METHOD AND APPARATUS FOR BREAKING BRIDGES OF STORED MATERIAL IN SILOS

In a method of breaking a bridge of stored material in a silo (20), an air nozzle (44) is lowered onto the top of the bridge at the end of an air hose (46) and compressed air is supplied through the nozzle to dislodge the material (34) locally as the nozzle is lowered downwardly into the opening created by the air blast, thereby creating a bore hole (34) through the bridge. The nozzle and hose are then raised and a flail (68) is passed down through the bore hole (54) and is suspended at the bottom of the bore hole, whereafter the flail is caused to oscillate randomly to impact the material (34) and enlarge the bore hole, whilst the flail is moved upwardly slowly thereby causing shedding of material from the bridge. This weakens the bridge which eventually collapses so that the material of the bridge falls to the bottom of the silo ready for removal from the bottom outlet of the silo.
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METHOD AND APPARATUS FOR BREAKING BRIDGES OF STORED MATERIAL IN SILOS

This invention relates to apparatus for dislodging materials supported by the walls of storage vessels such as silos so that the material will fall to the bottom of the vessel where it is removed. More particularly, the invention relates to apparatus for breaking bridges of material in such vessels.

Bulk materials are often stored in large containers or storage vessels commonly called silos. The materials may be in powder or granular form and include products such as grain, coal, ore and animal feeds. These silos receive the material from the top and dispense it from the bottom as required to act as a storage buffer in the system of delivery from the original source of the material to the end user. Such materials are often stored in silos for a significant period without dispensing, and during this period the material will settle and tend to consolidate locally in the silo. As a result, it is not unusual for the bottom of the silo to empty, leaving a bridge of material somewhere above the bottom of the silo supported only by contact with
the walls of the silo. The bridge can be very resistant to collapse and is a source of great danger to anyone attempting to enter the silo from the bottom to collapse the material.

There are further hazards from bridges because the material may be of a type subject to spontaneous combustion because it mixes as dust with the air in the silo. Such a mixture may explode in the presence of a spark caused by metal parts rubbing against one another. In general, the unpredictable nature of the atmosphere in silos combined with the possibility of sudden collapse of the bridge, leads to a most hazardous situation.

Various methods of breaking silo bridges have been tried. In theory the best approach is to disturb the bridge from the bottom where the maximum compression of the material exists. If the bottom layer can be broken, then stress lines will pass upwardly into the less compacted material resulting in fracture and collapse. This leads to the clearly hazardous approach of entering the bottom of the silo and attempting to loosen the bottom of the bridge while standing under it.
Because of the extreme danger of working on a bridge from beneath it, most attempts to collapse bridges are now made from the top. This has involved various techniques involving prodding the bridge from the top which tends to result in consolidating the bridge because the material at the top is less compacted than that at the bottom. The density of the material is then increased and the likelihood of the bridge remaining in place is also increased. This is also particularly true when vibrating devices are used from the top. Because of these difficulties explosive charges have also been used.

In summary, the problems of breaking bridges are quite significant. They are both dangerous and unpredictable. It is therefore desirable to find a method and structure capable of breaking bridges in a predictable fashion without danger to the operator and with no likelihood of causing explosions from spontaneous combustion. For reasons of safety, it is desirable to operate from the top of the silo and yet apply forces to break the bridge from the bottom of the bridge. This invention is directed to a method and apparatus capable of achieving these results.

In a first of its aspects, the invention provides a method of breaking a bridge of stored material in
a silo having a top access opening and a bottom outlet, the method comprising the steps: concentrating an air blast at the top of the bridge to dislodge the material locally and feeding the air blast downwardly into an opening created by the air blast dislodging the material; continuing to feed the air blast downwardly until the air blast penetrates the bridge thereby creating a bore hole through the bridge; discontinuing the air blast; passing a flail through the bore hole and suspending the flail at the bottom of the bore hole; causing the flail to oscillate randomly to impact the material and enlarge the bore hole; and moving the flail upwardly slowly thereby causing shedding of material from the bridge, which shedding weakens and eventually collapses the bridge so that the material of the bridge falls to the bottom of the silo ready for removal from the bottom outlet of the silo.

In another of its aspects, the invention provides a method of breaking a bridge of stored material in a silo having a top access opening and a bottom outlet, the method comprising the steps: applying a concentrated air blast to the top of the bridge to blow material upwardly away from the air blast; allowing the air clast to penetrate the bridge as it continues to dislodge and force material
upwardly away from the bridge;
maintaining the air blast until the bridge is penetrated to form a bore hole through the bridge;
lowering an impact tool through the opening to the underside of the bridge; and
energising the impact tool to dislodge material adjacent the underside of the bore hole to weaken and destroy the bridge from the underside of the bridge.

