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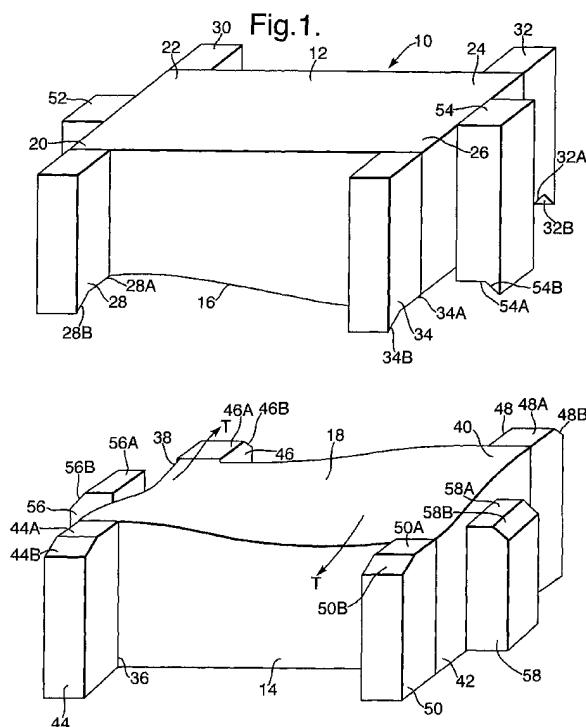
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(54) **A forming die**

(57) A forming die (10) comprises a first die part (12) and a second die part (14). The first die part (12) has a first shaped forming surface (16) and the second die part (14) has a second shaped forming surface (18). The first die (12) has a number of pillars (28,30,32,34). Two of the pillars (28,34) are arranged at a first side of the first die (12) and two of the pillars (30,32) are arranged at a second opposite side of the first die (12). The second die (14) has a number of pillars (44,46,48,50). Two of

the pillars (44,50) are arranged at the first side of the second die (14) and two of the pillars (46,48) are arranged at the second opposite side of the second die (14). The pillars (28,30,32,34) on the first die (12) are locatable on the pillars (44,46,48,50) on the second die (14). The pillars (28,30,32,34) on the first die (12) and the second die (44,46,48,50) have interlocking means (28B,30B,32B,34B, 44B,46B,48B,50B) to prevent relative movement between the first die (12) and the second die (14).



Description

[0001] The present invention relates to a forming die and in particular to superplastic forming die for forming a blade or vane of a gas turbine engine.

[0002] It is known to manufacture a fan blade for a turbofan gas turbine engine by diffusion bonding three titanium workpieces together to form an integral structure and then to supply inert gas into the integral structure to superplastically form the integral structure to shape.

[0003] During the superplastic forming process the diffusion bonded titanium workpieces, or integral structure, are placed in a superplastic forming die and heated to superplastic forming temperature. The superplastic forming die has vertical legs extending down from the upper die, which abut the sides of the lower die to resist the twisting of an upper die part relative to a lower die part due to the contouring of the faces of the die.

[0004] A problem with the die is that the vertical legs deform with continued use, leading to cracking and ultimately failure of the vertical legs. The upper die part twists by up to 16mm from its designed position. This causes deformation, bowing, of the die parts and deformation of the platens upon which the die rests. The quality of the superplastically formed fan blades continuously deteriorates during this time, but this is countered by packing of the kiss faces of the die parts until acceptable fan blades are no longer produced.

[0005] Accordingly the present invention seeks to provide a novel superplastic forming die which reduces, preferably overcomes the above mentioned problems.

[0006] Accordingly the present invention provides a forming die comprising a first die part and a second die part, the first die part having a first shaped forming surface, the second die part having a second shaped forming surface, the first die part having at least two pillars, a first one of the at least two pillars being arranged at a first side of the first die part and a second one of the at least two pillars being arranged at a second opposite side of the first die part, the second die part having at least two pillars, a first one of the at least two pillars being arranged at a first side of the second die part and a second one of the at least two pillars being arranged at a second opposite side of the second die part, the pillars on the first die part being locatable on the pillars on the second die part, the pillars on the first and second die part having interlocking means to prevent relative movement between the first die part and the second die part.

