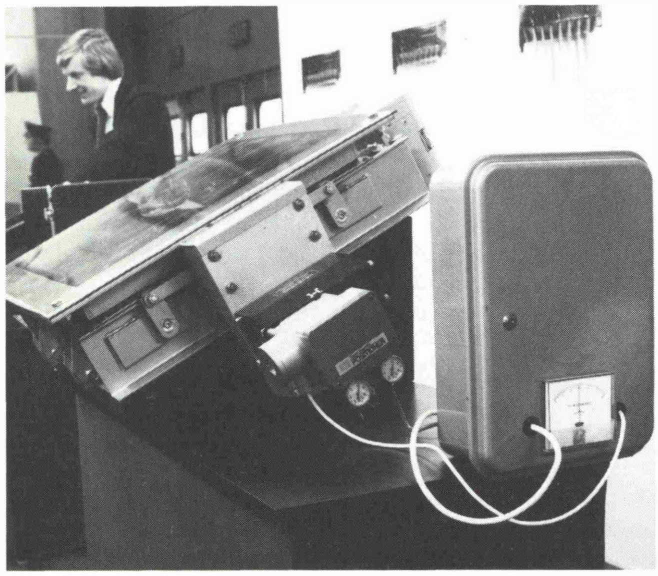


Fig. 10: Electro-pneumatic positioner and actuator fitted to a HBD600S

Where the Hogan is used to feed, say, PVC powder to a grinding mill, the amperage load of the grinder motor is used to regulate the PVC discharge into the grinder to prevent overloading, but at the same time maintaining maximum throughput.

The list is endless, if the discharge rate is directly proportional to a downstream signal then that signal can be used to control the discharge rate.

5. Mass Flow Hoppers

One area where the Hogan finds an unexpected use is on mass flow bins. As their name implies, mass flow bins should not require an activation device since they are designed to discharge all of their contents because of their shape. However, in discharging these mass flow devices the opening required to ensure immediate discharge from the static state is generally always larger than that necessary to give the required discharge rate in the dynamic state. So here the Hogan fits perfectly. The Hogan can be made the same size as the designed opening. With the blades fully open the situation is as the hopper design requires with a completely clear opening to allow mass flow to be initiated.

Once mass flow has been initiated, the blades can be moved to a position that reduces the discharge area and so flow rate, to that required for the downstream process. Since the material in the bunker is now flowing it will continue to do so until the bunker is empty or the blades on the Hogan are closed.

Because the Hogan is, in its own right, a flow promoter, it is possible that the mass flow bunker will be suitable for more than just the one material they are generally designed for, so giving greater versatility to the system.

6. Problem Applications

There are certain materials with which the Hogan, in its standard configuration, does not perform well.

Amongst these are materials such as woodshavings, plastic film and sugar beet pulp. These materials absorb vibration

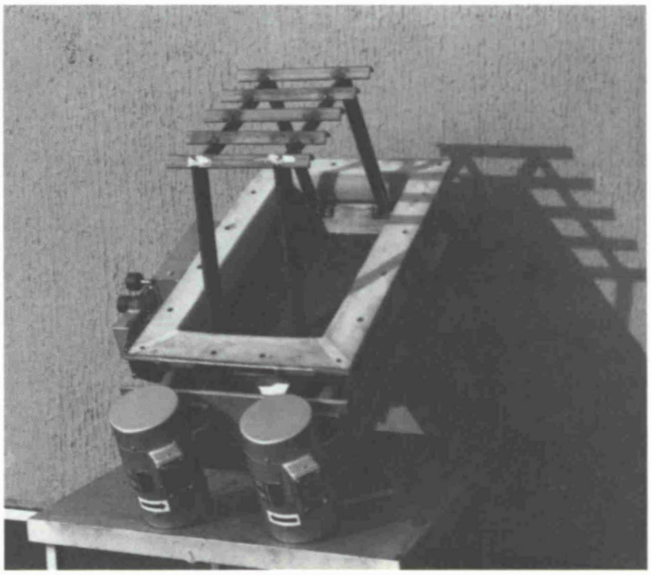


Fig. 11: Bridge-breaker fitted to a Hogan

and the particles interweave themselves forming extremely stable bridges, sometimes even made worse by vibration.

Problem materials, such as above, can be moved successfully by adding an extruded and specially designed bridge breaker or grid onto the Hogan (see Fig. 11).

The grid is attached to the vibrating main body and consequently activation is concentrated on the narrow cone section of the storage system where the bridges tend to occur.

