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(54) **SPLITTING DEVICE, IN PARTICULAR TO ASSIST IN THE EXCAVATION OF STONE BLOCKS AND PROCEDURE FOR THE EXCAVATION OF STONE BLOCKS**

(57) Described is a splitting device (10) to assist in the excavation of stone blocks, which comprises one or more valves (11) connectable through hydraulic conduits to as many splitting cushions (1), said valves (11) being connected, by means of a conduit (19) provided with a shut-off valve (20), with an inlet (17) of said device (10) of water coming from a hydraulic pump and with the lateral inlet (13) of a Venturi tube (14), which is in turn connected, by means of an inlet (15) of the Venturi tube (14), with said inlet (17) of the device (10) and, by means of an outlet (16) of the Venturi tube (14), with an outlet valve (18) of said device (10).

The invention also relates to a method for the excavation of stone blocks, comprising the following steps:

- inserting one or more splitting cushions (1) inside an opening generated, between a mountain (A) and a bank (B), by cutting the bank (B);
- inflating said splitting cushions (1) with water, with consequent enlargement of said opening, moving the top of the bank (B) away from the mountain (A);
- propping the bank (B);
- deflating said one or more splitting cushions (1) and consequent lowering of said splitting cushions (1) into said opening; the steps of inflating, propping and deflating being repeated until a desired width of said opening is reached.

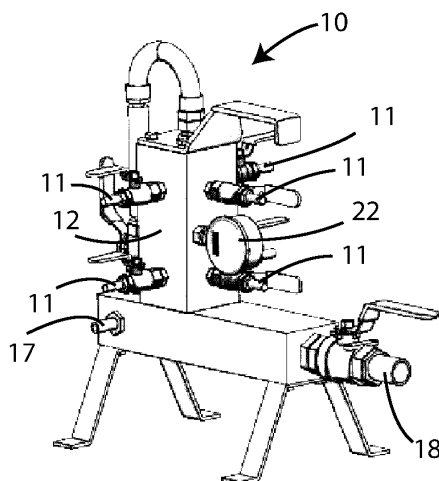


Fig. 3a

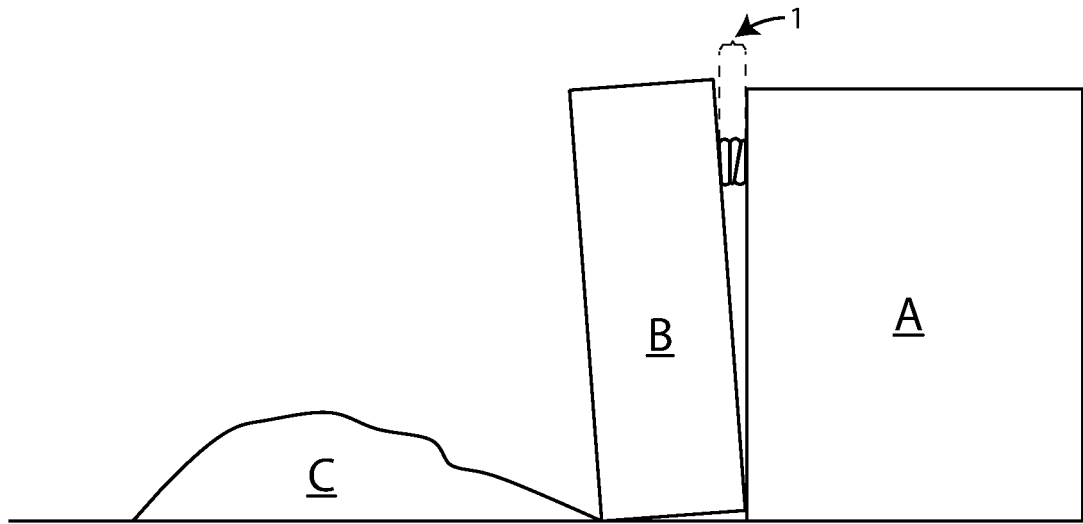


Fig. 6

Description

[0001] This invention relates to a splitting device, in particular to assist in the excavation of stone blocks and a method for the excavation of stone blocks.

[0002] In more detail, the invention relates to a device and a method of the type mentioned, in particular for, but not limited to, the excavation of blocks in marble, granite and other hard stone quarries.

[0003] As is well known, the extraction of marble, granite and other stone in quarries currently involves, after the cutting of a block of stone (also called a bank), which can be achieved, for example, by chain saws or diamondtipped wire cutting machines, the excavation and handling of the block of stone itself.

[0004] In particular, the excavation step, that is, the step for detaching the block of stone previously cut from the mountain, traditionally comprised the creation of seats on the upper side of the cut surfaces, inside of which hydraulic jacks were placed, whose function was to push the block of stone, at its upper part, allowing the block itself to detach and at the same time facilitating its tipping.

[0005] Over the years, the use of jacks has been replaced by splitting cushions which, after being inserted completely or partially deflated in the upper part of the gap created between the bank and the mountain during the cutting step, are inflated by the introduction of a pressurised fluid inside them, expanding from an initial thickness of a few millimetres to a thickness of about 20-30 cm (or more, if several cushions are placed one on top of the other), with a thrust force which depends on the pressure exerted by the fluid and can reach 500-1000 tons. If necessary, two or more cushions can also be arranged, suitably spaced, in the same opening, thus multiplying the thrust exerted on the bank.

