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(54) **A method of fragmentation blasting.**

(57) The method of fragmentation blasting includes the step of forming blast holes (16) through a blast area (10) and also void holes (17) spaced between blast holes. The blast holes are charged with explosive material but the void holes are left empty to form free faces internally of the blasting area. Thus, the void holes will, in association with an external free face retract and reflect energy waves as additional tensile forces to more fully fragment the stone. Prior to forming the blast holes and void holes the blast area is split on a plane at or adjacent to the floor bottom to induce an interface between before fragmentation blasting takes place. This is done by drilling holes (12) on a plane as close as possible to that of the quarry floor (11) and loading the holes with explosive. Pre-splitting of the back and side face or faces of the blast area (10) may also be done before fragmentation blasting takes place. This is done by drilling new vertical holes (14) and loading the holes with explosive. The blast holes are charged and detonated sequentially blasting in sequence the explosive material in individual blast holes is detonated in sequence preferably separate quantities of explosive material are provided in each blast hole to form at least two spaced decks and each deck is ignited separately. The sequential blasting of individual blast holes and of the decks in each blast hole is controlled by a combination of

short delay detonators and a sequential blasting machine. As a result of the void holes, the fragments of stone are small enough to eliminate the need for primary crushers and machinery for transporting large initial fragments to a primary crusher.

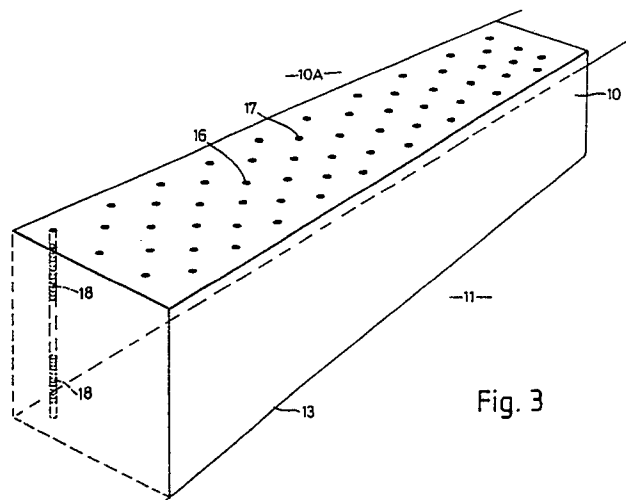


Fig. 3

EP 0 331 399 A1

A METHOD OF FRAGMENTATION BLASTING

This invention relates to a method of fragmentation blasting.

In fragmentation blasting, a number of blast holes are drilled in an area of rock, known as the blast area. The detonation of the explosive results in shock energy radiating out from the explosive energy source. Initially, this wave energy overcomes the compressive strength of the rock around the periphery of the shothole. This results in the rock being crushed to powder for several centimeters around the circumference of the shothole. At this stage the energy is not sufficient to overcome the compressive strength of the rock and is transmitted in wave form through the rock until it comes in contact with a 'free face', when it is refracted and reflected back into the rock as a tensile force. The refracted energy is dissipated from the 'free face' and is responsible for the spalling of the rock from the front of the face observed when blasting. The reflected energy waves travel back into the rock and as the tensile strength of rock is less than the compressive strength it results in the rock being cracked. The gas volume and heat generated by the explosion then expands into these cracks and propels the rock into the atmosphere.

Blasting stone to reduce it to a desired size is a function of the amount of explosive energy applied to fragment the stone. The amount of explosive in relation to the amount of stone is termed the blasting ratio. By increasing the amount of explosive per unit volume of stone the fragmentation of the stone will increase.

In theory, the amount of explosive per unit volume of stone should be sufficient to reduce the rock to fragments of the desired size, namely 9" and less, but in practice, such a blasting ratio would produce a gas volume and amount of heat which would project its stone completely out of control with detriment to safety and loading.

Another impractical method would be to drill small diameter blast holes in such a number that sufficient energy could be applied in a controlled manner but even if such could be done it would be uneconomic.

At present, economic fragmentation blasting produces fragmented stone of a size considerably greater than 15 cubic inches, and those stone fragments have to be transported to a primary crusher which reduces them to about 15 cubic inches. From the primary crusher the fragmented stone is transferred to a secondary crusher which reduces the fragments to the required size of 9 cubic inches and less.