According to yet another aspect of the invention, apparatus is provided for breaking a bridge of stored material in a silo having a top access opening and a bottom outlet, the apparatus comprising:
a air outlet head;
suspension means coupled to the head for hanging the head from the top access opening;
air supply means coupled to the head and extending downwardly from the top access opening to supply compressed air to the head so that when the head is placed near the bridge, the air blast dislodges material and allows the head to be lowered thereby forming a bore hole through the bridge.

In still a further aspect of the invention, the invention provides a combination of apparatus for breaking a bridge of stored material in a silo
having a top access opening and a bottom outlet, this apparatus comprising an air outlet head, suspension means coupled to the head for hanging the head from the top access opening, air supply means coupled to the head and extending downwardly from the top access opening to supply compressed air to the head so that when the head is placed near the bridge, the air blast dislodges material and allows the head to be lowered thereby forming a bore hole through the bridge; and

a flail for passing downwardly through the bore hole and operable near the bottom of the hole to dislodge material from the underside of the bridge to weaken and break the bridge.

The invention will now be further described by way of example with reference to the drawings in which:

Fig.1 is a diagrammatic side view, partly in section, showing the preferred embodiment of apparatus according to the invention being used to break a bridge in a silo;

Fig.2 is a sectional side view of the apparatus shown in Fig.1 and drawn to a larger scale; in Fig.1 and drawn to a larger scale;

Fig.3 is a further sectional view showing a flail forming part of the apparatus according to a
preferred embodiment in use to break the bridge; and

Fig. 4 is a perspective view of an alternative air outlet head for use in accordance with the invention.

Reference is made first to Fig. 1 which illustrates a silo designated generally by the numeral 20 and supported on legs 22. The silo includes a cylindrical side wall 24 extending upwardly from a frusto-conical floor 26 which terminates at its smaller end in a bottom outlet 28. In practice this outlet would be associated with equipment for moving material from the silo, but for simplicity the silo has been drawn without this equipment.

At its upper extremity, the wall 24 terminates in a roof 30 which is also frusto-conical in this particular example, and terminates at its upper extremity in top access opening 32 through which material is fed into the silo by elevating equipment (not shown).

The silo 20 is shown with a typical bridge 34 which, in this drawing is well defined, but which in practice can take almost any form consistent with it being self supporting inside the wall 24. Typically,
the bridge will have a hollow or domed undersurface 36 due to the natural strength of such a structure and its ability to support the remainder of the bridge. It is partly for this reason that it is desirable to dislodge the bridge by applying forces to the underside 36 where gravity aids the effort of dislodging the material.

Fig.1 also shows diagrammatically apparatus designated generally by the numeral 38 suspended by a cable 40 using any suitable suspension structure, not shown. A flexible armoured air line 42 of compressed air feeds the structure 38 which consists of an air outlet head 44. This head is suspended by an extension piece 46 coupled at its upper end to a connector 48 which in turn is attached to the cable 40.

In general, the arrangement in Fig.1 is such that air from the air line 42 is directed to the lower extremity of the air outlet head 44 where it forms an air blast to dislodge material from the bridge to form a bore hole down which the apparatus 38 works its way towards the underside 36 of the bridge 34. This will be better described with reference to Fig.2.

As seen in Fig.2, the air outlet head 44 is attached by an integral threaded coupling 50 to the lower end of the extension piece 46. Similarly,
the upper end of the extension piece is attached to the connector 48 at a coupling 52. Initially, before the apparatus has penetrated the bridge, and depending upon the position of the bridge in the silo, the head 44 may be used by connection to the connector 48 only. As the head works its way through the bridge it will be withdrawn periodically to permit extension pieces such as piece 46 to be added. This means that the air line 42 must be disconnected, fed through the piece 46 and then the piece threaded through the head 44. This procedure has to be repeated each time an extension piece is added or removed. After such assembly the air line is held tightly to retain it to one side inside the connector 48.

In the position shown in Fig.2, the head 44 has penetrated part of the bridge 44 opening up a bore hole 54. The lower end of the head 44 consists of an annular manifold 56 having a downwardly opening slit 58 shaped to create a blast of air in the form of a curtain to dislodge material from below the head 44 and to entrain it to escape vertically through the tubular head 44 as indicated in the drawing. A certain amount of air will of course find its way around the outside of the head, but this will be negligible due to the looseness of
the material and the fact that the bore hole will change in shape. (The form of the bore hole shown in the drawing is of course idealised for clarity of drawing and explanation).