[0006] In particular, with reference to Figures 1 and 2, a splitting cushion according to the prior art is indicated with the numerical reference 1 and consists of two metal sheets 1', 1" facing each other, generally made of steel with high strength and ductility, less than 1 mm thick and coupled by means of a welding line 2 along the entire perimeter, with the exception of a passageway constituted by an inlet nozzle 3 for a fluid, designed for coupling on a quick coupling 4, in order to ensure the locking of an effective and safe connection pipe for the operator during the injection of water under pressure, said nozzle 3 being placed integrally on the plates 1', 1", generally on a corner of the cushion itself, by means of its welding to the plates 1', 1", by the addition of material 5.

[0007] The splitting cushion 1, once inserted inside the cut bank, is inflated with pressurised water until it reaches the bursting and thus structural failure of the welds.

[0008] Normally, the maximum opening which can be achieved with this system is variable between 20 and 30 cm. The block is suitably propped during the inflation step of the splitting cushion 1, so that any premature breakage of the splitting cushion 1 does not cause the block to

return to its initial position.

[0009] Once the splitting cushion 1 reaches failure and the block is suitably propped, the known technique is to use the bucket of one or more excavators to pull down the block. This manoeuvre is very delicate, dangerous and costly in terms of wear of machinery and is sometimes impossible given the impossibility of reaching certain areas of the quarry with excavators. The limitation of this operation stems from the dangerous manoeuvre of pushing the block, as the operator must necessarily apply considerable force on the bucket to move the block and cause it to fall. This operation is all the more dangerous the higher the bank to be tipped.

[0010] In order to solve this problem, a method has been proposed, according to Italian patent No. 1391826, for the excavation of stone blocks, which comprises the insertion of one or more splitting cushions inside an opening generated, between a mountain and a bank, cutting the bank; inflating the splitting cushions, with consequent widening of said opening, moving away the top of the bank from the mountain; propping the bank, for example with a piece of stone material inserted in the opening previously widened; deflating the splitting cushions, with consequent descent of the splitting cushions inside the opening; the steps of inflating, propping and deflating being repeated until the desired width of said opening is reached.

[0011] In order to enable the deflating step of the splitting cushions, this procedure according to the prior art uses pressurised air as a fluid to be introduced inside the splitting cushions and splitting cushions made of flexible materials, such as, for example, rubber or, for some particular applications, Kevlar. In this way, once the insertion of pressurised air has stopped, it tends to escape from the splitting cushions, causing deflation.

[0012] However, this solution according to the prior art involves a number of risks and limitations. In fact, by using air as the fluid, the working pressures are necessarily low, limiting the use of the splitting device, as the force it can generate is limited. Moreover, the use of pressurised air involves significant risks associated with a possible rupture or burst, which could put the user's safety at risk. This risk is closely linked to the fact that the use of pressurised air does not allow fine adjustment of the flow rate.

[0013] Moreover, using the splitting device according to the prior art, it is not possible to use liquids in place of pressurised air, as it would not be possible to guarantee the correct deflation of the cushions, a certain quantity of liquid remaining inside the cushion and adversely affecting its use, as it would no longer be possible to insert it inside the cut due to the swelling caused by the water. As a result, the procedure for inflating and deflating and the use in quarries for tipping marble blocks would also cease.

[0014] This context leads to the solution according to the invention, which proposes to provide a splitting device, in particular to assist in the excavation of stone

blocks by means of inflatable splitting cushions, and a method for the excavation of stone blocks which is able to considerably increase the maximum opening which can be reached and consequently considerably reduce the level of risk associated with the final excavation operation, with the possibility of eliminating it completely if there is no need to use the excavator bucket to tip the stone block, at the same time eliminating the limits and the risks resulting in the use of air as a fluid under pressure for the inflation of the splitting cushions.

[0015] The main aim of the invention is therefore to make the manoeuvre of tipping the stone block with the help of excavator buckets easier and safer for the operators, and in some cases even avoiding their use. Compared to a current limit which cannot be exceeded of a 20-30 cm opening at the top of the bank, by means of the splitting device, in particular to assist in the excavation of stone blocks by means of splitting cushions, and the method for the excavation of stone blocks according to the invention, it is possible to achieve openings much greater than one metre in length, up to even 1.5 metres. This possibility results in an extremely reduced effort, by the operator, in order to tip the block and, where the dimensions and weight of the block allow it, the direct tipping of the block.

[0016] This and other results are obtained, according to the invention, by proposing a splitting device, in particular to assist in the excavation of stone blocks by means of inflatable splitting cushions, and a method for the excavation of stone blocks which allow not only the inflation by means of a liquid, in particular water, which is safer and more effective than pressurised air, but also the deflation of the splitting cushion, with the consequent possibility of progressively inserting the splitting cushion deeper and deeper into the cut of the stone block, where it can exert its action more effectively.

[0017] The aim of the invention is to provide a device and a method for the excavation of stone blocks which allows the limitations of the prior art solutions to be overcome and to obtain the technical results described above.

[0018] A further aim of the invention is that said device can be made and said method can be implemented with substantially low costs, with regard both to the production costs and the management costs.

[0019] Another aim of the invention is to provide a splitting device, in particular to assist in the excavation of stone blocks and a method for the excavation of stone blocks which are simple, safe and reliable.

