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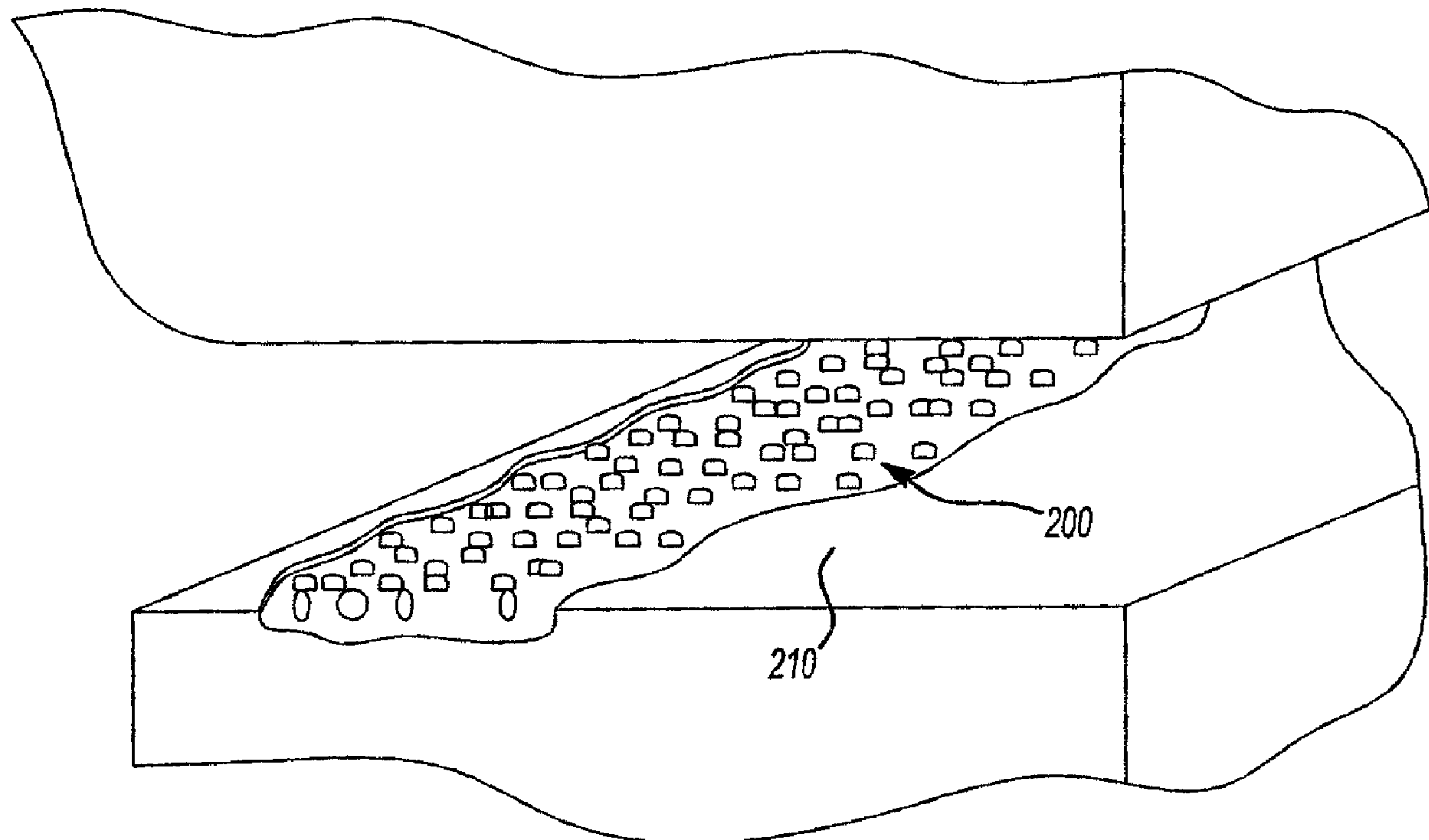
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(54) Title: SHEET METAL FORMING DIE ASSEMBLY WITH TEXTURED DIE SURFACES



(57) **Abrégé/Abstract:**

An improved stamping die assembly is provided for controlling the flow of sheet metal during the draw forming process. The die assembly includes a textured die surface on the one or both sides of the binder mating surfaces that replaces conventional draw and lock beads. The textured die surface can be formed using direct metal deposition of a hard material, harder than the existing die surfaces, on the existing die base material to achieve an engineered textured surface. The textured die surface optimizes the performance of the die by enabling longer die life, higher coefficients of friction between the mating binder surfaces and reduction of wrinkles and stringers typically caused by draw and lock beads in the draw forming process.

A B S T R A C T

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SHEET METAL FORMING DIE ASSEMBLY WITH TEXTURED DIE SURFACES

The present invention relates in general to a sheet metal forming die assembly. More specifically, but without restriction to the particular embodiment and/or use which is shown or described for purposes of illustration, the present invention relates to an improved sheet metal draw forming die assembly with textured surfaces.

Sheet metal draw forming and stamping die assemblies have been used for many years to form various sheet metal components. Draw forming press assemblies are used in the automotive industry to form various outer body panels such as a hood, roof or door exterior panel. A typical configuration for an outer body panel draw forming press assembly would include a press, an upper die, a lower punch, a lower binder, a lower shoe, a press bed and cushion pins.

As is well known in the art, draw beads and lock beads are commonly used in the upper die and lower binder mating surfaces to control the flow of the sheet metal during the forming process. The mating components of the draw and lock beads are machined into the binder and upper die mating surfaces, respectively. Draw and lock beads usually consist of geometric shapes that include sharp radii and are designed to locally control and even stop sheet metal flow during the forming operation. A disadvantage of the draw and lock beads is that they are subject to high wear. To service and repair the beads, the die and binder are typically removed from the press.

Utilizing draw and/or lock beads in the press assemblies can require additional press tonnage to prevent uplift between the binder and upper die as the sheet metal attempts to flow around the bead geometry during the draw forming process. Furthermore, additional material is required beyond the product trim line to form the sheet metal into the bead configuration. In addition, draw and lock beads can cause

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sheet metal wrinkling and stringers as the sheet metal flows in relation to the beads during the draw forming process. The die and binder repairs, sheet metal stringers and wrinkles, additional press tonnage and extra sheet metal stock required for the bead geometry all increase the costs and decrease the productivity of manufacturing automotive sheet metal outer body panels.