The machinery for transporting the large initial

fragments of stone to the primary crusher and the primary crusher itself are expensive items and savings in cost could be achieved if the initial fragments were already in the region of 15 cubic inches.

It is therefore an object of this invention to provide a method of fragmentation blasting which obviates or mitigates the aforementioned disadvantages.

According to the present invention there is provided a method of fragmentation blasting which includes the step of forming blast holes through the blast area and also void holes spaced between blast holes, whereby said void holes form free faces internally of the blasting area and will, in association with external free face retract and reflect energy waves as additional tensile forces to more fully fragment the stone.

Preferably, the method also includes the step of splitting the blast area on a plane at or adjacent to the floor bottom to induce an interface therebetween before fragmentation blasting takes place.

Preferably also, the method also includes the step of pre-splitting the back and side face or faces of the blast area before fragmentation blasting takes place.

Preferably also, the method includes the step of sequentially blasting the blast holes.

Said sequential blasting preferably includes the steps of detonating in sequence the explosive material in individual blast holes.

Preferably also, separate quantities of explosive material are provided in each blast hole to form at least two spaced decks and preferably, each deck is ignited separately.

Preferably also the sequential blasting of individual blast holes and of the decks in each blast hole are controlled by a combination of short delay detonators and a sequential blasting machine.

An embodiment of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

Fig. 1 is a diagrammatic perspective view of a blast area showing the pre-splitting of the blast area at floor level.

Fig. 2 is a view similar to Fig. 1, but showing the pre-splitting of the blast area at the back and side face;

Fig. 3 is a view similar to Fig. 1 but showing the blast and void holes; and

Fig. 4 is a diagram in plan illustrating a sequential blasting operation.

Referring firstly to Fig. 1, the numeral 10 denotes an end portion of a mass of rock 10A, the

end portion 10 of which is to be quarried by fragmentation blasting, i.e. primary blasting, it is therefore known as the blast area.

The blast area is firstly split from the quarry floor 11 of the rock mass. This operation is conducted prior to the primary blasting. It consists of drilling holes 12 on a plane as near as possible to the plane of the quarry floor 11 and to a depth equal to the desired depth D of the blast area. These holes are lightly loaded with explosives and detonated simultaneously to induce a crack between all holes. By inducing an interface 13 between the quarry floor 11 and the volume of rock in the blast area 10.-

A. Energy from the primary blast is not required to overcome the shear force necessary to shear off the blast stone from the quarry floor.

B. A uniform level plane for the loading machine to load is created. The breakout force required by the loading machine will be much less than with the conventional method.

C. The need for subgrade drilling is eliminated, and

D. The need for an explosive base charge is also eliminated.

It must be stressed that accurate drilling is an essential factor at this stage of operation. Standard drilling equipment in its present form would not suffice.

In addition to pre-splitting of the blast area at floor level, pre-splitting of the back and side face or faces may also be conducted prior to primary blasting (Fig. 2). This involves drilling holes 14 along the desired back and side line of the blast area 10 on single planes. These holes are loaded with explosives and detonated simultaneously. Thus a crack 15 is induced along the back and side wall of the blast area. By inducing this break, energy from the primary blast is not required to overcome the shear force necessary to shear the blast bulk stone away from the back and side wall.

Referring now to Fig. 3, a pattern of substantially upright holes 16, 17 are drilled through the blast area, being slightly angled downwardly and forwardly. A selection of these holes 16 are loaded with explosive material, i.e. blast holes while others 17 remain empty as 'void holes'.

Considering the mechanics by which explosives reduce the rock in size, the nearer the 'free face' is to the shock wave radiating from the shot-holes the sooner these waves will be reflected as a tensile force. Thus the tensile energy wave will not have dissipated as much energy in travelling through the rock if it has a shorter distance to travel. By drilling void holes 17 in the blast area 10 a greater area of 'free face' is available to the energy waves, i.e. the surface area of the circum-

ference and length of the void holes becomes 'free face'. The geometry and balance of the void and primary blast holes 17, 16 will depend upon individual circumstances. The diameter of the void and blast holes will also depend upon individual circumstances. For the purposes of this embodiment the void and blast holes have a diameter of $5\frac{3}{8}$ ". The depth of the void and primary blast holes will be such that they touch the plane of the horizontal pre-split holes. Explosive loading of the blast holes will require to be designed so that a balance and even distribution of energy is achieved.

