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(54) **Isostatic die, particularly for ceramic tiles and relative method.**

(57) The isostatic die for pressing items, in particular ceramic tiles, makes for greater uniformity of pressing by compensating for differences of density occurring when loading the matrix with the powders to be pressed ; said die consists of an elastic membrane (5), delimiting externally a cavity in the punch or in the matrix, the membrane being connected to elements (1 ; 3 ; 18 ; 103a ; 111 ; 128 ; 129 ; 208 ; 316) for controlling deformation, among which is a plate (18 ; 111) attached in a predetermined way to the membrane (5) and/or to the cavity of the matrix and/or of the punch ; its use is foreseen in establishments for the manufacture of ceramic items.

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The Invention concerns an isostatic die, particularly for ceramic tiles, divided into two semi-dies (punch and matrix), at least one semi-die having at least one cavity containing a substantially incompressible fluid, the side of the cavity facing the clay mixture to be pressed being closed by an elastic element, said elastic element comprising a central zone and a peripheral zone.

The state of the art involves Patent IT-A-1 104 511, by the same applicant relating to a method and a device for achieving uniform pressing of ceramic tiles.

The method envisages the application to the free surface of the clay mixture introduced into the opening of the die, during the action of pressing of an elastic moulding surface, or elastic membrane, held in firm contact with the clay mixture, to form one face of the tile, by means of an incompressible fluid: this, to neutralize the effects of zones of disuniform density in the body of the formed tile which would cause uneven shrinkage on firing, with consequent variations in the size, or linearity, of the sides of the tile and/or of the planarity of its surface and with the additional possibility of cracking or breakage.

The methods and the device according to the state of the art have introduced the fundamental concept of an incompressible fluid, for example, oil, acting on an elastic membrane and interposed between the punch and the membrane.

However, said method and device do not always enable sufficiently flat (back) surfaces, and hence sufficiently uniform tile thickness, to be readily achieved, particularly in the case of large formats: indeed, in the die described in the state-of-the-art patent, a variant has recently been proposed featuring an auxiliary punch base with, on its front face, a chessboard-like array of large flat squares surrounded by channels for the distribution of the liquid, communicating with the internal surface of the overlying membrane by means of large, corresponding square alveoli, forming part of an intermediate punch-plate superimposed on said auxiliary punch base; the smooth inner surface of the overlying (vulcanized) membrane is moulded to afford an array of large, flat square protruding bosses surrounded by channels corresponding exactly to the aforesaid configuration of the upper face of said base of auxiliary punch.

In particular, the drawback of this punch consists in the precariousness of the anchorage of the elastic membrane, due mainly to the tendency of the fluid under pressure to tear it along the narrow anchorage zones; also, it is of extremely complex construction and cannot be renovated should the membrane be damaged; furthermore, the considerable size of the square alveoli causes a notable deformation of the membrane with consequent unacceptable defects of planarity in the pressed tile. Furthermore, the membranes according to the state of the art, particularly in the case of en bloc dies, have a tendency to assume a convex shape during the loading of the clay powder to be pressed, with consequent undesirable alteration in the thickness of the soft layer of mixture.

Finally, with the conventional mixture loading devices, there is no control over the thickness of the mixture-layer to be pressed, with resulting unacceptable variation in the density and/or thickness of the body of the tile.

Such prior art may be subject to further improvements with a view to eliminating the said drawbacks.

A primary object of the present invention is to find an isostatic die of the aforesaid type that need not be built up of several transverse component parts to enable a membrane to be attached to intermediate supports.

A further object of the present invention is to eliminate the complex machining needed on the surface of the punch to create the interconnecting conduits of the alveoli.

A further object of the present invention is to avoid ridging or curling of the membrane during pressing.

A further object of the present invention is to allow the manufacture of items, particularly tiles with more or less deep veinings, or cavities, on one face without occasioning, on the opposite face, undesirable differences of lustre due to differences of compactness: this, to reduce the use of material necessary for the manufacture of the item, thereby reducing weight and cutting the costs of manufacture and transport.

A further object of the present invention is to find an isostatic die in which the membrane retains its flat shape before pressing.

A further object of the present invention is to control the thickness of the soft layer of powders to be pressed, so as to obtain uniform thickness and density in the body of the pressed tile.

The invention resolves said technical problems by adopting an isostatic die, particularly for ceramic tiles, divided into two semi-dies (punch and matrix), at least one semi-die having at least one cavity containing a substantially incompressible fluid, the side of the cavity facing the mixture to be pressed being closed by an elastic element, said elastic element comprising a central zone and a peripheral zone, characterized in that at least the central zone of said elastic element is connected to controlling devices for controlling the deformation of the elastic element during pressing housed inside said at least one cavity and that the elastic element is coupled to said deformation-controlling devices on at least two non-parallel planes.

In one particularly advantageous embodiment, the elastic element consists of an elastic membrane.

In another particularly advantageous embodiment, said deformation-controlling devices consist of a moulding plate anchored to said elastic element.

In another particularly advantageous embodiment, the moulding plate is continuous and fixed to said elastic element in such a way that the whole surface of said plate facing the powders to be pressed is anchored to said elastic element.

In another particularly advantageous embodiment, the moulding plate presents a plurality of through-apertures, in such a way that said elastic element is anchored to said plate at least in the zones defining the border of said apertures on the side of the plate facing away from the powders to be pressed.

It is to be noted that the moulding plate has the additional function of allowing the distribution of the incompressible fluid in the cavity of the relative semi-die.

It is to be noted, furthermore, that, on completion of the membrane-shaping process, the moulding plate can be eliminated, for example, by a chemical process, whereby a substance that will corrode said plate, but not the membrane, is introduced into the cavity, or by a physical process, whereby, for example, the semi-die is heated to a temperature at which the plate melts, while the membrane remains firmly attached to the cavity.

It is to be noted, furthermore, that, in the embodiment with a plate with apertures, the surface of the plate facing the bottom of the cavity is treated with an adhesive, while the opposite surface is treated with a non-stick agent to prevent the membrane from adhering to it.

In a further particularly advantageous embodiment, said elastic element is anchored to said plate over its entire surface on the opposite side to that facing the powders to be pressed.

Furthermore, elastic elements can be placed between the bottom of the cavity and said plate.

In another particularly advantageous embodiment, said deformation-controlling devices consist of appendages protruding from the face of said elastic element facing the cavity and anchored in a plurality of non-communicating grooves in the bottom of the cavity itself; said grooves being advantageously spread with adhesive to ensure that the membrane adheres to them during the moulding process.

It is to be noted that the distribution of said grooves can be based on an labyrinth pattern so designed as to determine areas of membrane anchorage delimiting a formation of communicating chambers in the cavity of the semi-die, destined to receive the incompressible fluid.

It is to be noted, furthermore, that the holes for the introduction and discharge of the incompressible fluid protrude from the bottom of the cavity through a spot-facing that can be blocked with a plug during the moulding of the elastic membrane, the plug remaining partially incorporated in the membrane itself.

In order to prevent said membrane adhering to the bottom of the cavity, those areas of the bottom of the cavity of the semi-die where the membrane should not adhere can be sheathed in plastic, or paper, with holes punched where said apertures occur.

In another particularly advantageous embodiment, said appendages consist of caps, or hollow elements with the concavity facing the surface of the bottom of the cavity of said at least one semi-die, the back of said hollow elements being anchored to said elastic element.

The sides of said hollow elements being coupled so that they slide in the cavity of said at least one semi-die or being fixed to it.

In another particularly advantageous embodiment, the cavity communicates with a device regulating the volume of fluid in the cavity of the said at least one semi-die, said controlling device serving to alter the deformation of said elastic element during pressing.

Said device being such as to enable the ratio between the thickness of the unpressed powders and that of the powders after pressing to remain virtually constant throughout the pressed clay body.

The invention also adopts a method for the forming of ceramic items, particularly tiles, by means of an isostatic press comprising an elastic membrane delimiting a plurality of chambers containing an incompressible fluid, the chambers corresponding to cavities to be formed on the back of the tile, characterized in that the chambers are filled with a variable volume of incompressible fluid:

- during the loading of the powders, said volume being greater than that corresponding to the depth of the cavity to be formed on the back of the tile;
- during pressing, the excess of fluid is evacuated from said cavities in a controlled manner, to flow back into them when pressing is complete.

The ratio between the initial maximum and minimum thicknesses of the layer of powders and the ratio between the maximum and minimum thicknesses of said layer remains substantially constant during the pressing cycle and corresponds to that which is to be achieved in the formed tile.

The advantages offered by this invention are: lower manufacturing costs; lower running costs; possibility of renovating the die; improved functionality; possibility of adopting various, not only square, designs; maximum stability in the areas of adhesion; possibility of transforming traditional punches, even if en bloc, into punches according to the invention by the simple application of a distributing plate to, or above, the active surface of the punch itself; possibility of more efficient moulding of the membrane; greater protection of the membrane, particular where caps are adopted to isolate the membrane from the oil; possibility of greater control over the flexing of the membrane, reduction in surface defects; ease of removal of pressed items, facilitated particularly with

the adoption of the device regulating the volume of fluid and of the forming method associated thereto.

Some embodiments of the invention are illustrated, by way of example, in the 16 sheets of drawing attached, in which:

Figure 1 is a partial interrupted view of the punch, as it is used, on whose surface a moulding-distributing plate is positioned, shaped so as to constitute a labyrinth tray, or liquid chamber, to enable the penetration of liquid between it and the elastic membrane above it, in the thickness between the base and the plane of the raised borders of the tray;

Figure 2 is the transverse section II-II of Figure 1;

Figure 3 is a section as in Figure 2, but relating to the preceding moulding phase of the elastic membrane;

Figure 4 is a section as in Figure 2, as set up for the forming of the tile, that highlights, with an enlarged scale, on one side, possible deformations in the membrane, on the other side, uniformly distributed coplanar areas;

Figure 5 and 6 are plan views of variations in the design of the surface of the punch and of its covering distribution plates or membranes;

Figure 7 is section VII-VII of Figure 5, in the case with the punch covered with a membrane layer of reduced thickness directly against the active face of the punch;

Figure 8 is a partial, interrupted plan view of the corner of the punch in the case of a flat plate, distanced from the surface of the punch;

Figure 9 is section IX-IX of Figure 8;

Figure 10 is section X-X of Figure 8;

Figure 11 is a partial, interrupted plan view of the punch of the die, in the case of the elastic membrane having a labyrinth on its lower surface and of the punch having corresponding channels, the top part showing the metallic surface and the bottom part showing the elastic membrane;

Figure 12 is the vertical transverse section XII-XII of Figure 11;

Figure 13 is the vertical transverse section XIII-XIII of Figure 11;

Figure 14 is a section as in Figure 12, in the case where a sheet is inserted between the smooth upper surface of the punch and the internal labyrinthed surface of the membrane, which is self-adhesive, or however made to adhere, made of paper or plastic, having the function of a non-stick agent: the said sheet being punched (that is interrupted) in the areas corresponding to the areas of adherence of the membrane to the said face;

Figure 15 is a vertical section of a semi-die according to the invention in which a plate of flexible material is inserted between the elastic membrane and the smooth upper face of the punch to transmit the pressure to the entire surface in a more uniform manner by the elimination of the forces that tend to deform the elastic membrane in the horizontal plane and allow bending only in a vertical direction;

Figure 16 is a section as in Figure 15, but after the introduction of the liquid;

Figure 17 is a section as in Figure 15, but relating to the pressing phase of the product;

Figure 18 is the plan view, partially sectioned, of a punch whose top surface has alveoli for the introduction of the oil, each alveolus having a cap made of preformed elastic material, on the upper side made rough and covered in an adhesive substance, with covering elastic membrane vulcanized in situ, reproducing, on the external face, the negative of the back of the tile;

Figure 19 is the partial and partially sectioned elevation of a punch as in Figure 18 during the vulcanization of the elastic membrane over the preformed caps: purely by way of example, the first alveolus on the left being occluded by a plate cap whereas the second being occluded by a hollow cap;

Figure 20 is a perspective view of a plate cap;

Figure 21 is a perspective view of a hollow cap;

Figure 22 is a partial elevation of a punch with alveoli respectively for a plate cap and a hollow cap;

Figure 23 is a section of part of a punch with membrane and hollow cap for each alveolus;

Figure 24 is a vertical section of a membrane die for ceramic tiles of a type with a single imprint, with a single volume regulating device according to the invention, or even centralized in the case of a number of imprints, filled with liquid or incompressible type fluid, prior to use;

Figure 25 is a section as in Figure 24, but in the final pressing phase;

Figure 26 is a section as in Figure 24, but with the position of the baffle plate inverted and during the initial compression phase: in this case the' displacement of a part of the mixture occurs on contact with the bulging parts of the membrane, causing differences in compression in relation to the preceding case, which, however, can be corrected by altering the excess in depth taken on by the chambers of the punch in relation to the depth of the cavities on the back of the tiles;

Figures 27 and 31 show, in a sectioned side view, a improved die analogous to that in Figures 15 and 17, with elastic membrane having adjustable trim, in particular during the loading phase of the mixture;

Figures 28 and 32 show, in a sectioned side view, a die according to the invention in the loading phase in two different embodiments;

Figure 29 shows the invention in use without the

introduction of liquid between membrane and imprint, in the chamber that they define;

Figure 32 shows, again in a sectioned side view, the die illustrated in Figure 31 during the filling phase prior to pressing;

Figure 33 shows a pressing phase carried out with the combined use two embodiments of the present invention, one lower one, acting as a baffle plate, with pre-positioned membrane, and one upper one acting as a punch with pressure-equalizing fluid;

Figures 34 and 35 are sections as in Figures 27 and 28 in a version of design of the elastic media that act also as seals;

Figures 36 and 37 are sections as in Figure 35, but relating to different versions of coupling joint between moulding plate and elastic membrane;

Figures 38 and 39 are sections as in Figures 34 and 35, but relating to further versions of the die according to the invention, in which the moulding plate is divided in two parts, the innermost one having the function of defining the chamber of fluid during moulding and the outermost one, which is floating, acting as a stiffener;

Figures 40 and 41 are sections as in Figures 34 and 35, but relating to further versions with single-piece moulding plates and elastic membrane enveloping the plate on both its surfaces that lie in planes that are substantially parallel to the moulding plane;

Figure 42 is a section as in Figure 35, but relating to a further advantageous embodiment, in which the moulding plate is divided in two parts, the innermost part being simply a frame in the base of the cavity of the corresponding semi-die.

The Figures show: 1, a plate, for example, having a thickness ranging from a few tenths of a millimeter to a few millimeters, depending also on the dimensions of the tiles, glued or however coupled to the active face of punch P, corresponding to the back of the tile, having through-apertures with tapered raised edges 2 - for example, of the order of a millimeter, or part thereof - for example, advantageously in the shape of a rounded slot.

The apertures, with the preferred shape of a slot, are suitably spaced to anchor the elastic material of the membrane and have lengths, by way of example, of a few centimeters and widths of a few millimeters; the said apertures being distributed in relief inside a tray V having interconnecting chambers distributed around the said raised edges.

The set of edges 2 of the said apertures lying preferably on a plane parallel to that of the said plate constituting the base of the said tray.