Thus, there is a need for improved sheet metal flow control in a draw forming die assembly that overcomes the aforementioned drawbacks incurred when using draw and/or lock beads to control the sheet metal flow during the forming process.

10 Accordingly, the present invention eliminates or significantly reduces the need for draw and/or lock beads by providing a textured die surface for controlling sheet metal flow during the draw forming process. In accordance with one aspect of the present invention, a textured die surface is formed on a binder surface of a draw forming die assembly that is arranged to engage the sheet metal. The textured die surface increases the coefficient of friction between the binder surface and the sheet metal when the sheet metal is clamped between the binder surface and an upper die assembly perimeter surface during the draw forming process.

 In another aspect, the invention provides a die assembly for draw forming sheet metal stock into a desired part during a draw forming process, the die assembly
20 comprising:

 a first die having a first die inner surface arranged to engage one surface portion of the sheet metal stock during the forming operation and a first die perimeter surface further arranged to engage one surface of a perimeter portion of the sheet metal stock;

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a second die comprising a second die inner surface for engaging an opposite surface portion of the sheet metal stock during the forming operation; and

a binder assembly arranged to encompass the second die and having a surface further arranged to engage an opposite surface of the perimeter portion of the sheet metal stock to clamp the sheet metal stock between the binder surface and the first die perimeter surface during the forming operation, wherein the binder surface includes a textured surface portion formed on and metallurgically bonded to the binder surface that is arranged to engage the opposite surface of the perimeter portion of the sheet metal stock,

10 wherein the textured surface portion increases the coefficient of friction between the binder surface and the sheet metal stock when the perimeter portion of the sheet metal stock is clamped between the binder surface and the first die perimeter surface during the draw forming process.

In another aspect, the invention provides a die assembly for draw forming sheet metal stock into a desired part, the die assembly comprising:

a first die having an inner die surface arranged to engage one surface portion of the sheet metal stock during the forming operation and a perimeter die surface further arranged to engage one surface of a perimeter portion of the sheet metal stock;

20 a second die comprising an inner die surface for engaging an opposite surface portion of the sheet metal stock during the forming operation;

a binder assembly arranged to encompass the second die assembly and having a surface further arranged to engage an opposite perimeter portion of the sheet metal stock to clamp the sheet metal stock between the binder surface and the first die perimeter surface during the forming operation; and

- 2b -

a textured surface portion formed on and metallurgically bonded to the first die perimeter surface, wherein the textured surface portion of the first die perimeter surface is arranged to increase the coefficient of friction between the first die perimeter surface and the perimeter portion of the sheet metal stock when the perimeter portion of the sheet metal stock is clamped during a draw-forming process between the first die perimeter surface and the binder surface.

Additional benefits and advantages of the present invention will become apparent to those skilled in the art to which this invention relates from a reading of the
10 subsequent description of the preferred embodiment and the appended claims, taken in conjunction with the accompanying drawings.

Other aspects, features, and advantages of the present invention will become more fully apparent from the following detailed description of the preferred embodiment, the appended claims, and in the accompanying drawings in which:

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Figure 1A is a sectional view of a conventional three-piece die assembly arrangement;

Figure 1B is a sectional view of the conventional die assembly of Figure 1 shown after the upper die has draw formed the sheet metal over the lower punch;

Figure 2 is a sectional view of a conventional draw bead arrangement;

Figure 3 is a sectional view of a conventional lock bead arrangement;

Figure 4 is an exploded view of a textured die surface on the binder surface in accordance with the present invention;

Figure 5 is an illustration of a randomly dispersed particle textured die surface in accordance with the present invention;

Figure 6 is an illustration of a continuous bead textured die surface in accordance with the present invention;

Figure 7 is an illustration of a segmented bead textured die surface in accordance with the present invention; and

Figure 8 is an exploded view of a textured die surface on both the binder surface and the upper die perimeter die surface in accordance with the present invention.

In the following description, numerous specific details are set forth in order to provide a more comprehensive description of the present invention. It will become apparent, however, to one skilled in the art, that the present invention may be practiced without these specific details. In other instances, specific details of well-known features have not been described so as to not obscure the present invention.

Referring now to the drawings, Figure 1A illustrates a typical draw form die assembly arrangement with a flat binder face. The sheet metal 10 is in its original, pre-formed state secured by pressure between the lower binder face 20 and the upper die

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mating face 30. Figure 1B illustrates the die assembly in its post form state after a press (not shown) has imparted a force on the upper die 35 to form the sheet metal 10 over the lower punch 40 into the desired part.

During this process, the force imparted on the sheet metal by the upper die causes movement or stretching of the sheet metal, i.e. flow of the sheet metal at various locations in the die assembly. To control this sheet metal flow and increase the retention strength between the upper die and binder mating faces, draw beads and/or lock beads are used as shown in Figures 2 and 3, respectively. Figure 2 illustrates a conventional draw bead arrangement where the male portion 50 of the draw bead 55 is machined into the upper die 60 and the mating female portion 70 of the draw bead 55 is machined into the binder 80. Figure 3 illustrates a conventional lock bead arrangement 100 machined into the upper die 110 and binder face 120 in the same manner as the draw bead. The lock 100 bead is designed to locally stop sheet metal flow during the forming process and thus utilizes sharper radii when compared to draw bead 55.

Note that Figures 1-3 describe stamping and forming arrangements known in the art for illustration purposes only. It should be understood that not every feature of stamping and forming press assemblies are described and that this invention, as described below, can be applied to a variety of sheet metal stamping and forming press assemblies and the scope of the this invention is not to be limited by the arrangements shown and described in connection with Figures 1-3.

Referring now to Figure 4, a preferred embodiment of a textured draw die surface is shown in exploded view. The textured surface 200 is preferably created by direct metal deposition. Direct metal deposition is generally known to one of ordinary skill in the art and can be accomplished in several ways. Fundamental to the process is

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an intense, localized heat source that creates a molten pool in the substrate at a specific focal point. Metallic particles are simultaneously fed into the focal point area of the substrate molten pool and become dispersed throughout the molten pool volume. Subsequently, particle feeding and the application of heat are ceased, which results in a rapid cooling of the molten pool and a metallurgically bonded deposition on the outer layer of the substrate is formed. Direct metal deposition of particles of varying melting and/or hardness properties thus enables the deposition of hard material metallurgically bonded to the existing die base material to achieve an engineered textured surface.