Arranged in each blast hole 16 are two or more spaced 'decks' of explosive packages or 'charge weights' 18. For the purpose of this embodiment, two decks per hole have been considered, but there may be more than two per hole provided there is sufficient distance between the decks to avoid sympathetic detonation.

To maximise the concept of the void holes, the energy should be applied to the rock in a uniform and balanced manner and, because of the increased blasting ratio, it should be applied at a speed which will minimise excessive projection of the stone. To do this sequential blasting is applied where not only are the individual blast holes detonated on a separate time delay but there is a separate delay interval between decks in each hole.

Sequential Blasting employs the use of an exploder which has an inbuilt facility to transmit electrical detonation pulses at a predetermined timing to initiate several blasting circuits.

Thus by using a combination of electric short delay detonators a sequential blasting machine the variation of delay timing available to balance a blast is far in excess of more normal blasting where the delay element is inherent in the detonator.

The diagram, Fig. 4, sets out a typical three row blast using standard sequential timing and will be familiar to those skilled in the art. The diagram shows 30 blast holes each containing two charge weights. It also shows the detonation delay time D and detonation firing time F (in milli seconds) of the two charge weights in each blast hole. From this it can be seen that the charges are detonated in sequence, there being in this example five circuits which are actuated in sequence, each, after the first circuit, commencing while the previous circuit is still proceeding through its sequence. The diagram also indicates the echelon line 20 and the echelon angle 21.

Claims

1. A method of fragmentation blasting which includes the steps of forming blast holes through the blast area, charging the blast holes with explosive material and detonating the explosive material so that energy waves are retracted and reflected back from an external free face as tensile forces to fragment the stone, characterised in that void holes are formed between the blast holes whereby said void holes form free faces internally of the blasting area and will, in association with an external free face retract and reflect energy waves as additional tensile forces to more fully fragment the stone.

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2. A method as claimed in claim 1, characterised by the step of splitting the blast area on a plane at or adjacent to the floor bottom to induce an interface therebetween before fragmentation blasting takes place.

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3. A method as claimed in claim 1 or claim 2, characterised by the step of pre-splitting the back and side face or faces of the blast area before fragmentation blasting takes place.

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4. A method as claimed in any one of claims 1 to 3 characterised in the step of sequentially blasting the blast holes.

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5. A method as claimed in claim 4, characterised in that sequential blasting includes the steps of detonating in sequence the explosive material in individual blast holes.

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6. A method as claimed in any one of claims 1 to 5, characterised in that separate quantities of explosive material are provided in each blast hole to form at least two spaced decks.

7. A method as claimed in claim 6, characterised in that each deck is ignited separately.

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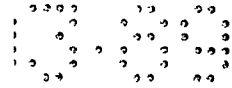
8. A method as claimed in any one of claims 4 or 7 characterised in that the sequential blasting of individual blast holes is controlled by a combination of short delay detonators and a sequential blasting machine.

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Neu eingereicht / Newly filed
Nouvellement déposé

