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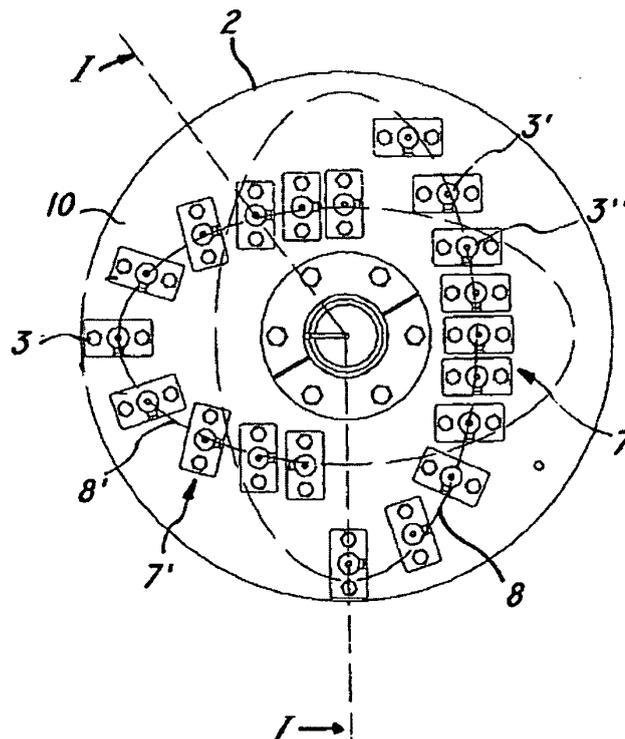
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(54) **Jet tool and tool holding head for surface working of slabs and blocks of stone, cementitious or the like materials**

(57) A high pressure fluid jet tool for surface working of slabs or blocks of stone, marble or the like, comprises a support plate (2) with a plurality of nozzles (3) mounted thereto for connection to a high pressure fluid line (4), means for removably anchoring the plate (2) to a spindle (6) that rotates about an axis of rotation (X) substantially perpendicular to the surface to be worked (S). The plu-

rality of nozzles (3) includes at least two separate arrays of nozzles (7, 7') arranged over the plate (2) along respective mutually offset curved lines (8, 8'), so that, as the plate (2) is rotated, the fluid jets (J) interact with the surface to be worked (S) in apparently random paths. A tool holding head is provided for surface working of slabs and blocks of stone, marble, granite, stone and/or cementitious agglomerates.



**FIG. 2**

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## Description

### Field of the invention

**[0001]** The present invention generally finds application in the technical field of stone working and particularly relates to a high pressure fluid jet tool for surface working of products of various materials, as well as a head comprising such tool.

**[0002]** The tool and tool holding head are particularly suitable for surface finishing of slabs or blocks of stone, marble, granite or stone or cementitious agglomerates or materials and the like.

### Background Art

**[0003]** Surface finishing treatments, such as polishing, smoothing, flaming and similar processes on slabs and products of stone materials, particularly granite and marble, are aimed at producing particular surface effects to add ornamental or functional value to the product, such as non-slip properties.

**[0004]** When treatments do not require material removal or surface deformation of the slabs, tools are generally used with one or more cutting edges, which operate by cutting or hitting the surface.

**[0005]** Nevertheless, these treatments involve a high slab damage risk if excessive pressure is exerted by the tool or the product is already cracked.

**[0006]** Flaming processes are instead carried out by exposing the surface layer of the slab to high temperatures by direct action of an oxyhydrogen flame delivered by single or multiple blowtorch systems.

**[0007]** These solutions suffer from apparent drawbacks, particularly associated with the thermal effects of the flame which extends through a few millimeters into the slab and can thus cause ruptures and/or fractures of various lengths depending on the compositions of the materials being treated.

**[0008]** Furthermore, due to uniform displacements between the head and the slab, repeated effects are created, such as transverse scratches, in the case of single blowtorches, or parallel to the working direction.

**[0009]** Particularly, all current flaming processes apparently suffer from the effects of the schematic and repetitive operation of blowtorches.

**[0010]** Another substantial drawback consists in the high fuel consumption required for feeding the flame, particularly when using multiple blowtorch flaming machines.

**[0011]** In an attempt to obviate the above drawbacks, a number of solutions have been proposed, in which the normal tools or the flame are replaced by one or more high pressure water jet nozzles.

**[0012]** Various machine tool solutions are currently available, which have nozzles arranged along one or more straight lines for simultaneously working the slab surface from a stationary or movable position, generally

on a plane parallel to the one defined by the slab.

**[0013]** US 5,291,694 discloses an apparatus for surface treatment of stone surfaces, having a nozzle holding head with seven high pressure liquid jet nozzles arranged along a circumference.