Materials that are fibrous or long and thin in character should be treated as a special area and applications referred to the manufacturer, since materials such as woodshavings cause problems whereas bran, malt coombs and pollards do not.

A grid is also used when extremely dense materials are to be handled, such as iron oxide, arsenic oxide and other metallic powders in the 2,000—2,500 kg/m³ bulk density range. To reduce the torque required to open the blades a low level grid, again attached to the vibration section, is added. The grid is contained within the frame work of the discharger and ensures thorough activation of the powder between the grid and the blades, whilst the grid itself bears some of the load that would otherwise stress the blades. A 55 % reduction in blade opening torque is achieved, allowing smaller less expensive actuators to be used.

A second area is the handling of powders that contain lumps that are larger than the blade opening required to meet the average process demand. For example, discharging 20 t/h of material from an HBD600S may require only a 20° opening of the blades. At this opening the gap between the blades may only be 20 mm, thus if the material being discharged contains lumps larger than this then these lumps are held back at the blades.

The discharge rate then progressively decreases at a rate proportional to the percentage of oversize in the material as the blade gap is blinded by these lumps. Of course, opening the blades further when this happens cures the problem, but it means that a steady discharge rate is not possible. Therefore using the Hogan at low discharge rates on materials with large particle sizes can cause problems.

7. Sizing of Discharger

The Hogan Bin Discharger comes in a range of sizes, shown in Table 1.

Table 1

Internal Dimensions of Discharger	Size Designation
200 mm x 200 mm	HBD 200S
300 mm x 300 mm	HBD 300S
600 mm x 600 mm	HBD 600S
600 mm x 300 mm	HBD 600R
900 mm x 900 mm	HBD 900S
900 mm x 600 mm	HBD 900R
1,200 mm x 1,200 mm	HBD 1200S
1,200 mm x 900 mm	HBD 1200R

Because the machine is of a unit type construction it is possible to build the unit any particular size to suit an existing outlet, so units with 1,200 mm x 300 mm, and 1,400 mm x 1,000 mm have been built for special applications. The possibilities are infinite and units as large as 2.5 m x 2.5 m have been designed.

In determining the size of machine to suit a particular application three factors are of major importance:

1. The nature of the powder to be discharged.
2. The geometry of the storage hopper.
3. The rate of discharge required.

Obviously the more difficult the powder, the larger the silo and the larger the discharge rate so the larger the Hogan machine must be. But because when the blades are fully open the discharge rates from the Hogan are extremely high it has been found that the size of Hogan used for any particular application can be significantly smaller than the alternative bin activator, which may require a device a third or half that of the silo diameter, not only to promote flow but to ensure a large enough cross-sectional area between the cone and wall to give a reasonably large discharge rate but with a width small enough to allow bridging of the material to stop flow when vibration stops.

Fig. 12 shows an installation where 2.5 m diameter activators have been replaced by 600 mm square Hogans, the internals of the activators were removed and the activator shell used as a transition piece.

The material being discharged is a 25 % fat milk powder and it discharges at the rate of 8 t/h from 4 m meter diameter silo.

Despite the Hogan being much smaller than the previous discharge unit fitted, flow within the silo is still such that first in is first out, and the silo can be completely emptied if required.

Table 2 gives a comparison of Hogan Discharger size to maximum discharge rates. Table 3 gives a list of silo diameters and the size of Hogan required. It must be stated, however, that these are only guidelines, there being many exceptions to this because of the peculiarities and wide ranging properties of powders handled in bulk, for example, there are HBD600S machines installed where they discharge grain at over 1,000 t/h.