A number of risers 3, or keys, can be fixed to the said active face of the punch, each riser being inserted in a said slot and with its extremities coupled to those of the slot itself, whereas the sides of the risers remain clear of the corresponding edges of the said slots with a clearance 4 of at least a few tenths of a millimeter, sufficient to permit the passage of the filling material - for example, vulcanized rubber - that is to constitute the elastic element, or elastic membrane 5, the membrane adapting itself to the disuniformity of the mass of mixture placed in the mould of the die to obtain a uniform compression in the mass itself, in its every point during pressing.

The presence of the said keys constituting gripping elements and reducing the thickness of the membrane in relation to the raised edges that make up the design of the base of the tile.

Elastic membrane 5 also having indentations 6, 6a formed during moulding by corresponding bosses 7 on moulding matrix 8 of membrane 5 (Figure 3).

Membrane 5 also having an indented peripheral border 9 whose base is coplanar with those of indentations 6 that, during pressing, form the so called "feet" or support ribs on the back of the tile, or their complements.

There are also a number of holes 10 for the introduction of liquid 11, for example oil, in tray V, after the membrane has been moulded, after the possible chemical disintegration and/or physical elimination of the material of the plate, for example, by making use of the same hole; hole 10 being closeable with plug 12 to prevent it from becoming filled with the material the membrane is made of when it is poured or else when it is being moulded. The plug itself - for example, cylindrical - penetrates in a corresponding hole in plate 1, when still in situ, and, together with one or more other analogous plugs, act as a reference pin for the plate.

A layer 13 of non-stick material applied to the internal surface of tray V to prevent the moulding material of membrane 5, however placed in it, from sticking to it permanently: the keys, the flat portions of the punch and the internal portions of the openings or raised holes - that is the lower uncovered surface of tray V - on the other hand, are covered with an adhesive substance.

Figure 4 shows: 14, the tile being formed; 8, the buffer plate constituting the base of the matrix of the die, whose external face corresponds to the flat top face of the tile; 15, one of the walls of a mould or cavity of the die; 16, 17 (Figures 5 and 6) elastic membranes having a different design to that of membrane 5 of the first Figures; 16a, 17a, indentations in the external face of elastic membrane 16 and 17: respectively with apertures 16b of tray V in relation to indentations 16a; 18, (Figures 8 and 9) a flat plate positioned above, distanced from, active surface 19 of punch P, which can be seen through apertures 20: said plate being treated with non-stick agent; 21, a gasket for liquids in a seat obtained in the body of the punch P; 22, the base of punch P; 23, an externally conical bush inserted in hole 24 of punch P during as-

sembly to fit tightly, with a wet seal, the lower inlet of hole 25 obtained in the lower part of tubular appendage 26 made of the same material as the elastic membrane by means of a pin with its upper extremity inserted in hole 27 in distribution plate 18 before membrane 5 is moulded; 23a, the hole of bush 23; 28, a lower layer of membrane 5 distancing distribution plate 18 from active surface 19, even in part pre-formed and inserted; 29, an advantageous alternative version of bush 23 fitted tightly into hole 25 of the lower appendage of membrane 5; said bush having base 30 with seal 31, truncated cone stem 32 with axial hole 33 having seal 34 around the end cylindrical portion. It is to be noted that the apertures 16b and 20 could be replaced with a series of holes spaced out along the same path of the aperture.

The moulding of the elastic membrane is as follows: tray V, having been obtained by blanking and drawing or by pressing, or even simply by blanking in the case of the flat plate 18, its surface facing the membrane having been treated with a non-stick agent, is placed on the upper surface of punch P, positioning it by means of suitable pins 12 (not shown in Figure 9), subsequently also acting as plugs, otherwise glueing it on or keeping it raised to permit the penetration beneath it of the elastic material during moulding that also has to be present in punch P; having inserted, where necessary, keys 3, covered in adhesive material, as with the other surfaces that can come into contact with the material as it is poured through the apertures, the elastic material making up membrane 5, or membranes 16, 17 is then poured, either cold or heated: this, in such a way so that the said material infiltrates through the clearances 4 to fill even the interstices existing between the external surface of the punch and the external surface of the tray and remaining stuck to it; the surface of the elastic membrane that moulds the back of the tile during pressing being shaped, with in situ moulding, by matrix 8 (Figure 3); plugs, or pins 12, are then extracted from holes 10 so that they may be used, entirely or in part, as feed or discharge channels for the incompressible fluid, centering them on the corresponding channels made for this purpose in the plate on which the punch is positioned: this after having possibly eliminated - either chemically or physically as described earlier - the tray-shaped or flat plate V; having introduced the liquid - for example, oil - under a modest pressure, sufficient to cause the separation of the surface of elastic membrane in contact with the surface of the tray (if it has not been eliminated), until it is full, the inlet and outlet holes for the said liquid are then closed off.

Operation is as follows: if, as the punch enters the matrix, whose base consists of baffle plate M that defines the front face of the tile, the mixture is not uniformly distributed and/or does not have a constant density, the membrane deforms, in as much as the mixture is compressed only in the zones that are less compacted, (see Figure 4, which highlights the zones that remain flat and coplanar): this results in the back surface of the tile possibly having slight deformations (concave or convex) in areas that do not correspond to points of support or reference 6, 9,16a, 17a.

In the case of Figure 7, where keys 3 are missing, the elastic layer of the membrane is in points thinner and the stiffness is given by the presence of the surface of punch P rather than by the surface of key 3.

As regards the elastic membrane, it can be stiffened transversely by means of, advantageously, inextensible fibres inserted in it, during vulcanization: this prevents marked undulation, whilst conserving longitudinal elasticity.

It is to be noted that the feet or ribs on the back of the tile can be of any other convenient form, for example, even of the type having cells in the form of a honeycomb.

Furthermore, the punch can perform the function of the baffle plate and vice-versa.

The Figures also show: 101, the top face of punch P having anchorage grooves 102, even having sides diverging downwards thereby creating undercut, covered with adhesive substance, and peripheral frame 103 with internal face similarly treated: grooves 102 being filled by appendages 103a of the elastic membrane; 104, grooves on the external surface of elastic membrane 5 vulcanized in situ, reproducing in relief the design of the back of the tile to be formed; 106, a metallic tablet, partially incorporated, for vulcanizing the internal surface of membrane 5 in relation of hole 107 for the supply of liquid 11 to chambers 108, or interconnected cavities (Figure 12), protruding from the said internal surface and fitting, creating a seal against the poured material, in spot facing 109 that is the upper enlargement of the said hole: said tablet advantageously being tapered to be held with undercut in the elastic membrane to enable the instantaneous flow of the liquid as soon at it is opened; 110 (Figure 14), a sheet of non-stick material; 111 (Figure 15), a plate, advantageously continuous with rounded edges and possibly with an inclined lower peripheral face in flexible material, even in steel.

The plate 111 is of a thickness that ranges, for example, from a few tenths of a millimeter to a few millimeters and is interposed between the bottom surface of a cavity in the body of punch P and the lower, smooth surface of membrane 5 that provides an extensive and continuous vulcanized anchorage surface 112 (Figure 15) so as to avoid rippling and therefore excessive undulation.

In this case, with the presence of plate 111, which in practice stiffens membrane 5, the intermediate anchorage areas of the membrane/plate assembly are eliminated, except in the peripheral areas.

It is to be noted that plate 111 is able to absorb the loads set up in the membrane caused by disuniform-

ities in the density and/or composition of the powders to be pressed; in particular, the plate has to have a modulus of elasticity that enables it to deflect elastically and to compensate for the differences in reaction loads transmitted by the powder to the membrane: compared to the versions with intermediate anchorage elements, the adoption of a continuous floating plate has the advantage of being able to compensate deformation during pressing over much wider areas than those defined by intermediate anchorage elements, which have to be positioned close enough to each other to prevent excessive bulging of the elastic membrane during the pressing cycle.

The Figures also show: 114 (Figure 17), the punch and 115, the matrix of the die; 116, the external peripheral anchorage zone of the membrane; 117 (Figure 18), the top, flat surface of punch P, having frame 118; 119, the lowered plane of an alveolus with underlying tapered cavity 121 with liquid inlet hole 121; 122, a hollow cap joining with rim 123 of the alveolus; 124, grooves that surround the raised sections 125 of the membrane 126 that shape the back of the tile during pressing; 129 (on the left of Figure 19) the supporting surface of the bottom face of the elastic pre-pressed plate cap 128; 129, the top face of the elastic pre-pressed hollow cap, having peripheral rim 130; 131, (Figure 23) longitudinal oil, or liquid in general, inlet channels, communicating with transverse channels 132; 133, the intermediate anchorage zones of membrane 126, achieved with the application of a suitable substance; 134 peripheral anchorage zones; 8, the moulding matrix of the elastic membrane 126.

The edges of the elastic plate 128 and the external face of rim 130 of the hollow cap can be anchored to rim 123 of the corresponding alveolus: in the first case the liquid being prevented from coming into contact with the anchoring zones 133 and 134.

If, on the other hand, the cap is not anchored along the rim, it becomes easier for the membrane 126 to move as the cap is floating.

The join with the top face of each cap 129, 130 is obtained during vulcanization phase of the membrane 126.

The Figures also show: 201, the punch which is made to enter into matrix 202 to compress the mixture 204, wet or even dry, against the baffle plate 203; 5, an elastic membrane, or elastic element, to contain the body of liquid 11 interposed so as to fill interconnecting cavities between the membrane itself and the top face of baffle plate 203; 207, support ribbing on the back of the tile in relation to the corresponding protuberances 208 of the internal surface of the membrane 5.

The protuberances are anchored by vulcanization, and/or glueing, in the hollows 209 of the top face of baffle plate 203; 210, an inlet and outlet channel for the fluid communicating with above mentioned cavities, originating from tube 211 connected to chamber 212 of the cylinder 213, for example, double acting.

A piston, 214, of cylinder 213 is activated by pressurized inert gas in tank 215 that constitutes- the liquid volume regulator, the tank being connected to the other chamber 216 by means of tube 217. Each chamber 212, 216, advantageously for shock absorption, being filled with liquid; 218, 219, 220, 221 respectively, the two opposing end covers of the cylinder and corresponding stroke limiting elements for piston 214, in other words calibration devices in function of the volume of liquid to expel and to re-absorb; 222, a throttling and closing control mechanism, for example, a solenoid valve, inserted in tube 211; 223 (Figure 25) the formed tile.

Figure 26 shows: 224, a cylinder, whose piston 225, as with 213 but single acting, separates liquid chamber 226 from chamber 227 having return spring 228; 229, the punch having channel 230 for the introduction of the liquid in interconnected cavities 231, enclosed between punch 229 and membrane 5; 232, the earth or powder, dry or wet, with which the tile is formed; 233 a projection of the powder 232 above the closing line of the matrix, that is created at the beginning of the pressing due to the entry of protuberances of membrane 5 into the body of powder 232; 234, the punch.

Figures 24 and 25 show respectively: A, B the starting thicknesses, maximum and minimum, of the body of powder to be pressed and A', B' the final thicknesses.

The volume regulating device can, however be of a different type to those indicated and in whichever way adjustable.

With particular reference to Figures 27 to 41, 301 indicates as a whole a further version of the die object of the current invention.

Die 301 is of a type including a punch 203 in which there is at least one cavity, or recess, 303 in which a deformable membrane 5 in elastic material, for example rubber, is anchored, for example, by vulcanization, or glueing, which is anchored on a plate 11 of a stiffer material than that forming membrane 5, for example a metal. Membrane 5 is, as a rule, vulcanized on plate 111 and has a peripheral lip 306 so shaped to be inserted in a corresponding seat 307 of the recess. Between the metallic plate 11 and the plane of said recess an elastic means is interposed acting also as a peripheral seal 308, anular and deformable, which ensures sealing whilst permitting relative perimetric displacement between plate and imprint.

Punch 203 has holes 309 to introduce fluid in chamber "C" which is defined by the base of the punch, plate and perimetric elastic medium prior to the introduction of the fluid due to the plate 111 resting on elastic medium 308.

In the plane of cavity 303 there are closed seats 310 in which elastically deformable spacer elements

311 are inserted, for example, helical springs, that permit the adjustment of the trim of the plate during the loading phase of the product to be pressed and which retract partially or entirely into their seats during the pressing.

In the plane of the imprint there can be threaded holes 312 (Figure 31) for adjusting screws 313 that support the plate during the loading phase of the product to be pressed.

The top end of threaded holes 312 can open out into cylindrical seats 314 in which can be placed corresponding elastically deformable spacer elements 311: advantageously, the screws have support caps 315 at their top end: said screws have the further function of adjusting the preloading of spacer elements 311 so as to vary the trim of the membrane during the loading of the powders.

In the version illustrated in Figure 30, the plate 316 has a greater thickness and the membrane is in contact only with its rear surface: the punch 318 has a peripheral step with sharp corner in relation to which a first perimetric elastic element 308a and a second perimetric elastic element 308b are assembled: between step 319 and the corresponding seat 320 of plate 316 a seal 321 is assembled made of a material such as rubber.

322 indicates a moulding matrix for the membrane that has protuberances 323 distributed that create in membrane 5 indentations 323 which will create the so-called "feet" or support ribs on the back of the tile.

During the vulcanization phase, plate 111 is kept in the correct position with the insertion through punch 203 of pins 325, that is a pair adjusting-screw dowels 313a.

In Figures 28, 30 and 33 fluid 11 introduced in chamber C has been represented schematically with closely spaced dots: the seal is ensured by lip seal 306 cooperating with perimetric elastic media 308 or with seals 308a, 308b.

In Figures 32 and 33, Q indicates the material to be pressed and L the matrix of the die.

Figures 29 and 32 show how the screws 313 enable the positioning of the various areas of the plate at the desired elevations, functioning as reference elements for the plate during the moulding phase.

Figure 33 shows a further possible use for the invention as described: it shows how punch 203 can be used as an upper pressure-equalizing punch and made to interact with another beneath whose sole function is a controlling one; adjusting screws 313 adjusts the trim of the plate, enabling thicknesses S1 and S2 of the material to be pressed to be predetermined.

Figures 38, 39 show a further structural variation of the die object of the present invention, in which plate 111 is divided in two parts, one a floating, stiffening element for membrane 5, the other fixed to the base of the cavity, for example, by means of screws 363, in such a way that its outer edge extends inside the seat in the base of the cavity for the lip 306 of the elastic membrane 5, so as to create an undercut seal to prevent the fluid from leaking: in a particular case not shown the lip can cover entirely the underside of the plate 111, as in the case of Figure 9, acting as a sealing a support element for the plate with a function analogous to that of layer 28.

In the version of Figure 38, elastic elements 360 are inserted between the floating, stiffening part 362 of membrane 5 and the sides of the seat of lip 306: these elastic elements have the function of lifting membrane 5 after pressing and of centering stiffening plate 362 in relation to the cavity of the corresponding semi-die.

Intermediate layer 364 of membrane 5 is anchored to stiffening plate 362 and distanced from underlying moulding plate 111, so as to include a truncated cone stopper 365 in relation to each fluid inlet hole 309.

Figures 40, 41 show a version of die in which the plate 111 is made adherent on both its sides to membrane 5, as in the version of Figure 9: with respect to this version, however, lower layer 367 of the said membrane has rim 366 inserted in a groove in the base of the cavity of the corresponding semi-die, the height of rim 366 being such as to define chamber C for the fluid.