**[0014]** The head is eccentrically rotary driven by a drive shaft so that the liquid jet propelled by each nozzle, in combination with the linear translational motion imparted to the head, describes non linear traces.

**[0015]** While these solutions generally protect the material from damages caused by excessive tool pressure, they still cannot produce a surface effect that acceptably reproduces the random effect produced by an exclusively manual treatment.

**[0016]** Conversely, the effects of the schematic and repeated operation of blowtorches are normally apparent.

### Disclosure of the invention

**[0017]** The object of the present invention is to overcome the above drawbacks, by providing a jet tool for surface working of slabs or blocks of stone, marble, granite, cementitious agglomerates or the like using high pressure fluid, that is highly efficient and relatively cost-effective.

**[0018]** A particular object is to provide a jet tool that allows quick surface finishing, while obtaining a final product with aesthetic and functional effects as similar as possible to those that can be obtained by manual working, and while eliminating or at least substantially reducing the presence of repeated patterns on the treated surface.

**[0019]** A further object is to provide a tool holding head that allows such surface working to be carried out in a cost-effective manner.

**[0020]** These and other objects as more clearly apparent hereafter, are fulfilled by a jet tool as defined in claim 1, which comprises a support plate, a plurality of nozzles mounted to said plate for connection to a high pressure fluid line to generate fluid jets directed towards the surface to be worked and means for removably anchoring said plate to a spindle that rotates about an axis substantially perpendicular to the surface to be worked.

**[0021]** According to the invention, the plurality of nozzles comprises at least two separate arrays of nozzles arranged over the plate along respective mutually offset curved lines so that, as said plate is rotated, the fluid jets interact with the surface to be worked in apparently random paths.

**[0022]** Thanks to this particular configuration, once the plate is rotated by external means, the nozzles will direct their respective fluid jets to the surface of the product in an apparently random manner.

**[0023]** According to yet another aspect of the invention, a tool holding head is provided for surface working of slabs or blocks of stone, marble, granite or stone and/or cementitious or the like agglomerates or materials, com-

prising at least one fluid jet tool as defined in one or more of claims 1 to 10, motor means for rotating the tool and means for selectively feeding a high pressure working fluid to the tool.

**[0024]** Thanks to the particular configuration of the tool holding head of the invention, surface working of the product may be carried out in a relatively quick and efficient manner, while providing advantages in terms of overall throughput of the machine for which the head is designed.

#### Brief description of the drawings

**[0025]** Further features and advantages of the invention will be more apparent upon reading of the detailed description of a preferred, non-exclusive embodiment of a jet tool and a tool holding head according to the invention, which are described as a non-limiting example with the help of the annexed drawings, in which:

FIG. 1 is a perspective view of a jet tool of the invention;

FIG. 2 is a top view of the tool of FIG. 1;

FIG. 3 is a sectional front view of the tool as taken along the plane  $I-I$  of FIG. 2;

FIG. 4 is a top view of a detail of the tool of FIG. 1;

FIG. 5 is a top perspective view of a tool holding head of the invention;

FIG. 6 is a front view of the tool holding head of FIG. 5;

FIG. 7 is a sectional view of the tool holding head as taken along the plane  $II-II$  of FIG. 6.

#### Detailed description of a preferred embodiment

**[0026]** Referring to the above figures, the jet tool of the invention, generally designated by numeral 1, may be used for surface working of slabs or blocks of stone, marble, granite or stone, cementitious or the like agglomerates or materials, and particularly for surface finishing treatments using high pressure fluid jets.

**[0027]** The working fluid is preferably water and will be locally directed to the surface S to be treated, with a pressure preferably exceeding 500 kg/cm<sup>2</sup>, to roughen the surface S by material removal.

**[0028]** As shown in FIG. 1, a jet tool of the invention comprises a support plate 2 with a plurality of nozzles 3, 3', 3'',... mounted thereto for connection to a high pressure fluid line 4 to generate fluid J, J', J'', ... directed towards the surface to be worked S, means 5 for removably anchoring the plate 2 to a spindle 6 that rotates about an axis of rotation X substantially perpendicular to the surface to be worked S.

**[0029]** In accordance with a peculiar feature of the invention, at least two distinct arrays 7, 7' of nozzles 3, 3', 3'', ... are arranged over the plate 2 along respective mutually offset curved lines 8, 8'.

**[0030]** For sake of clarity, the nozzles 3, 3', 3'', ... and their respective jets J, J', J'' will be designated by non-

indexed reference numbers, referring to the nozzle element 3 and the jet J only, unless otherwise stated.