[0007] Preferably the first die part having at least two additional pillars, a first one of the at least two additional pillars being arranged at a first end of the first die part and a second one of the at least two additional pillars being arranged at a second opposite end of the first die part, the second die part having at least two additional pillars, a first one of the at least two additional pillars being arranged at a first end of the second die part and a second one of the at least two additional pillars being

arranged at a second opposite end of the second die part, the additional pillars on the first die part being locatable on the additional pillars on the second die part, the additional pillars on the first and second die part having interlocking means to prevent relative movement between the first die part and the second die part.

[0008] Preferably the first die part having at least four pillars, two of the at least four pillars being arranged at a first side of the first die part and two of the at least four pillars being arranged at a second opposite side of the first die part, the second die part having at least four pillars, two of the at least four pillars being arranged at a first side of the second die part and two of the at least four pillars being arranged at a second opposite side of the second die part, the pillars on the first die part being locatable on the pillars on the second die part, the pillars on the first and second die part having interlocking means to prevent relative movement between the first die part and the second die part.

[0009] Preferably the first die part having one of the four pillars arranged at a corresponding one of the corners of the first die part, the second die part having one of the four pillars arranged at a corresponding one of the corners of the second die part.

[0010] Preferably the first die part is an upper die part and the second die part is a lower die part.

[0011] Preferably the pillars extending vertically from the corresponding die part, each pillar having a horizontal face and an adjacent face angled to the horizontal face, the vertical pillars on the upper die part being locatable on the vertical pillars on the lower die part.

[0012] Preferably the horizontal faces of the vertical pillars are equal in area.

[0013] Preferably the adjacent faces of the vertical pillars are equal in area.

[0014] Preferably the horizontal faces of the additional vertical pillars are equal in area.

[0015] Preferably the adjacent faces of the additional vertical pillars are equal in area.

[0016] Preferably the forming die is a superplastic forming die or a hot forming die.

[0017] The present invention will be more fully described by way of example with reference to the accompanying drawings in which:-

Figure 1 is an exploded perspective view of a superplastic forming die according to the present invention.

Figure 2 is side view of the superplastic forming die shown in figure 1.

Figure 3 is a view of one end of the superplastic forming die shown in figure 1.

Figure 4 is a view of the other end of the superplastic forming die shown in figure 1.

Figures 5 to 11 alternative pillar arrangements.

[0018] A superplastic forming die 10 according to the present invention is shown in figures 1 to 4. The super-

plastic forming die 10 comprises an upper die part 12 and a lower die part 14. The upper die part 12 has an upper shaped forming surface 16 and the lower die part 14 has a lower shaped forming surface 18. The upper die part 12 has four corners 20, 22, 24 and 26 and a respective vertical pillar 28, 30, 32 and 34 is arranged at each corner 20, 22, 24 and 26 of the upper die part 12. The lower die part 14 has four corners 36, 38, 40 and 42 and a respective vertical pillar 44, 46, 48 and 50 is arranged at each corner 36, 38, 40 and 42 of the lower die part 14. Each vertical pillar 28, 30, 32, 34, 44, 46, 48 and 50 has a horizontal face 28A, 30A, 32A, 34A, 44A, 46A, 48A and 50A respectively and each vertical pillar 28, 30, 32, 34, 44, 46, 48 and 50 has an adjacent face 28B, 30B, 32B, 34B, 44B, 46B, 48B and 50B respectively angled to the horizontal face 28A, 30A, 32A, 34A, 44A, 46A, 48A and 50A respectively. The vertical pillars 28, 30, 32 and 34 on the upper die part 12 are locatable on the vertical pillars 44, 46, 48 and 50 on the lower die part 14.

[0019] The horizontal faces 28A, 30A, 32A, 34A, 44A, 46A, 48A and 50A of the vertical pillars 28, 30, 32, 34, 44, 46, 48 and 50 are equal in area. The adjacent faces 28B, 30B, 32B, 34B, 44B, 46B, 48B and 50B of the vertical pillars 28, 30, 32, 34, 44, 46, 48 and 50 are equal in area.

[0020] The upper die part 12 has additional vertical pillars 52 and 54 at opposing ends of the upper die part 12 and the lower die part 14 has additional vertical pillars 56 and 58 at opposing ends of the lower die part 14. Each additional vertical pillar 52, 54, 56 and 58 has a horizontal face 52A, 54A, 56A and 58A respectively and each additional vertical pillar 52, 54, 56 and 58 has an adjacent face 52B, 54B, 56B and 58B respectively angled to the horizontal face 52A, 54A, 56A and 58A respectively. The additional vertical pillars 52 and 54 on the upper die part 12 are locatable on the additional vertical pillars 56 and 58 on the lower die part 14.