[0020] A first specific object of the invention therefore relates to a splitting device, in particular to assist in the excavation of stone blocks, which comprises one or more valves connectable to as many splitting cushions, said valves being connected, by means of a conduit provided with a shut-off valve, with an inlet of said device of inflation water and with the lateral inlet of a Venturi tube, which is in turn connected, by means of an inlet of the Venturi tube, with said inlet of the device and, by means of an outlet of the Venturi tube, with an outlet valve of said

device.

[0021] In particular, according to the invention, said valves are connected to each other by means of a manifold, which is in turn connected to said lateral inlet of said Venturi tube.

[0022] A second specific object of the invention is a method for the excavation of stone blocks, comprising the following steps:

- 10 - inserting one or more splitting cushions inside an opening generated, between a mountain and a bank, by cutting the bank;
- inflating said splitting cushions, with consequent enlargement of said opening, moving the top of the bank away from the mountain;
- 15 - propping the bank;
- deflating said one or more splitting cushions and consequent lowering of said splitting cushions into said opening;

the steps of inflating, propping and deflating being repeated until a desired width of said opening is reached.

[0023] In particular, according to the invention, the steps of inflating, propping and deflating are repeated until the splitting cushions reach a depth close to the centre of gravity of the bank.

[0024] Preferably, according to the invention, after reaching the desired width of said opening or the depth close to the centre of gravity of the bank, there is a final step of:

- inflating the splitting cushions until they break.

[0025] In particular, according to the invention, said splitting cushions can be superposed on each other to form a multiple cushion, preferably a double or triple cushion, which may be obtained by gluing together two or more splitting cushions (1), at the respective metal sheets (1', 1").

[0026] The present invention is now described, by way of example and without limiting the scope of the invention, with reference to the accompanying drawings which illustrate preferred embodiments of it, wherein:

- 45 - Figure 1 shows a perspective view of a detail of a splitting cushion according to the prior art;
- Figure 2 shows a front view of a splitting cushion according to the prior art;
- Figures 3a and 3b show two perspective views of a splitting device, in particular to assist in the excavation of stone blocks according to a first embodiment of the invention;
- 50 - Figure 4 shows a schematic view of an element of the splitting device, in particular to assist in the excavation of stone blocks of Figure 3;
- 55 - Figures 5-7 show three different steps of the method for the excavation of stone blocks according to the invention; and

- Figures 8a and 8b show two perspective views of a splitting device, in particular to assist in the excavation of stone blocks according to a second embodiment of the invention.

[0027] As shown in Figure 3, a splitting device, in particular to assist in the excavation of stone blocks according to the invention, indicated in its entirety with numerical reference 10, is characterised in particular in that it is capable of including a plurality of valves 11, connectable to as many splitting cushions 1 through respective conduits (not shown), said device being configured in such a way as to be able to operate said valves 11 in delivery or in suction mode, in accordance with operating the inflation or deflation of the splitting cushions 1. In particular, the valves 11 are connected to a manifold 12 and, by means of this, to the lateral inlet 13 of a Venturi tube 14, equipped with an inlet 15 and an outlet 16, respectively connected to the inlet 17 and to an outlet valve 18 of the device 10. The inlet 17 is in turn connected, through hydraulic conduits, to a hydraulic pump (not shown).

[0028] The device 10 further comprises a conduit 19, provided with a valve 20, connecting the inlet 17 of the device 10 with the manifold 12. The device also comprises a pressure gauge 22.

[0029] The operation of the device 10 to assist in the excavation of stone blocks according to the invention is as follows. By sending pressurised water from the hydraulic pump, hereafter also referred to as inflation water, to the device 10 through the inlet 17, whilst at the same time keeping the outlet valve 18 closed and the valves 11 connected to the splitting cushions 1 to be inflated being open, the inflation water fills the splitting cushions 1. On the contrary, by sending the same pressurised water coming from the hydraulic pump to the device 10 through the inlet 17, keeping the valve 20 of the conduit 19 closed and opening the valve 18 of the outlet of the device 10, the inflation water enters the Venturi tube from the inlet 15 and, crossing the restriction 21, simultaneously increases its speed and generates a negative pressure at the lateral inlet 13, through which the inflation water present in the manifold 12 and in the splitting cushions 1 is sucked into the Venturi tube, which consequently deflate. The inflation water is then expelled through the outlet 16 and the outlet valve 18 of the device 10.

[0030] In particular, the negative pressure which can be reached at the narrowing 21 of the Venturi tube is close to the absolute vacuum.

[0031] In particular, the device 10 shown by way of example in Figures 3a and 3b consists of a piece of equipment which can be connected to a hydraulic pump, this equipment being characterised by being light, in such a way that it can be carried by hand, and being arranged with six valves 11, so that at least two triple splitting cushions can be used together in one bank. A plurality of hydraulic hoses necessary for the connections to the splitting cushions 1 are also provided with the device 10 to assist in the excavation of stone blocks according to the

invention, in such a way as to reduce the head losses within the piping as much as possible, in order to fully exploit the suction capacity of the system.

[0032] It should be noted that the application of the Venturi principle using water as a fluid is not so common, this principle being normally used to suck air or other gases. The dimensioning of the device 10 to assist in the excavation of stone blocks according to the invention has therefore been performed and optimised by successive test phases, which have led to a suction capacity being obtained which is sufficient to be able to deem manageable, in terms of time, the deflation step of the splitting cushions 1. By further increasing the performance of the device 10 it is possible to achieve ever higher suction flow values.