**[0031]** Nevertheless, it shall be understood that all the features as described and designated by non-indexed reference numerals, will also relate to the other nozzles arranged on the support plate 2 and all the parts in any one of the nozzles 3 will also be found in a substantially identical manner in all the others.

**[0032]** With the particular arrangement of the nozzles 3, once the plate 2 is rotated, the fluid jets J will impinge upon the surface to be worked S, as shown in FIG. 6, and cause material removal without generating any visible effect caused by overlapped working lines.

**[0033]** Thus, if the plate 2 rotates clockwise, the high pressure fluid jet J delivered by a given nozzle, such as the nozzle designated by 3', will not impinge upon the point of the surface S that has just been acted upon by the fluid jet J from the adjacent nozzle 3'', thereby achieving a final effect as close as possible to manual working.

**[0034]** In one preferred, non exclusive embodiment of the invention, more clearly shown in FIG. 2, both the curves 8, 8' along which the nozzles 3 are disposed may be elliptic arcs centered on the axis of rotation X of the plate 2.

**[0035]** In the configuration of the figures, the longer axes  $a_{MAX}$ ,  $a'_{MAX}$  of the two ellipses 8, 8' are substantially orthogonal to each other. Nonetheless, they can also form an angle  $\alpha$  defined by the two longer axes  $a_{MAX}$ ,  $a'_{MAX}$ , of predetermined value.

**[0036]** Experimental tests surprisingly showed that improved processing throughput and effectiveness may be achieved, in terms of ornamental and final functional effect, at values of the angle  $\alpha$  falling in a range from 60° to 120° and preferably from 70° to 110°.

**[0037]** Advantageously, each of the two ellipses 8, 8' may have a longer axis  $a_{MAX}$ ,  $a'_{MAX}$  that is 1.5 to 1.9 times the corresponding shorter axis  $a_{MIN}$ ,  $a'_{MIN}$ . These values may be selected according to the speeds of rotation and translation with which the tool 1 is effectively driven during each specific process.

**[0038]** Also, the longer and shorter axes  $a_{MAX}$  and  $a_{MIN}$  of one of the two ellipses, such as the ellipse 8, may be 0.6 to 1.4 times the homologous axes  $a'_{MAX}$  and  $a'_{MIN}$  of the other ellipse 8'.

**[0039]** FIG. 3 is a front sectional view of the jet tool 1, which shows that the nozzles 3 may be attached to the plate 2 using respective pairs of plates 9, 9' that are removably fastened to the top face 10 and the bottom face 11 of the plate 2 respectively.

**[0040]** The nozzles 3 may be fitted in special through cavities 12 of substantially circular shape, that are arranged along the two curved lines 8, 8' and define receptacles for respective nozzles 3, as more clearly shown in FIG. 4.

**[0041]** The centers of the adjacent through cavities 12 may delimit a portion of the corresponding elliptic arc 8, 8' that subtends a center angle  $\beta$  falling in a range from 5° to 30° and preferably from 10° to 20°.

**[0042]** FIG. 4 also shows that the means 5 for anchoring the plate 2 to the spindle 6 may consist of a substantially central passage 13 formed on the plate 2 and a plurality of auxiliary holes 14 arranged at the periphery of the central passage 13.

**[0043]** Finally, additional anchor receptacles 15 may be provided over the plate 2 for one or more weights, not shown, for balancing the whole tool 1 during its rotary motion, whose position will be selected as a function of the particular arrangement of the nozzles 3 and will be required whenever the latter are not evenly arranged.

**[0044]** A particular application of the above described jet tool 1 is shown in FIG. 5 and in FIG. 6. According to this particular configuration of the invention, a tool holding head 16 is provided for surface working of a slab K or a block of stone or the like material, which comprises a high pressure fluid jet tool 1 as described above, defining a substantially central axis of rotation X, motor means 17 for rotatably driving the tool 1 about the axis of rotation X and means 18 for selectively feeding a high pressure working fluid to the tool 1.

**[0045]** The selective feed means 18 may include a feed line 4 with a manifold 19 having a plurality of outlets, generally designated by numeral 20, connected to respective nozzles 3 via corresponding feed pipes 21, as only partially shown in the figures, to carry the working fluid from the manifold 19 to the corresponding nozzle 3.

**[0046]** In the preferred, not exclusive configuration of the present invention, as shown in the figures, the manifold 19 may be substantially cylindrical and coaxial with the support plate 2, with a first face 22 having a flange 23 for anchorage to the plate 2 at the central passage 14 and auxiliary holes 14 thereof, and an opposite face 24 associated to the drive means 17.

**[0047]** The latter may in turn include a motor driven spindle 6 which is integral with the manifold 19 and drives it into rotation about its axis X integrally with the tool 1.