The manifold 56 should be robust because it will inevitably aid in dislodging the material by mechanical impact.

A fixed air line 60 is attached both to the manifold and, by a bracket 62, to the tubular wall 64 of the head to feed air to the manifold 56. The tube 60 projects beyond the wall 64 terminating at an air line coupling 66 by which the air line 42 is connected to the tube. The arrangement is such that the attachment can take place readily because the coupling stands proud of the wall 44 during engagement.

In use, the apparatus 38 shown in Fig.1 will be assembled to have sufficient length to engage the bridge 34 and then, with the air supply provided by the air line 42 switched on, material will be dislodged and the apparatus can be lowered into the material. By selecting the right extension pieces, and arranging to suspend them from above the access opening 32, it will be possible to lower the apparatus to the point where the connector 48 is
accessible with the apparatus essentially standing on the bridge. Alternatively, the apparatus can be removed to add new extension pieces, but in this event there may be some difficulty in re-engaging the head 44 in the bore hole. Decisions will have to be made in use depending upon the particular circumstances and these will be determined to some extent by the experience with particular materials and their characteristics.

The procedure will continue until such time as the head 44 projects through the bridge and at this point it will be withdrawn leaving the bore hole behind it. In some instances it may be necessary to move the apparatus through the bridge several times to make a clean bore hole but all of this movement is advantageous because it is possible that the bridge will collapse once the bore hole is made. However, should the bridge remain in place after a clean bore hole is provided, then the apparatus described so far is complemented and used in combination with apparatus to be described with reference to Fig. 3. This complementary apparatus is designed to enlarge the bore hole and to cause fracture of the bridge and eventual collapse.
Reference is next made to Fig. 3 which shows a lower end of the bore hole 54 and a flail designated generally by the numeral 68 which has been lowered through the bore hole and which is suspended adjacent the end of the bore hole. The end of the flail is shown in perspective to illustrate its shape and to indicate that it is moving.

The flail 68 can take many forms but in a preferred embodiment it is a weight 70 having a generally hammer head form with angled edges. The weight is attached to the end of a flexible air line 72 and has an opening 74 allowing air from the air line to escape under pressure. Preferably this opening is angled to that the reactive force caused by the release of pressurised air causes the weight 70 to fly randomly to impact the side wall of the bore hole 54. As a result, parts 76 of the material of the bridge will fall off the bridge, and by moving the flail upwardly, it will be possible to gradually enlarge the bore hole causing fractures in the material of the bridge. Commonly, once the underside 36 (Fig. 1) of the bridge is disturbed, stresses will build up in the material above this and the material will then be unable to support itself as these stresses spread. There will consequently tend to be a break up of the bridge once there is a
reasonable transfer of load from the underside to
the remainder of the material. Of course, some
material may fall leaving another dome, but this
dome can also be broken down by lifting the flail
to the new dome level and using it there.

The structure shown and described has been
simplified for the purposes of drawing. In very large
silos there may be provided several access openings
and it may be necessary to use the equipment at
several positions in a bridge before all of it
falls away. For instance, part of the bridge could
remain attached to the side wall supported by
internal structure of the silo. It would therefore
be necessary to break down parts of such material
hung up in this way. In this case there is no
bridge but simply material which does not fall for
removal from the silo.

Further variations would include some
changes to the air outlet head 44 and to the flail
itself. It has been found that flails made from
chain, different forms of weights, etc. have been
useful and the selection of the flail would
depend to some extent on experience and the type
of material forming the bridge 34. Generally,
granular material will respond well to chain flails whereas a more powdered material may well respond better to a weight of the type shown in Fig. 3.

An alternative air outlet head is shown in Fig. 4. This arrangement may well prove more useful where a powdered material is being broken up. The head shown in Fig. 3 has a tubular wall 78 to which are welded air tubes 80, 82. These tubes terminate at their upper extremities in the same fashion as tube 60 shown in Fig. 2.

At their lower extremities, the air tubes 62 terminate in angled orifices 84, 86 which are positioned to create a swirling action at the lower end of the head. Evidently, such an arrangement could be varied by increasing the number of tubes and also by combining this with a manifold encircling the wall 78. However, such a device has particular utility where the material is very resistant to the air blast because two sources of air can be used, one with each of the tubes 80, 82.

