(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 659 527 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **94203545.2**

(22) Date of filing: **06.12.94**

(51) Int. Cl.6: **B28B 17/00**, B30B 11/00, B28B 13/02, B28B 3/00

(30) Priority: **21.12.93 IT RE930089**

(43) Date of publication of application: **28.06.95 Bulletin 95/26**

(84) Designated Contracting States: **AT BE CH DE DK ES FR GB GR IE IT LI LU MC NL PT SE**

(71) Applicant: **MASS S.p.A.**
12 Via Contarella
I-42019 Scandiano (Reggio Emilia) (IT)

(72) Inventor: **Bardelli, Lodovico**
12/A Via Chiozzino
I-42019 Scandiano (Emilia) (IT)

(74) Representative: **Corradini, Corrado**
Studio Ing. C. CORRADINI & C. S.r.l.
4, Via Dante Alighieri
I-42100 Reggio Emilia (IT)

(54) Method and plant for forming tiles of uniform compaction and thickness, and tiles obtained thereby.

(57) A method for manufacturing ceramic tiles in general by pressing in an isostatic mould in which the die (2) provided for forming the feet contains a membrane (22) rigidly supported at the feet, said mould being mounted in a press equipped with a carriage (47) for charging material into the mould cavities, comprises, at predetermined intervals, a) measuring within the tile the maximum deviations from a reference plane of those regions (66) adjacent to the feet (33), b) processing said deviations in a microprocessor, and c) modifying, on the basis of the extent and distribution of the measured and processed deviations, at least one of the following parameters: carriage (47) traversing speed, commencement of the descent of the mould lower die (2) in relation to the carriage (47) position, inclination of the dividing flaps (16) present in the carriage cavity.

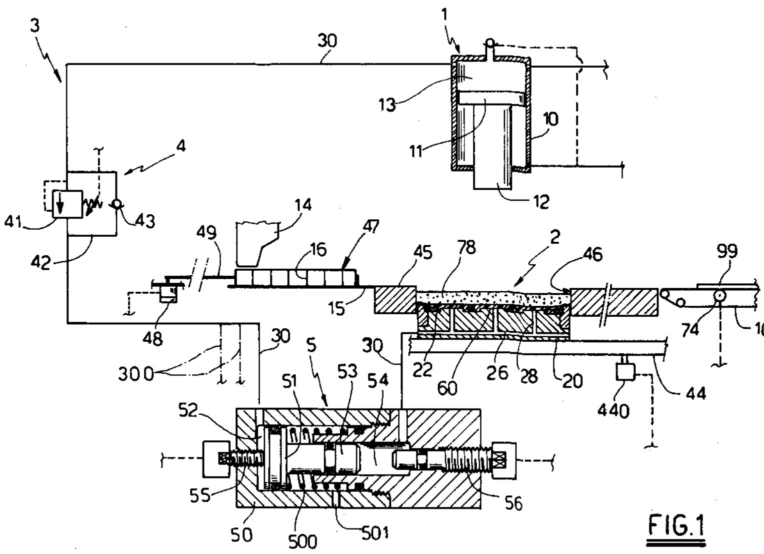

FIG.1

EP 0 659 527 A1

This invention relates generally to a method for manufacturing ceramic tiles, and more specifically to a method for forming tiles of uniform compaction and thickness. The invention also relates to the means for implementing said method.

Ceramic tiles in general are known to be formed in convenient moulds positioned on suitable forming presses. In modern production cycles said presses are hydraulic and basically comprise:

- a bed supporting the lower and intermediate mould plates;
- two vertical columns connected together at their top by a fixed cross-member;
- a vertically movable cross-member slidingly mounted on said columns and to the bottom of which the mould upper plate is fixed; and
- a hydraulic cylinder-piston unit secured to said fixed cross-member and slidingly driving said movable cross-member.

In such hydraulic presses the operating pressure of said cylinder-piston unit can be adjusted as required, ie on the basis of the parameters for the work underway.

The moulds to be associated with said presses comprise the three said plates, of which the intermediate plate comprises at least one forming cavity to be charged with at least one material to be compacted, the lower plate comprises at least one die to define the base of said at least one cavity and to form one of the two tile faces, and the upper plate is provided with at least one die to form the other tile face.

In all cases said at least one material is charged by a carriage arranged to occupy a first position to the side of the die plate, where it receives said at least one material, and a second position overlying the die plate, where it discharges said at least one material into said at least one cavity.

The to-and-fro movement of the carriage is generated by a connecting rod-crank system operated by a convenient drive unit, the carriage consisting of a rectangular frame with flaps fixed to two opposing sides thereof. Normally said flaps are fixed to those two sides of the frame which are parallel to the carriage movement. A feed hopper for said material is also associated with said carriage.

In certain cases the hopper is stationary and the respective carriage comprises a rear horizontal plate arranged to close and open the discharge mouth of the hopper when the carriage is in its advanced or discharge position and, respectively, when the carriage is in its withdrawn or loading position.

In other cases the hopper is arranged to move relative to the carriage with reciprocating rectilinear motion parallel to the carriage movement.

The depth of the forming cavity in the die plate is determined by the lower die which can assume three operating positions, namely:

- a raised (extracted) position in which its upper face is coplanar with that of the die plate to enable the tile to be removed by the advancing carriage,
- an intermediate (or charging) position in which it determines the depth of the forming cavity and hence the thickness of the material layer to be compacted, and
- a lowered (or pressing) position in which the respective (lower) attachment plate rests on the press bed, with the upper surface of said layer being spaced from the upper face of the die plate.

It should be noted here that the forming method mostly followed is to fix those dies for forming the tile exposed face to the mould upper plate, because otherwise said exposed face would become damaged on withdrawing the tile from the press.

It should also be noted that the known dies for forming the tile laying face, commonly known as "reverse face dies" can have their active face formed in various ways.

In current reverse face dies said active face can be defined:

- by the surface of a metal structure;
- by the surface of a slab of relatively soft material, such as vulcanized rubber or another equivalent elastomer, which clings to or rests on a rear metal structure, or
- by the surface of a membrane which is positioned to close at least one rear chamber filled with incompressible liquid such as hydraulic oil. The quantity of oil present in said chamber is constant, and if more than one chamber is present these intercommunicate to enable oil to flow during pressing.

These dies are commonly known as isostatic dies.

In addition, those dies provided for forming the tile exposed face, and commonly known as "exposed face dies", have their active face defined by the surface of a metal structure.

As is well known to the expert of the art, that pressing method using membrane or isostatic dies enables uniformly compacted tiles to be obtained, this not being possible if using dies with a metal active surface.

The lack of compaction uniformity derives from irregular distribution of material in the mould cavity by the charging carriage, and results in defects during the subsequent tile firing. Isostatic moulds overcome this drawback by ensuring uniform pressing, by which on termination of the firing cycle the tiles possess good physical and mechanical characteristics.

The invention relates to moulds provided with such isostatic dies.

Although said dies have the aforesaid advantages plus further advantages which it is not necessary to refer to herein, they have proved unsatisfactory when used in recent ceramic techniques.