Thus, in accordance with the present invention, the textured die surface is
10 designed to replace or significantly reduce the need for conventional draw beads and lock beads. In a preferred embodiment shown in Figure 4, the textured surface 200 is applied to the lower binder surface 210 only. The size of the particles used in creating the textured surface can be varied depending on the specific frictional requirements of the press forming operation. Furthermore, different material particles, such as carbide, can be utilized in the textured surface depending on the wear resistance characteristics required. Finally, also depending on the process wear and frictional requirements,
different particle patterns can be deposited onto a die surface as shown in Figures 5, 6 and 7. Figure 5 illustrates an example of a randomly dispersed particle pattern 300;
Figure 6 illustrates an example of particles deposited in a continuous bead pattern; and
20 Figure 7 illustrates an example of particles deposited in a segmented bead pattern 500.

Another embodiment of the present invention is shown in Figure 8, where a textured surface is applied to both the binder surface 630 and the upper die perimeter surface 610 thus creating both a binder textured surface 600 and an upper die perimeter textured surface 620. Applying the textured surface to both components

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increases the coefficient of friction between both die components and the sheet metal and therefore provides more control over the sheet metal during the forming process. Furthermore, it should be noted that the textured die surface can also be applied to the upper die perimeter surface 610 only. Finally, it should also be noted that the textured surface can be applied to only a portion of the binder surface and/or the upper die perimeter surface.

By replacing the lock and draw beads with the textured surface, a higher coefficient of friction can be achieved while eliminating some of the drawbacks associated with the beads such as wear, repair, stringers, wrinkles and the requirement for extra sheet metal stock. Note that draw and lock beads are machined directly into the die material and are naturally high wear components that require frequent maintenance and repair. The particles used in the textured die surfaces typically consist of a harder material than the die base material and also can typically encompass a height range of 0.10 mm to 0.75 mm whereas a typical lock bead height dimension can be approximately 8 mm. The carbide particle textured surface, for example, has improved wear characteristics over typical die materials, such as SAE G3500 - Alloyed Grey Cast Iron or SAE 0050A - Cast Steel, which are also used for the integrated draw and/or lock beads. Thus, the material as well as the size of the textured die surface particles enhance the textured die surface's wear characteristics as compared to draw and/or lock beads.

In addition, using the textured surface in place of the draw and/or lock beads allows for a reduction of the sheet metal blank size and therefore a corresponding cost savings. By not using the draw and/or lock beads, the blank size can be reduced by the amount of material that would have to be formed into the draw and/or lock bead configuration thus saving money in the piece cost of the sheet metal components.

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Furthermore, the textured surface will not create the uplifting force that draw and lock beads do and therefore press tonnage can potentially be reduced also saving money in manufacturing expenses. Finally, eliminating the draw and/or lock beads in favor of the textured surface will also require less press travel and therefore provide the opportunity, combined with the requirement for less tonnage, to use a smaller press than would be required for the same component with beads.

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The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A die assembly for draw forming sheet metal stock into a desired part during a draw forming process, the die assembly comprising:
 - a first die having a first die inner surface arranged to engage one surface portion of the sheet metal stock during the forming operation and a first die perimeter surface further arranged to engage one surface of a perimeter portion of the sheet metal stock;
 - a second die comprising a second die inner surface for engaging an opposite surface portion of the sheet metal stock during the forming operation; and
 - a binder assembly arranged to encompass the second die and having a surface further arranged to engage an opposite surface of the perimeter portion of the sheet metal stock to clamp the sheet metal stock between the binder surface and the first die perimeter surface during the forming operation, wherein the binder surface includes a textured surface portion formed on and metallurgically bonded to the binder surface that is arranged to engage the opposite surface of the perimeter portion of the sheet metal stock, wherein the textured surface portion increases the coefficient of friction between the binder surface and the sheet metal stock when the perimeter portion of the sheet metal stock is clamped between the binder surface and the first die perimeter surface during the draw forming process.
2. The die assembly of claim 1, wherein the textured surface portion of the binder surface is formed by direct metal deposition.
3. The die assembly of claim 2, wherein the textured surface portion of the binder surface comprises a plurality of particles of varying melting properties introduced during the direct metal deposition process.
4. The die assembly of claim 1, wherein the textured surface portion of the binder surface comprises a random pattern of particles of varying sizes.
5. The die assembly of claim 1, wherein the textured surface portion of the binder surface comprises particles of a harder material than the binder base metal.

6. The die assembly of claim 1, wherein the textured surface portion of the binder surface comprises a plurality of particles arranged to form at least one bead raised from the binder surface, the particles consisting of a harder material than the binder base metal.
7. The die assembly of claim 6, wherein the at least one bead consists of a plurality of beads, said plurality of beads arranged in a predetermined pattern.
8. The die assembly of claim 1, wherein at least a portion of the first die perimeter surface includes a textured surface portion arranged to engage the one surface of the perimeter portion of the sheet metal stock.
9. The die assembly of claim 8, wherein the textured surface portion of the first die perimeter surface is formed by direct metal deposition.
10. The die assembly of claim 8, wherein the textured surface portion of the first die perimeter surface comprises a plurality of particles of varying melting properties introduced during the direct metal deposition process.
11. The die assembly of claim 8, wherein the textured surface portion of the first die perimeter surface comprises a random pattern of particles of varying sizes.
12. The die assembly of claim 8, wherein the textured surface portion of the first die perimeter surface comprises a plurality of particles arranged to form at least one bead raised from each of the binder surface and the first die perimeter surface, the particles consisting of a harder material than the binder base metal and the first die base metal.
13. The die assembly of claim 12, wherein the at least one bead consists of a plurality of beads.
14. The die assembly of claim 13, wherein the plurality of beads are arranged in a predetermined pattern.

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15. The die assembly of claim 8, wherein the textured surface portion of the first die perimeter surface comprises particles of a harder material than the binder base metal and the first die base metal.

16. A die assembly for draw forming sheet metal stock into a desired part, the die assembly comprising:

- a first die having an inner die surface arranged to engage one surface portion of the sheet metal stock during the forming operation and a perimeter die surface further arranged to engage one surface of a perimeter portion of the sheet metal stock;

- a second die comprising an inner die surface for engaging an opposite surface portion of the sheet metal stock during the forming operation;

- a binder assembly arranged to encompass the second die assembly and having a surface further arranged to engage an opposite perimeter portion of the sheet metal stock to clamp the sheet metal stock between the binder surface and the first die perimeter surface during the forming operation; and

- a textured surface portion formed on and metallurgically bonded to the first die perimeter surface, wherein the textured surface portion of the first die perimeter surface is arranged to increase the coefficient of friction between the first die perimeter surface and the perimeter portion of the sheet metal stock when the perimeter portion of the sheet metal stock is clamped during a draw-forming process between the first die perimeter surface and the binder surface.