**[0048]** Furthermore, the motor means 17 may include a drive shaft 25, with an axis W parallel to or coincident with the axis of the manifold and thence the axis of rotation X of the tool 1, and having a first axial end 26 associated with the spindle 6 and a second axial end 27, opposite to the first end 26, with a rotary joint 28 for connection of an external motor, not shown, to the drive shaft, for driving the latter into rotation.

**[0049]** Also, the drive shaft 25 may have a substantially axial passage 29 for the pipes 30 that are designed for feeding high pressure working fluids to the manifold 19, as more clearly shown in the section of FIG. 7.

**[0050]** Therefore, a frame 31 may be provided for support and protection of the head 16, comprising a protective shell 32, which is only partially shown for the tool 1 to be exposed to view, an anchor portion 33 for anchoring the head 16 to an external machine, not shown, for guided displacement of the head 16 over a plane  $\pi$  parallel to the surface of the slab L or block being processed.

**[0051]** In a particular application, the portion 33 for anchoring and guiding the frame 31 may be mounted to a

carriage that slides along a predetermined direction or with equivalent means, such as an anthropomorphic arm, not shown, with the slab L or block that can also have its own translational motion.

**[0052]** The frame 31 may also include an additional support portion 34 for the drive means 17, having lock means 35 for locking the pipe 30, such as a clamp, to prevent any undesired twisting of the pipe 30 during rotation of the manifold 19.

**[0053]** In a particular embodiment of the tool holding head 16 of the invention, the selective feed means 18 may also be associated with a microprocessor control unit, to be used for selective, sequential, controlled or random enabling/disabling of one or more nozzles 3 of the plurality.

**[0054]** Thus, each nozzle 3 may be fed with a pressure that is not necessarily equal to the feed pressure of the other nozzles of the plurality and may also be temporarily not fed, thereby increasing the random arrangement of the patterns generated by the jets J.

**[0055]** The above disclosure clearly shows that the invention fulfills the intended objects, and particularly meets the requirement of providing a jet tool that allows surface treatment of slabs or blocks of stone, marble, granite, stone and/or cementitious and the like agglomerates or materials, in a quick, efficient and safe manner.

**[0056]** Thanks to its particular configuration, the tool can direct the fluid jet to obtain surfaces with even and homogeneous treatments, with no or minimized presence of repeated patterns, which are as close as possible as those that can be obtained by manual working.

**[0057]** The tool and head of the invention are susceptible to a number of changes or variants, within the inventive concept disclosed in the appended claims. All the details thereof may be replaced by other technically equivalent parts, and the materials may vary depending on different needs, without departure from the scope of the invention.

**[0058]** While the tool and head have been described with particular reference to the accompanying figures, the numerals referred to in the disclosure and claims are only used for the sake of a better intelligibility of the invention and shall not be intended to limit the claimed scope in any manner.

## Claims

1. A high pressure fluid jet tool for surface working of slabs or blocks of stone, marble, granite or the like, comprising:

- a support plate (2);
- a plurality of nozzles (3, 3', 3'', ...) mounted to said plate (2) for connection to a high pressure fluid line (4) to generate fluid jets (J, J', J'', ...) directed towards the surface to be worked (S);
- means (5) for removably anchoring said plate

(2) to a spindle (6) that rotates about an axis of rotation (X) substantially perpendicular to the surface to be worked (S);