[0033] Figures 5-7 illustrate the steps of the method for the excavation of stone blocks according to the invention, according to a specific implementation thereof, as made possible by the use of the splitting device, in particular to assist in the excavation of stone blocks described above.

[0034] The steps of the method are repeated iteratively with cycles of inflation and deflation until the splitting cushions 1 are broken, and in particular, as illustrated in Figures 5-7, they are as follows:

- inserting one or more splitting cushions 1, of the single, double or triple type, inside an opening generated, between the mountain A and the bank B, by cutting the bank B;
- inflation said splitting cushions 1, by introducing water inside, which expands and widens the opening, moving the top of bank B away from mountain A (as shown in Figure 5);
- propping the bank B;
- deflation of said splitting cushions 1, by extraction of the water present inside them carried out by means of the device 10 according to the invention, with consequent lowering of the splitting cushions 1 inside the opening (Figure 6);

the steps of inflating, propping and deflating being repeated until the splitting cushions 1 reach a depth close to the centre of gravity of the bank (Figure 7), being followed by a final step of:

- inflating the splitting cushions 1 until they break.

[0035] The splitting of the bank B obtained through the method described above may be sufficient to cause the overturning of the bank B on a cushion C constituted by a pile of stone material debris, mixed with slurry produced by the cuts, whose function is to dampen the fall of the bank B in order to limit its breakage. If this is not the case, the bank should be tipped in a different way, which may also be a prior art way.

[0036] In particular, a double or triple splitting cushion 1 preferably consists of two or three single splitting cush-

ions 1, coupled to each other, for example by gluing. In fact, the overlapping of the single cushions alone may not be sufficient to ensure the correct deflation and descent of the splitting cushions 1 in the opening, so that they can remain attached to each other. In detail, the production process preferably involves the use of a special glue, and the application of a constant weight in the area where the cushions are glued for more than 24 hours. Moreover, both versions of multiple splitting cushions 1, both the double and the triple one, are advantageously equipped with a handle, as per previous Italian patent No. 277284, in order to be able to move them without difficulty, considering their weight. In fact, the double pillow can weigh approximately 24 kg and the triple pillow approximately 36 kg.

[0037] During the first step of inflating the splitting cushions 1, it is possible to achieve an overall opening width at the top of the bank B of at least 40-50 cm. If a multiple splitting cushion is used, the various cushions of which it is composed inflate in a fairly regular and uniform manner, reaching an opening of about 15-16 cm each for the triple ones.

[0038] During the propping step of the block, the hydraulic power unit is turned off and the inlet valves 11' for the entrance of water to the splitting cushions 1 are closed, in order to keep the splitting cushions 1 under pressure.

[0039] During the deflation step of the splitting cushions 1, a flow rate of water and pressure entering the splitting device 10 according to the invention generates a negative pressure which allows the water contained in the spreader cushions 1 to be sucked in, even when the latter are at a lower height than that at which the device 10 is located, in particular at a depth of at least 6-7 metres.

[0040] After two or three inflating and deflating steps, it is already possible to achieve a much larger opening width at the top of the bank B than is currently possible using the prior art excavation procedures, even up to 150 cm.

[0041] Several experimental tests were firstly carried out in the workshop, with the aim of understanding the actual performance of device 10, in terms of the useful suction capacity available at different heights. Subsequently, several experimental field tests were carried out, obtaining the results shown in the following examples.

[0042] In particular, the nameplate data of the splitting device, in particular to assist in the excavation of stone blocks, used for this and subsequent examples, is as follows: flow rate of incoming water between 8 and 13 l/min, measured driving pressure between 30 and 40 bar, flow rate of sucked water equal to 8-9 l/min at -0.85 bar depression.

Example 1

[0043] The splitting cushion used was a double cushion, the dimensions of the bank were 5x3x9 m.

[0044] At the end of the procedure, the width of the

opening at the top of the bank B was 70 cm and the depth reached by the splitting cushion 1 inside the opening was approximately 2 m from the top level of the bank.

Example 2

[0045] The splitting cushion used was a triple cushion, the dimensions of the bank were 5x3x9 m.

[0046] At the end of the procedure, the width of the opening at the top of the bank B was 110 cm and the depth reached by the splitting cushion 1 inside the opening was approximately 3 m from the top level of the bank B.

Example 3

[0047] The same splitting cushion as in example 2 was used with bank dimensions of 5x3x9 m.

[0048] At the end of the procedure, the width of the opening at the top of the bank B was 132 cm and the depth reached by the splitting cushion 1 inside the opening was approximately 4 m from the top level of the bank B.

[0049] The tests carried out have given very good results in terms of the maximum opening which could be reached and the water tightness of the splitting cushions 1 during the excavation process. In particular, multiple splitting cushions 1 remained bonded throughout the duration of the excavation steps, until they broke. The improvement between the second and third examples is due to the fact that in example 3 the deflation steps were optimised, seeking the best conditions for the cushions to expand as much as possible before breaking. It is therefore to be expected that even better results can be achieved by further refining the operating methods.

[0050] There are clear advantages compared with the excavation of stone blocks according to the prior art, due to the possibility of deflating the splitting cushions in order to lower them into the bank. In conjunction with the use of multiple cushions, the result obtained by means of the splitting device, in particular to assist in the excavation of stone blocks and the method for the excavation of stone blocks according to the invention is to obtain openings on the top of the bank which are increasingly larger.