17. The die assembly of claim 16, wherein the textured surface portion of the first die perimeter surface is formed by direct metal deposition.

18. The die assembly of claim 17, wherein the textured surface portion of the first die perimeter surface comprises a plurality of particles of varying melting properties and sizes introduced during the direct metal deposition process.

19. The die assembly of claim 16, wherein the textured surface portion of the first die perimeter surface comprises a plurality of particles arranged to form at least one bead raised from the first die perimeter surface, the particles consisting of a harder material than the first die base metal.

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20. The die assembly of claim 19, wherein the at least one bead consists of a plurality of beads, said plurality of beads arranged in a predetermined pattern.

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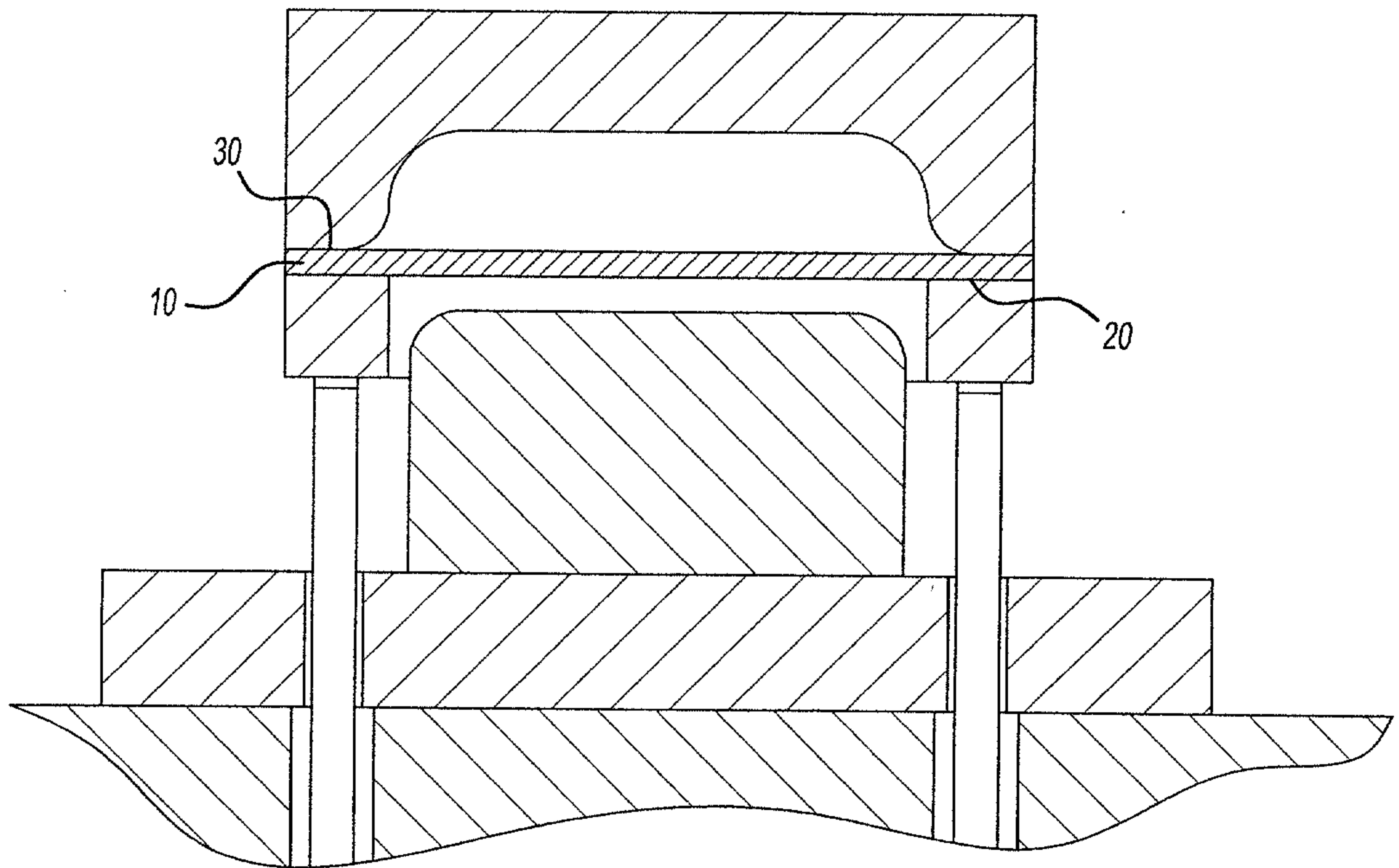