In this respect, uniform compaction is achieved at the expense of geometrical or shape defects, in terms of a tile thickness which is not uniform from one point to another.

In particular, although said dies covered with a membrane closing at least one rear chamber filled with oil have numerous advantages, they have proved unsatisfactory in manufacturing relatively large dimension tiles of relatively small overall thicknesses.

This is because tiles obtained using such dies have a relatively much greater compaction at their feet than in the surrounding regions where the actual body of the tile is formed.

In this respect the degree of clay compact ion at the feet depends only on the reaction offered by the membrane consequent on its deformation, and it is apparent that where the membrane is thinnest, ie at the depressions in which the tile feet are formed, for equal absolute deformation it undergoes relative specific deformations which are much greater than those in surrounding regions where it is of greater thickness.

A much higher reaction force is therefore available in the thinner regions, resulting in greater clay compaction.

In addition the tile has a rather irregular surface, ie different thicknesses, at the depressions between said feet.

The problems arising from the aforegoing result in the rear lattice being able to be seen on the exposed side of the tile, this being unacceptable from the appearance aspect.

This differential compaction at the lattice supported by the membrane and in the surrounding regions results in differential porosity of the tile exposed face, and hence a different absorption capacity of its various regions, to the detriment of uniform glaze distribution, leading to regions of different tonality and/or differential brightness, said differential porosity being also visible on those tiles which do not require glazing after firing.

It is apparent that said drawbacks are more serious the greater the density difference between the more compacted regions and the less compacted regions, and the lesser the tile thickness (in accordance with the current tendency in the ceramic sector).

Again, said different compaction is also problematic for other ceramic products, such as two or more component tiles, known as granite tiles, and tiles with at least two components such as floor tiles.

From tests carried out it has been found that the aforesaid problems are practically non-existent or at least acceptable if the tile thickness measured in the regions between the feet deviate by about 1 to 3 tenths of a millimetre from the distance existing between the tile exposed face and the connection region for the feet.

It should also be noted that an irregular tile thickness in the regions between the feet results in fairly rapid membrane wear, with the consequent need to halt the production cycle for its replacement.

As stated, the aforesaid problems derive from the uneven distribution of the material charged into the forming cavity.

In other words, if said layer is homogeneous and regular the tile compaction and thickness would be perfect even if traditional non-isostatic moulds are used.

However, proper charging of the forming cavity has proved particularly problematic because it depends on a plurality of parameters which are particularly difficult to control and combine, considering that some of them can vary considerably and several times over a relatively short period.

The parameters that govern good charging of the forming cavity on the basis of the characteristics of the charged material, such as moisture content, particle size and density, can be non-exhaustively listed as follows:

- operating speed of said carriage, on which the distribution of said layer depends;
- the moment in which the lower die descends in relation to the advancing carriage, to define the height of said layer, this moment also influencing the layer distribution;
- inclination of the transverse flaps present on the carriage.

Notwithstanding the various attempts already carried out in this sense, means are still not available for achieving substantially uniform charging of the forming cavity, to obtain tiles of substantially uniform compaction and thickness.

In the known art the charging of the forming cavity is adjusted as a result of visual checks on the surface of the regions between the feet and on the uniformity or non-uniformity of the tile thickness.

On the basis of these visual checks the carriage travel speed is adjusted, as are the other listed parameters, after which the checks are repeated and further adjustments made if necessary.

However such a procedure, besides being very complicated, has been found not to give the desired results.

The main object of the present invention is to provide a method and its means of implementation able to produce tiles which are of uniform compaction and thickness and are statistically identical.

According to a first aspect the method of the invention comprises continuously forming tiles, automatically monitoring the planarity of those tile regions between the feet and, if unsatisfactory, to automatically modify at least one of the parameters governing the charging of the forming cavities, in accordance with an established priority based on the type, size and position of the defect shown up by said planarity monitoring.

Preferably the planarity monitoring and the possible adjustment of said at least one parameter are effected at a frequency equal to the production rate of the press, ie in practice in real time.

All the objects of the invention are achieved in this manner.

In this respect, as the surface configuration of said (rear) regions of the tile is strictly related to its compaction, and as both the said surface configuration and compaction depend practically totally on how the forming cavity has been filled, said adjustment enables the forming cavity to be filled with a layer of substantially uniform density and thickness, hence tiles of practically uniform compaction and thickness are produced, with all the resultant advantages stated in the introduction.

Specifically, said planarity monitoring assumes a reference point or plane and measures the maximum distance between said reference and the tile region adjacent to the foot, to deduce from said measurement any geometrical irregularity on the rear of the tile, or in other words its non-uniformity of thickness.

The various parameters responsible for the filling of the mould cavity are automatically adjusted on the basis of said non-uniformity.

Adjustments are made only when the thickness non-uniformity exceeds a certain value considered acceptable, such as 0.2-0.3 mm.

Because of the method of charging the mould cavity, the filling irregularities occur in the direction of movement of the charging carriage, hence the thickness non-uniformity measurements are made in the same direction, this being the direction in which the tile advances after being formed.

Knowing the influence of the said parameters on material distribution in this direction, they can be easily varied until virtually regular charging is achieved.

The means for implementing said method comprise an isostatic mould to be positioned on a hydraulic press, those dies thereof for forming the tile laying face comprising an elastomeric membrane carrying impressions for forming the tile feet, and closing a series of rear chambers for containing hydraulic oil, said chambers being hydraulically connected to the press cylinder-piston unit which exerts the forming pressure.

Specifically, said hydraulic connection is made by a hydraulic circuit which incorporates, starting from said cylinder-piston unit, a valve unit arranged to allow oil to pass alternately in the two opposing directions, and at least one pressure multiplier device, during the course of each pressing the opening of said valve unit in one direction depending on a pressure less than the maximum operating pressure of said cylinder-piston unit, whereas the opening of said valve unit in the opposite direction depends on the repositioning of said pressure multiplier device.

By virtue of said configuration, below the membrane in that region between the impressions in which the tile feet are formed, ie in the region in which said slab is of greatest thickness, a hydraulic counterpressure is made available such as to raise the slab during the final pressing stage.

Specifically, because of said counterpressure in the regions between the tile feet, depressions are created, the depth of which depends on the characteristics of the layer of pulverulent material contained in the mould forming cavities.

With the aforesaid means there is associated a device able to measure the surface conformation or planarity of said depressed regions, and which is combined with a system which on the basis of the data obtained by said measuring device acts on the means on which the charging of the forming cavity depends.

For example said system consists of an electronic device the input of which is connected to said measuring device, and the output of which is connected to said means on which said charging depends, so as to adjust, or not, its manner of operation and possibly its configuration in response to the readings taken.

In this manner after a series of successive automatic adjustments the forming cavity is filled with a layer having practically uniform density and thickness, so that besides being uniformly compacted the tiles also have uniform thickness.

All the problems stated in the introduction are hence solved.

The operational stages of the method of the invention and the characteristics and constructional merits of the relative plant for its implementation will be apparent from the detailed description given hereinafter with reference to the accompanying figures, which illustrate a preferred embodiment of said plant by way of example.