Layer 367 and the corresponding rim 366 can be pre-formed as in caps 129, 130 of Figure 19, or even integral 368, 369 with membrane 5 as shown in Figure 41, in which case there also being elastic elements 360 for the formation of chamber C.

In this way, then, the invention as described fulfills its objects, in particular in the way in which chamber C between plate 111 and imprint 303 remains defined without the intervention of thrust of the pressurized fluid that is introduced, due to the prior lifting of the plate itself which, on completion of the vulcanization phase, is supported on perimetric elastic elements 308, or on spacer elements 11; furthermore, it can assume a non planar configuration, but predetermined as required, in readiness for the loading of the material to be pressed.

In the version of Figure 34, perimetric elastic medium 308, being toroidal in form, is substituted with elastic medium 350 having a trapezoidal section, and cooperates with lip 306 of membrane 5: this providing increased safety against leakage of the liquid.

In the version of Figure 36, the peripheral coupling joint 351 between membrane 5 and plate 111 consists of a plurality of annular extensions 352, for example, a pair of extensions, defining, between them, a groove 353 in which the moulding membrane is anchored: the said annular extensions can be of different thicknesses, one with respect to the other, and can, furthermore, penetrate into lip 306 of mem-

brane 5 to differing depths; furthermore, they can be parallel to each other or inclined with respect to one another.

Figure 37 shows how the lip 306 can have a pair of opposing appendages 354, one penetrating plate 111, the other penetrating the body of punch 203: this to further improve sealing against leakages of the fluid.

In Figure 42, the lower portion of the moulding plate is limited to a peripheral frame 372 extending towards the seat of lip 306 so as to divide it into two limbs during moulding, in a way analogous to that of Figure 35.

Each limb of lip 306 can have an annular sealing appendage 371 inserted in corresponding grooves respectively in the body of matrix 203 and in floating plate 111.

Frame 372 can be fixed to the base of the cavity by means of screws 363, or simply placed on it, in both cases the said frame being treated with a non-stick agent so as not to adhere to the material making up membrane 5 during moulding: this contributes to improving the coupling of the membrane to the semi-die.

The version of Figure 42 is of particularly simple construction.

It is to be noted that elastic elements 308, 350 have the double function of lifting the plate and of sealing against fluid leakage from chamber C, whereas elastic elements 311, 360 do not have a sealing function, being therefore isolated, that is, peripherally interrupted to allow the passage of fluid into the cavity.

Furthermore all the elastic elements mentioned above can be inserted between the sides of the seat for lip 306 and floating plate 111, to contribute advantageously to its centering in the cavity of the corresponding semi-die.

The invention as described is susceptible to numerous changes and variations all included in the domain of the present invention.

Furthermore, all the details of execution may be replaced by others that are technically equivalent.

In practice the materials employed, as well as the forms and dimensions, can be varied as required without departing from the giuridical domain of the following claims.

Claims

1. An isostatic die, particularly for ceramic tiles, comprising two semi-dies (punch and matrix), at least one semi-die having at least one cavity containing a substantially incompressible fluid (11), said at least one cavity being closed on the side facing the clay mixture to be pressed by means of an elastic membrane (5), the elastic membrane (5) comprising a central zone and a peripheral zone, characterised in that at least the central zone of said elastic membrane (5; 128; 130) is joined to controlling means (1; 3; 18; 103a; 111; 128; 129; 208; 316) for controlling the deformation of the elastic element and that the elastic membrane is attached to said means of controlling deformation on at least two non-parallel planes.

2. An isostatic die, as claimed in claim 1, characterised in that said means of controlling deformation consist of a moulding plate (1; 18; 111; 316; 362; 372) anchored to said elastic membrane (5).

3. An isostatic die, as claimed in claim 2, characterised in that the moulding plate (111; 316; 362; 372) is continuous and fixed to said membrane (5) in such a way that the surface of said plate facing the powder to be pressed is anchored to said elastic membrane (5).

4. An isostatic die, as claimed in claim 3, characterised in that around the edge of said elastic membrane (5) there is a peripheral appendage (103a; 306) inserted in a corresponding groove (116; 307) cut to correspond with the bottom of said cavity.

5. An isostatic die, as claimed in claim 4, characterised in that the outer edge of said plate (111, 362) is rounded and abuts the inside wall of said peripheral appendage (103a; 306).

6. An isostatic die, as claimed in claim 5, characterised in that the lower peripheral surface of the outer rounded edge of said plate (111; 362; 372) is bevelled.

7. An isostatic die, as claimed in one or more claims 3 to 6, characterised in that between said plate (111; 316) and the bottom of said cavity (303) is inserted at least one elastic element (308; 308a; 308b, 311).

8. An isostatic die, as claimed in claim 7, characterised in that the inner edge of said peripheral appendage (306) is in the form of a lip curling around the edge of said plate and cooperating with a perimetric elastic element (308; 308a; 308b; 311; 350; 360).

9. An isostatic die, as claimed in claims 7 or 8, characterised in that said elastic membrane (308; 308a; 308b; 311; 350; 360) lodges in a seat (310; 312) in the bottom of said cavity (303).

10. An isostatic die, as claimed in claims 7, 8 or 9, characterised in that said at least one elastic ele-

ment (308; 308b; 350; 360) is lodged in a seat in the body of the plate (111; 362).

11. An isostatic die, as claimed in claims and/or 10, characterisedin that said at least one elastic element (311) cooperates with an axial-adjustment element (313, 313a) lodging in said seat (312) formed in the bottom of said cavity.

12. An isostatic die, as claimed in claims 9 and/or 10, characterised in that said at least one elastic element (308) has a circular right-angle cross section.

13. An isostatic die, as claimed in claims 9 and/or 10, characterised in that said at least one elastic element (350) has a trapezoidal right-angle cross section.

14. An isostatic die, as claimed in claim 7 and one or more of claims 8 to 13, characterised in that said lip has at least one annular appendage (354) penetrating a corresponding groove in the die element (111, 203) opposed to it.

15. An isostatic die, as claimed in claim 7 and one or more of claims 8 to 14, characterised in that the edge of the plate (111) has a plurality of annular projections (352) cooperating with the lip (306).

16. An isostatic die, as claimed in one or more of the preceding claims, characterised in that, between the plate (111) and the surface of the membrane (5) in contact with the powder to be pressed is a stiffening plate (362) cooperating with the elastic elements (360).

17. An isostatic die, as claimed in claim 16, characterised in that the moulding plate comprises a fixed part (11) integral with the bottom of said cavity and a floating part (362) stiffening the membrane (5): the fixed part of said plate extending peripherally into the seat of the lip (306) of the membrane (5) at least as far as is necessary to form an undercut anchorage for the membrane itself.

18. An isostatic die, as claimed in claim 17, characterised in that the fixed part of said moulding plate is in the form of a peripheral frame (372).

19. An isostatic die, as claimed in one or more of the preceding claims, characterised in that the plate (111) is fixed to the membrane (5) on both its faces parallel to the moulding surface: the lower part (367; 369) of said membrane having a peripheral rim (366; 368) lodging in a corresponding groove in the bottom of the cavity and its height determining the height of the chamber (c).

20. An isostatic die, as claimed in claim 9, characterised in that said elastic membrane comprises two perimetric, concentric elastic elements (308a; 308b) cooperating with an annular seal (320) inserted between the plate (316) and the body (318; 319) of said semi-die.

21. An isostatic die, as claimed in claim 2, and in one or more of claims 3 to 20, characterised in that the membrane is stiffened, in the direction parallel to the moulding surface, by means of inextensible fibres.

22. An isostatic die, as claimed in claim 3, when dependent on claim 2, characterised in that the moulding/distribution plate (1; 18; V) has a plurality of through-apertures (8; 16b) shaped in such a way that said elastic membrane (5) is anchored to said plate at least in the zones defining the edge (8) of said apertures on the side of the plate facing away from the powders to be pressed.

23. An isostatic die, as claimed in claim 22, characterised in that the plate (1; 18; V) is made of material that can be disintegrated once the membrane (5) is formed.

24. Isostatic die, as claimed in claim 22, characterised in that the edges (2) of said apertures (8; 16b) are raised in relation to the bottom of the cavity of the relative semi-die and lie substantially on one and the same plane.

25. An isostatic die, as claimed in claim 22, characterised in that said plate (1; 18; V) has holes (1) for the introduction and discharge of the liquid, it being possible to block said holes during moulding by means of plugs (12).

26. An isostatic die, as claimed in claim 22 and one or more of claims 23 to 25, characterised in that, in the apertures of the plate (1; 18; V) are inserted risers (3) fixed to the bottom of the relative cavity of the semi-die and having sufficient clearance (4), with respect to said apertures, to permit the flow of the material constituting the plate during moulding for adhesion to the bottom of the cavity.

27. An isostatic die, according to 22, characterised in that said elastic membrane (5) is anchored to said plate (18) throughout its whole surface on the side facing away from the powders to be pressed.

28. An isostatic die, as claimed in claim 27, characterised in that the plate (18) is raised from the bottom of the cavity of the relative semi-die so as to

facilitate the penetration of the material constituting the membrane (5) during the moulding of said membrane.

29. An isostatic die, as claimed in claim 28, characterised in that the surface of the plate (18) facing away from the powders to be pressed is affected by the presence of spacing elements precast in the same material as the membrane (5).

30. An isostatic die, as claimed in one or more of claims 22 to 29, characterised in that the surface of the membrane (5) facing the powders to be pressed has, corresponding to said apertures, indentation (6; 7) to form the reliefs on the back of the tile.

31. An isostatic die, as claimed in claims 1 or 2, characterised in that said deformation-control elements consist of appendages (26; 103a; 128; 129; 208) protruding from the surface of said elastic element facing the cavity and anchored in a plurality of non-communicating grooves (102) cut into the bottom of the cavity itself.

32. An isostatic die, as claimed in claim 30 and one or more of claims 22 to 29, characterised in that the appendage (26) is in the form of a tube sheathing the internal surface of the hole (27) through which the fluid flows: the lower end of said tubular appendage being coupled to a truncated-cone bushing (23,; 29), cooperating with peripheral seals (21; 31).

33. An isostatic die, as claimed in claim 32, characterised in that said bushing (129) has a truncated-cone stem (132) fitted with a peripheral seal (134).

34. An isostatic die, as claimed in claim 31, characterised in that the grooves (102) follow a labyrinth pattern, so as to define a plurality of interconnecting chambers.

35. An isostatic die, as claimed in claim 34 characterised in that the grooves (102) have bevelled sides to enable said appendages to be lodged in the undercut.

36. An isostatic die, as claimed in one or more of claims 31 to 35, characterised in that said appendages (103a; 128; 129; 208; 26) are integral with the membrane (5) and formed of the same material as the membrane itself.

37. An isostatic die, as claimed in one or more of the preceding claims, characterised in that the semi-die (P) has a hole (107) for the passage of the fluid with a spot-facing (109) that can be blocked during moulding by a plug (106), partially incorporated in the membrane (5).

38. An isostatic die, as claimed in one or more of claims 31 to 37, characterised in that between the membrane (5) and the bottom of the cavity of the relative semi-die there is a non-stick sheet with holes coinciding with the grooves (102).

39. An isostatic die, as claimed in claim 31, characterised in that said appendages (122; 128; 129; 130) are inserted into interconnecting alveoli (119) with a lowered base formed in the body of the relative semi-die (P).

40. An isostatic die, as claimed in claim 39, characterised in that said appendages consist of hollow elements (129; 130) with their cavities facing the bottom surface of the cavity of said at least one semi-die, the back of said hollow elements being anchored to said membrane (5).

41. An isostatic die, as claimed in one or more the preceding claims, characterised in that the cavity communicates with a device (213; 214; 215) that regulates the volume of incompressible fluid in the cavity of said at least one semi-die and serves to vary the deformation of said elastic element during pressing and/or during the loading of the mixture.

42. An isostatic die, as claimed in claim 41, characterised in that said device regulating the incompressible fluid consists of a tank (215) containing inert gas under pressure acting on the fluid contained in the cavities of the semi-die by means of a cylinder (213; 224) communicating with said cavity via throttle valve (222).

43. An isostatic die, as claimed in one or more of the preceding claims, characterised in that the surface of said plate (1; 18; V) destined to define the chambers for the passage of the incompressible fluid is treated with a non-stick substance.

44. A method for the moulding of ceramic items, in particular tiles, by means of an isostatic die comprising an elastic membrane (5) delimiting a plurality of chambers (216; 231) in which is contained an incompressible fluid, the chambers corresponding to cavities to be formed on the back of the tile, characterised in that a part of said incompressible fluid is evacuated in a controlled manner during the pressing cycle from said chambers.

45. A method, as claimed in claim 44, characterised

in that the chambers are initially filled with a volume of said fluid greater than that corresponding to the depth of the cavities to be formed on the back of the tile; the excess fluid, evacuated during pressing in a controlled manner, flowing back into the cavities when pressing is complete.

46. A method, as claimed in claim 45, characterised in that the ratio between the initial maximum (A) and minimum (B) thicknesses of the layer of powders and the ratio between the maximum (A) and minimum (B) thicknesses of said layer during the pressing cycle remain substantially constant.

47. A method, as claimed in claim 46, characterised in that said ratio corresponds to that which must be achieved in the pressed tile.