Fig-1 A
PRIOR ART

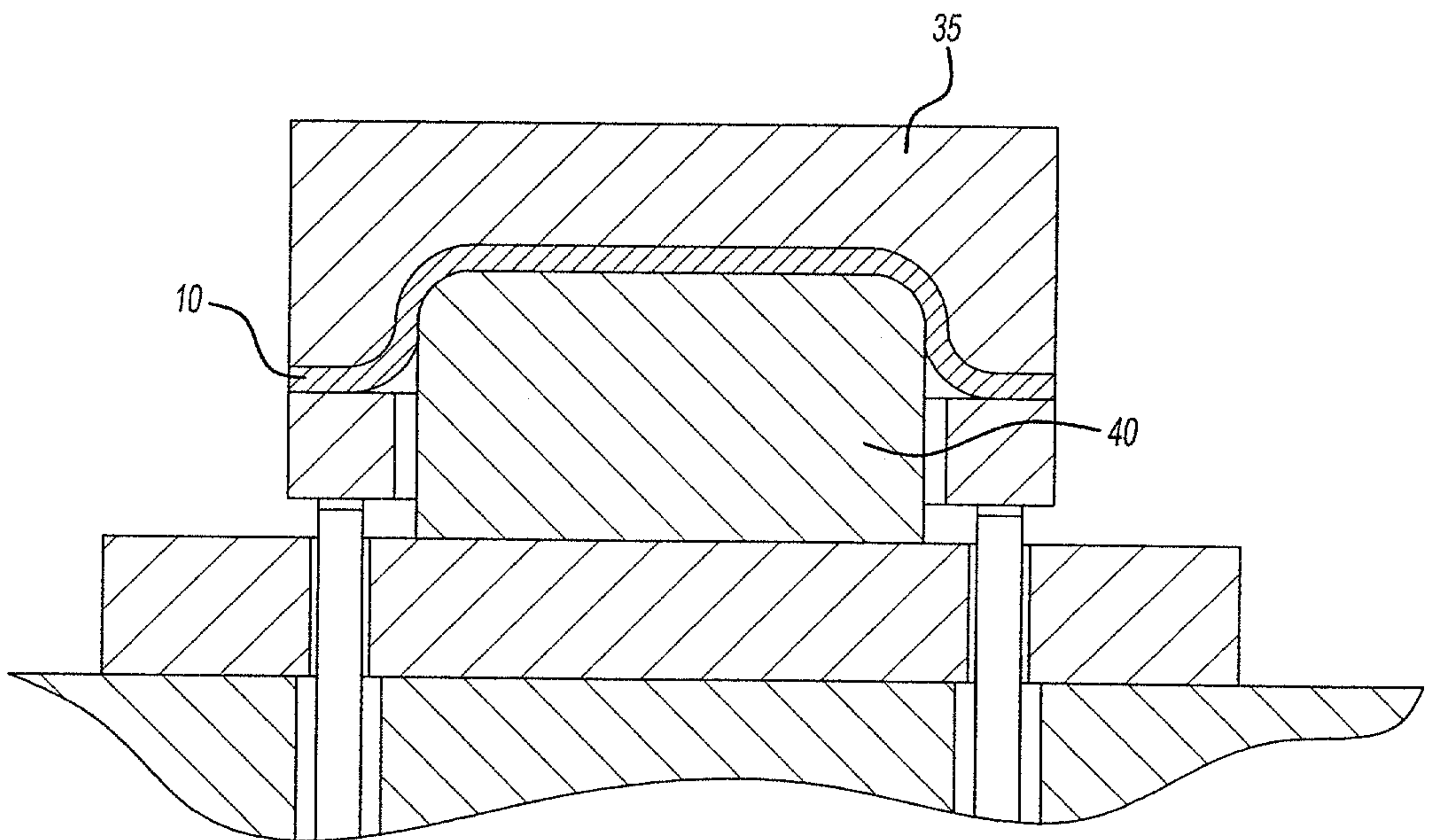


Fig-1 B
PRIOR ART

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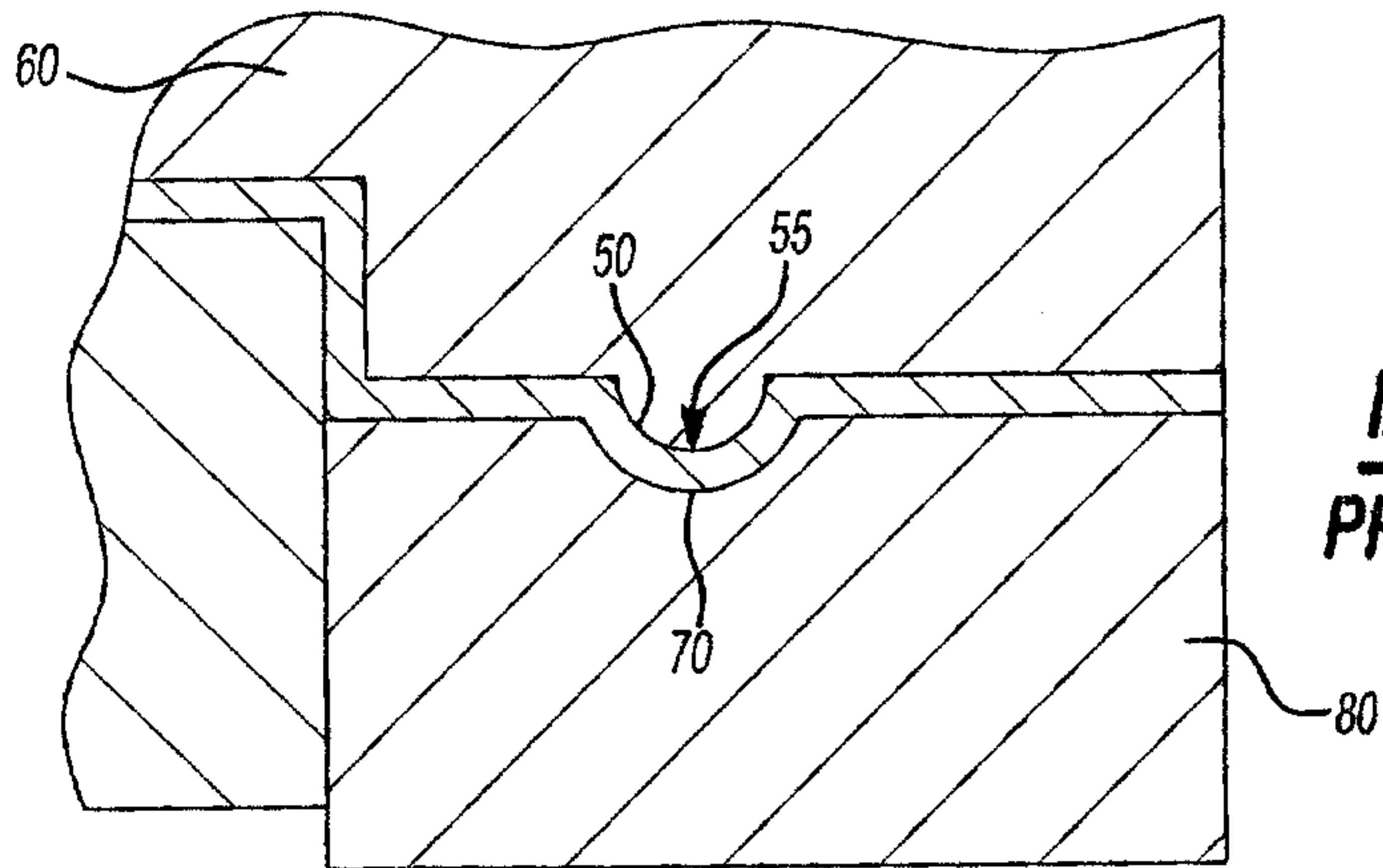