Figure 1 is a schematic view showing the plant according to the invention.

Figure 2 is a partial view from above on an enlarged scale with parts removed, showing a reverse face die according to the teachings of the invention; on its left side the die is shown covered with rubber whereas on its right side this rubber is omitted.

Figure 3 is a part section on the line III-III of Figure 2, on an enlarged scale.

Figure 4 is a view showing part of the unit for monitoring the planarity of the tile laying face.

Figure 5 is a schematic view from above of the charging carriage for the plant mould.

Figure 6 is a part section on the line VI-VI of Figure 5, on an enlarged scale.

Figure 7 is a section on the line VII-VII of Figure 6, on an enlarged scale.

Figure 1 shows in combination the hydraulic cylinder-piston unit 1 of a ceramic press, a reverse face die 2 pertaining to a ceramic mould for locating on the bed of said press, and a hydraulic circuit 3 connecting together said unit 1 and die 2 as described hereinafter, and into which there are connected a valve unit 4 and a pressure multiplier 5.

Said press and mould are shown only partially and schematically for reasons of clarity and simplicity, and also because they are well known to the expert of the art and well defined in the introduction.

As is usual, said cylinder-piston unit 1 comprises a cylinder 10 which is connected to a source of pressurized hydraulic liquid, and within which a piston 11 is mounted to slide under sealed conditions.

The rod 12 of this latter emerges from the lower end of the cylinder 10 where it fixedly carries the press movable cross-member which supports the mould upper plate (not shown), provided lowerly with a die, also not shown.

Said (upper) die cooperates with the (lower) die 2 to form the tiles, by moulding their exposed face.

The mutual position of the two dies can be inverted.

In Figure 1 the reference numeral 45 indicates the ceramic mould intermediate plate or die plate, which can either be fixed to the press bed or be supported on said bed by yieldable supports, not shown, of hydraulic or mechanical type.

Said die plate 45 comprises at least one forming cavity 46 for charging at least one pulverulent material 78 to be compacted, such as atomized clay.

The base of the cavity 46 is defined by the die 2, which can move in height as explained in the introduction.

For this purpose the die 2 is fixed to the mould lower plate 44, which is supported by the press bed by way of a series of actuators 440, for example four in number.

According to the invention said actuators 440 are of fine adjustment type, for the reasons given hereinafter.

Specifically said actuators 440 are remotely adjustable.

Actuators of the type described in Italian patent applications 46814 A/90 and RE92A000009 filed in the name of the present applicant have proved particularly satisfactory for the purposes of the invention, and to which texts reference should be made for further details.

To the side of the die plate 45, which in Figure 1 is shown in its maximum raised position, there is a horizontal surface 15 on which the carriage 47 slides for filling the cavity 46.

The carriage 47 is driven to slide forwards (towards the right in Figure 1) and rearwards (towards the left) by a connecting rod-crank system 49 operated by a drive unit 48.

According to the invention said unit 48 comprises a direct current electric motor with an electronic card for continuous r.p.m. adjustment.

A clay feed hopper 14, of known type in the illustrated embodiment, is associated with the carriage 47.

As can be seen in Figure 5, the carriage 47 comprises a rectangular frame 64, the front cross-member of which is provided with a pusher 65 and a scraper 66.

The purpose of the pusher 65 is to remove the tiles 99 (Figure 1) from the die plate 45 and rest them on a conveyor 100 during the outward travel of the carriage, whereas the scraper 66 levels the clay layer 78 deposited in the cavity 46 and cleans the upper face of the die plate 45 during the return travel of the carriage 47.

From Figures 5 and 6 it can be seen that the longitudinal members of the frame 64 are provided with mutually facing seats receiving the ends of a series of transverse dividing flaps 16.

Each flap 16 is provided with a series of equidistant plates 17 arranged perpendicular thereto and symmetrically about it, the plates of each series being interposed between the plates of the two adjacent series.

Each flap 16 comprises two opposing through holes 160 through which there are inserted, with a certain radial clearance, two threaded shafts 67 the threads of which upperly engage two elastic rods 68.

Said threaded shafts 67 are rotated by two electric motors 670 of double direction of rotation.

Said shafts 67 have a thread which for one half of their length is left handed and for the other half is right handed.

Said rods 68 are elastically flexible, and consist for example of pieces of harmonic steel wire.

Each rod 68 supports the corresponding end of the flap 16 by way of a pin 69 which is perpendicular to this latter (Figures 6 and 7).

As can be seen from Figure 7, the pin 69 has a frusto-conical end which together with a terminal frusto-conical head 70 forms a circumferential groove of V-shaped cross-section.

This groove engages a respective hole in the flap 16, this hole having flared ends the generating lines of which define an angle less than the angle at the vertex of said V shape.

By this means the inclination of the flap 16 to the vertical can be adjusted.

Said adjustment is made by a threaded push rod 71 controlled by a micromotor 171 of two directions of rotation, which is fixed below the pin 69.

The push rod 71 rests against the rear face (with reference to the direction of advancement of the carriage 47) of the flap, against the opposite face of which there acts a flat spring 72.

The purpose of the rods 68 is to discretely adjust the distance between the flaps 16, in particular at the commencement of the production cycle of a determined material;

- the threaded shafts 67 enable the position of said flaps 16 to be finely adjusted, and
- said push rods 71 and said flat springs 72 enable the inclination of said flaps 16 to be adjusted, as stated.

As can be seen in Figure 4, below the conveyor 100 there is provided a device for measuring the planarity of those regions 66 of the tile 99 lying between the feet 33 (see Figures 1, 4).

It comprises a series of identical units (for example four in number) positioned side by side in a direction transverse to the conveyor 100 and all connected to a central processing and control system 174, such as a programmable electronic processor.

Each individual unit comprises a vertical core 73 slidable within a hollow body 75 provided with three windings, of which the central winding is connected to a power supply 173. The core 73 supports an idle roller 74 with its axis horizontal and positioned transverse to the conveyor 100 to make contact with the laying face of the tiles 99.

Said other two windings are connected in series and their ends are connected to a reading unit 76 connected to the central processor 174 and to a display 77, for example of liquid crystal type.

Said core 73, said body 75 and said reading unit 76, in combination with said central processor 174, act as a unit for measuring and processing the vertical travel amplitude of the roller 74, the output signals (data) of which are displayed on the display 77.

It should be noted that the number of display cells of this latter is at least equal to the number of depressed regions 66 of the tile 99 to be contacted by the roller 74.

The central control processor 174 is connected at its input to the units 76, and at its output (dashed lines at the bottom of Figure 4) to the actuators 440 and motor 48 (Figure 1), and to the motors 670 and micromotors 171 (Figure 5).

The operation of said measurement device is described hereinafter.

A description of the techniques used in relation to the dialogue and interaction between the parts connected to the central processor 1784 will not be given as these are within the knowledge of an electronics expert on the basis of the explanations given.

With the central control processor 174 there is associated at least one feeler arranged to contact the exposed face of the tiles 99 in transit on the conveyor 100. The purpose of said at least one feeler, indicated by 374 in Figure 4, is to monitor the thickness of the tiles, and is connected to the processor 174.