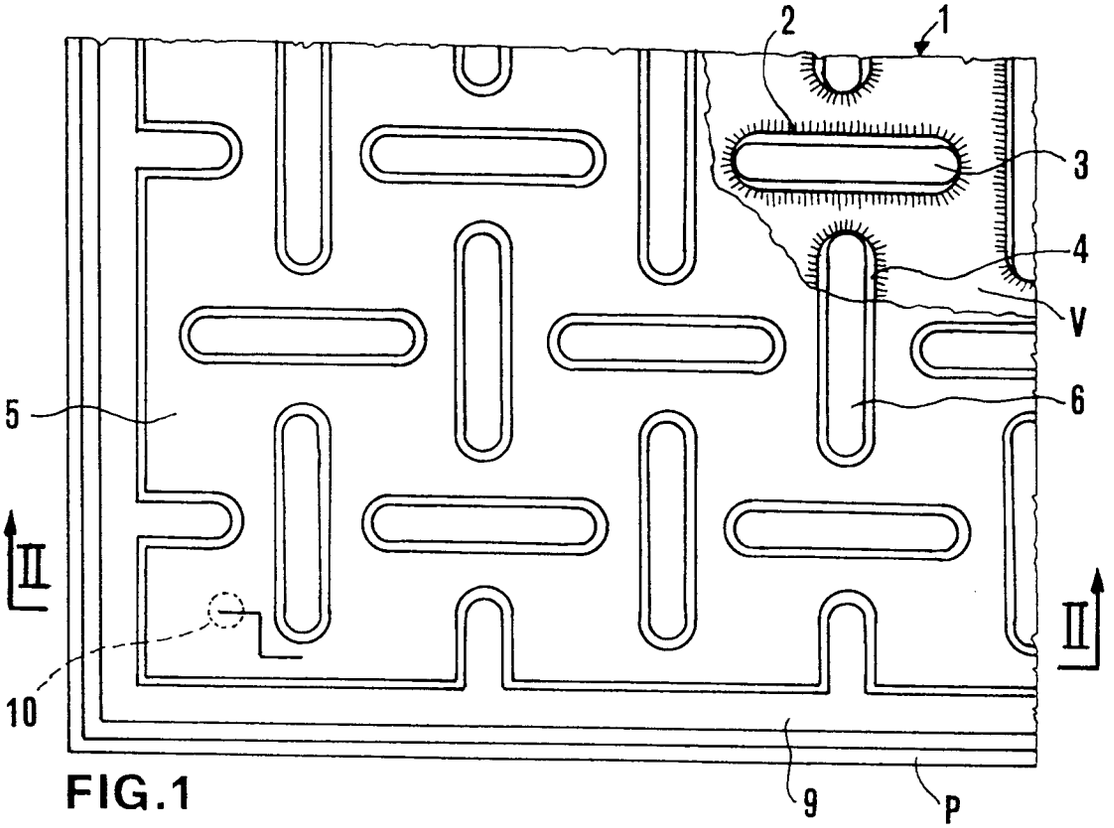


FIG.1

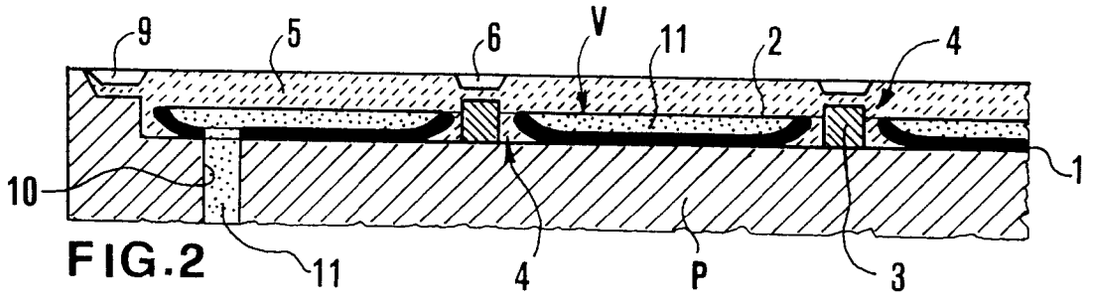


FIG.2

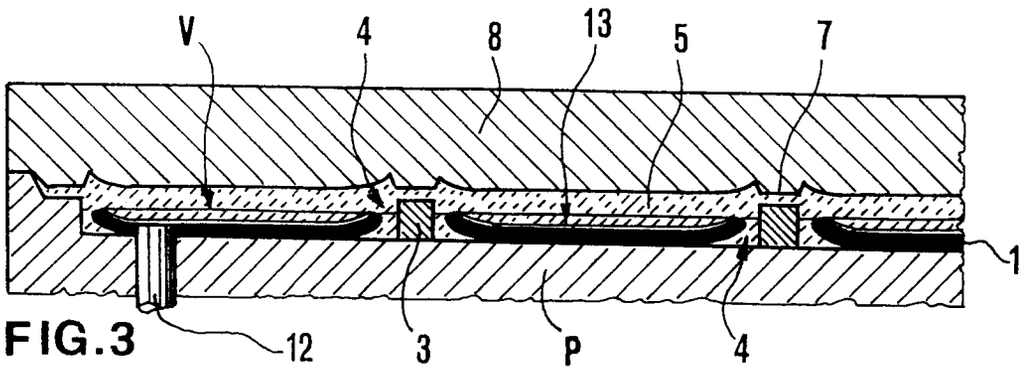


FIG.3

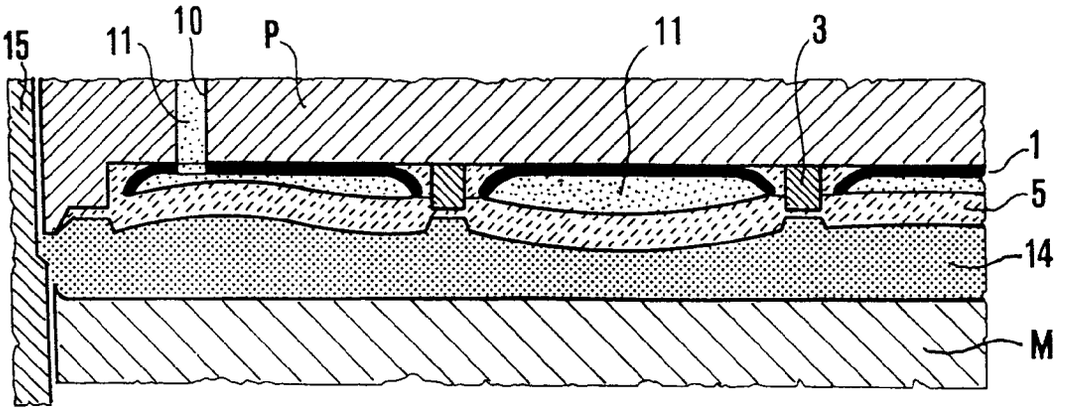


FIG.4

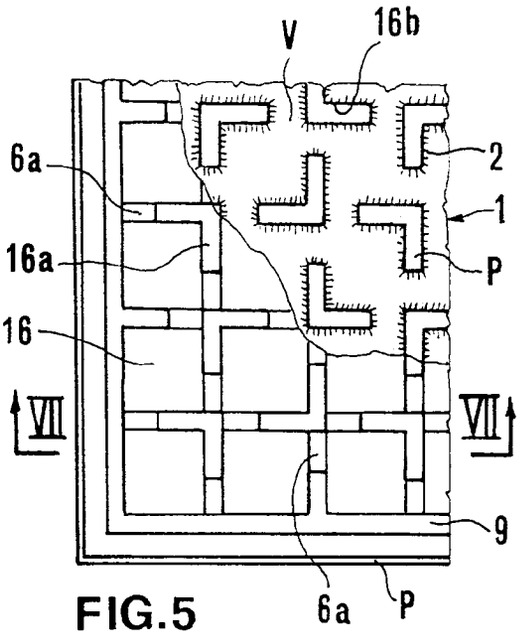


FIG.5

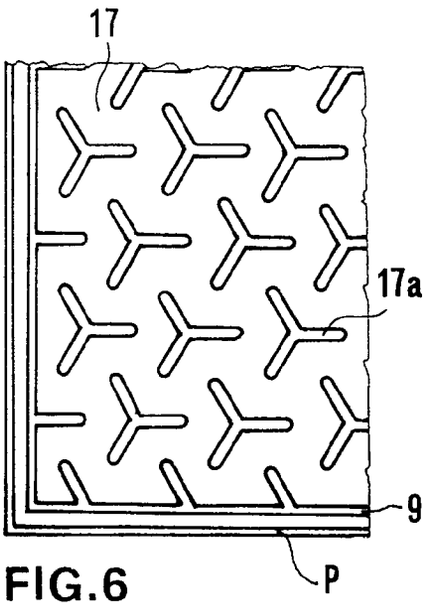


FIG.6

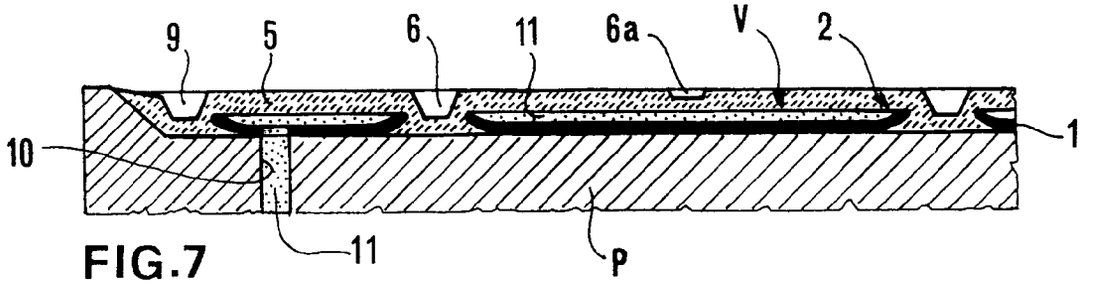


FIG.7

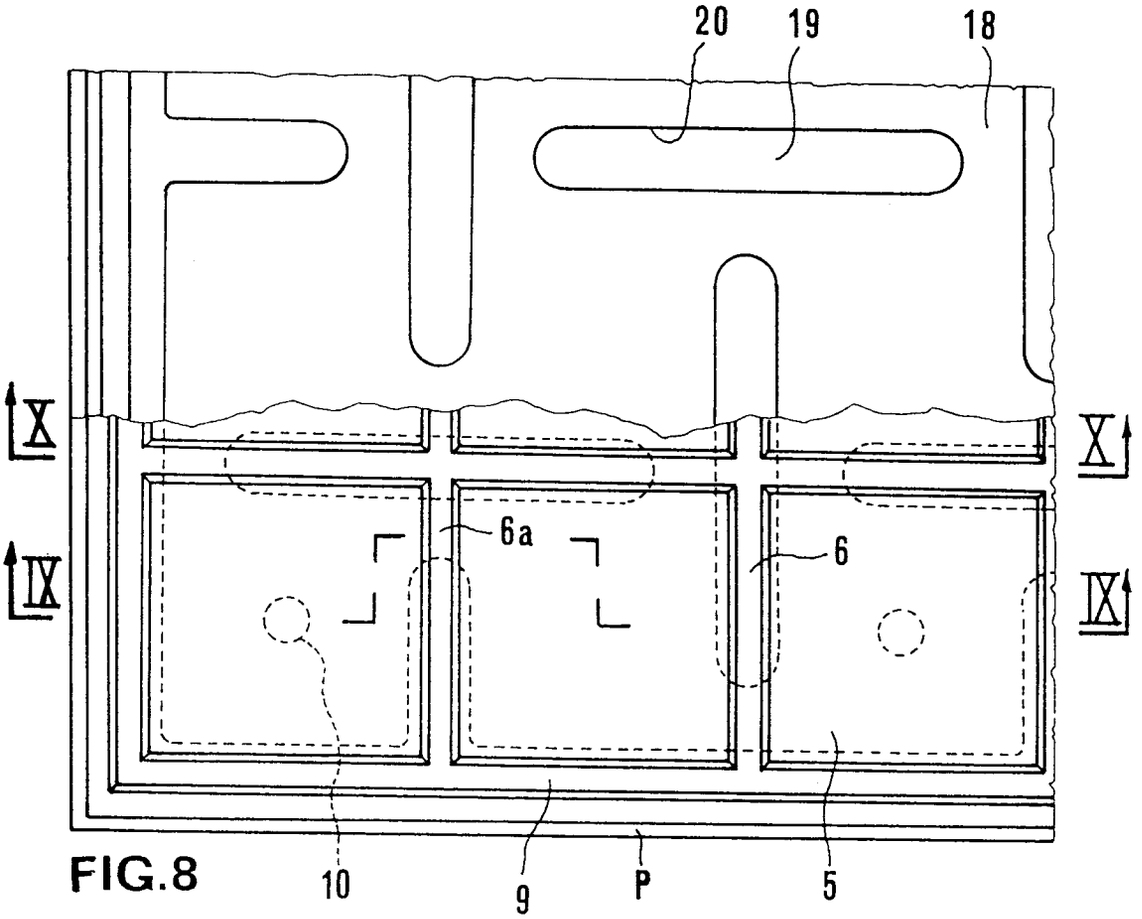


FIG.8

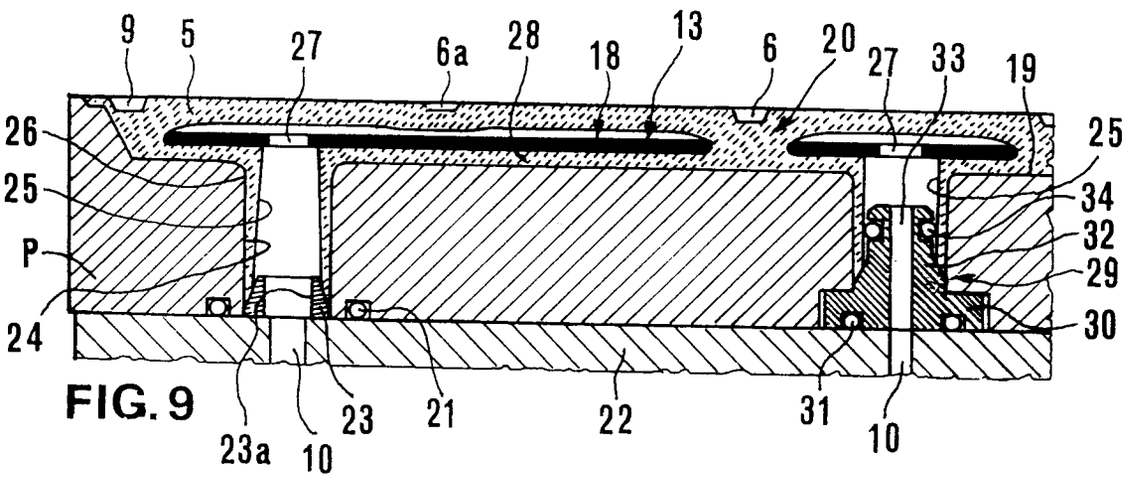