- characterized in that** said plurality of nozzles (3, 3', 3", ...) comprises at least two distinct arrays (7, 7') of nozzles (3, 3', 3", ...) arranged over said plate (2) along respective mutually offset curved lines (8, 8'), so that, as said plate (2) is rotated, the fluid jets (J, J', J", ...) interact with the surface to be worked (S) in apparently random paths.
2. Jet tool as claimed in claim 1, **characterized in that** at least one of said curves (8, 8') is an elliptic arc centered on said axis of rotation (X).
  3. Jet tool as claimed in claim 1, **characterized in that** both of said curves (8, 8') are elliptic arcs substantially centered on said axis of rotation (X).
  4. Jet tool as claimed in claim 3, **characterized in that** the longer axes ( $a_{MAX}$ ,  $a'_{MAX}$ ) of said ellipses (8, 8') are substantially orthogonal to each other.
  5. Jet tool as claimed in claim 3, **characterized in that** the longer axes ( $a_{MAX}$ ,  $a'_{MAX}$ ) of said ellipses (8, 8') form together an angle ( $\alpha$ ) falling in a range from 60° to 120° and preferably from 70° to 110°.
  6. Jet tool as claimed in claim 4 or 5, **characterized in that** each of said ellipses (8, 8') has a longer axis ( $a_{MAX}$ ,  $a'_{MAX}$ ) that is 1.5 to 1.9 times the corresponding shorter axis ( $a_{MIN}$ ,  $a'_{MIN}$ ).
  7. Jet tool as claimed in claim 4 or 5, **characterized in that** the longer axis ( $a_{MAX}$ ) and the shorter axis ( $a_{MIN}$ ) of one of said ellipses (8, 8') is 0.6 to 1.4 times the longer axis ( $a'_{MAX}$ ) and the shorter axis ( $a'_{MIN}$ ) respectively of the other of said ellipses (8').
  8. Jet tool as claimed in claim 1, **characterized in that** said plate (2) has a plurality of through cavities (12) of substantially circular shape arranged along said curved lines (8, 8') and defining receptacles for respective nozzles (3, 3', 3", ...).
  9. Jet tool as claimed in claim 8, **characterized in that**, for each of said elliptic arcs (8, 8') the centers of the adjacent through cavities (12) delimit a portion of the arc (8, 8') that subtends a center angle ( $\beta$ ) falling in a range from 5° to 30° and preferably from 10° to 20°.
  10. Jet tool as claimed in claim 1, **characterized in that** said anchor means (5) include a central passage (13) formed on said plate (2) for connection of said plate (2) with a rotary spindle (6).
  11. A tool holding head for surface working of slabs or blocks of stone, marble, granite, stone and/or cementitious agglomerates, comprising at least one high pressure fluid jet tool (1) defining a substantially central axis of rotation (X), motor means (17) for rotatably driving said at least one tool (1) about said axis (X), means (18) for selectively feeding a high pressure working fluid to said at least one tool (1), **characterized in that** said at least one jet tool (1) is as claimed in one or more of claims 1 to 10.
  12. Tool holding head as claimed in claim 11, **characterized in that** said selective feed means (18) include a feed line (4) with a manifold (19) having a plurality of feed pipes (21) in fluid communication with respective nozzles (3, 3', 3", ...) of said tool (1).
  13. Tool holding head as claimed in claim 12, **characterized in that** said manifold (19) is substantially cylindrical and coaxial with said support plate (2), with a first face (22) having a flange (23) for attachment to said tool (1) and an opposite face (24) associated to said motor means (17).
  14. Tool holding head as claimed in claim 12, **characterized in that** said motor means (17) include a motor driven spindle (6) integral with said manifold (19) for rotating the latter about its axis (X) integrally with said tool (1).
  15. Tool holding head as claimed in claim 14, **characterized in that** said motor means (17) include a drive shaft (25) with an axis (W) parallel to and coincident with the axis (X) of said manifold (19), said shaft (25) having a first axial end (26) associated with said spindle (6), a second axial end (27), with a rotary joint (28) for connection of a motor to the shaft and a substantially axial passage (29) for at least one pipe (30), allowing a working fluid to be fed to said manifold (19).
  16. Tool holding head as claimed in claim 11, **characterized in that** said selective feed means (18) include a microprocessor control unit for selective, sequential, controlled or random enabling/disabling of one or more of said nozzles (3, 3', 3", ...).
  17. Tool holding head as claimed in any preceding claim, **characterized in that** it comprises a frame (31) for support and protection of said tool (1), said frame (31) having lock means (35) for locking said pipe (30) and guide means (33) for guiding said head (16) over a plane (x) parallel to the surface to be work