[0051] According to the alternative embodiment shown with reference to Figures 8a and 8b, the device according to the invention may further be provided with a manually servo-operated plunger valve 23 made of a metal material, comprising a fixed lever 24 and a movable lever 25 of the plunger valve 23, with a closing direction of the movable lever 25 towards the fixed lever 24 to open the valve and thereby allow water to enter inside the device 10. The system is equipped with an internal spring (not shown) which allows the mobile lever 25 to return automatically to the rest position if it is stressed and then released and it keeps it in the closed condition if not stressed. In this way, the manually operated servo-assisted plunger valve 23 adds fundamental aspects of

safety and ease of use for the device according to the invention, which also entails the applicability of the device to other fields, other than those of stone material excavation, always considering its use in combination with metal cushions in single or multiple versions. Specifically, the splitting device according to this embodiment is able to guarantee greater safety for the operator, as the plunger valve 23 is monostable, that is, if it is activated and released suddenly, it returns to the rest condition, in which it does not allow the passage of water inside it and therefore inside the body of the splitting device. This allows the downstream system, that is, the splitting cushions 1 inflated with water, to not alter their state should the user feel unwell. A valve of this type is considered to be technically safe since, in the event of an illness, the system around the user does not change its state from a dynamic point of view. The system remains stationary, protecting the user from possible changes, breakage and movement of material caused by the continuous pressure which the system would exert on the cushions by continuing to inflate them.

[0052] A second advantage connected to the use of the plunger valve 23 is that of the modularity of the flow rate: as the valve is manual, and thanks to the system adopted by means of a servo-assisted lever, the flow rate of water to the splitting cushions can be adjusted moment by moment, making it possible for the operator to have total control over the opening of the splitting cushions during both the inflation and deflation steps. The modularity of the capacity therefore allows precise control of the opening of the cushions in such a way that operations are always performed in total safety.

[0053] The presence of valve 23 thus extends the field of application of the system comprising the device 10 in combination with metal splitting cushions, in single and multiple versions, and thanks to the inflation and deflation procedure it is usable in different situations.

[0054] In particular, a preferred application relates to safety equipment used by specialist teams and the fire service during rescue operations in traffic accidents and in the event of natural disasters, such as earthquakes, enabling the splitting device according to the invention to be classified as hydraulic rescue equipment. In fact, the system can easily be used to lift debris, girders, and other materials which would otherwise hinder the rescue of human lives, as in addition to its ease of use and compatibility with fire pumps and hoses and the relative safety systems, it offers significant performance in terms of applied force.

[0055] The inflation and deflation procedure, combined with the advantage of being able to fine-tune the flow rate of water and the degree of inflation and deflation of the cushions, makes it possible to determine by exactly how much a piece of debris can be raised or lowered, with a precision and level of safety which no similar system using air as the inflation fluid can guarantee.

[0056] The device according to the invention allows safe operation at pressures of up to 40 bar, achieving

thrust forces far in excess of what is currently possible with prior art splitting cushions.

[0057] In addition, the metal cushion, being very thin and made of metal material, lends itself very well to being placed in narrow, tight places which are difficult to reach with the equivalent air system currently used.

[0058] The invention is described by way of example only, without limiting the scope of application, according to its preferred embodiments, but it shall be understood that the invention may be modified and/or adapted by experts in the field without thereby departing from the scope of the inventive concept, as defined in the claims herein.

Claims

1. Splitting device (10), **characterised in that** it comprises one or more valves (11) connectable through hydraulic conduits to as many splitting cushions (1), said valves (11) being connected, by means of a conduit (19) provided with a shut-off valve (20), with an inlet (17) of said device (10) of water coming from a hydraulic pump and with the lateral inlet (13) of a Venturi tube (14), which is in turn connected, by means of an inlet (15) of the Venturi tube (14), with said inlet (17) of the device (10) and, by means of an outlet (16) of the Venturi tube (14), with an outlet valve (18) of said device (10).
2. Device (10) to assist in the excavation of stone blocks according to claim 1, **characterised in that** said valves (11) are connected to each other by means of a manifold (12), which is in turn connected to said lateral inlet (13) of said Venturi tube (14).
3. Device (10) to assist in the excavation of stone blocks according to claim 1 or 2, **characterised in that** it further comprises a plunger valve (23), provided with a movable lever (25) and a spring for automatically returning the movable lever (25) to the closed position.
4. Method for the excavation of stone blocks, comprising the following steps:
 - inserting one or more splitting cushions (1) inside an opening generated, between a mountain (A) and a bank (B), by cutting the bank (B);
 - inflating said splitting cushions (1) with water, with consequent enlargement of said opening, moving the top of the bank (B) away from the mountain (A);
 - propping the bank (B);
 - deflating said one or more splitting cushions (1) and consequent lowering of said splitting cushions (1) into said opening;

the steps of inflating, propping and deflating being repeated until a desired width of said opening is reached.