FIG.9

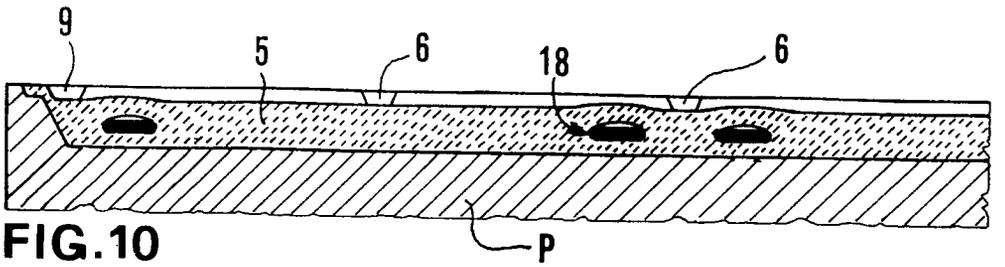


FIG.10

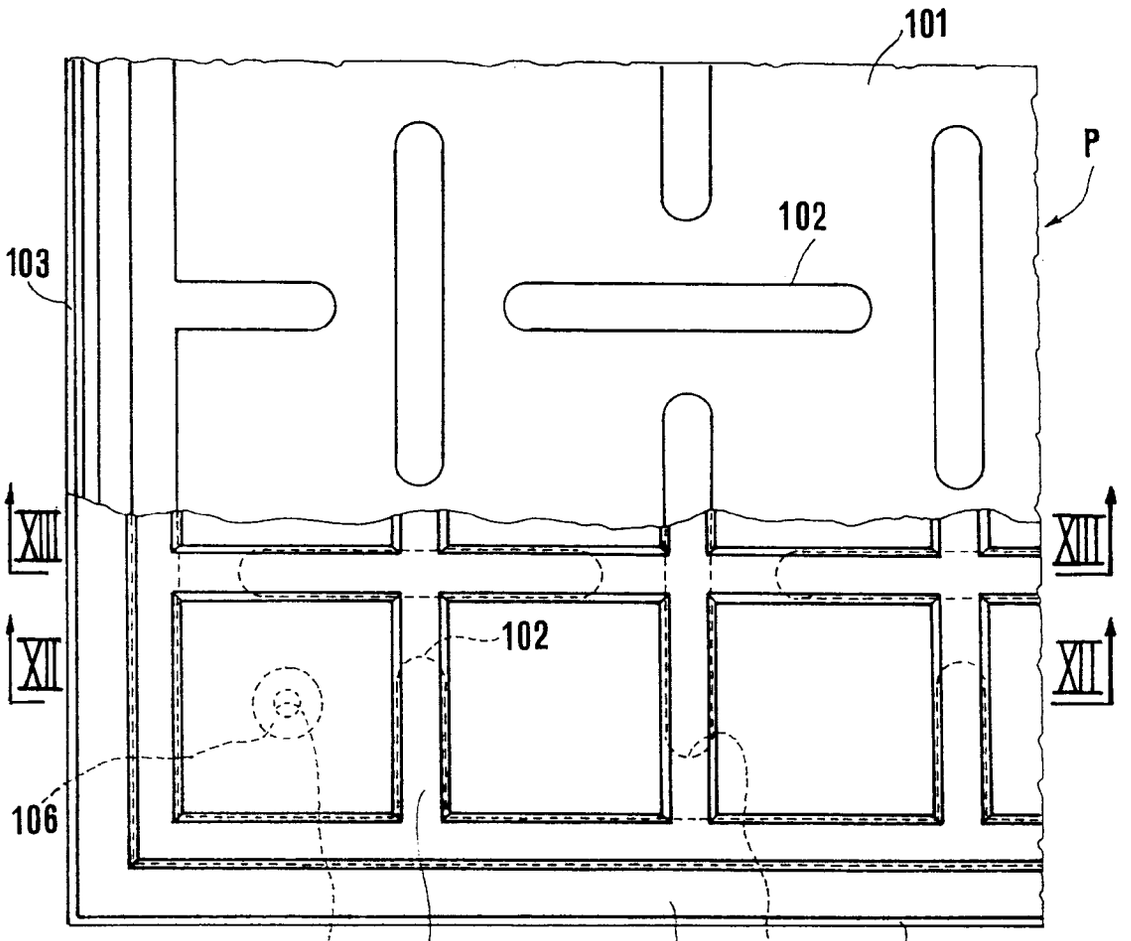


FIG.11

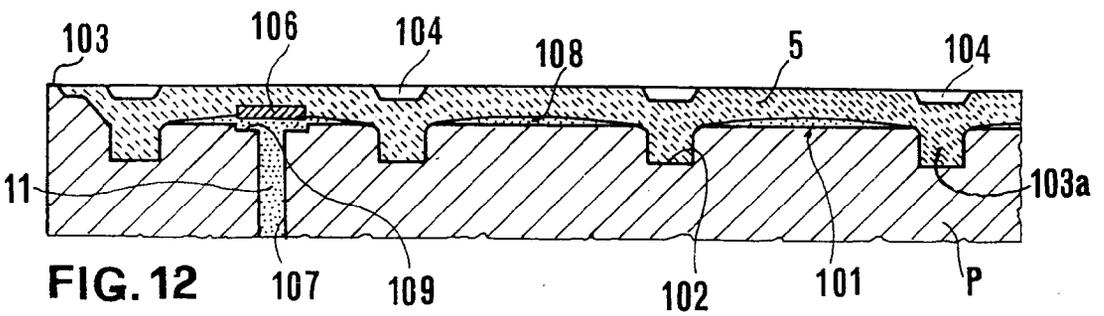


FIG.12

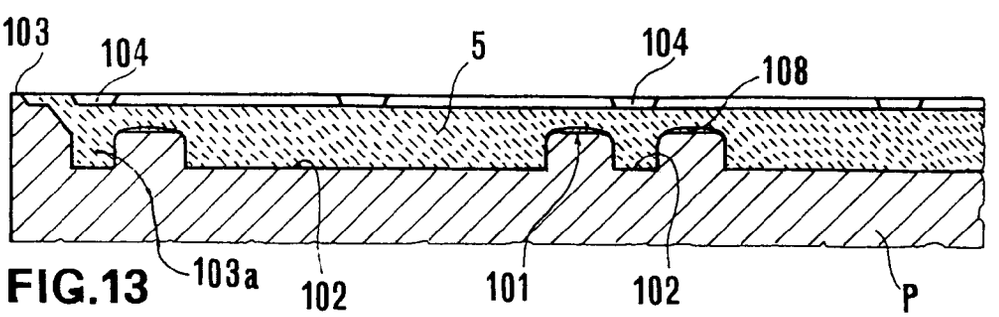


FIG.13

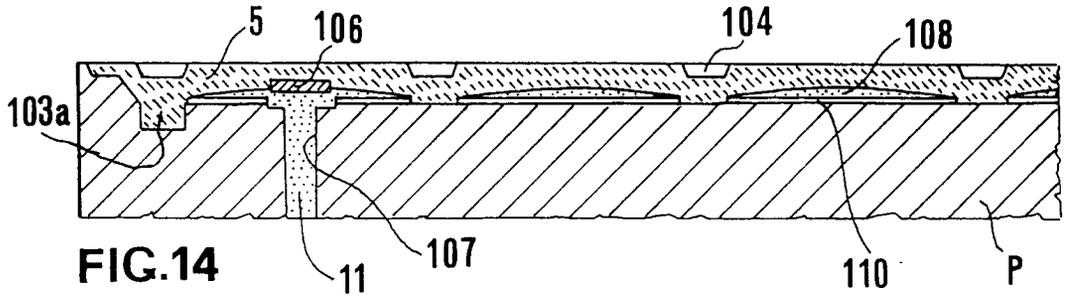


FIG.14

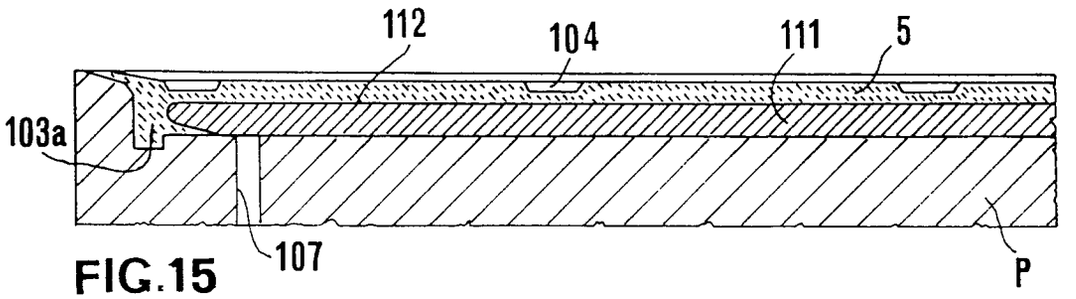


FIG.15

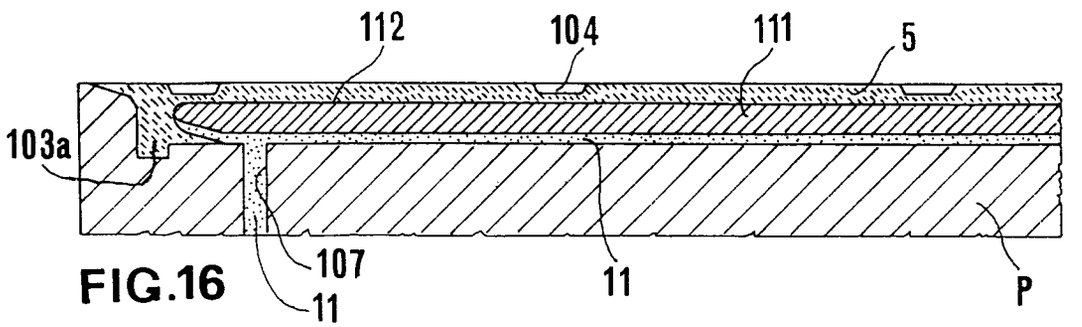


FIG.16

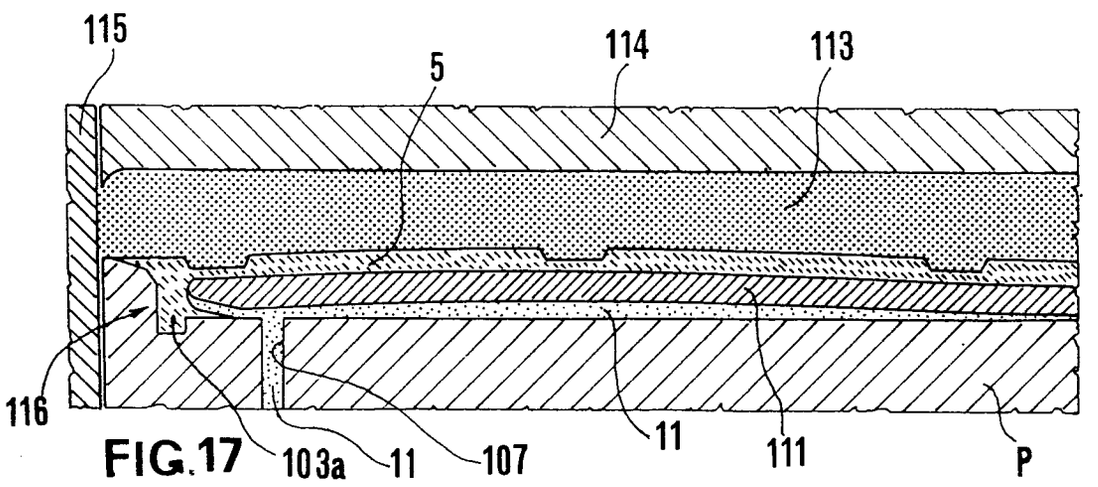


FIG.17