[0021] The horizontal faces 52A, 54A, 56A and 58A of the additional vertical pillars 52, 54, 56 and 58 are equal in area. The adjacent faces 52B, 54B, 56B and 58B of the additional vertical pillars 52, 54, 56 and 58 are equal in area.

[0022] The provision of the equal areas for the horizontal faces and angled faces spreads the loads evenly across the base area of the die 10.

[0023] Each adjacent, angled, face has a minimum area of about $5\text{cm} \times 12.5\text{cm} = 62.5\text{cm}^2$ and the adjacent, angled, faces have a minimum total area of about 375cm^2 . Each horizontal face has a minimum area of about $12.5\text{cm} \times 12.5\text{cm} = 156.25\text{cm}^2$ and the horizontal faces have a minimum total area of about 937.5cm^2 . The angled faces preferably have a hardened surface for example stellite.

[0024] The adjacent faces 28B, 30B, 32B and 34B on the upper die part 12 extend away from the horizontal faces 28A, 30A, 32A and 34A respectively of the upper die part 12 towards the lower die part 14 and in particular

the adjacent faces 28B, 30B, 32B and 34B are arranged to face towards the lower die part 14 and towards the die 10. The adjacent faces 44B, 46B, 48B and 50B on the lower die part 14 extend away from the horizontal faces 44A, 46A, 48A and 50A respectively of the lower die part 14 away from the upper die part 12 and in particular the adjacent faces 44B, 46B, 48B and 50B are arranged to face away from the upper die part 12 and away from the die 10. The adjacent faces 28B, 30B, 32B and 34B are arranged parallel to the corresponding adjacent faces 44B, 46B, 48B and 50B respectively. The adjacent faces 28B, 30B, 32B and 34B thus face towards the corresponding adjacent faces 44B, 46B, 48B and 50B.

[0025] Similarly the adjacent faces 52B and 54B on the upper die part 12 extend away from the horizontal faces 52A and 54A respectively of the upper die part 12 towards the lower die part 14 and in particular the adjacent faces 52B and 54B are arranged to face towards the lower die part 14 and towards the die 10. The adjacent faces 56B and 58B on the lower die part 14 extend away from the horizontal faces 56A and 58A respectively of the lower die part 14 away from the upper die part 12 and in particular the adjacent faces 56B and 58B are arranged to face away from the upper die part 12 and away from the die 10. The adjacent faces 52B and 54B are arranged parallel to the corresponding adjacent faces 56B and 58B respectively. The adjacent faces 52B and 54B thus face towards the corresponding adjacent faces 56B and 58B.

[0026] In use an integral structure comprising diffusion bonded titanium workpieces is placed in the superplastic forming die 10. The upper and lower shaped forming surfaces 16 and 18 are twisted in order to provide a twisted shape to the integral structure comprising diffusion bonded titanium workpieces for example to form a twisted shape necessary to produce a fan blade, or a fan outlet guide vane. The upper and lower shaped forming surfaces 16 and 18 produce lateral and twisting forces T on the die 10. The lateral and twisting forces T are resisted by the adjacent, angled, faces 28B, 30B, 32B, 34B, 44B, 46B, 48B and 50B on the pillars 28, 30, 32, 34, 44, 46, 48 and 50 on the upper and lower die parts 12 and 14. The adjacent, angled, faces 52B, 54B, 56B and 58B on the additional pillars 52, 54, 56 and 58 resist longitudinal movement. The adjacent, angled, faces 28B, 30B, 32B, 34B, 44B, 46B, 48B, 50B, 52B, 56B and 58B form interlocking means to prevent relative movement of the upper and lower die parts 12 and 14.

[0027] The two vertical pillars 28 and 32 arranged at diametrically opposite corners 20 and 24 on the upper die part 12 and the two vertical pillars 44 and 48 arranged at diametrically opposite corners 36 and 40 on the lower die part 14, with the angled faces being arranged inclined in opposite directions, which resists the twisting forces T.

[0028] The advantage of the present invention is that twisting of the die parts is reduced, preferably prevent-

ed, and this improves the die stability, die conformance and die life. Also the platens are protected from deformation. Additionally the quality of the fan blades or other article produced by the die is improved.

[0029] It may be possible to arrange the vertical pillars of the upper and lower die parts of the die such that the adjacent, angled, faces of the vertical pillars extend away from the horizontal faces towards the upper die as shown in figure 5.