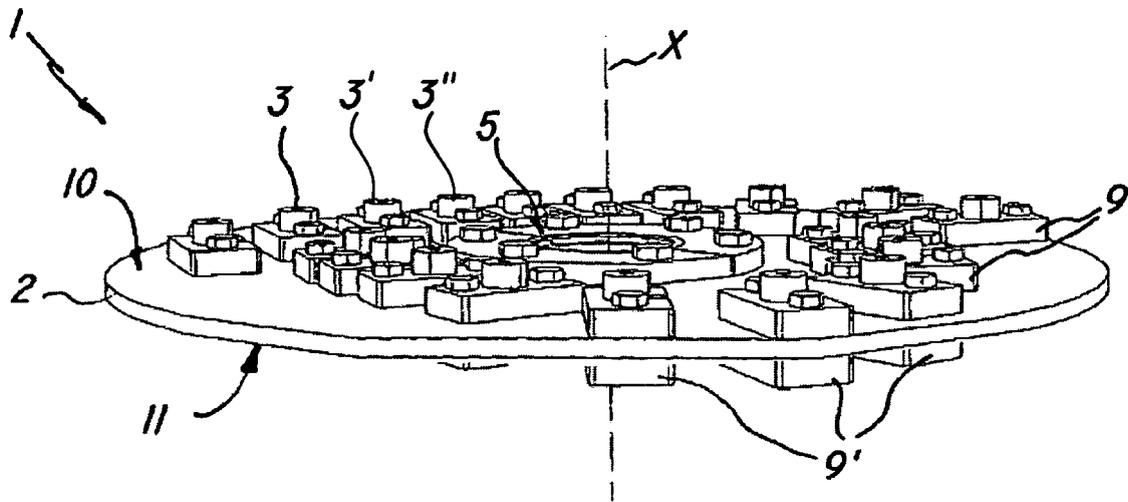


FIG. 1

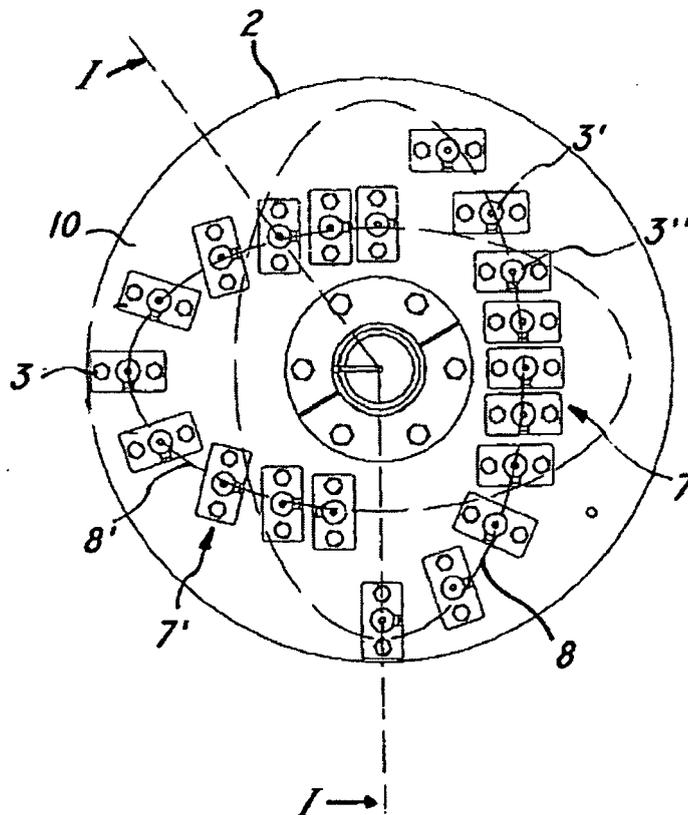


FIG. 2

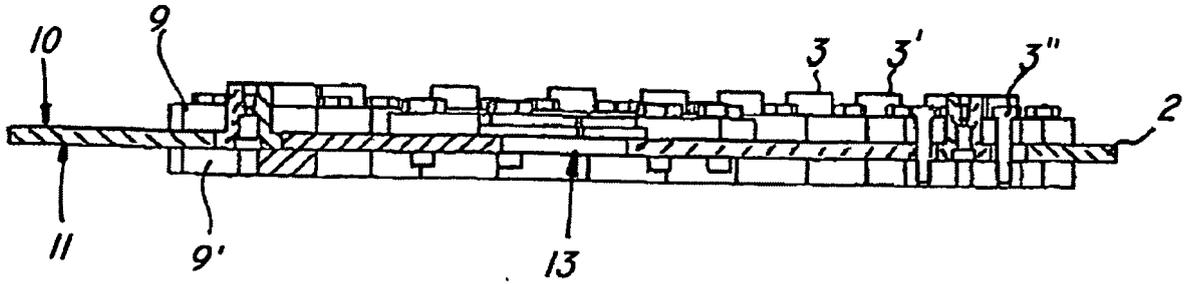