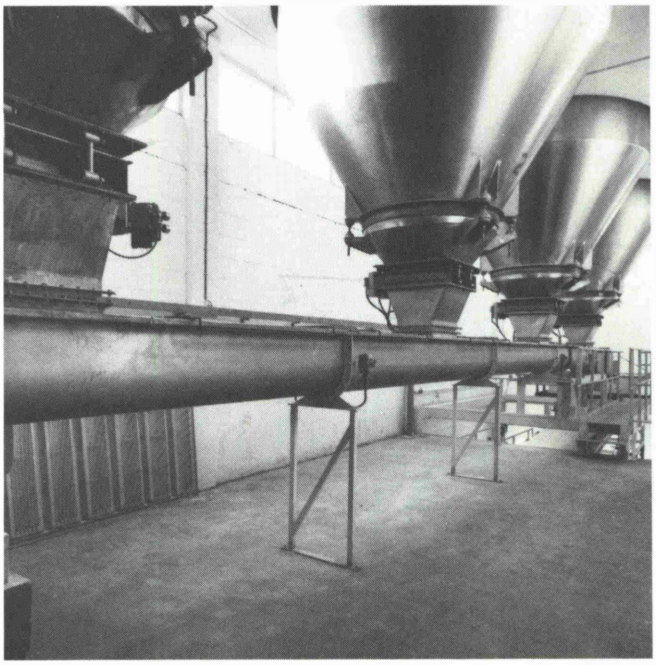


Fig. 12: 2.5 m diameter activators replaced by 600 mm square Hogans

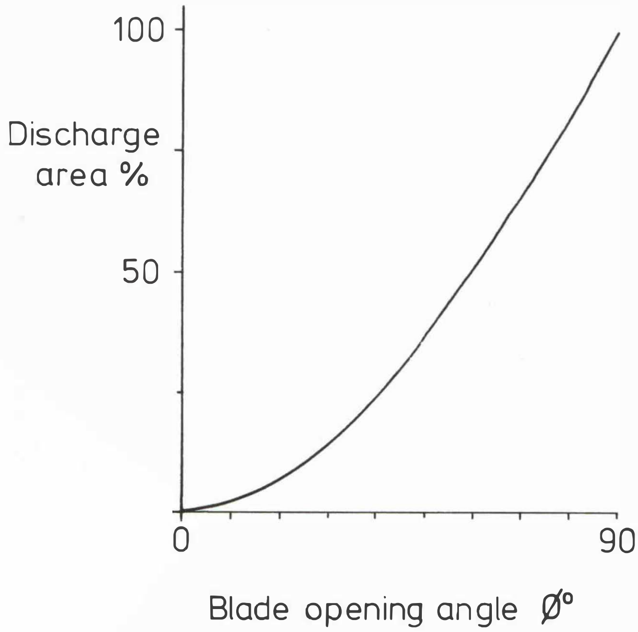


Fig. 13: Theoretical variation of discharge area with blade opening angle

Table 2

Flow rate t/h	Hogan bin discharger size
10	HBD200S
25	HBD300S
50	HBD600R
100	HBD600S
150	HBD900R
225	HBD900S
300	HBD1,200R
380	HBD1,200S

Table 2 is based upon material with a 650 kg/m³ bulk density.

Table 3

Silo diameter	Range of Hogan required
0.5—1 m	HBD200S
1—2 m	HBD300S to HBD600R
2—5 m	HBD600S to HBD900S
5—8 m	HBD1,200S + R

8. Variation of Discharge Rate with Blade Opening

Fig. 13 shows the theoretical variation of discharge area with increasing blade angles. In practice the discharge rate at the low angles of opening is much lower because of bridging and blinding effects at the very low angles. The actual discharge rate at these low angles being largely influenced by the properties of the powder itself.

Again, at the very top end of the scale the maximum discharge rate is very dependent upon the product. As stated earlier the maximum can be as high as 1,000 t/h or as little as 100 t/h, but there are many products that do follow Fig. 13 and Table 4 lists results obtained in an HBD300S on potash powder of 1,300 kg/m³.

Table 4

Blade opening	Discharge Rate
5°	50 kg/h
10°	250 kg/h
20°	820 kg/h
30°	1,820 kg/h
40°	3,180 kg/h
50°	4,770 kg/h
60°	6,800 kg/h
70°	8,980 kg/h
80°	11,275 kg/h
90°	13,600 kg/h

Thus a major advantage of the Hogan is its large turndown ratio, in the above example of around 250:1 (since it is a small unit). With larger units, the turndown ratio drops into the 150:1 to 100:1 range, for example, a HBD900S can discharge 250 t/h of pulverised fuel, but will only turndown to 2 t/h without losing consistency.

Therefore, in an application where a difficult powder is stored in a large silo, but only a small discharge rate is required, a unit large enough to ensure mass flow can be fitted with the knowledge that with a small blade opening the required discharge rate will be achieved.

Alternatively, with a reasonably free flowing powder a high discharge rate can be achieved by using a small discharger.