[0030] Although the adjacent, angled, faces of the pillars have been provided on the sides of the pillars remote from the die parts, it may be possible for the adjacent, angled, faces of the pillars to be provided on the sides of the pillars adjacent the die parts as shown in figures 6 or 7. Alternatively each pillar may have two adjacent angled faces, one on the side of the pillar remote from the die and one on the side of the pillar adjacent the die as shown in figures 8, 9, 10 or 11.

[0031] Although the present invention has been described with reference to a die comprising vertically arranged upper and lower die parts and vertical pillars, it may be equally possible for the die to comprise horizontally arranged first and second die parts and horizontal pillars. In that instance the horizontal pillars have vertical faces and adjacent, angled, faces. Clearly the die parts could be arranged in other orientations.

[0032] Although the present invention has been described with reference to a superplastic forming die it may be used on a hot forming die or other two part die.

[0033] Although the present invention has been described with reference to two pillars on each side and one pillar on each end of each die part, it may be possible to provide only one pillar on each side of each die part. More preferably it may be possible to provide one pillar on each side and one pillar on each end of each die part.

Claims

1. A forming die (10) comprising a first die part (12) and a second die part (14), the first die part (12) having a first shaped forming surface (16), the second die part (14) having a second shaped forming surface (18), **characterised in that** the first die part (12) having at least two pillars (28,30,32,34), a first one (28) of the at least two pillars (28,30,32,34) being arranged at a first side of the first die part (12) and a second one (32) of the at least two pillars (28,30,32,34) being arranged at a second opposite side of the first die part (12), the second die part (14) having at least two pillars (44,46,48,50), a first one (44) of the at least two pillars (44,46,48,50) being arranged at a first side of the second die part (14) and a second one (48) of the at least two pillars (44,46,48,50) being arranged at a second opposite side of the second die part (14), the pillars (28,30,32,34) on the first die part (12) being locatable on the pillars (44,46,48,50) on the second die part (14), the pillars (28,30,32,34,44,46,48,50) on the first and second die parts (12,14) having interlocking means (28B,30B,32B,34B,44B,46B,48B,50B) to prevent relative movement between the first die part (12) and the second die part (14).
2. A forming die as claimed in claim 1 wherein the first die part (12) having at least two additional pillars (52,54), a first one (52) of the at least two additional pillars (52,54) being arranged at a first end of the first die part (12) and a second one (54) of the at least two additional pillars (52,54) being arranged at a second opposite end of the first die part (12), the second die part (14) having at least two additional pillars (56,58), a first one (56) of the at least two additional pillars (56,58) being arranged at a first end of the second die part (14) and a second one (58) of the at least two additional pillars (56,58) being arranged at a second opposite end of the second die part (14), the additional pillars (52,54) on the first die part (12) being locatable on the additional pillars (56,58) on the second die part (14), the additional pillars (52,54,56,58) on the first and second die parts (12,14) having interlocking means (52B, 54B, 56B, 58B) to prevent relative movement between the first die part (12) and the second die part (14).
3. A forming die as claimed in claim 1 or claim 2 wherein the first die part (12) having at least four pillars (28,30,32,34), two (28,34) of the at least four pillars (28,30,32,34) being arranged at a first side of the first die part (12) and two (30,32) of the at least four pillars (28,30,32,34) being arranged at a second opposite side of the first die part (12), the second die part (14) having at least four pillars (44,46,48,50), two (44,50) of the at least four pillars (44,46,48,50) being arranged at a first side of the second die part (14) and two (46,48) of the at least four pillars (44,46,48,50) being arranged at a second opposite side of the second die part (14), the pillars (28,30,32,34) on the first die part (12) being locatable on the pillars (44,46,48,50) on the second die part (14), the pillars (28,30,32,34,44,46,48,50) on the first and second die parts (12,14) having interlocking means (28B,30B,32B,34B,44B,46B,48B, 50B) to prevent relative movement between the first die part (12) and the second die part (14).
4. A forming die as claimed in claim 3 the first die part (12) having one of the four pillars (28,30,32,34) arranged at a corresponding one of the corners of the first die part (12), the second die part (14) having one of the four pillars (44,46,48,50) arranged at a corresponding one of the corners of the second die part (14).

5. A forming die as claimed in any of claims 1 to 4 wherein the first die part (12) is an upper die part and the second die part (14) is a lower die part.