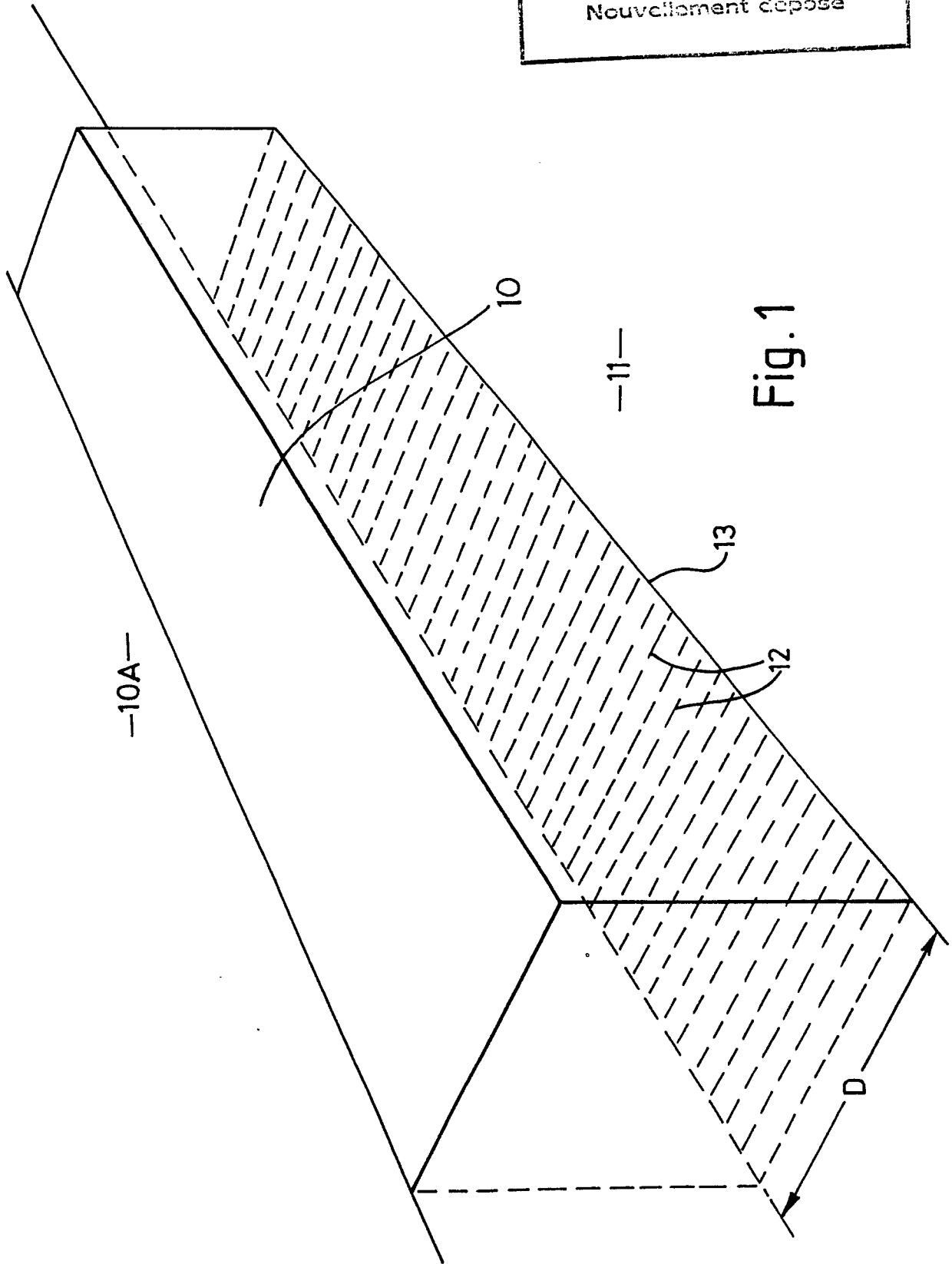
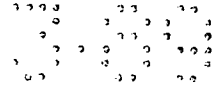