This latter, of programmable type as stated, is provided with means for storing geometrical characteristics of the tiles, such as the distance between the feet 33, their thickness, and the allowable average tile thickness, and with means for emitting correlations such that the readings provide the most appropriate adjustment for achieving a uniform layer of pulverulent material 78.

From Figure 1 it can be seen that from the chamber 13 of the cylinder-piston unit 1 there extends a pipe 30 valved by a sequence valve 41, regulated as indicated for the reasons which will be apparent hereinafter. Said valve 41 is arranged to allow oil to pass in the direction from the unit 1 to the die 2, the valve 41 being bypassed by a pipe 42 containing a non-return valve of ball type. This latter is arranged to allow oil to pass in the opposite direction to that just specified. As stated, the die 2 is connected to the pipe 30 via the multiplier device 5, and if the ceramic mould has several forming cavities, each provided with a die 2, a device 5 is provided for each of them. For this purpose the pipe 30 comprises as many branches 300 (indicated by dashed and dotted lines in Figure 1) as there are dies 2.

Again with reference to Figure 1 it will be seen that said multiplier 5 comprises a hollow body 50 within which a piston of different sections 51 and 53 is slidingly mounted, the section 51 being greater than the section 53.

Said piston sections 51 and 53 are contained in respective chambers 52 and 54 via suitable gaskets.

The first chamber 52 is connected to that branch of the pipe 30 connected to the valve unit 4, whereas the second chamber 54 is connected to that branch of the pipe 30 connected to the die 2.

Between the body 50 and the section 51 of greater cross-section there is interposed a compressed repositioning spring 500, the operating seat of which opens to the outside via a vent aperture 501.

Finally at the end of said chambers 52 and 54 there are provided respective threaded push rods 55 and 56 for adjusting the return and outward travel limits of said piston 51, 53 respectively.

According to the invention, said push rods 55 and 56, and said sequence valve 41, are preferably controlled by the central system 174.

As can be seen in Figures 2 and 3, the die 2 comprises a metal body 20 to be fixed to the lower plate 44 of the ceramic mould and comprising a series of through horizontal ducts 27, two in number in the illustrated embodiment (Figure 2), which are closed at one end whereas at their other end are connected to the pipe 30 (Figure 1).

Transversely to said ducts 27 there is provided a series of equidistant coplanar ducts 26 perpendicular thereto from which there branch a plurality of equidistant vertical holes 28.

Each individual hole 28 opens into the centre of the top of a circular raised portion 61 pertaining to a plurality of raised portions 61 uniformly distributed over the upper (or active) face of the body 20.

The raised portions 61 of each line or column of said plurality are offset from the raised portions 61 of the immediately adjacent lines or columns.

This is clearly shown to the right of Figure 2, from which it can also be seen that the end raised portions 61 of the alternate lines have a plan shape smaller in size than that of the remaining raised portions 61.

This is for reasons of uniformity of distribution of these latter.

Said raised portions can be replaced by projections of another shape, such as crossed ribs.

A perforated metal slab 21 having substantially the same plan configuration as the upper face of the body 20 is fixed by rear locking members 25 (Figure 3) such as screws, to the upper face of the body 20 from which said raised portions 61 rise.

Said slab 21 is provided with a number of holes equal in number to the raised portions 61, the inner diameter of said holes being greater than the outer diameter of the raised portions 61 (see Figures 2, 3).

The thickness of the slab 21 is practically equal to the height of the raised portions 61.

In addition the edges of said holes are flared upwards and comprise a lower recess defining an anchoring ledge for an overlying slab 22 of suitable material, such as vulcanized rubber or other equivalent elastomer, hereinafter also known as the membrane.

The coupling system between said two slabs 21 and 22 is not described as it is known in this specific sector.

What is important is that between the upper face of each raised portion 61 and the corresponding overlying membrane portion 22 there is defined a hydraulic chamber 60 which is connected to a respective vertical hole 28.

The depth of said chamber 60 is very small (see Figure 3), for example it can be practically zero, the seal being provided by a lateral gasket 62 associated with the respective raised portion 61.

As shown in Figure 3, in that face of the membrane portion 22 defining the upper end of said chamber 60 there is provided a lattice of small grooves extending towards the vertical hole 28.

This is to facilitate oil flow below the membrane portion.

For example said grooves 63 can be arranged in ray formation or can consist of a single spiral-shaped groove.

This is shown to the left of Figure 2 by dashed lines.

On the front (or active) face of the membrane 22 there is provided a plurality of small impressions 29, of elongate shape (Figure 2) with flared lateral walls (Figure 3), distributed in groups of hexagonal shape to define a configuration of honeycomb type (Figure 2, left side).

It should be noted that the shape of said impressions 29 can be other than that shown.

Said impressions, which cover the entire slab 21, are provided for forming the feet 33 of the tiles 99, these impressions having a very small depth for the aforesaid reasons.

Finally, the upper peripheral region of the body 20 is surrounded by a perimetral recess 200 (see Figure 3) receiving a perimetral frame 23 fixed by screws indicated schematically by 24.

The flat upper edge of said frame 23 is flush with the perimetral edge of the membrane 22, the constituent elements of said frame 23 having a transverse shape specular about the longitudinal axis of said screws 24.

This enables both the upper side and lower side of said elements to be utilized, which is particularly advantageous seeing that said elements, although of a particularly hard and resistant metal, are subject to more rapid wear than the membrane 22.

The aforedescribed plant implements the method of the invention as follows.

At the commencement of each pressing stage the press-mould unit, without for the moment considering the part for making the aforesaid adjustments, is configured as in Figure 1, in which:

- the piston 11 is raised,
- the piston 51, 53 of the multiplier 5 is at its return end of travel,
- the chambers 60 are practically empty, or contain traces of practically unpressurized oil, and
- the sequence valve 41 is set to a pressure less than the maximum operating pressure of the cylinder-piston unit 1 for the specific work underway.

After unloading the formed tile 99 and charging the mould with the material 78 to be pressed, the piston is enabled to descend, by which the material 78 present in the cavity 46 is pressed.

The chambers 60 do not contain oil, but before the pressing is complete, and more specifically when the pressure of the oil present in the operating chamber 13 reaches the set value of said valve 41, this valve opens to allow oil to pass.

Consequently oil is fed into the chamber 52 of the device 5, and correspondingly the chamber 54 feeds oil to the chambers 60 at a pressure greater than the pressing pressure.

In this manner on the lower face of that membrane portion 22 bounding each chamber 60 a specific pressure is available which is greater than the pressure which would prevail without the connection established by the circuit 3.

This causes the membrane 22 to rise so that the pressure at all points of the tile is equalized independently of the uniformity of the charged layer of material.

The result is that in addition to uniform compaction, there is a thickness difference at the various points of the tile. This difference is measured after expelling the tile, by the means associated with the rollers 74 positioned under the conveyor 100.

The measurements are made along bands parallel to the conveying direction in that any defects in charging the material 78 are distributed in said direction.

On passage of the tile 99, the central processor 174 processes the travel amplitudes of each roller 74, displaying the data on the respective display 77 and converting them into commands for adjusting the charging parameters.