6. A forming die as claimed in claim 5 wherein the pillars (28,30,32,34,44,46,48,50) extending vertically from the corresponding die part (12,14), each pillar (28,30,32,34,44,46,48,50) having a horizontal face (28A,30A,32A,34A,44A,46A,48A,50A) and an adjacent face (28B,30B,32B,34B,44B,46B,48B,50B) angled to the horizontal face (28A,30A,32A,34A,44A,46A,48A,50A), the vertical pillars (28,30,32,34) on the upper die part (12) being locatable on the vertical pillars (44,46,48,50) on the lower die part (14). 5
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7. A forming die as claimed in claim 5 wherein the horizontal faces (28A,30A,32A,34A,44A,46A,48A,50A) of the vertical pillars (28,30,32,34,44,46,48,50) are equal in area. 20

8. A forming die as claimed in claim 6 or claim 7 wherein the adjacent faces (28B, 30B, 32B, 34B, 44B, 46B, 48B, 50B) of the vertical pillars (28,30,32,34,44,46,48,50) are equal in area. 25

9. A forming die as claimed in claim 6, claim 7 or claim 8 wherein the horizontal faces (52A,54A,56A,58A) of the additional vertical pillars (52,54,56,58) are equal in area. 30

10. A forming die as claimed in claim 6, claim 7, claim 8 or claim 9 wherein the adjacent faces (52B, 54B, 56B, 58B) of the additional vertical pillars (52,54,56,58) are equal in area. 35

11. A forming die as claimed in any of claims 1 to 10 wherein the forming die (10) is a superplastic forming die or a hot forming die. 40
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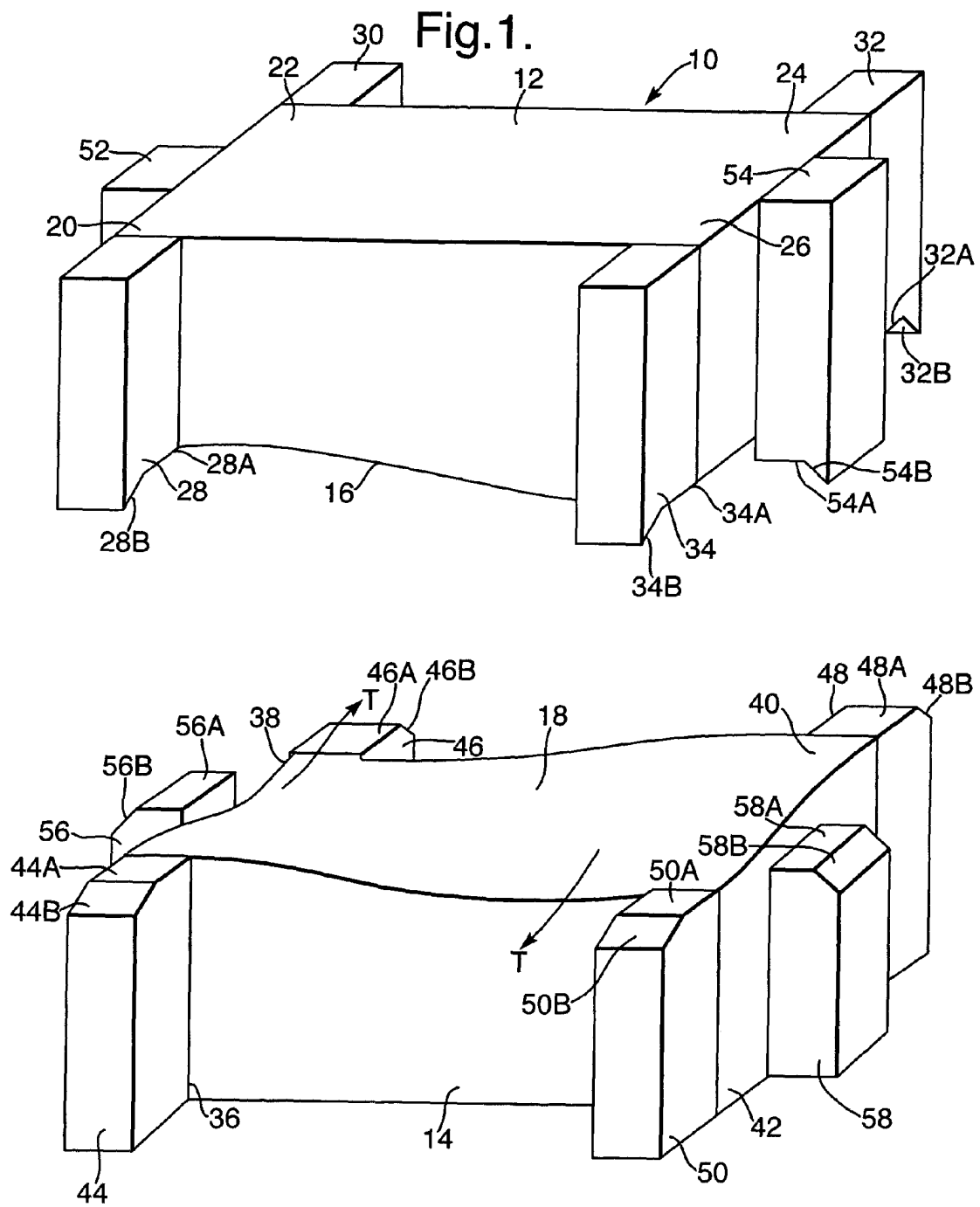