Fig-2
PRIOR ART

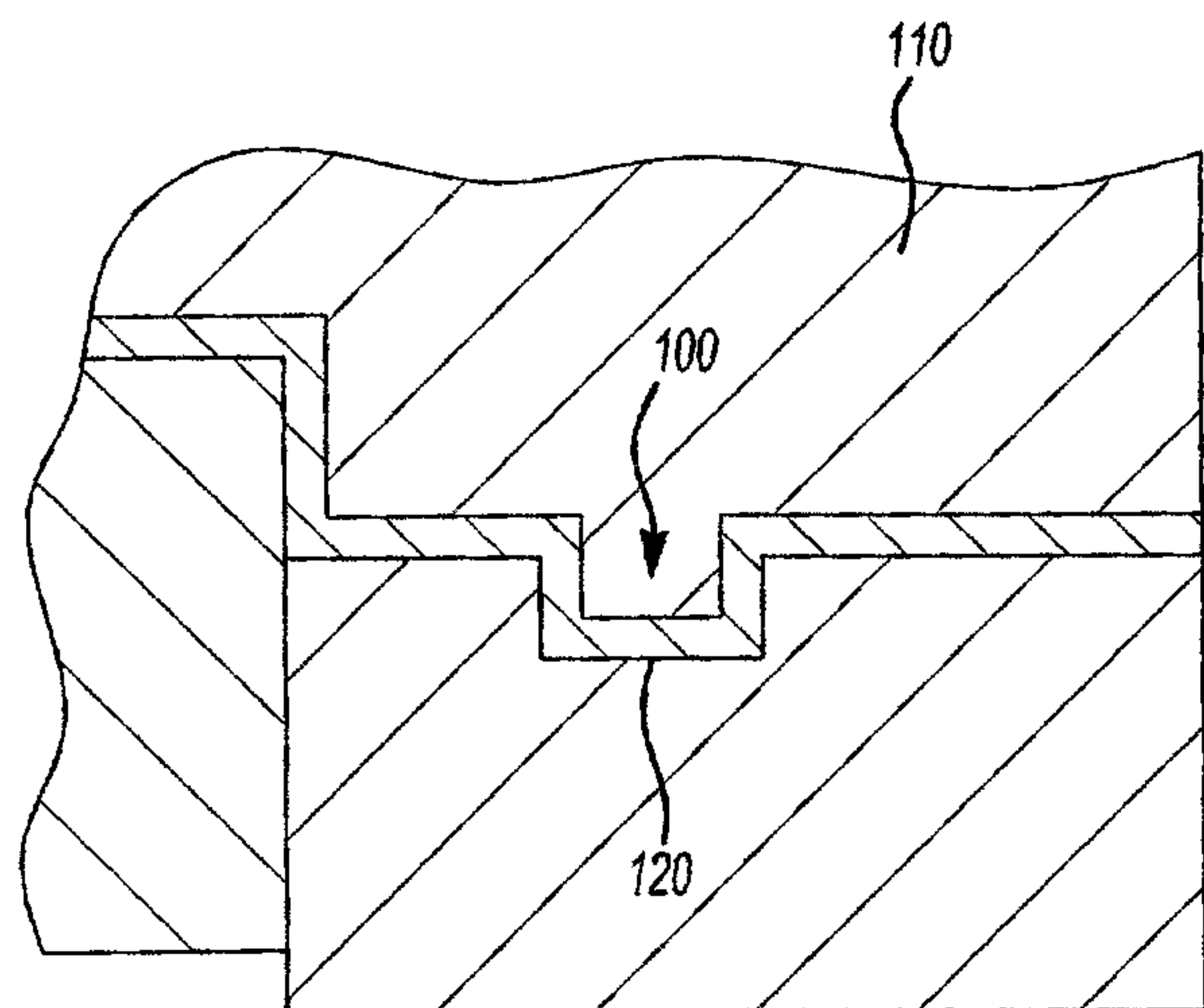


Fig-3
PRIOR ART

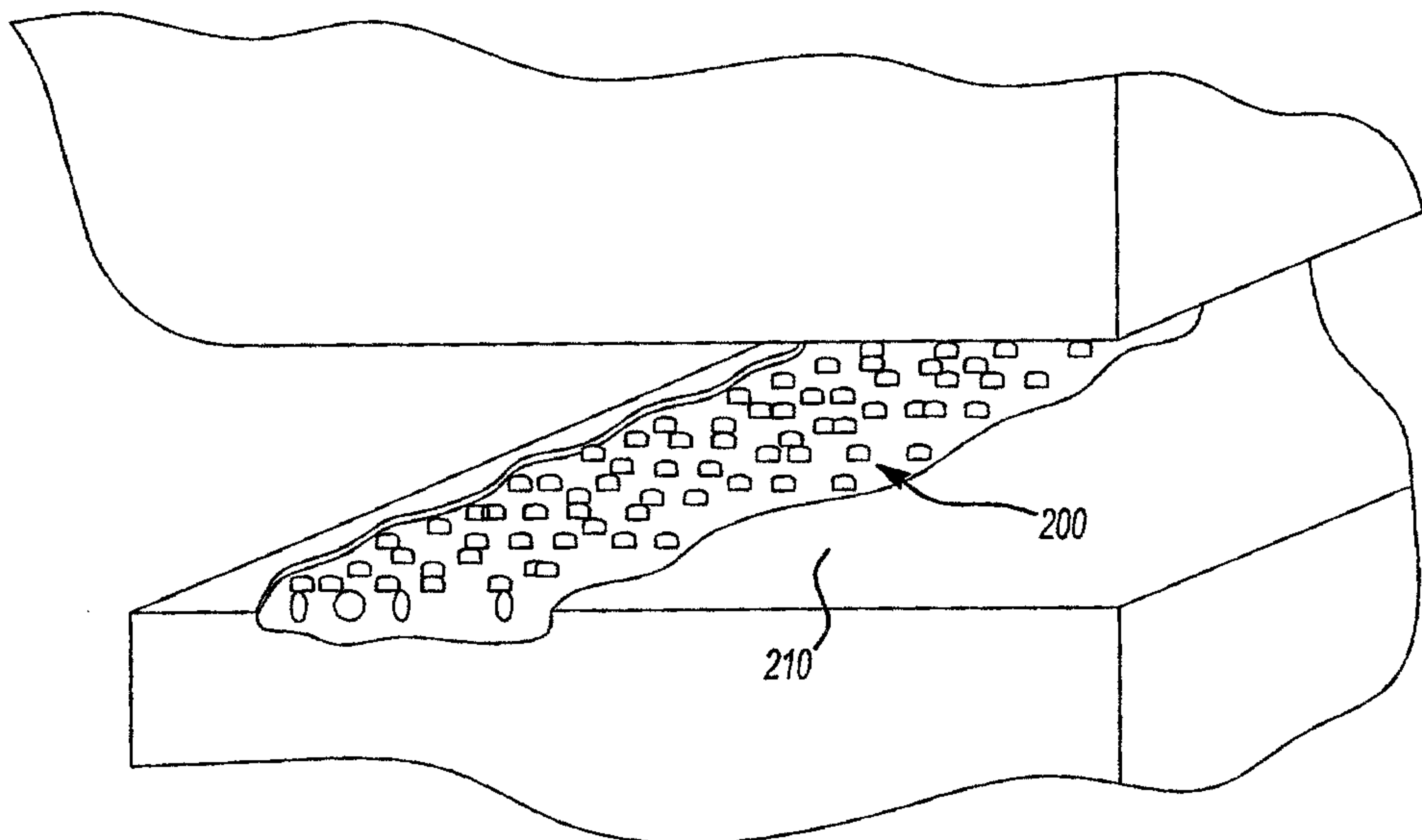