5. Method for the excavation of stone blocks according to claim 4, wherein the steps of inflating, propping and deflating are repeated until the splitting cushions (1) reach a depth close to the centre of gravity of the bank (B). 5
- 10
6. Method for the excavation of stone blocks according to claim 4 or 5, wherein, after reaching the desired width of said opening or the depth close to the centre of gravity of the bank (B), there is a final step of: 15
 - inflating the splitting cushions (1) until they break.
7. Method for the excavation of stone blocks according to any one of claims 4-6, wherein said splitting cushions (1) are superimposed on each other to form a multiple cushion. 20
8. Method for the excavation of stone blocks according to claim 7, wherein said multiple cushion is a double or triple cushion. 25
9. Method for the excavation of stone blocks according to claim 7 or 8, wherein said multiple cushion is obtained by gluing together two or more splitting cushions (1), at the respective metal sheets (1', 1"). 30

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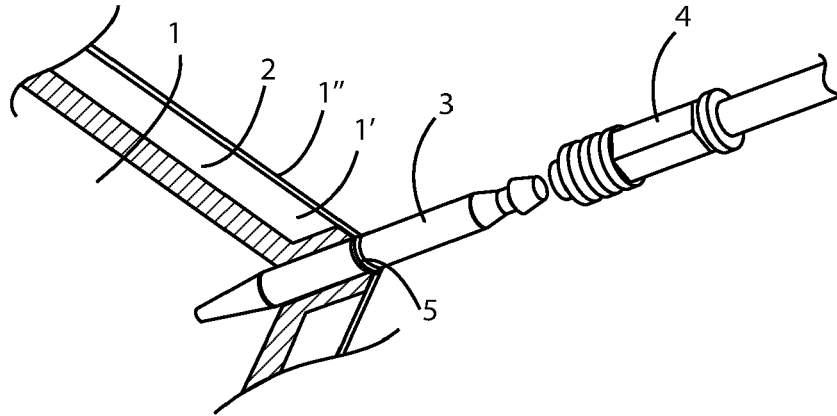


Fig. 1
(Prior Art)

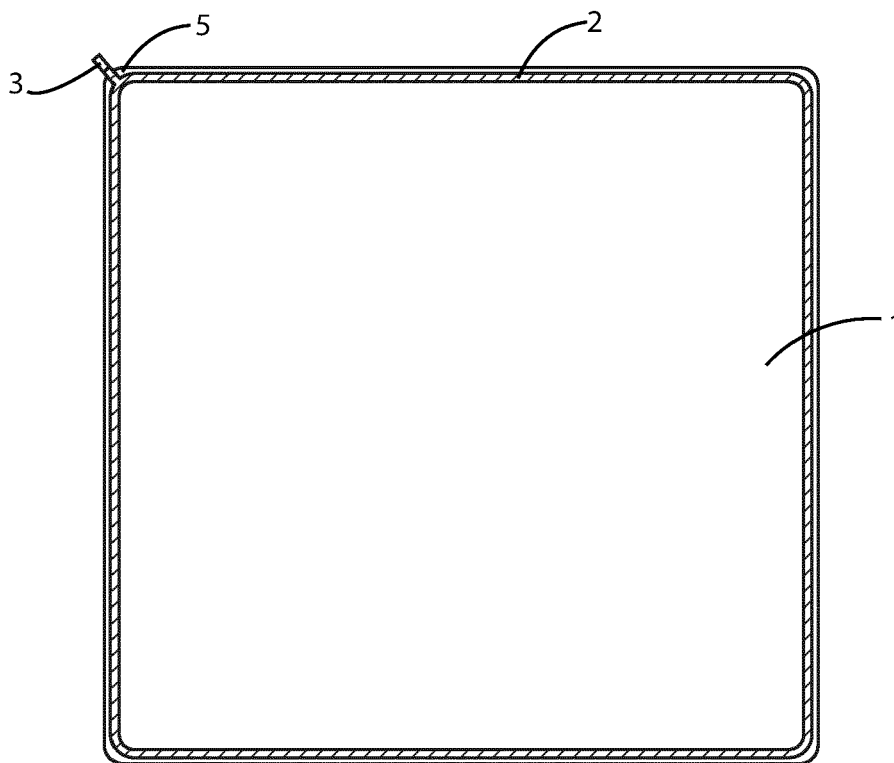


Fig. 2
(Prior Art)