Fig.2.

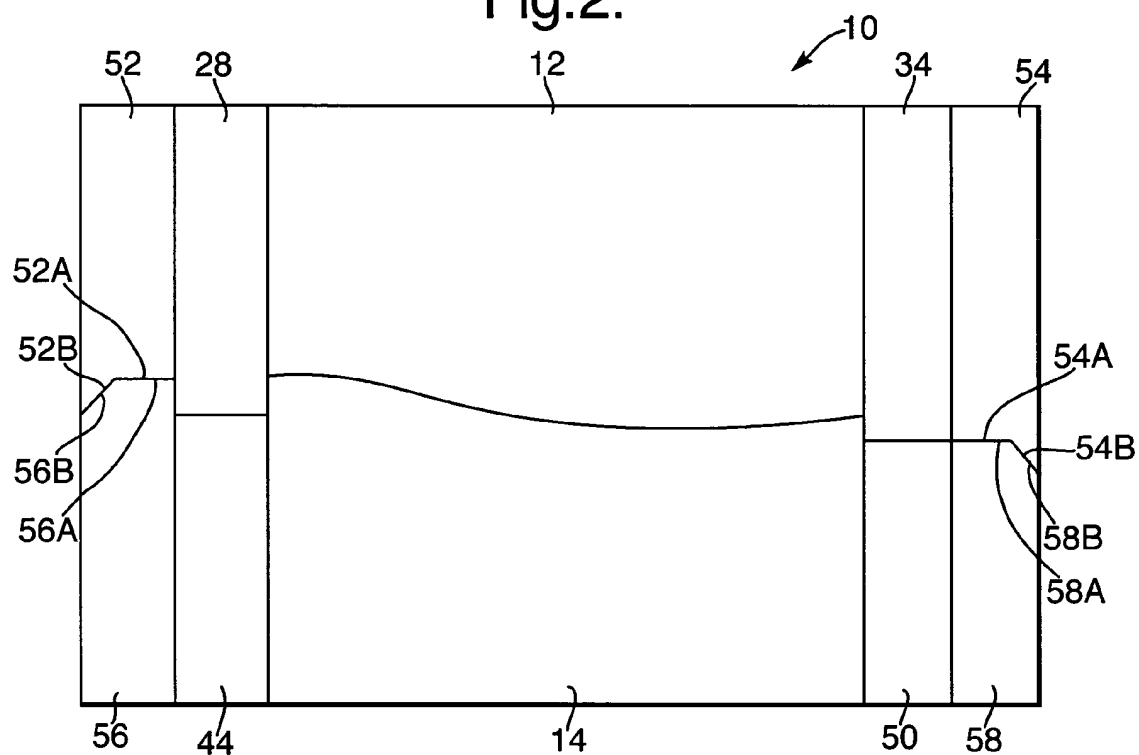


Fig.3.