Various materials can be used for the apparatus including metal and synthetic plastics. If metal is used it will preferably be coated in a
- non-metallic covering to minimise the possibility of sparks caused by metal-to-solid contact.

These and other variations are within the scope of the invention as described and claimed.
CLAIMS:

1. A method of breaking a bridge of stored material in a silo having a top access opening and a bottom outlet, the method comprising the steps:
   concentrating an air blast at the top of the bridge to dislodge the material locally and feeding the air blast downwardly into a cavity created by the air blast dislodging the material;
   continuing to feed the air blast downwardly until the air blast penetrates the bridge thereby creating a bore hole through the bridge;
   passing an impact tool through the bore hole to the underside of the bridge;
   causing the flail to oscillate randomly to impact the material and enlarge the bore hole; and
   lowering an impact tool through the opening to the underside of the bridge; and
   energising the impact tool to dislodge material adjacent the underside of the bore hole to weaken and destroy the bridge from the underside of the bridge.

2. A method as claimed in claim 1 in which the impact tool is a flail which is caused to
oscillate by a supply of compressed air allowed to escape through an outlet in the flail.

3. A method as claimed in claim 1 or 2 in which the air blast issues in an annular formation to dislodge the material within the formation and to blow the material upwardly away from this formation.

4. A method as claimed in claim 1 or 2 in which the air blast is directed in a swirling action.

5. A method as claimed in claim 1 in which the impact tool is a weight suspended from a compressed air supply line so that air exiting from the air supply line will cause random oscillations resulting in the weight hitting the material adjacent the bore hole.

6. Apparatus for breaking a bridge of stored material in a silo having a top access opening and a bottom outlet, the apparatus comprising:
   an air outlet head;
   suspension means coupled to the head for suspending the head from the top access opening;
   air supply means coupled to the head and extending downwardly from the top access opening to supply compressed air to the head so that when the head is placed near the bridge, the air blast
dislodges material and allows the head to be lowered thereby forming a bore hole through the bridge.

7. Apparatus as claimed in claim 6 in which the air outlet head includes air outlet means directly the air annularly downwards.

8. Apparatus as claimed in claim 7 in which the air supply means extends down to an annular manifold for supplying the air outlet means.

9. Apparatus as claimed in claim 7 in which the air outlet head includes air outlets for directing the air in a swirling action.

10. Apparatus as claimed in any of claims 7 to 9 in which the suspension means is tubular to form a passage to convey upwards the dislodged material entrained in air from the outlet.

11. Apparatus as claimed in claim 10 in which the air supply means is contained inside the tubular suspension means.

12. Apparatus as claimed in any of claims 9 to 11 in combination with a flail to be passed downwardly
through the bore hole and operable near the bottom of the bridge to dislodge material from the underside of the bridge to weaken and break the bridge.

13. Apparatus as claimed in claim 12 in which the flail is operated by air pressure.

14. The combination as claimed in claim 13 in which the flail comprised a weight, a compressed air line to which the weight is attached, and means defining an air outlet so that when compressed air is allowed to exit from the air outlet means, reactive forces drive the weight randomly to impact the material.

15. A method of breaking a bridge of stored material in a silo, substantially as hereinbefore described with reference to the drawings.

16. Apparatus for breaking a bridge of stored material in a silo, substantially as hereinbefore described with reference to the drawings.
INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 86/00586

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) 5

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

IPC 4: B 65 D 88/70

II. FIELDS SEARCHED

Classification System | Minimum Documentation Searched 7
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IPC 4 | B 65 D

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched 4

III. DOCUMENTS CONSIDERED TO BE RELEVANT 1

<table>
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<th>Category</th>
<th>Citation of Document, 11 with Indication, where appropriate, of the relevant passages 12</th>
<th>Relevant to Claim No. 12</th>
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<td>X</td>
<td>DE, A, 312465 (W. NOCON) 21 October 1982, see the whole document</td>
<td>6,7 1,2,3,4,5,8, 10,15,16 12-14</td>
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<td>Y</td>
<td>CA, A, 957660 (WORDEN) 12 November 1974, see the whole document</td>
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<td>Y</td>
<td>EP, A, 0114711 (G.E.M. CONSULTANTS B.V.) 1 August 1984, see the whole document</td>
<td>3,8,10 15,16</td>
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* Special categories of cited documents: 10

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“Z” document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search 6th January 1987

Date of Mailing of this International Search Report 29 JAN 1987

International Searching Authority EUROPEAN PATENT OFFICE

Signature of Authorized Officer M. VAN MUL
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 16/01/87.

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