FIG. 3

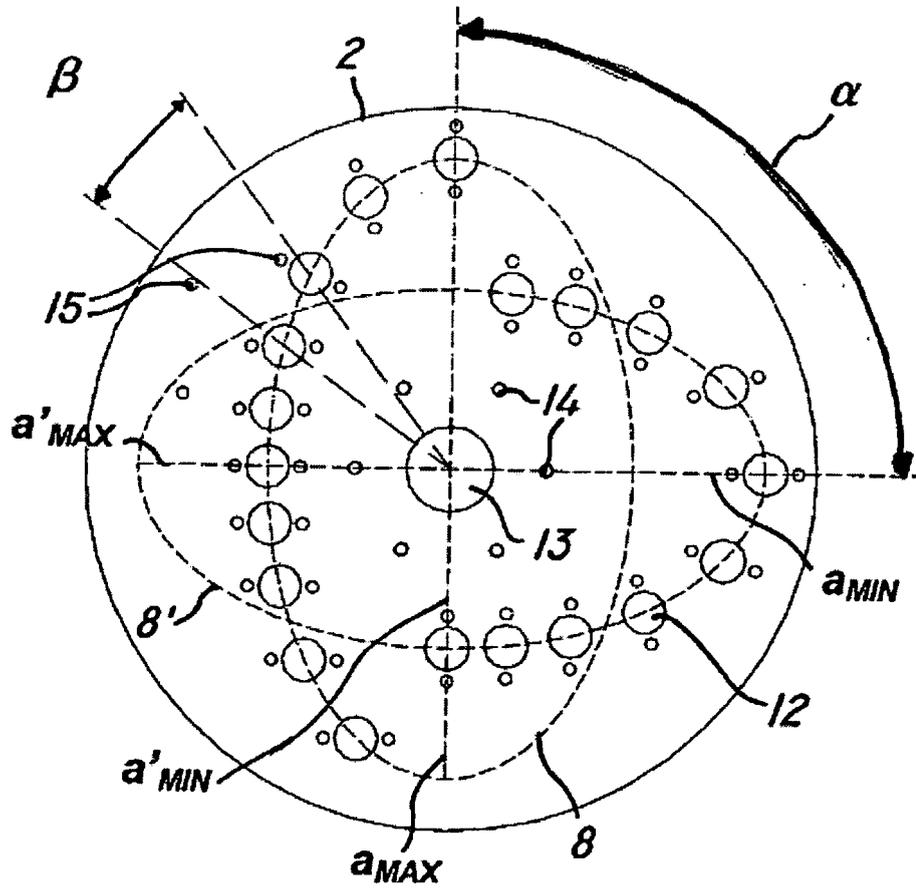


FIG. 4

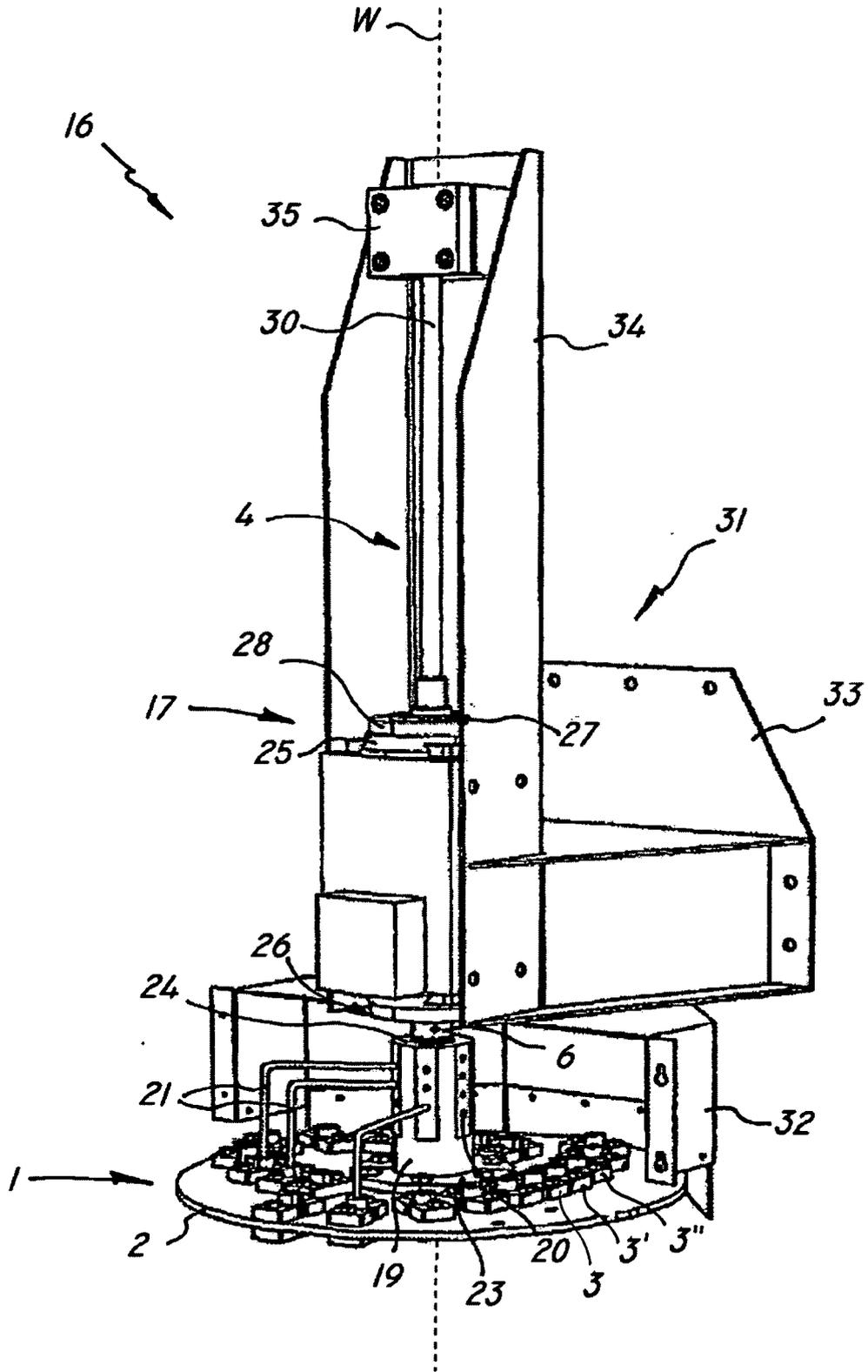


FIG. 5