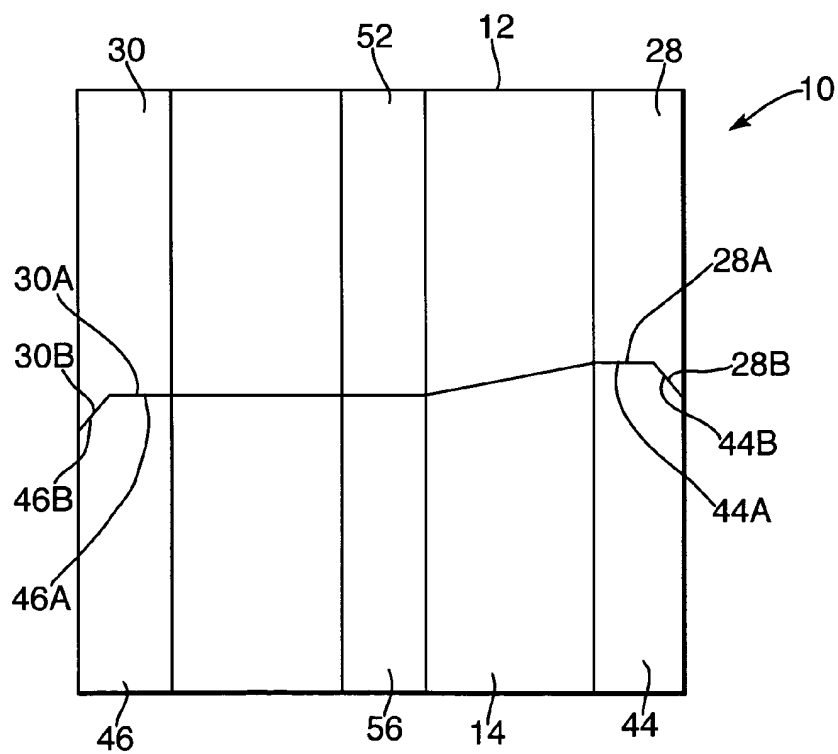


Fig.4.

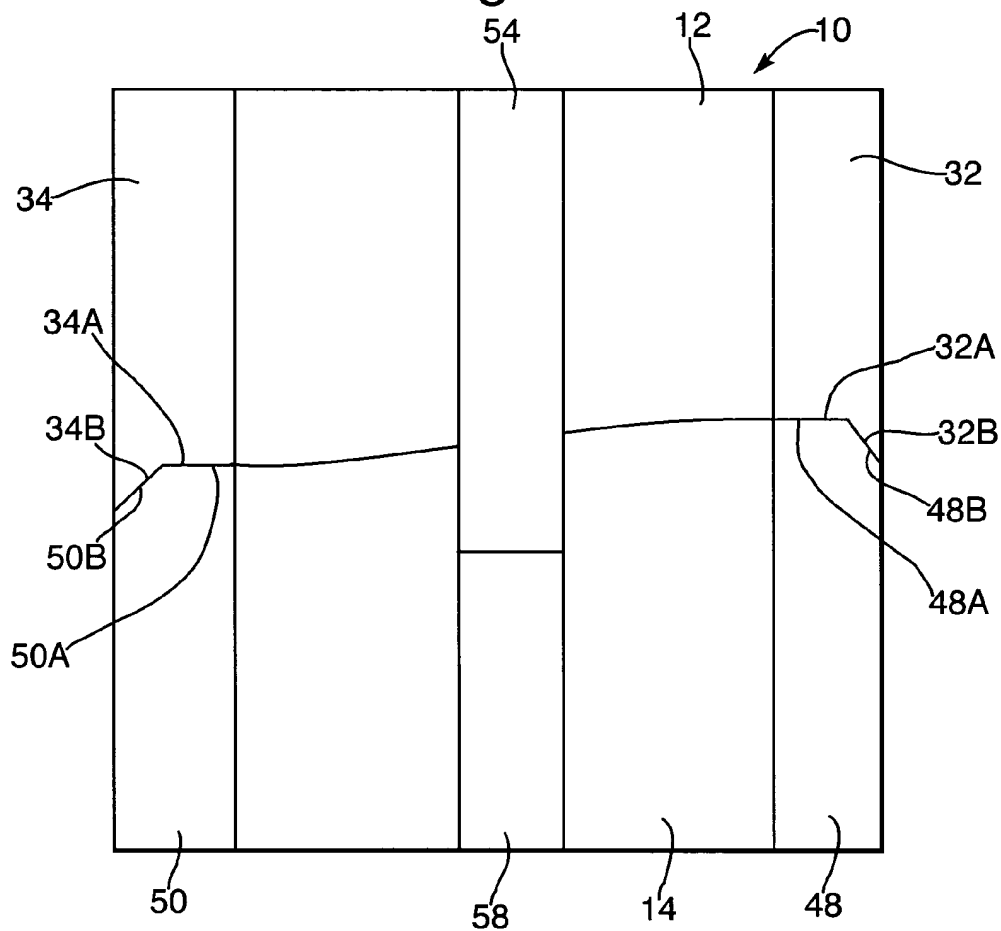


Fig.11.