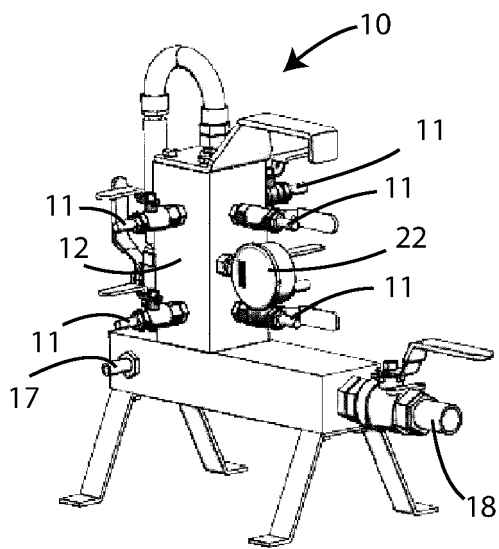


Fig. 3a

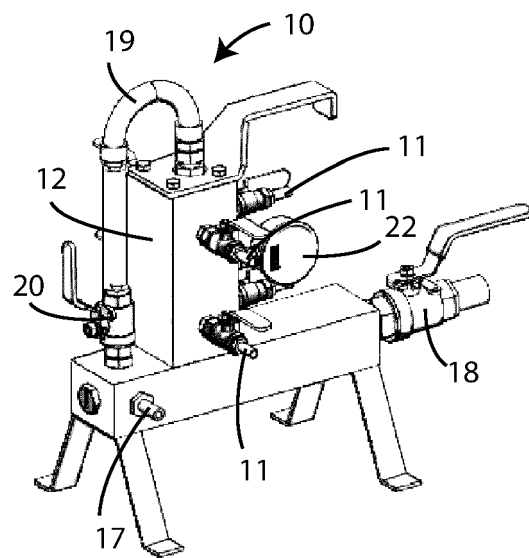


Fig. 3b

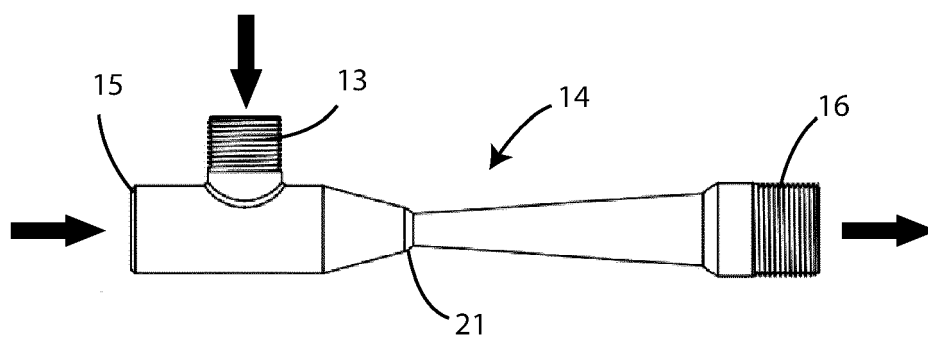


Fig. 4

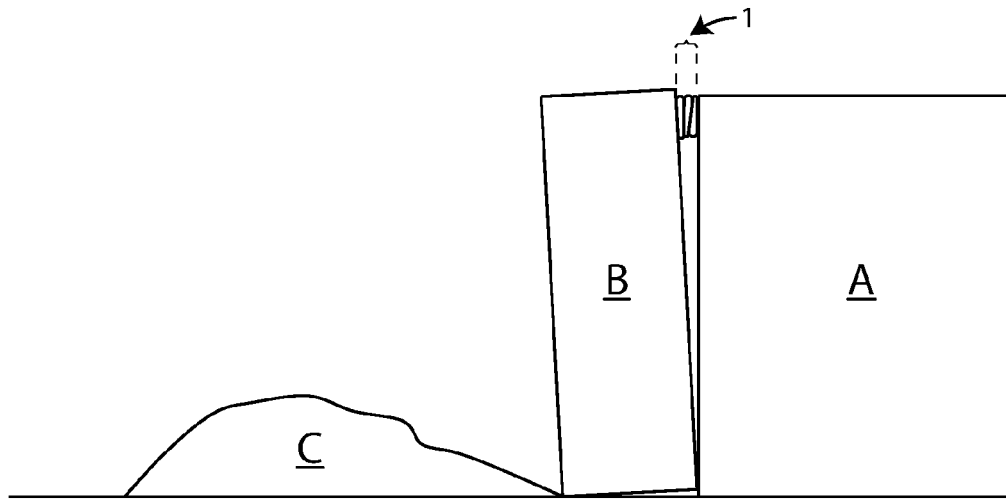


Fig. 5

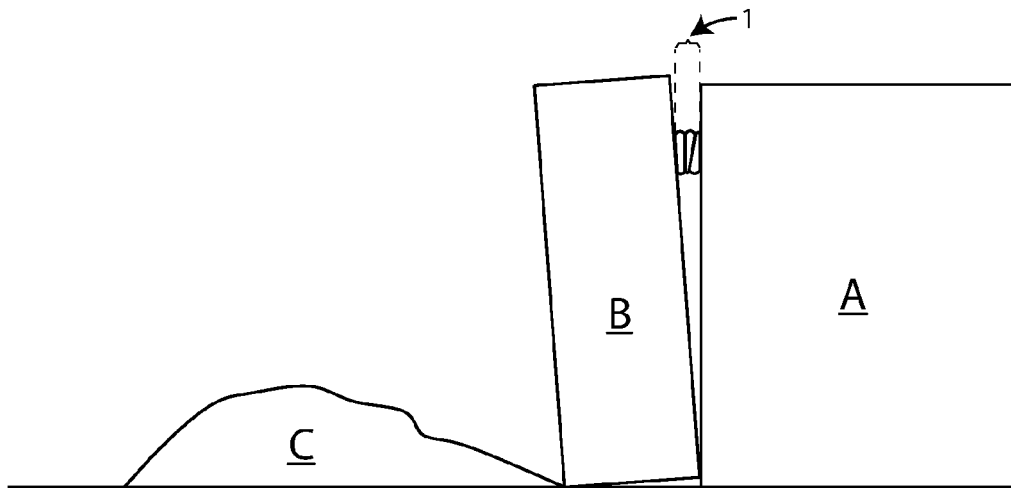