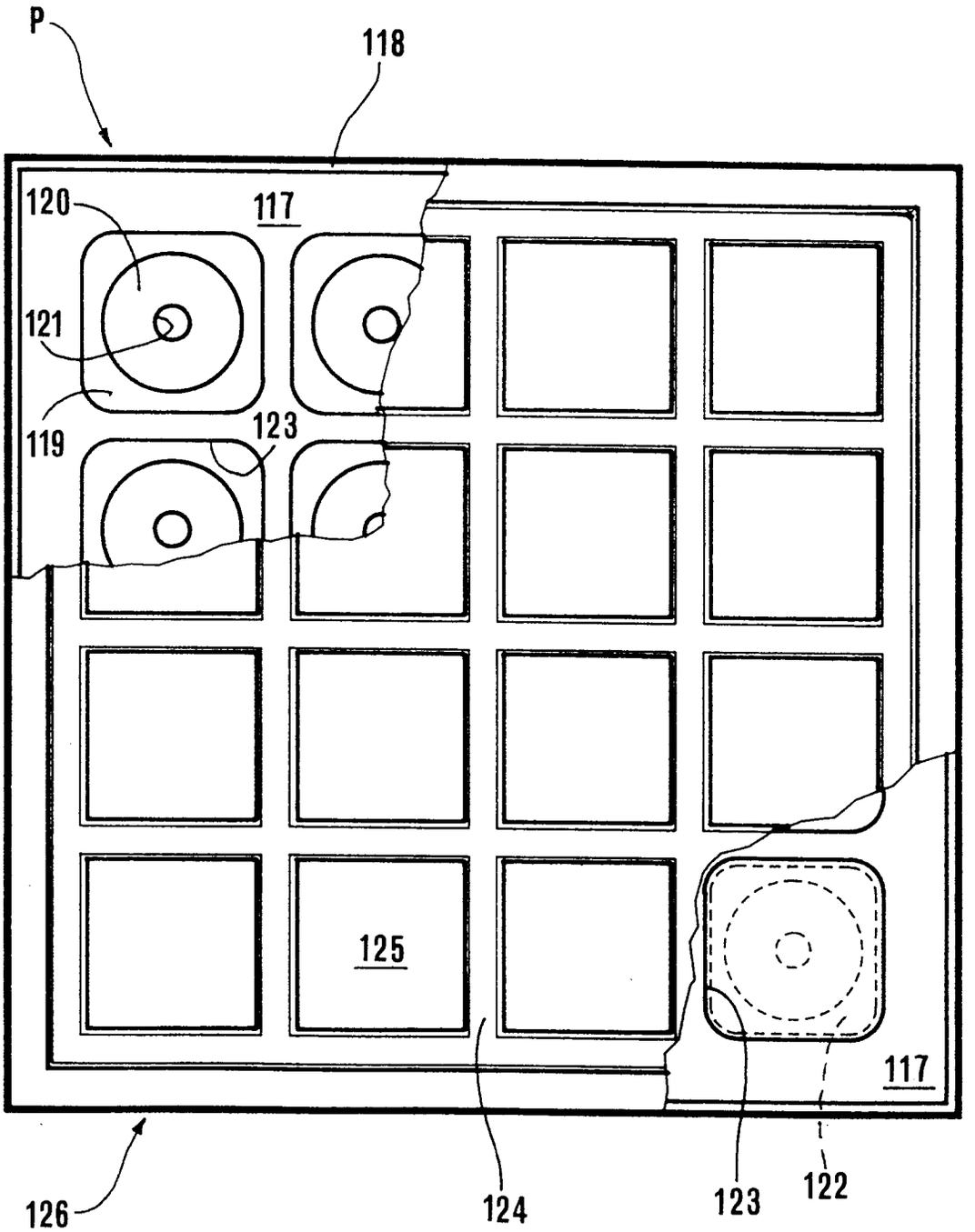


FIG.18

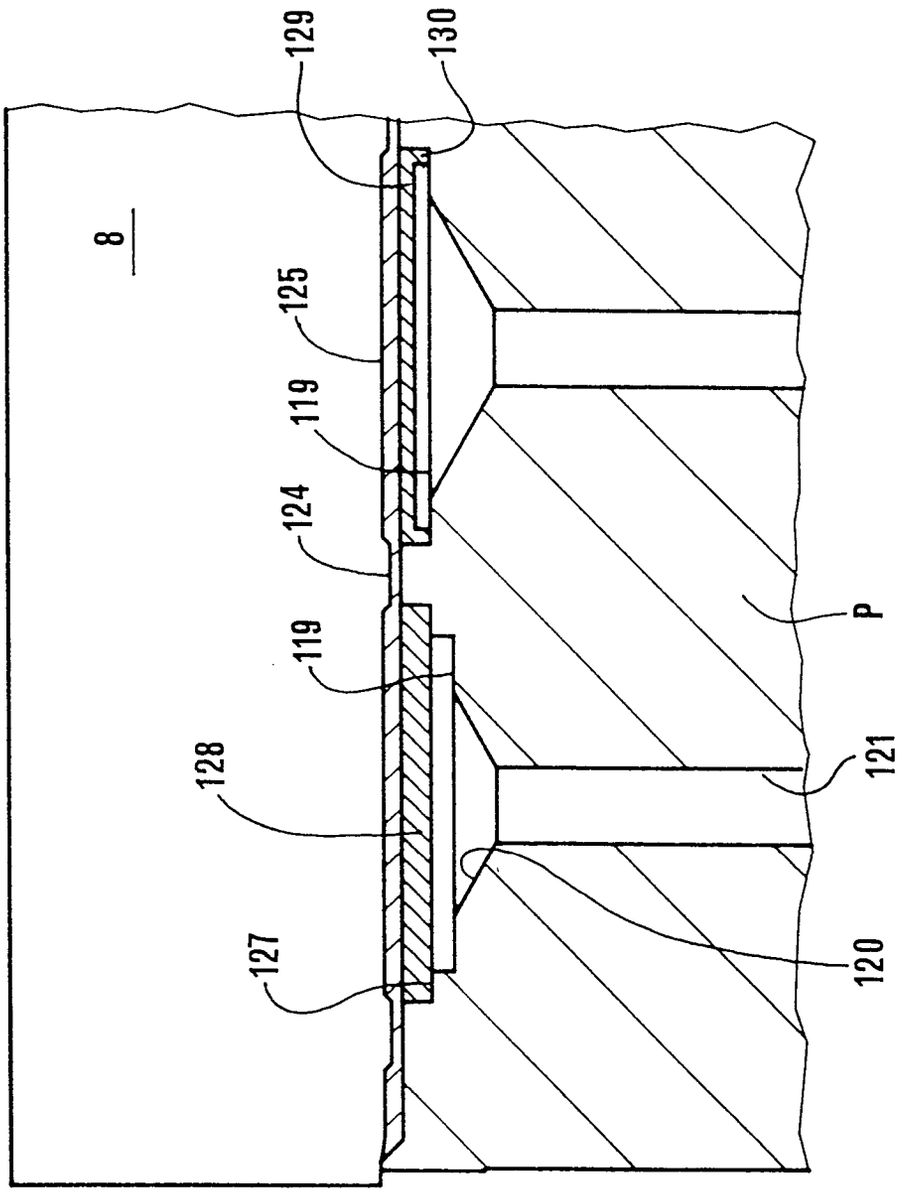

129
130
8
125
119
124
119
128
127
P
121
120

FIG.19

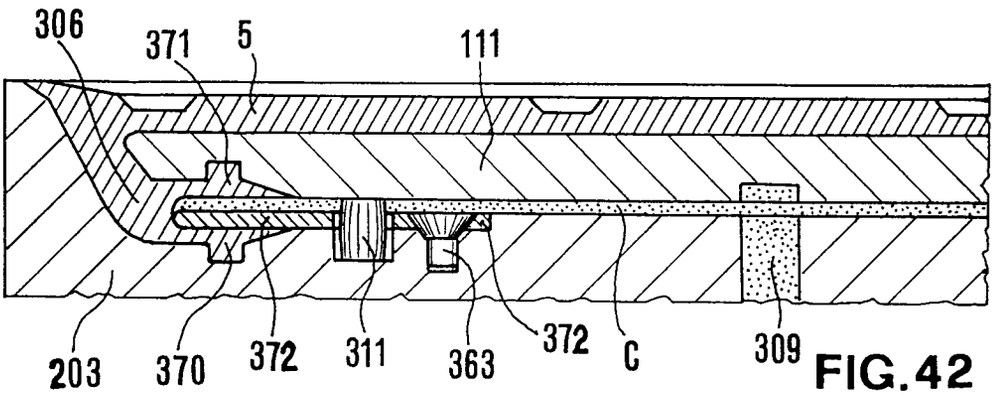

306
371
5
111
203
370
372
311
363
372
C
309

FIG.42

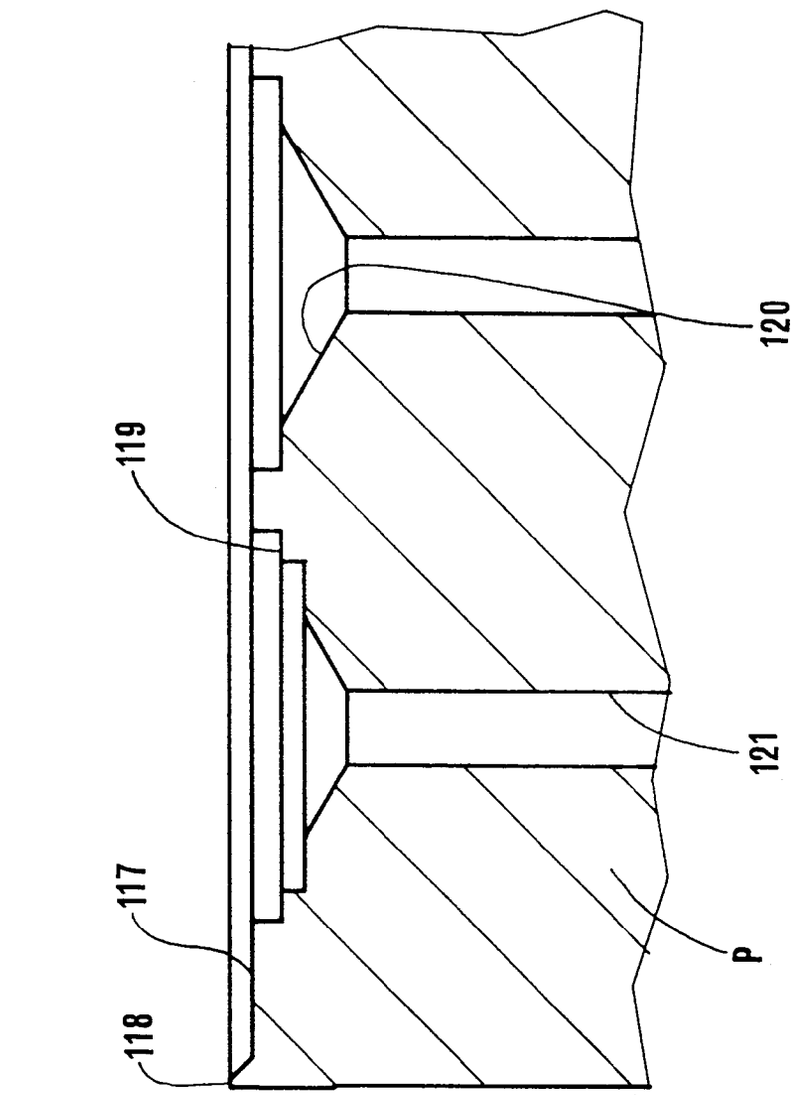


FIG.22

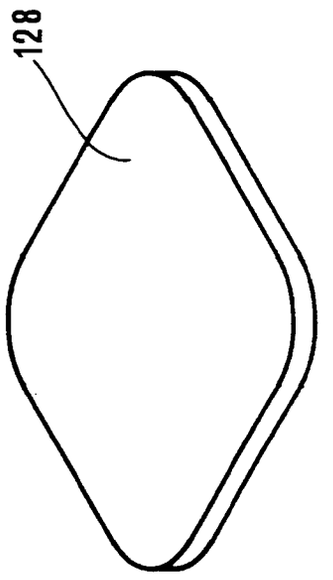


FIG.20

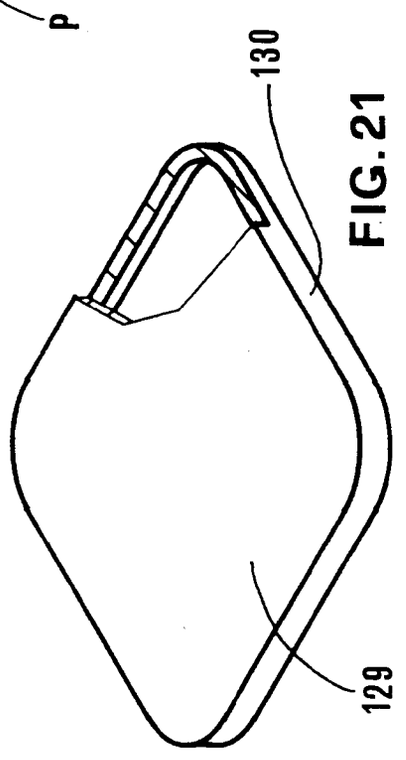


FIG.21

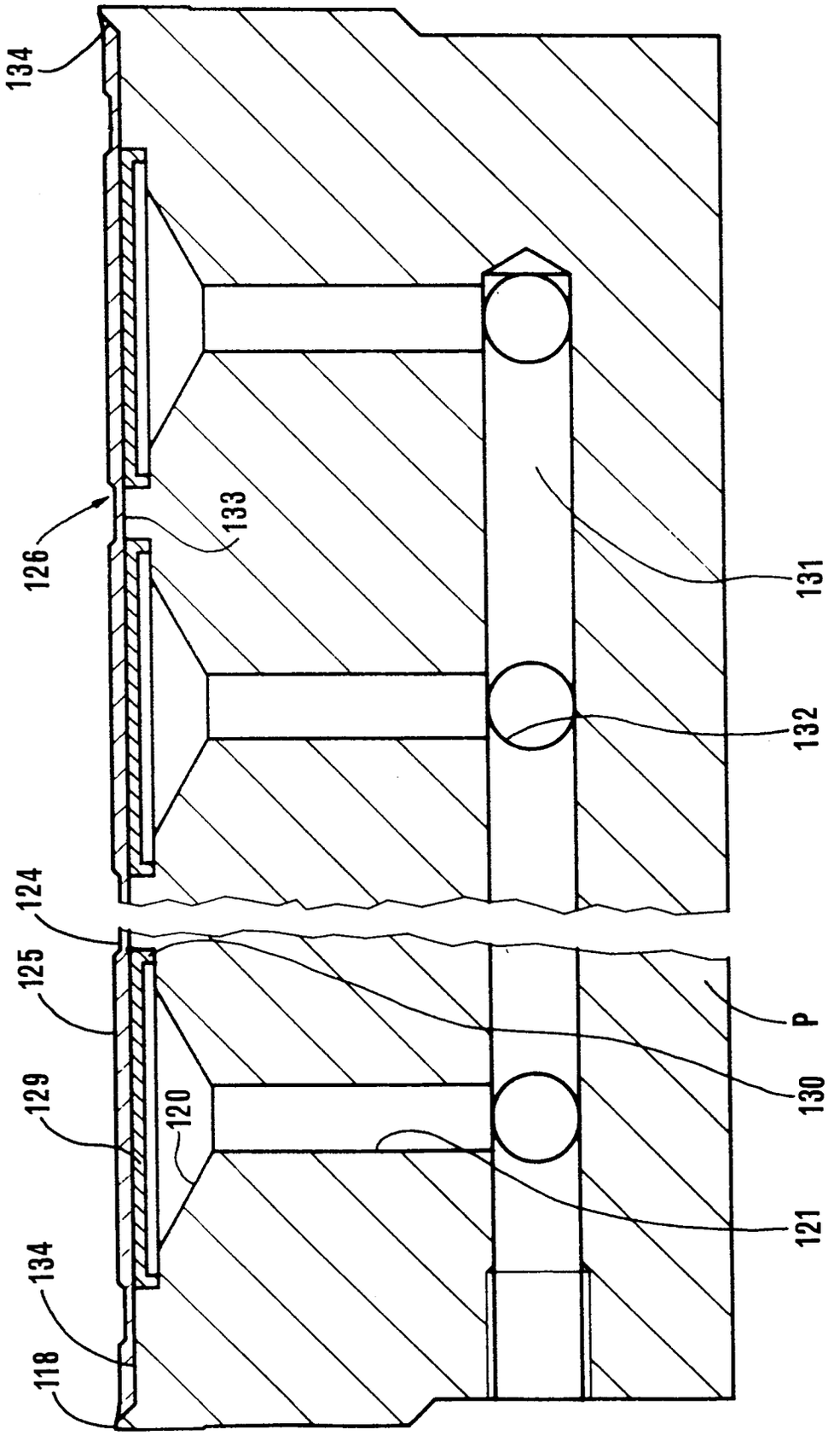


FIG.23