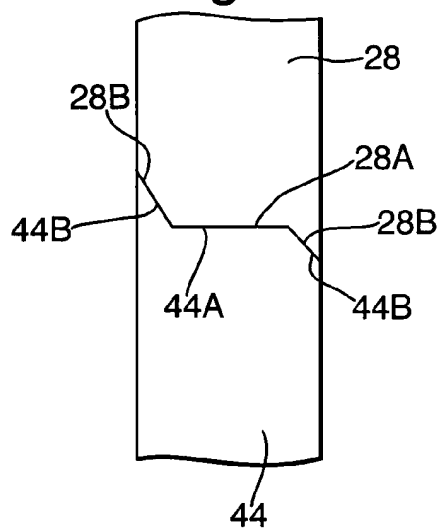


Fig.5.

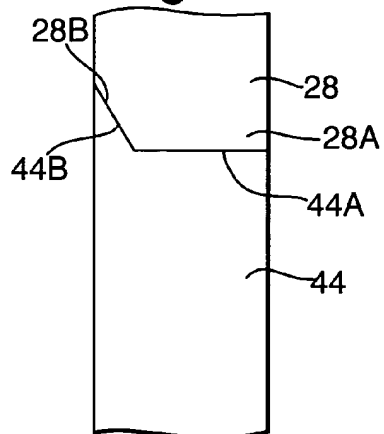


Fig.6.

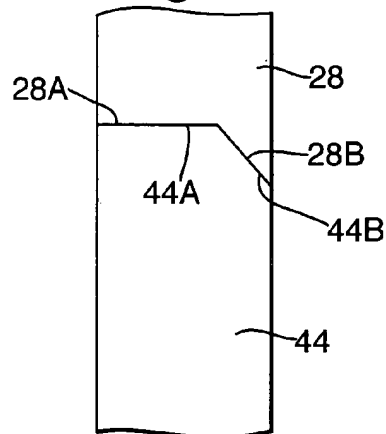


Fig.7.

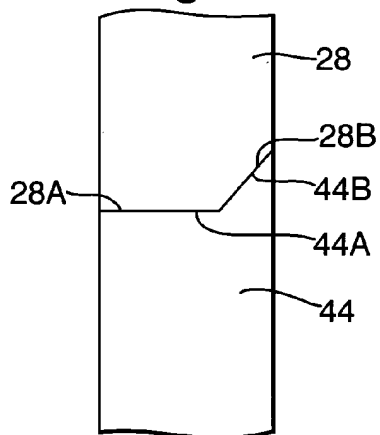


Fig.8.

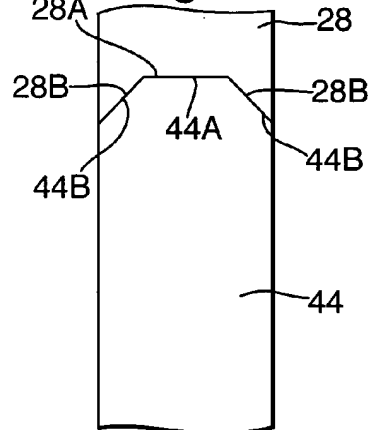


Fig.9.

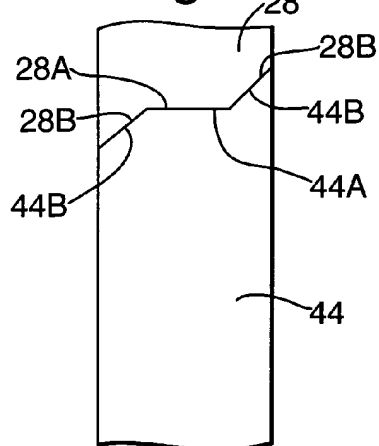
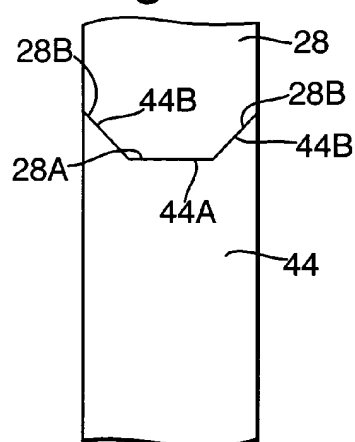


Fig.10.





European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 05 25 0140

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			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 21 March 2005	Examiner Vinci, V
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 05 25 0140

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