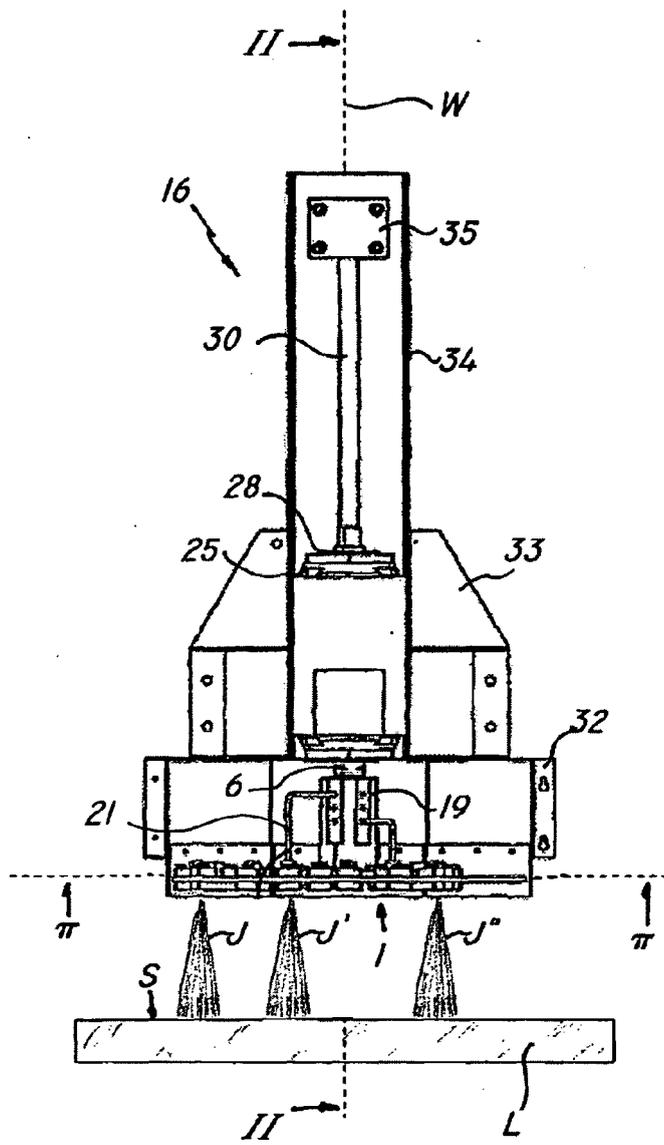


FIG. 6

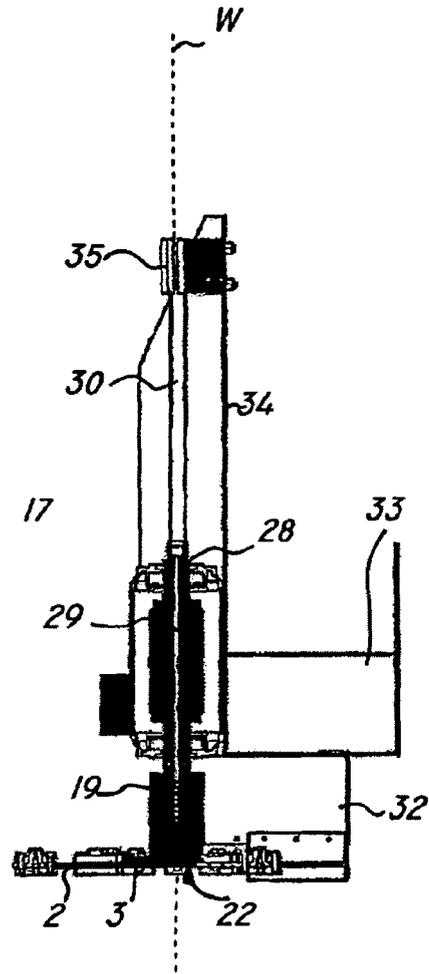


FIG. 7



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