9. Typical Applications

Some typical applications are given below and in Fig. 14:

(1) Silo diameter: 6 m
Capacity: 200 t
Hopper slope: 60°
Material stored: Meat & bone meal
Discharge rate: 50 t/h
HBD size: HBD1200R

(2) Silo diameter: 5 m
Capacity: 25 t
Hopper slope: 60°
Material stored: Pulverised coal
Discharge rate: First silo: 60 t/h
Second silo: 3—6 t/h
HBD size: HBD900S

(3) Silo diameter: 3 m (square)
Capacity: 20 t
Hopper slope: 60°
Material stored: Soft flour
Discharge rate: 5—20 t/h
HBD size: HBD600S

(4) Silo diameter: 4 m
Capacity: 50 t
Hopper slope: 65°
Material stored: Malt culms & malt dust
Discharge rate: 1 t/h to pelletizer plant
20 t/h to bulk road vehicle
HBD size: HBD600S

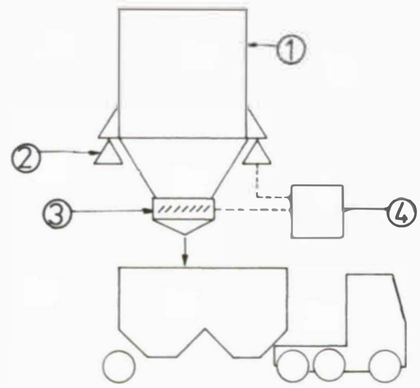
10. Unusual Uses for the Discharger

Because each blade produces a discrete uniform and consistent flow of powder, several unusual applications have been developed.

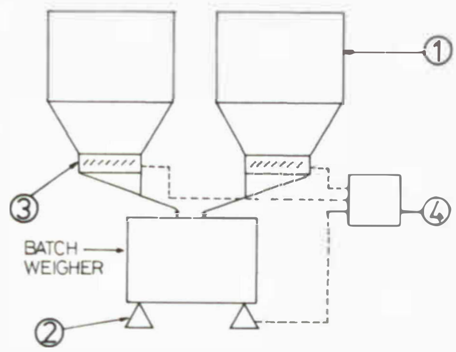
For instance, in filling moulding boxes with sand in a foundry, the old clam gate method caused a central heap in the box, this then had to be manually levelled off with the excess material going onto the floor, to be reclaimed and reprocessed. By using a Hogan the same size as the moulding box several much smaller heaps are formed, which allows speedier levelling and insignificant spillage and so reducing cost for labour and reprocessing the spilt sand.

Single blade units, the width of a conveyor belt, have been used to give a uniform coating to components moving on the conveyor belt.

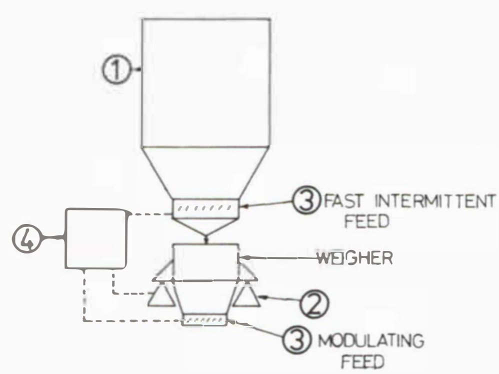
Fig. 14: Some typical applications



a) Fast discharge for road/rail vehicle filling

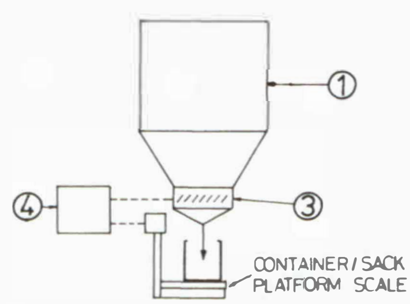


b) Batching system

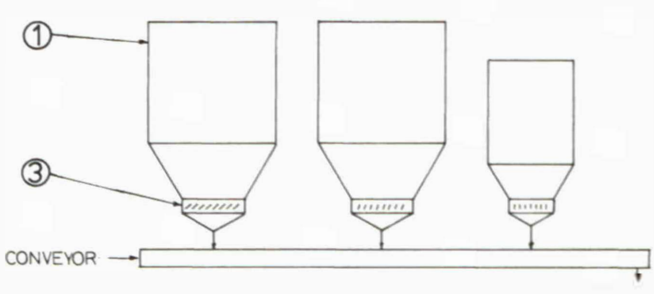


c) Low in weight systems

1. Silo
2. Load cells
3. Hogan discharger
4. Controller



d) Container/sack filling with fast/trickle function



e) Volumetric feed from any one silo or proportional from all silos