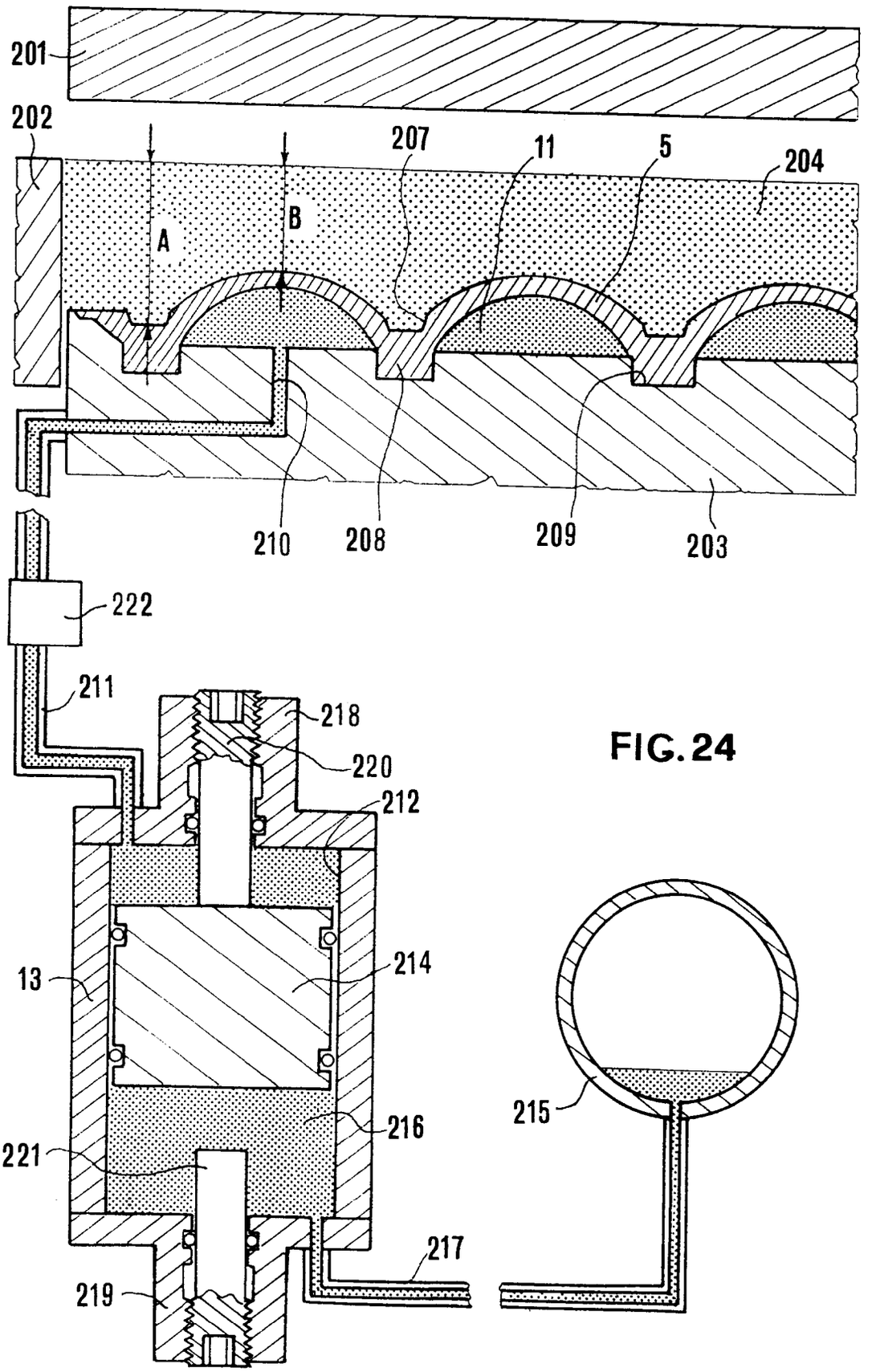

201
202
207
11
5
204
A
B
210
208
209
203
222
211
218
220
212
214
13
216
221
217
219
215

FIG. 24

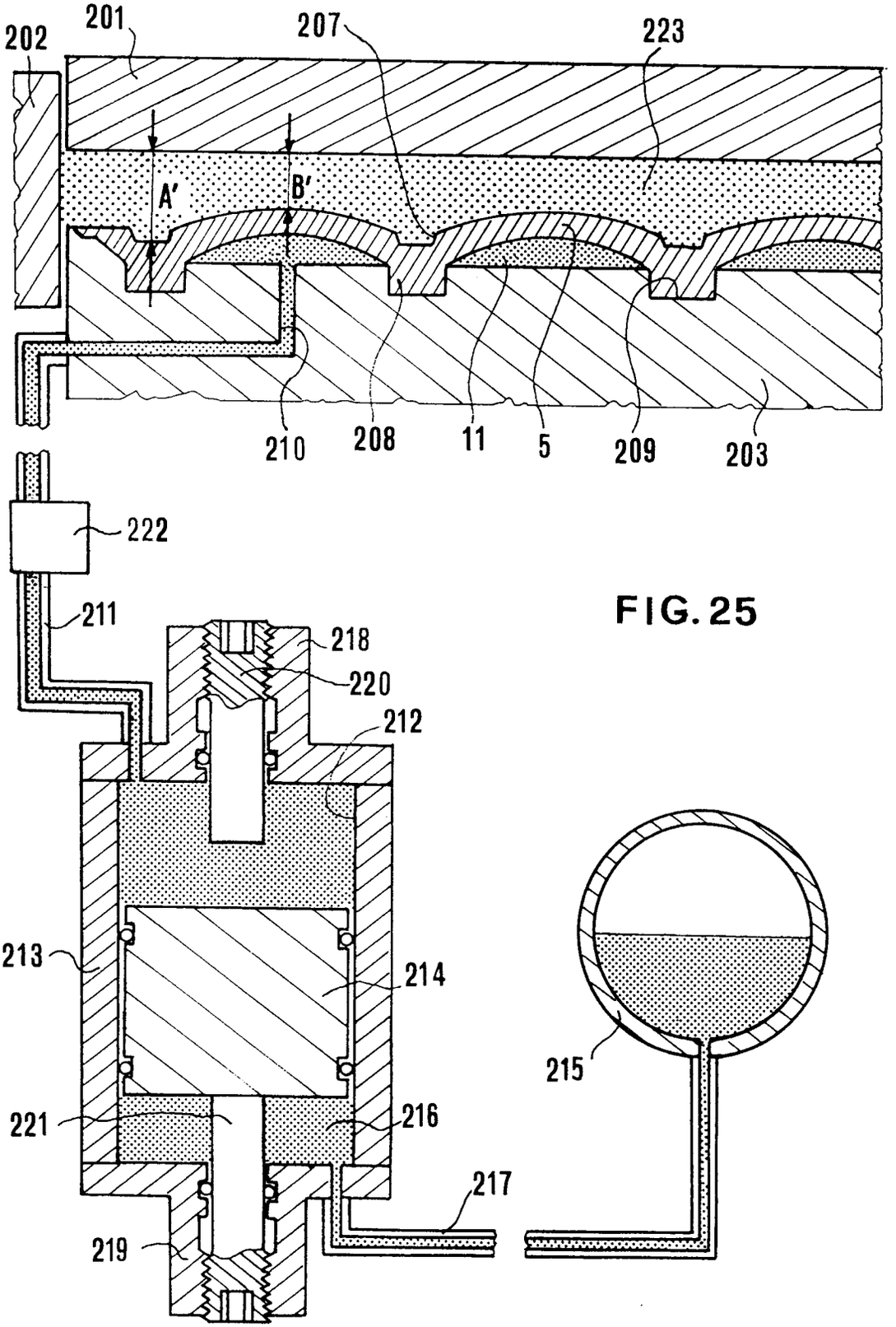
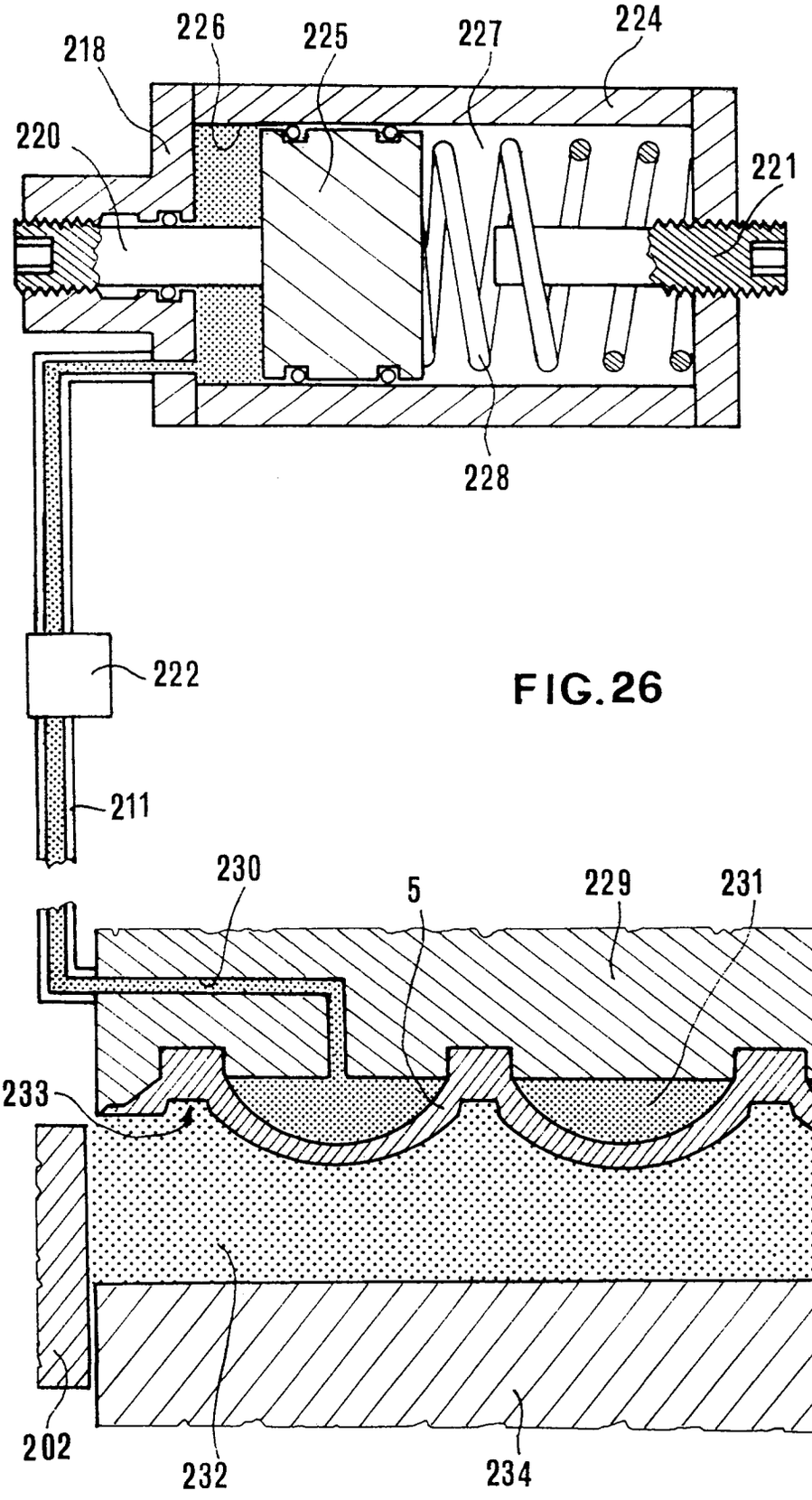

202
201
207
223
A'
B'
210
208
11
5
209
203
222
211
218
220
212
213
214
215
221
216
217
219

FIG. 25


218
226
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227
224
220
221
228
222
211
230
5
229
231
233
202
232
234