As will be more apparent hereinafter, the differences between said amplitudes are an indication of a shape defect in the tile, which defect can be practically eliminated by modifying the charging of the cavity 46, in particular the distribution of the material 78 within the cavity.

If the travel amplitudes of each roller 74 deviate from each other by a quantity less than the allowable, ie 0.2-0.3 mm, the tile 99 is acceptable in practice.

If not, then the distribution of these deviations indicates where too much or too little material has been charged into the mould cavity.

The same applies to the deviations of the various rollers 74 arranged transversely.

The adjustment occurs automatically by varying the parameters concerned, ie the carriage speed, the the mutual arrangement and inclination of its flaps 16, and the moment in which the lower die defining the mould cavity begins to descend.

Said parameters influence the material distribution within the mould cavity as follows:

- a greater carriage speed results in a greater quantity of material gathered at the right end of the cavity in Figure 1 and vice versa
- widening the flaps 16 in the central position increases the quantity of material at the centre of the cavity and vice versa
- inclining the flaps 16 forwards increases the quantity of material at the right end of the cavity in Figure 1 and vice versa
- advancing the descent of the lower die increases the quantity of material at the right end of the mould in Figure 1 and vice versa.

In general, slowing down the carriage within a certain region increases the material quantity charged into that region.

All said adjustments are preferably made during successive cycles, ie for successive tiles, until a statistically acceptable charging is achieved.

The invention is not limited to that illustrated and described, but also covers improvements and modifications falling within the scope of the following claims.

Claims

1. A method for manufacturing ceramic tiles in general by pressing in an isostatic mould in which the die provided for forming the feet comprises a membrane rigidly supported at the feet, said mould being mounted in a press equipped with a carriage for charging material into the mould cavities, characterised by comprising, at predetermined time intervals, the following operations:

- measuring within the tile the maximum deviations from a reference plane of those regions (66) adjacent to the feet
- processing said deviations in a microprocessor
- modifying, on the basis of the extent and distribution of the measured and processed deviations, at least one of the following parameters: carriage traversing speed, commencement of the descent of the mould lower die in relation to the carriage position, inclination of the divid-

ing flaps present in the carriage cavity.

2. A method as claimed in claim 1, characterised in that the deviation measurement is effected in the direction of tile advancement.

3. A method as claimed in claim 1, characterised in that when a material excess towards that side of the cavity more distant from the charging carriage is detected, at least one of the following parameters is modified as stated:
- the carriage traversing speed is reduced
- the commencement of die descent is delayed
- the dividing flaps present in the carriage cavity are inclined rearwards, and vice versa.

4. A method as claimed in claim 1, characterised in that when a material excess in the central region of the mould cavity is detected, the distance apart of the central flaps of the series of flaps present in the carriage is reduced, and vice versa.

5. A method as claimed in claim 1, characterised in that the carriage is driven at variable speed during each travel stroke, such that if an excessive material accumulation occurs within a certain region of the mould the carriage speed in said region is increased, and vice versa.

6. A plant for implementing the method claimed in claims 1 to 5, characterised by comprising
- a ceramic tile forming press, on which there is mounted
- a carriage (47) for charging the material to be formed into an isostatic press having a lower die (2) for forming the rear of the tiles (99), and in which
- a membrane (22) is provided lying over chambers (60) intended to contain hydraulic oil and is fixed to the die at those regions (29) which are to form the feet (33)
- said chambers being in hydraulic communication with the press operating cylinder (1), and, between them,
- means, positioned in the tile advancement direction, to measure the maximum distance, within the tile, between those regions (66) between the feet (33) and a reference plane (100), and
- an electronic processor for processing the measured data and for controlling at least one of the following:
- carriage operating means; lower die lowering means; and means for modifying the carriage configuration.

7. A plant as claimed in claim 6, characterised in that the hydraulic connection between the cylinder-piston unit (1) and the chambers underlying the membrane (22) comprise, in order starting from said unit (1), a valve unit (4) operating by a pressure lower than the maximum pressure of the unit (1), and a pressure multiplier (5).

8. A plant as claimed in claim 7, characterised in that said valve unit (4) comprises a sequence valve (41) provided with automatic regulating means and bypassed by a non-return valve such as a ball valve (43).

9. A plant as claimed in claims 6 to 8, characterised by comprising, within one and the same frame, more than one cavity (46) with their respective die (2) for forming the rear of the tile, each die comprising chambers (60) containing hydraulic oil and connected by independent hydraulic connections to that chamber of the unit (1) which exerts the forming pressure.

10. A plant as claimed in claim 6, characterised in that the means for measuring the maximum distance between the regions between the tile feet and a reference plane comprise a series of side-by-side feelers positioned along a line perpendicular to the tile removal direction.

11. A plant as claimed in claim 10, characterised in that each feeler comprises an idle roller (74) with its axis horizontal and positioned transverse to said tile removal direction, said roller being supported by a body (73) arranged to slide relative to an element (75), such as an electric coil, which in combination with said processor is able to measure, process and convert the travel amplitudes of said body (73).

12. A plant as claimed in claims 6 and 11, characterised in that said central processor (174) comprises means for storing tile geometrical characteristics, such as the distance between the feet (33), their thickness, and the average allowable tile thickness, and for emitting correlations such that the readings provide the most appropriate adjustment for achieving a uniform layer of pulverulent material.

13. A plant as claimed in claim 6, characterised in that said carriage is driven with horizontal reciprocating rectilinear motion by a connecting rod-crank system (49) operated by a direct current electric motor (48) with continuous r.p.m. adjustment operationally connected to said central processor (174).

14. A plant as claimed in claim 6, characterised in that the travel strokes of the lower die are controlled by fine adjustment means consisting of actuators (440) the operation of which is controlled by the central processor.

15. A plant as claimed in claim 13, characterised in that said carriage (47) comprises a rectangular frame (64) the longitudinal members of which are connected together by transverse flaps (16) of adjustable distance apart and adjustable orientation.

16. A plant as claimed in claim 15, characterised in that the distance between the flaps is adjusted by two threaded shafts (67) rotatably mounted on longitudinal members and driven by respective motors (670) controlled by the central processor (174), said two threaded shafts being inserted with clearance into respective holes provided at the ends of said flaps (16) and each comprising two opposing opposite handed threads supporting the flaps by way of quick release members.

17. A plant as claimed in claim 16, characterised in that said quick release members comprise an elastically flexible rod such as a piece of harmonic steel wire (68) to be received in the upper part of the helical groove of the respective threaded shaft and fixed to a pin (69) to which the corresponding end of the flap (16) is coupled.

18. A plant as claimed in claim 17, characterised in that said flaps (16) are supported by the respective pair of terminal pins (69) in a manner able to oscillate in the vertical plane.

19. A plant as claimed in claim 18, characterised in that said oscillation is achieved by a slack engagement between each end of the flap (16) and the respective support pin (69), below which there is a thrust-adjustable push rod (71) acting against the flap (16) in opposition to an elastic repositioning member which presses against that face of the flap facing the direction of advancement of the carriage (67).