Fig. 1



Neu eingereicht / Newly filed
Nouvellement déposé

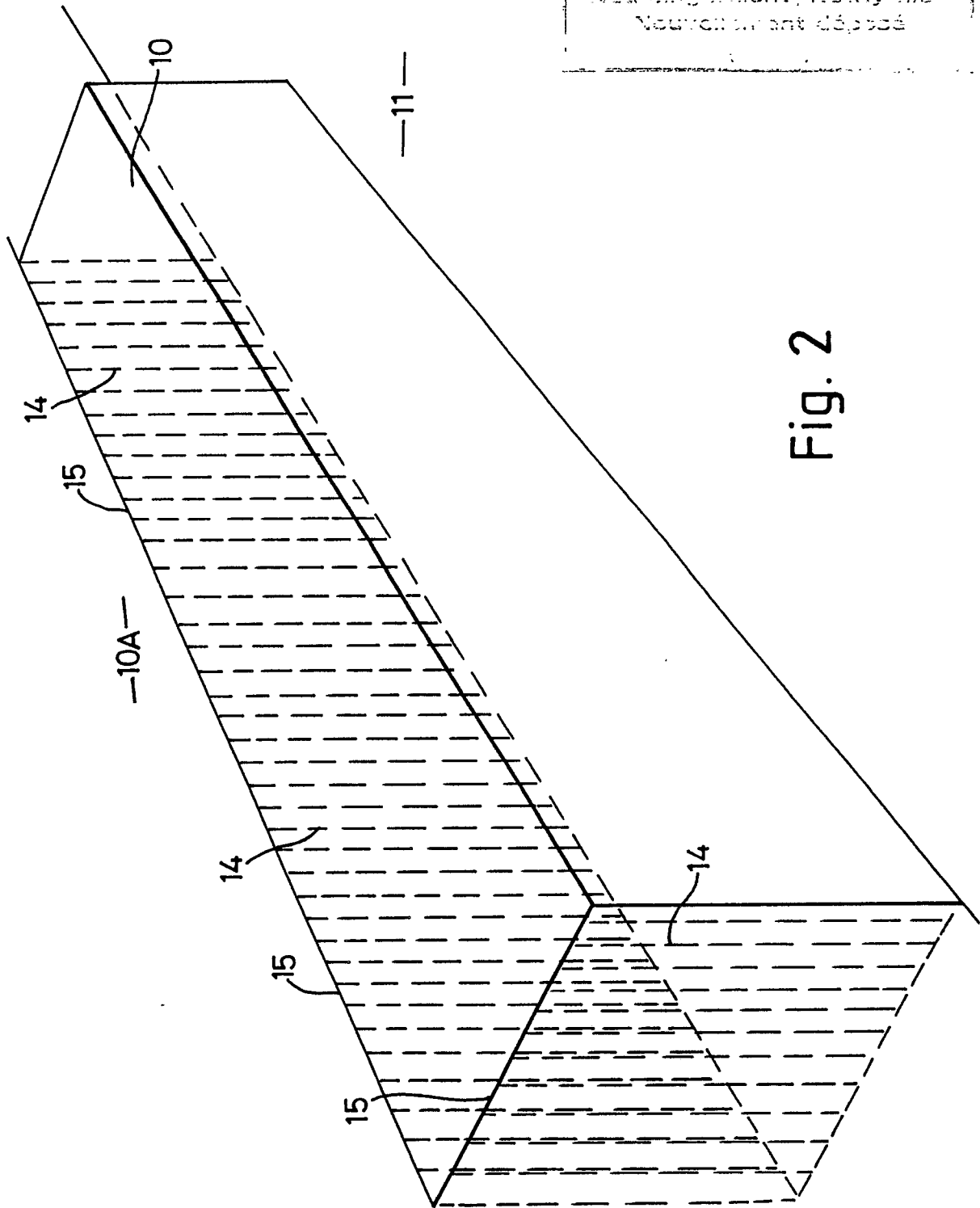


Fig. 2

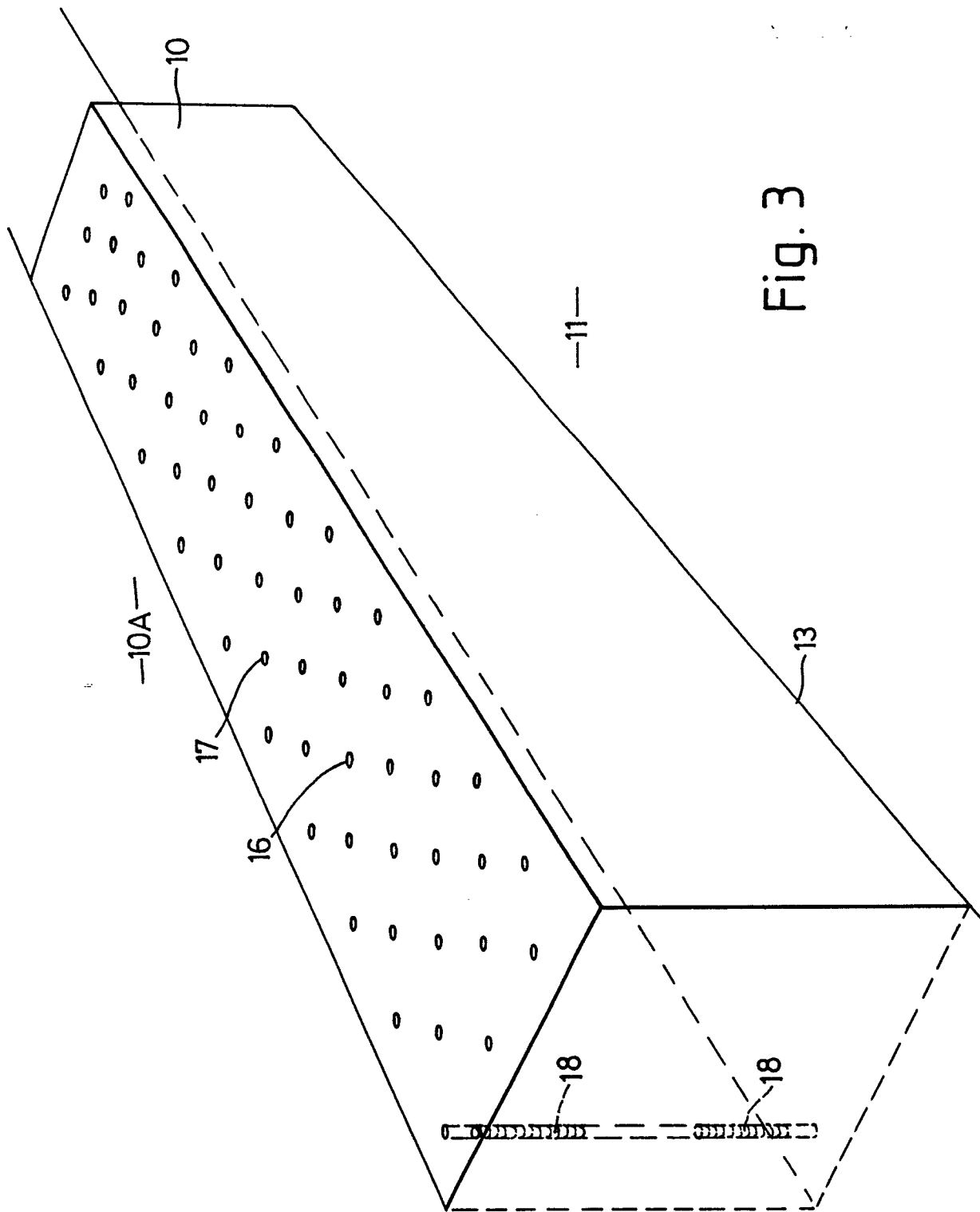
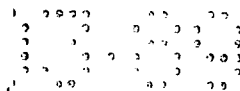


Fig. 3

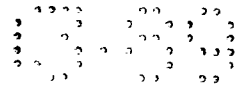
PRIMARY FREE FACE

ROW	D	F	D	F	D	F	D	F	D	F	D	F	D	F	D	F	D	F
ROW 1	25/25	50/50	75/85	100/160	125/185	150/210	175/235	200/260	225/285	250/320	275/295	300/330	325/370	350/430	375/480	400/540	425/590	450/690
ROW 2	100/100	150/150	140/200	175/235	200/260	225/285	250/320	275/395	300/480	325/445	350/530	375/555	400/640	425/665	450/690	500/740	550/840	600/940
ROW 3	175/175	225/225	225/285	250/310	275/335	300/360	325/395	350/420	375/505	400/580	425/665	450/690	500/740	550/840	600/940	650/1040	700/1140	750/1240

MACHINE SEQUENCE TIME

0 M/S 60 M/S 120 M/S 180 M/S 240 M/S

Fig. 4





DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
Y	US-A-4 690 058 (MOHANTY) * Column 2, lines 47-68; column 3; column 4, lines 1-36; figures 1A,2 * ---	1-8	F 42 D 3/04 F 42 D 1/00
Y	US-A-2 609 750 (McFARLAND) * Column 1, lines 17-22; column 2, lines 37-48; column 7, lines 4-10; figure 3 * ---	1-8	
A	US-A-3 877 373 (BERGMANU) * Column 23, lines 53-62; claim 1; figure 6 * ---	1-5	
A	US-A-2 772 632 (AITCHRISON) * Column 2, lines 7-69 * ---	8	
A	US-A-1 205 378 (HAMASAKI) ---		
A	US-A-3 654 866 (FRITZ) -----		
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			F 42 D
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 05-06-1989	Examiner RODOLAUSSE P. E. C. C.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	