Fig-4

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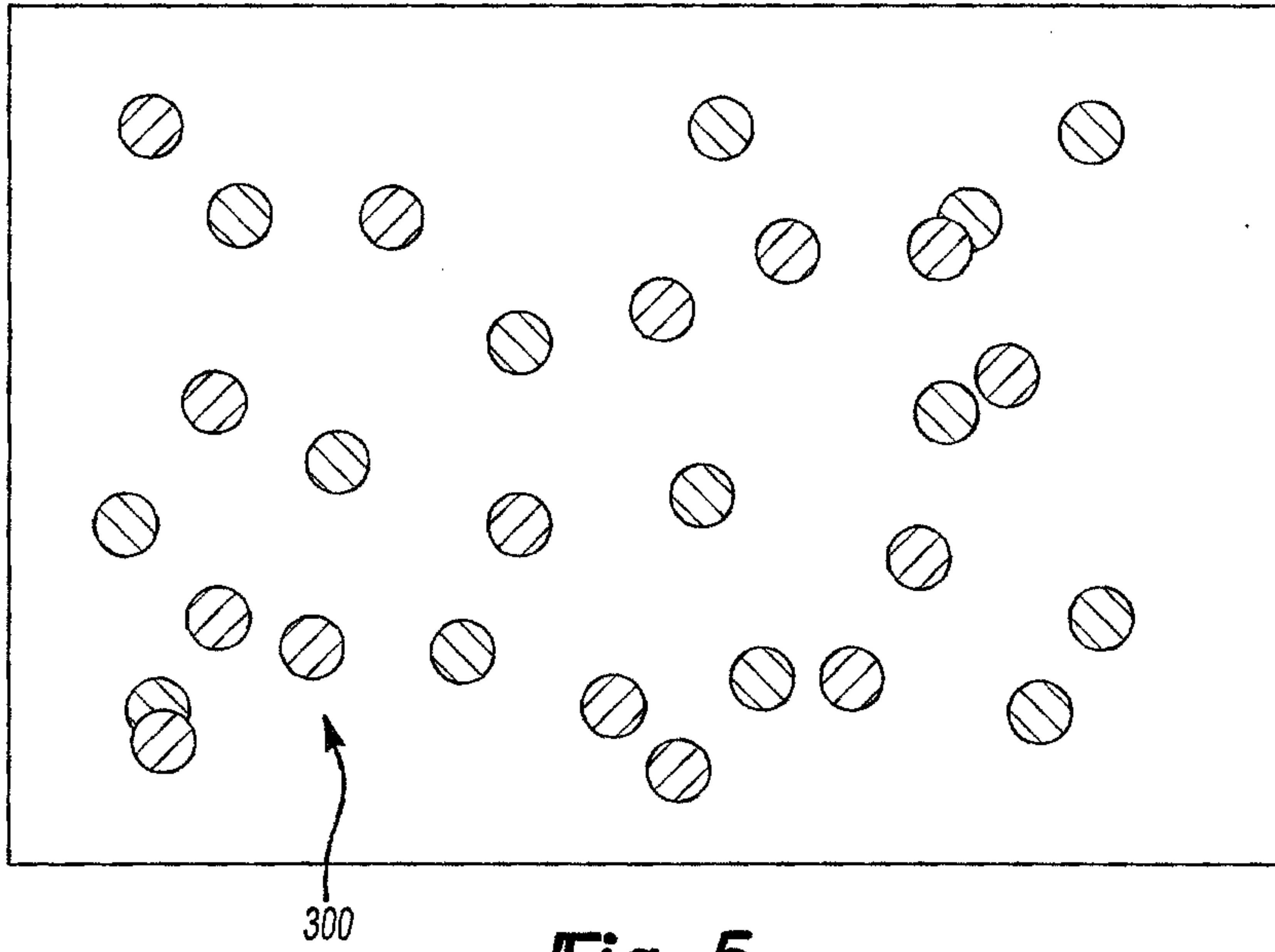