FIG.26

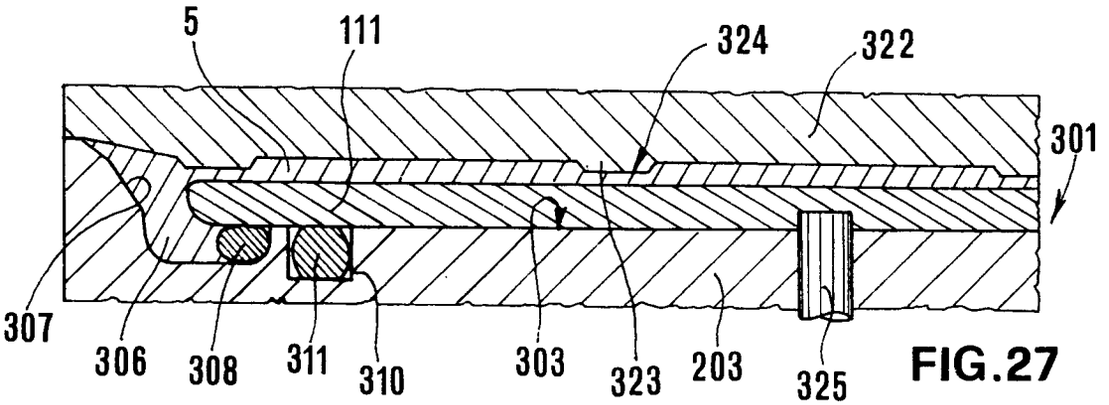

FIG.27

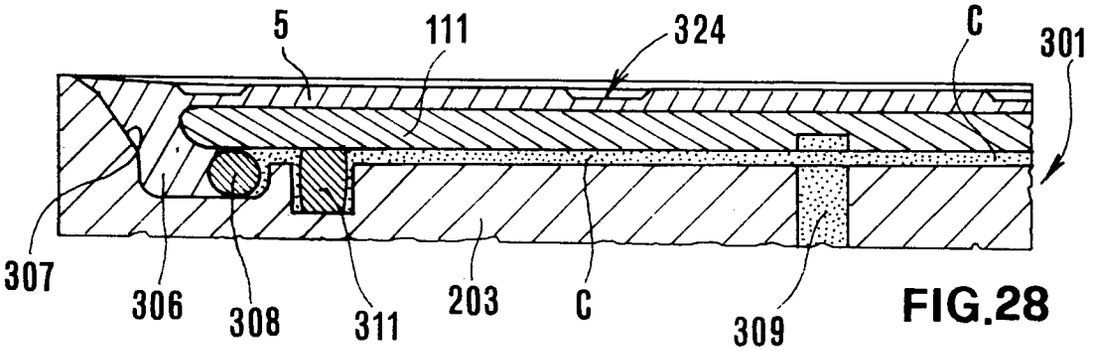

FIG.28

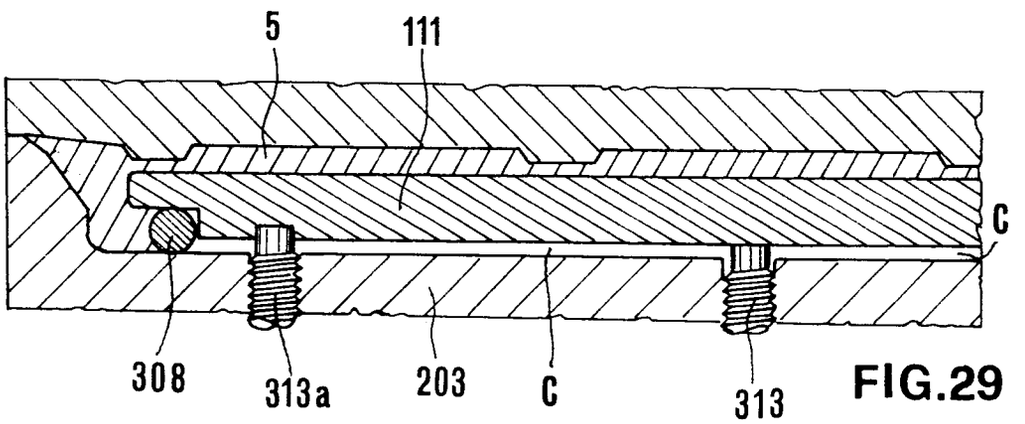

FIG.29

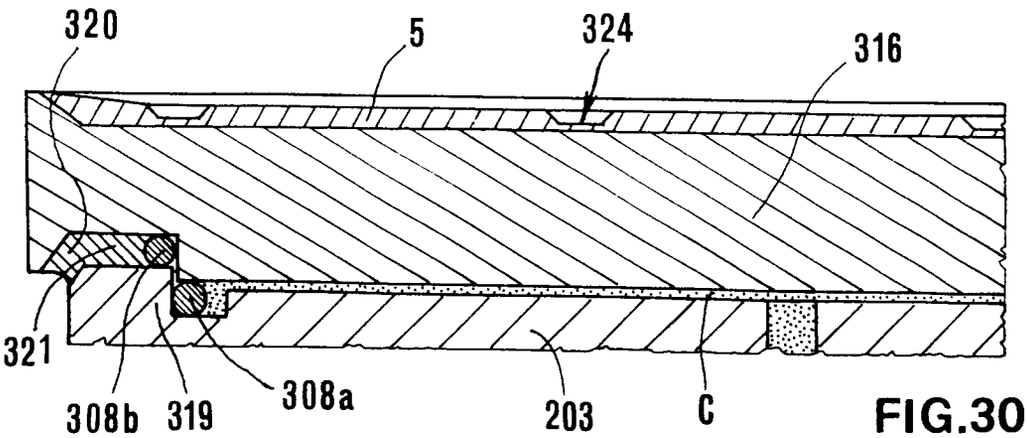

FIG.30

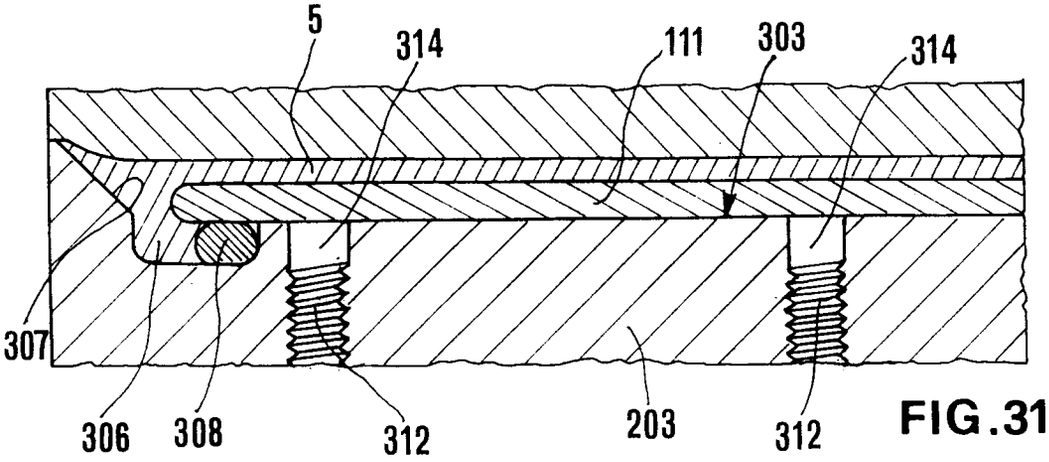

FIG.31

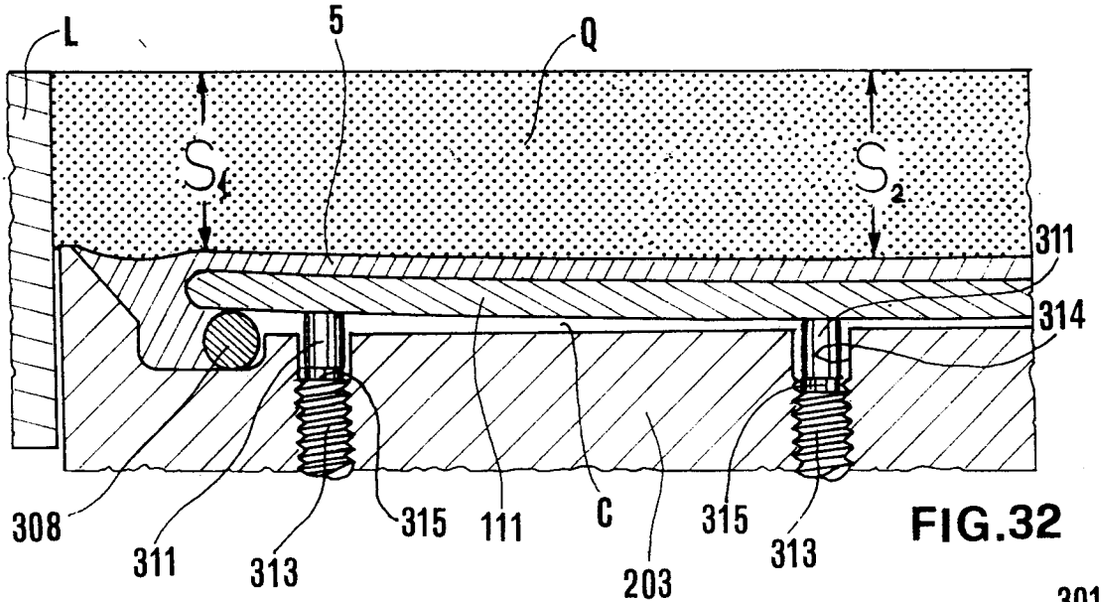

FIG.32

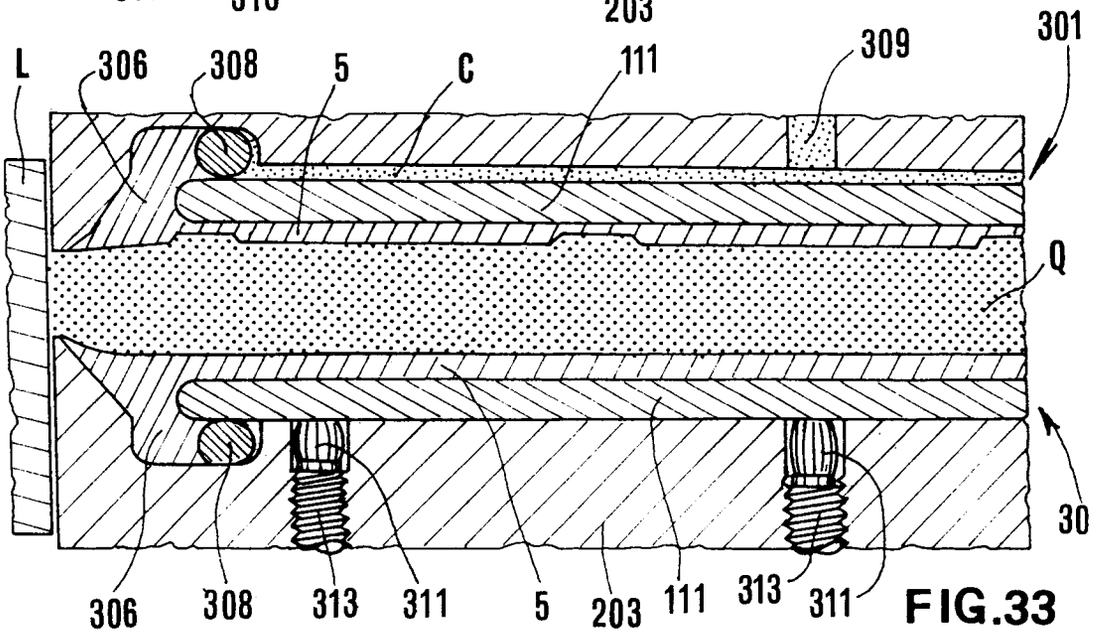

FIG.33

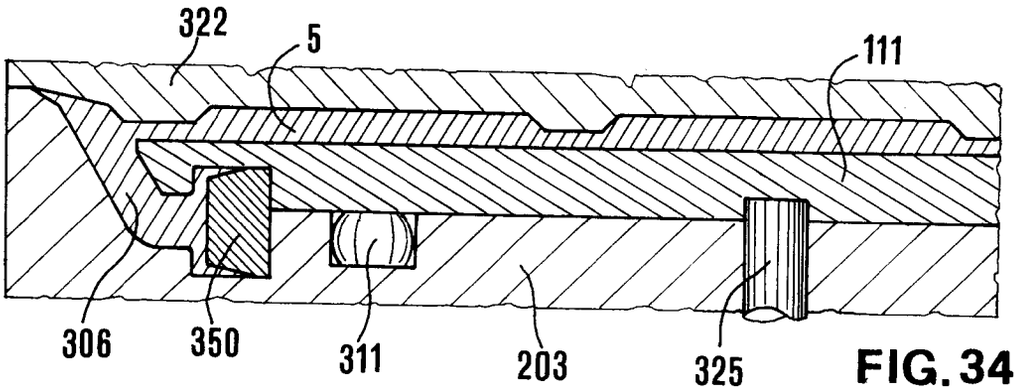

FIG. 34

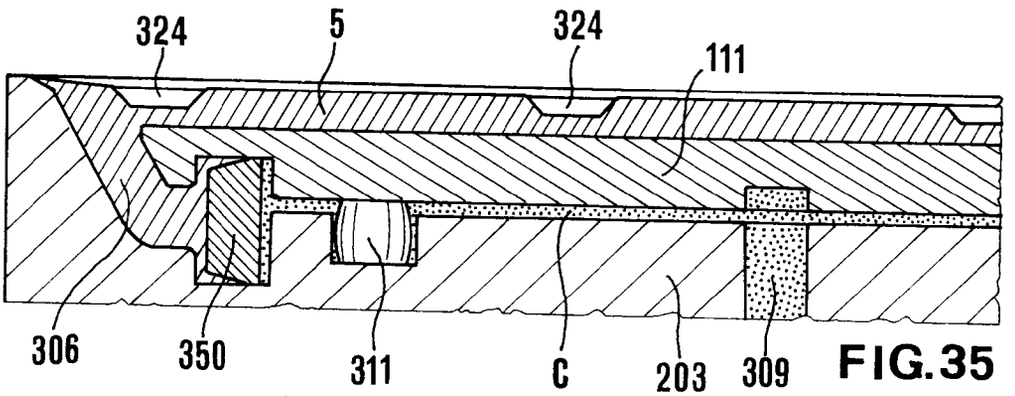

FIG. 35

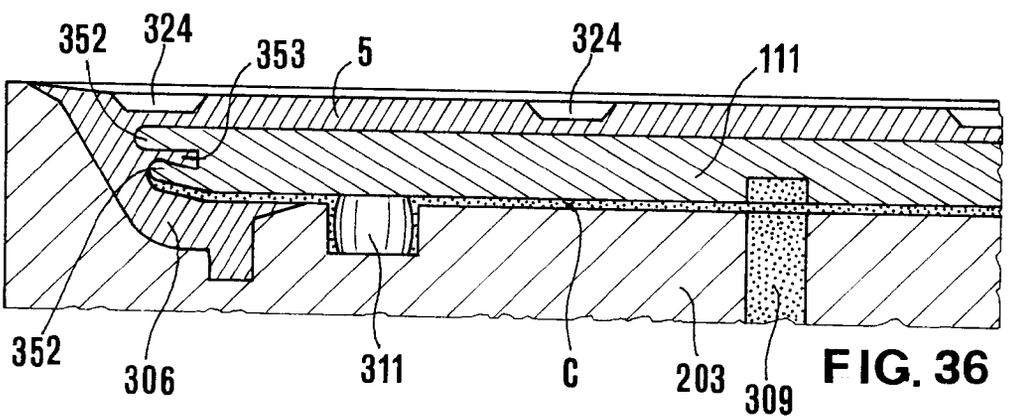

FIG. 36

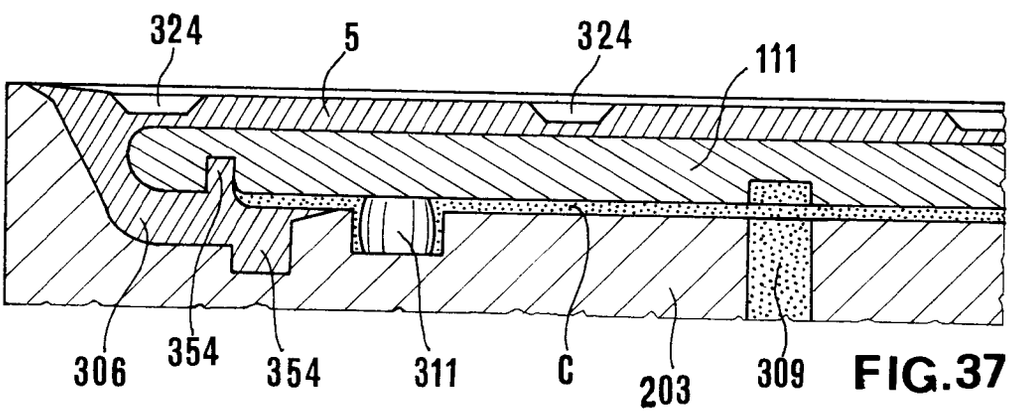

FIG. 37

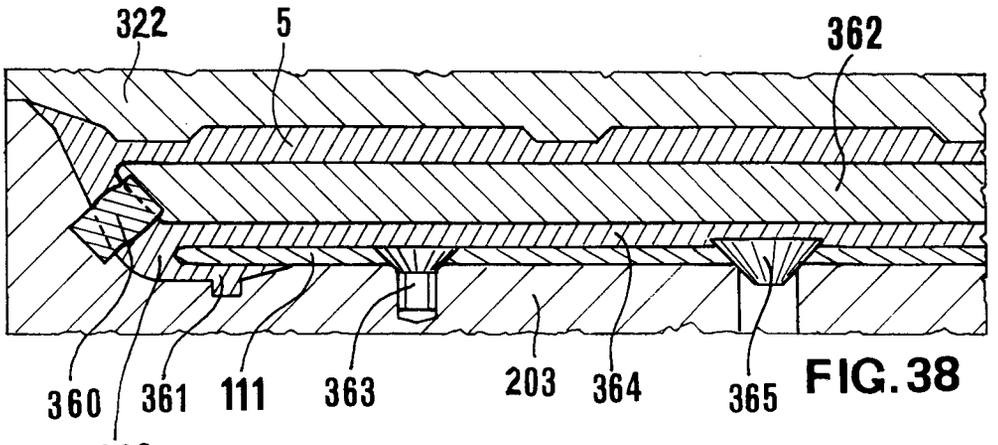

FIG.38

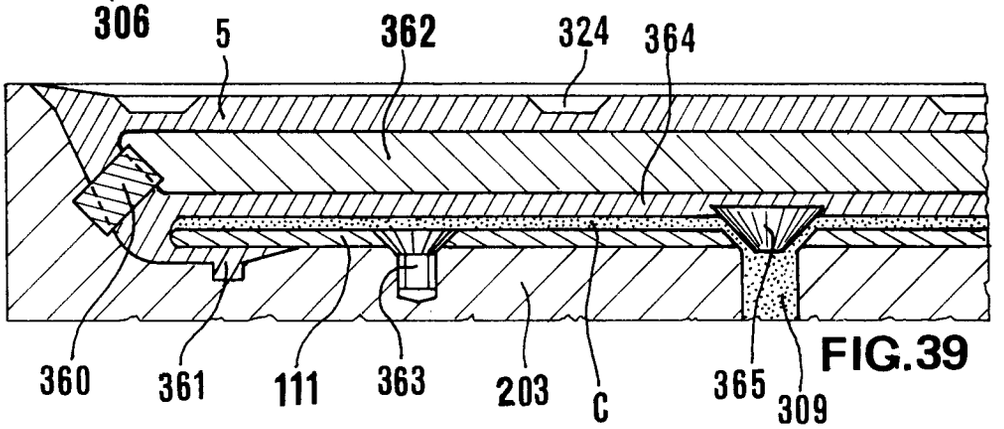

FIG.39

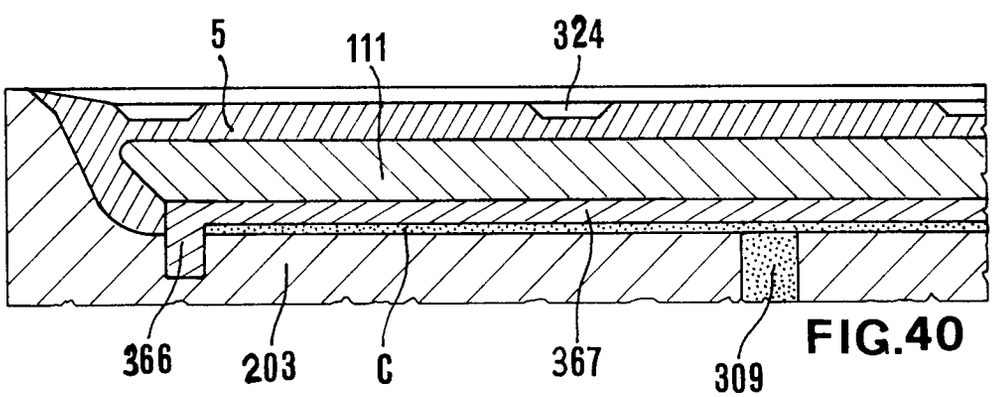

FIG.40

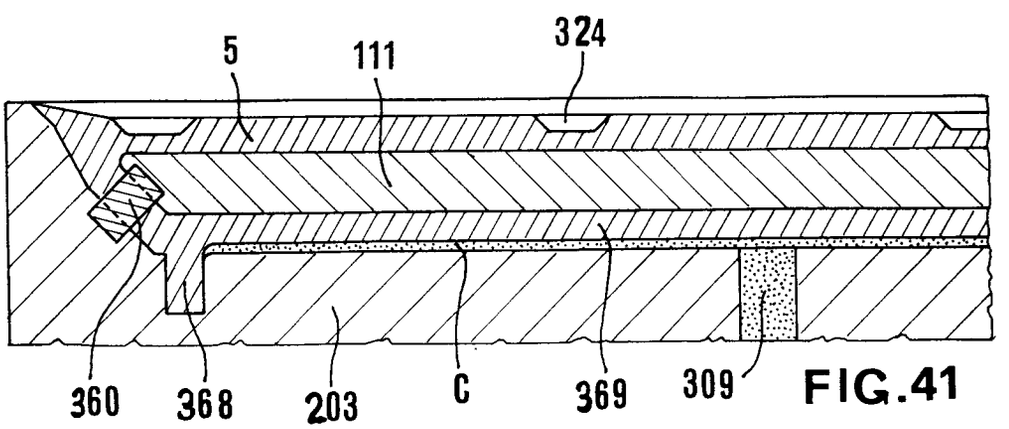

FIG.41