20. A plant as claimed in claim 19, characterised in that with each pair of opposing push rods (71) there is associated a respective pair of driving micromotors (171) controlled by the central processor (174).

21. Tiles obtained by the method in accordance with claims 1 to 5 and by the plant in accordance with claims 6 to 20, characterised by presenting substantially uniform compaction and a substantially uniform thickness.

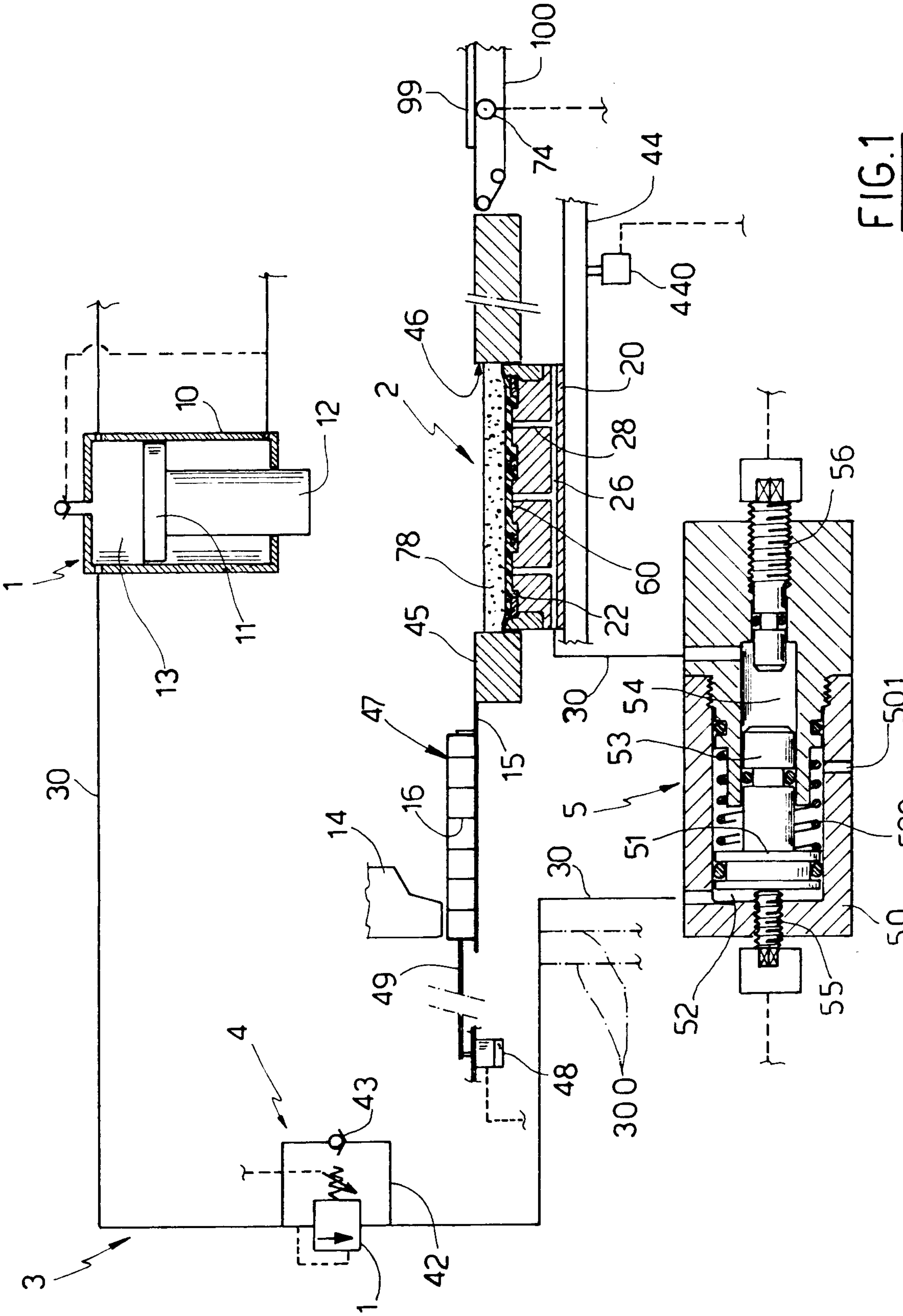
1
10
11
12
13
30
2
46
20
28
26
60
78
22
45
99
100
74
44
440
47
16
15
14
49
48
4
43
42
41
3
30
300
54
53
51
52
55
50
500
501
56
5