Fig. 6

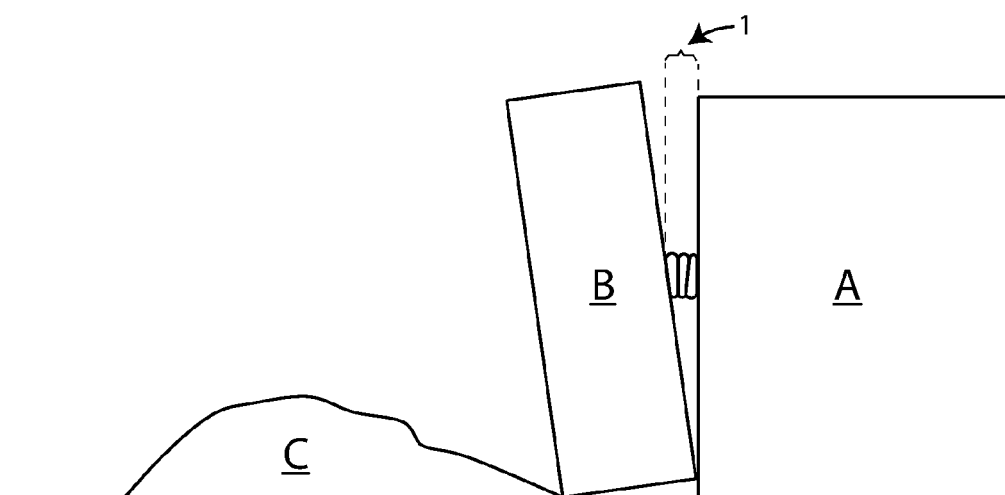


Fig. 7

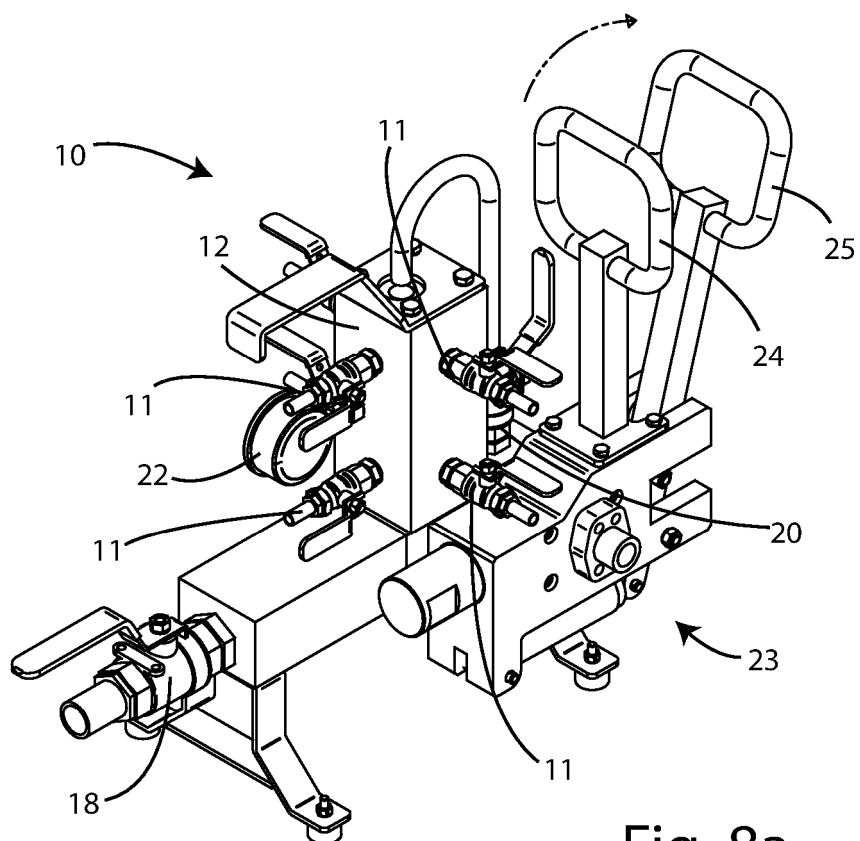


Fig. 8a

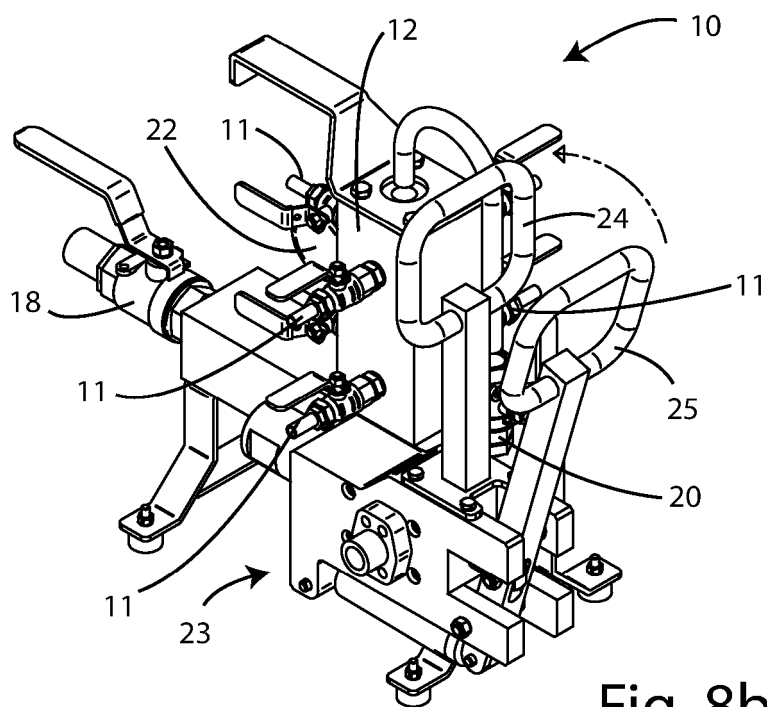


Fig. 8b



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