FIG.1

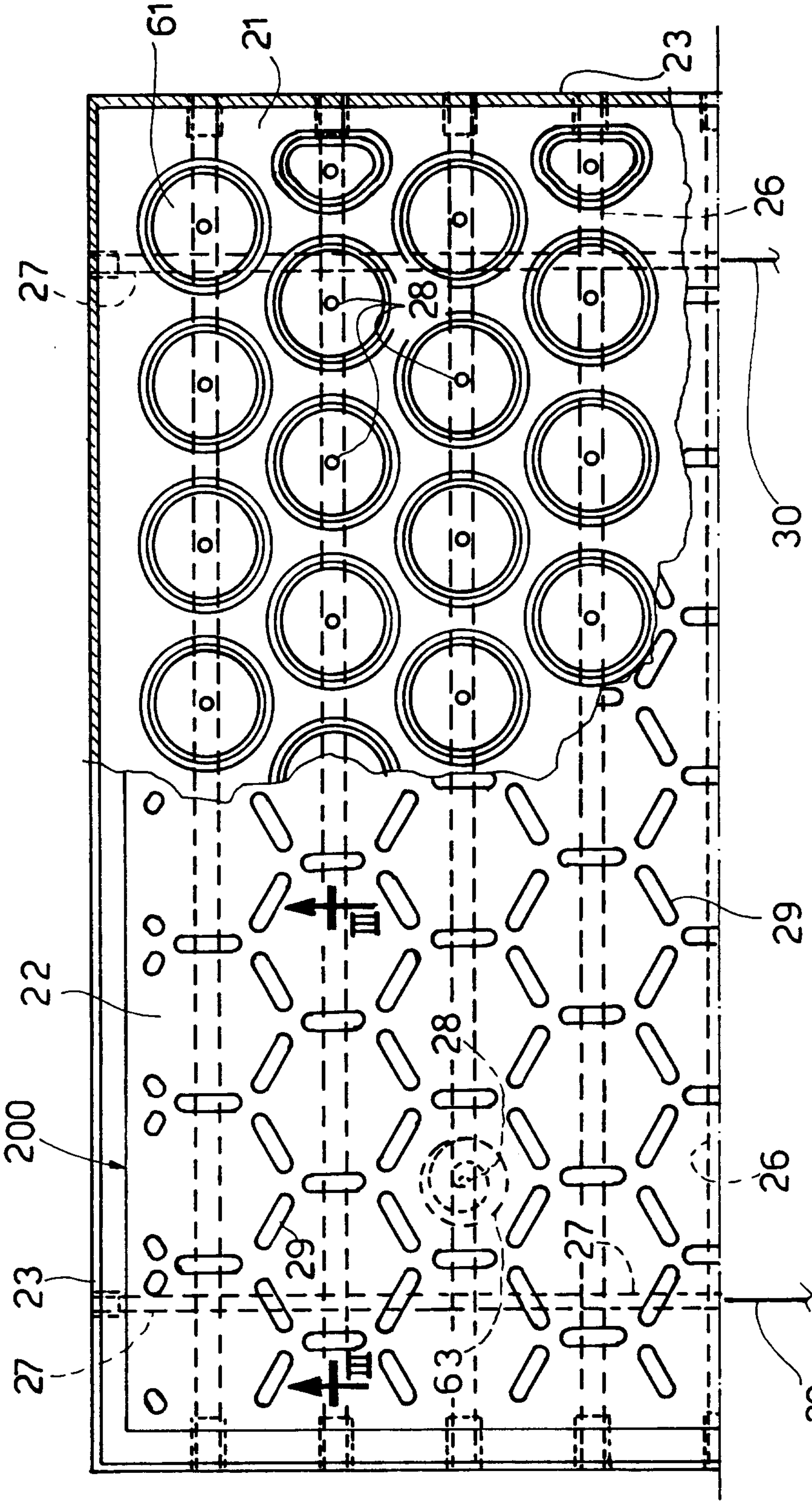

FIG.2

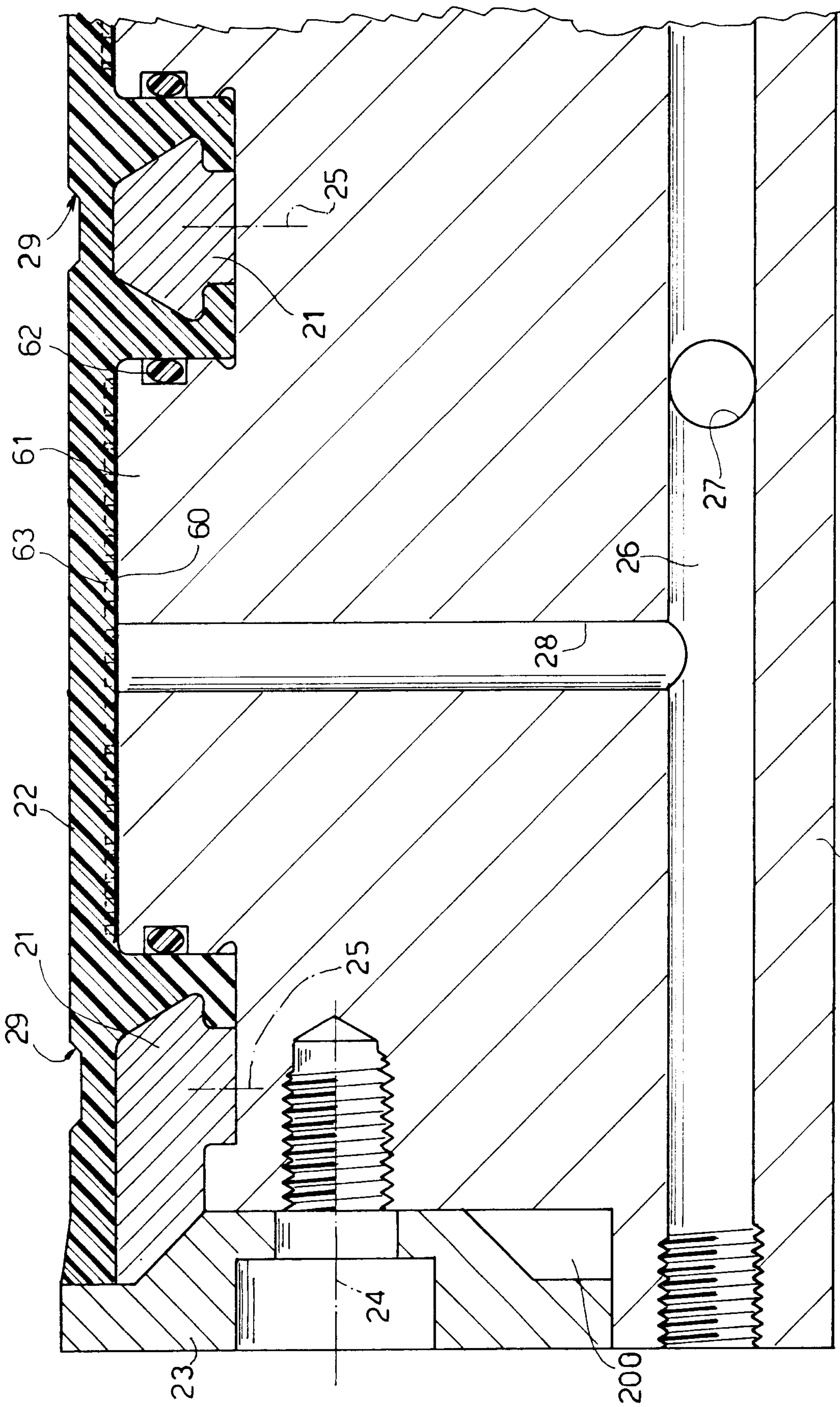

FIG.3

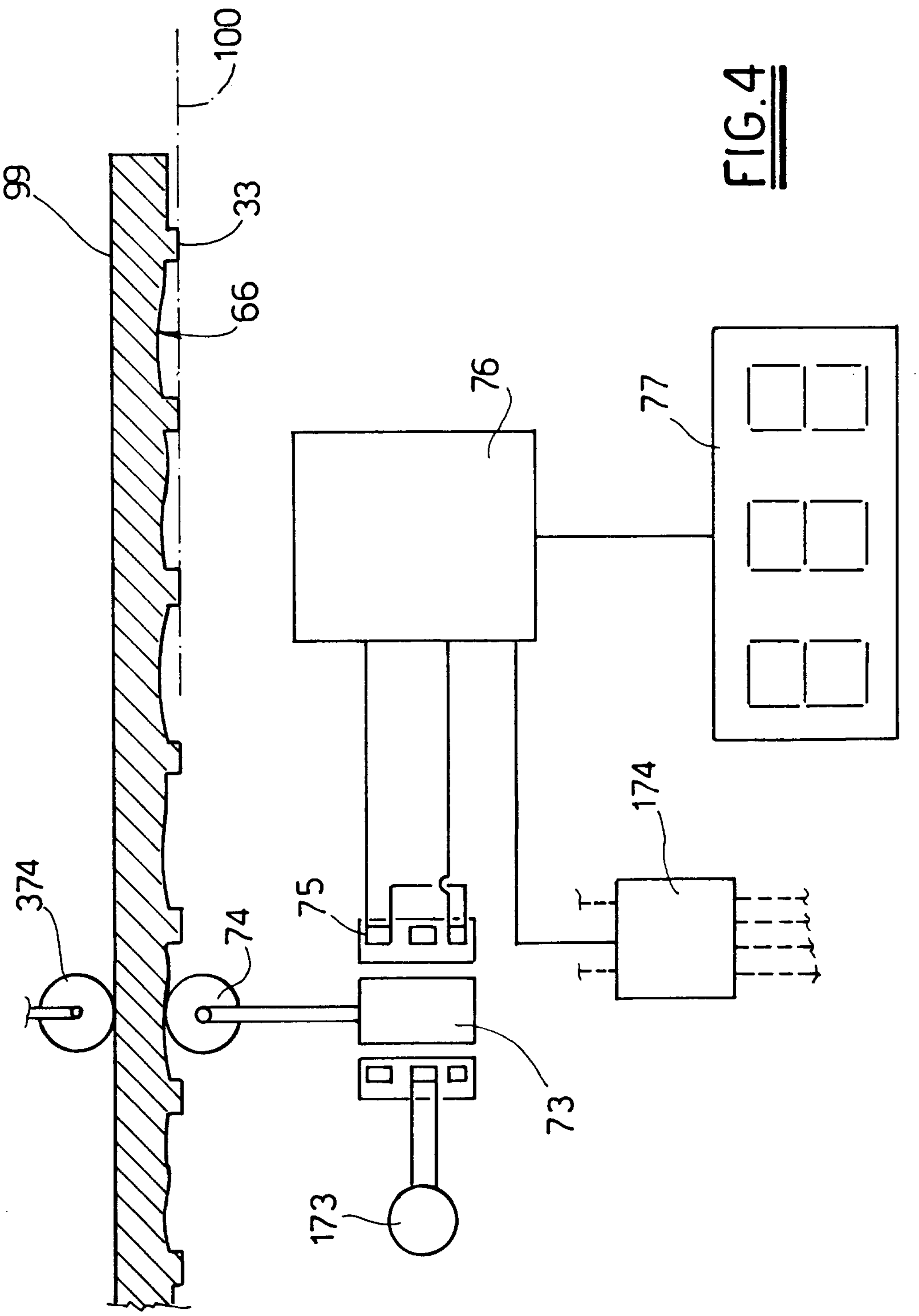

FIG.4

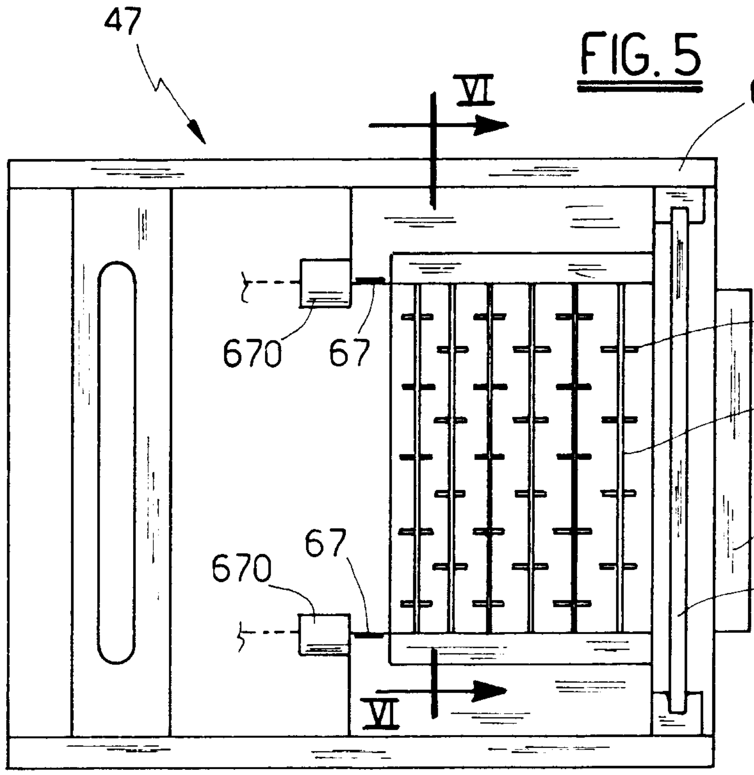

FIG. 5

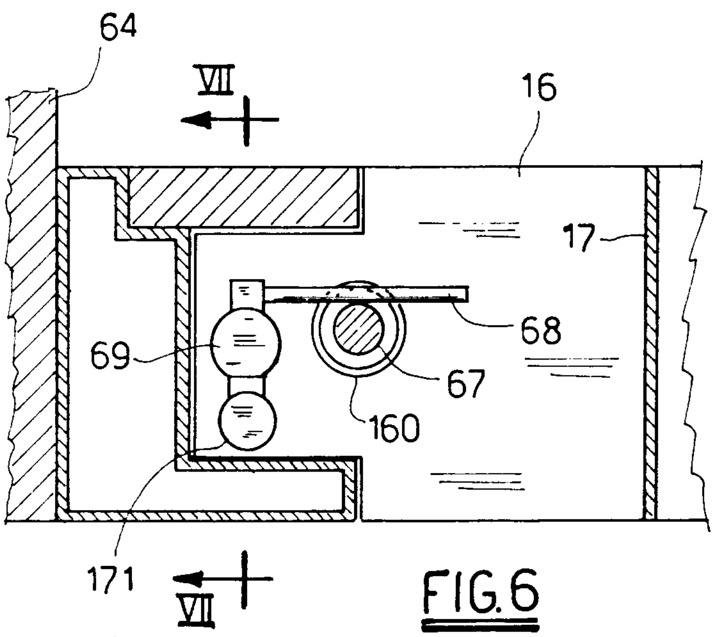

FIG.6

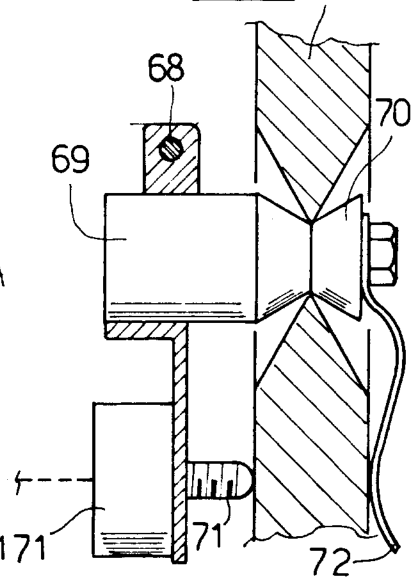

FIG.7

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 20 3545

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.6)
A	US-A-3 044 137 (G. E. KANTA) * the whole document * ---	1-3,6, 10,11, 13,14	B28B17/00 B30B11/00 B28B13/02 B28B3/00
A	FR-A-2 403 792 (WILHELM FETTE G.M.B.H.) * the whole document * ---	1,3,6, 12,14	
A	US-A-3 109 927 (F. A. LESNETT) * the whole document * ---	1,2,6, 10,11, 14,21	
A	US-A-3 079 661 (H. W. LAMB) * the whole document * ---	1,2,6, 10,11, 14,21	
A	US-A-3 604 075 (F. K. LOCKE) * the whole document * ---	1,3,5,6, 13	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
A	US-A-3 963 397 (H. F. CRUZEN) * the whole document * ---	1-3,6, 10,11,15	B28B B30B B29C
A	EP-A-0 392 593 (IBERDITAN S.A.) * the whole document * -----	1,3,4,6, 15,21	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	27 March 1995	Gourier, P

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