Fig-5

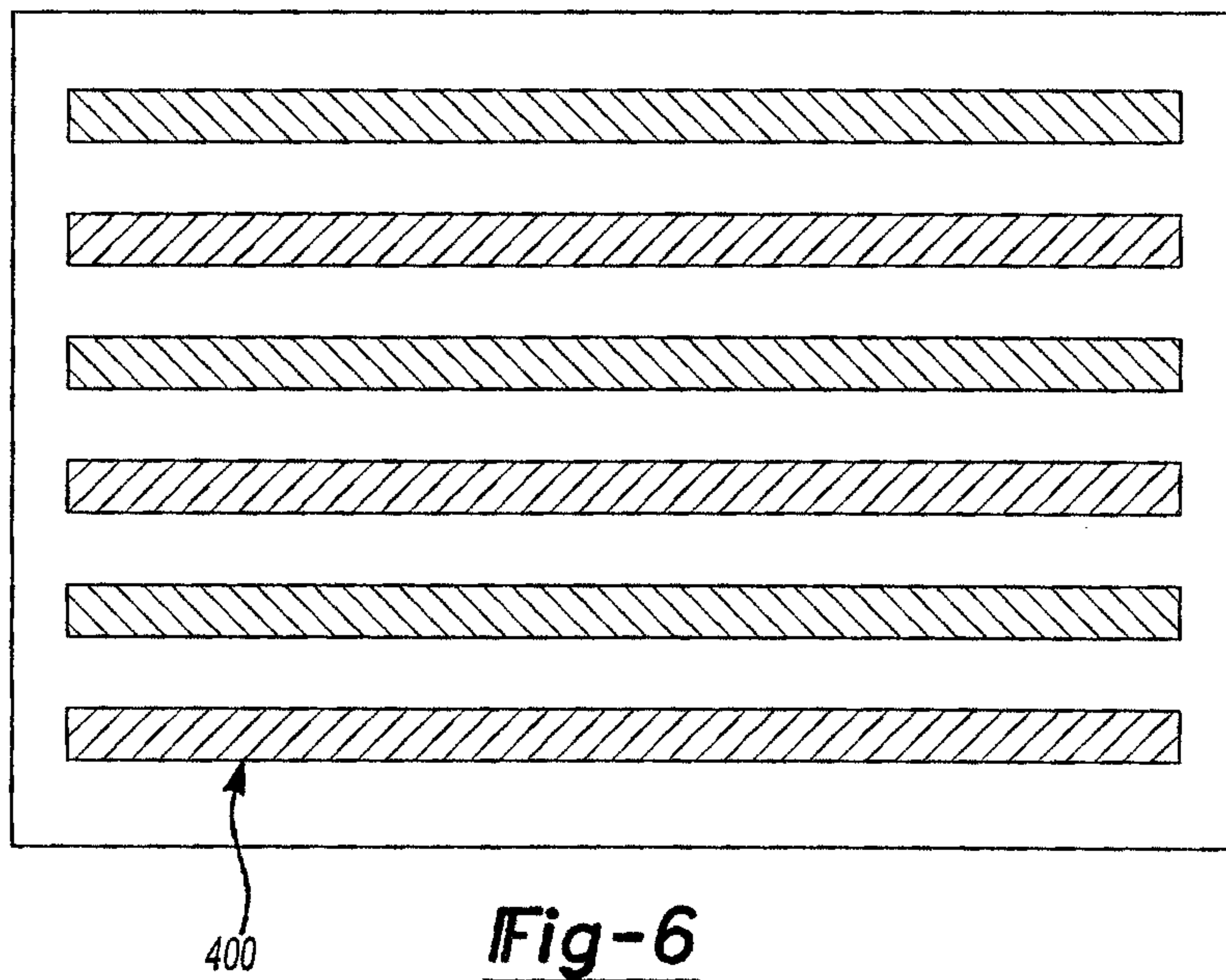
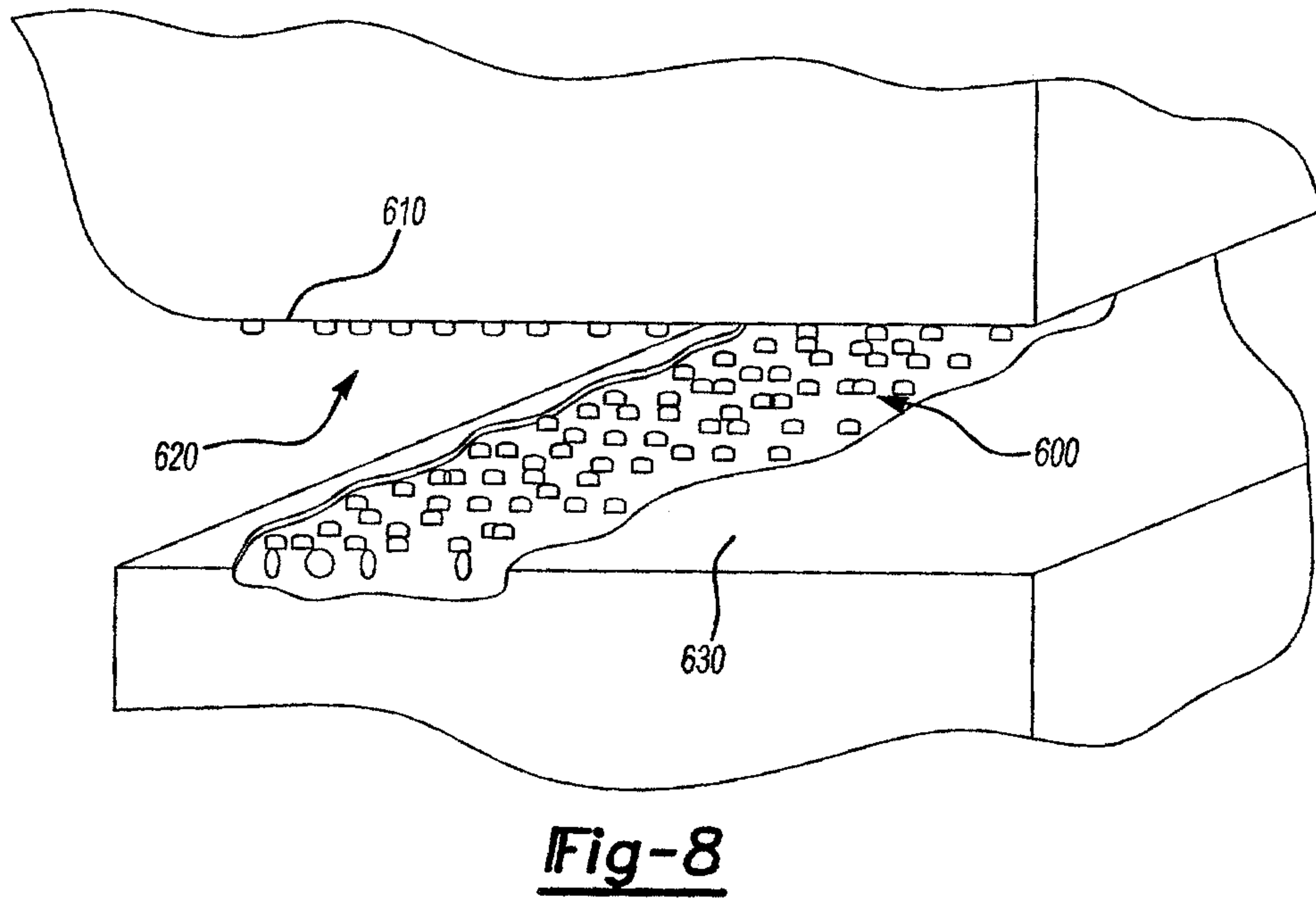
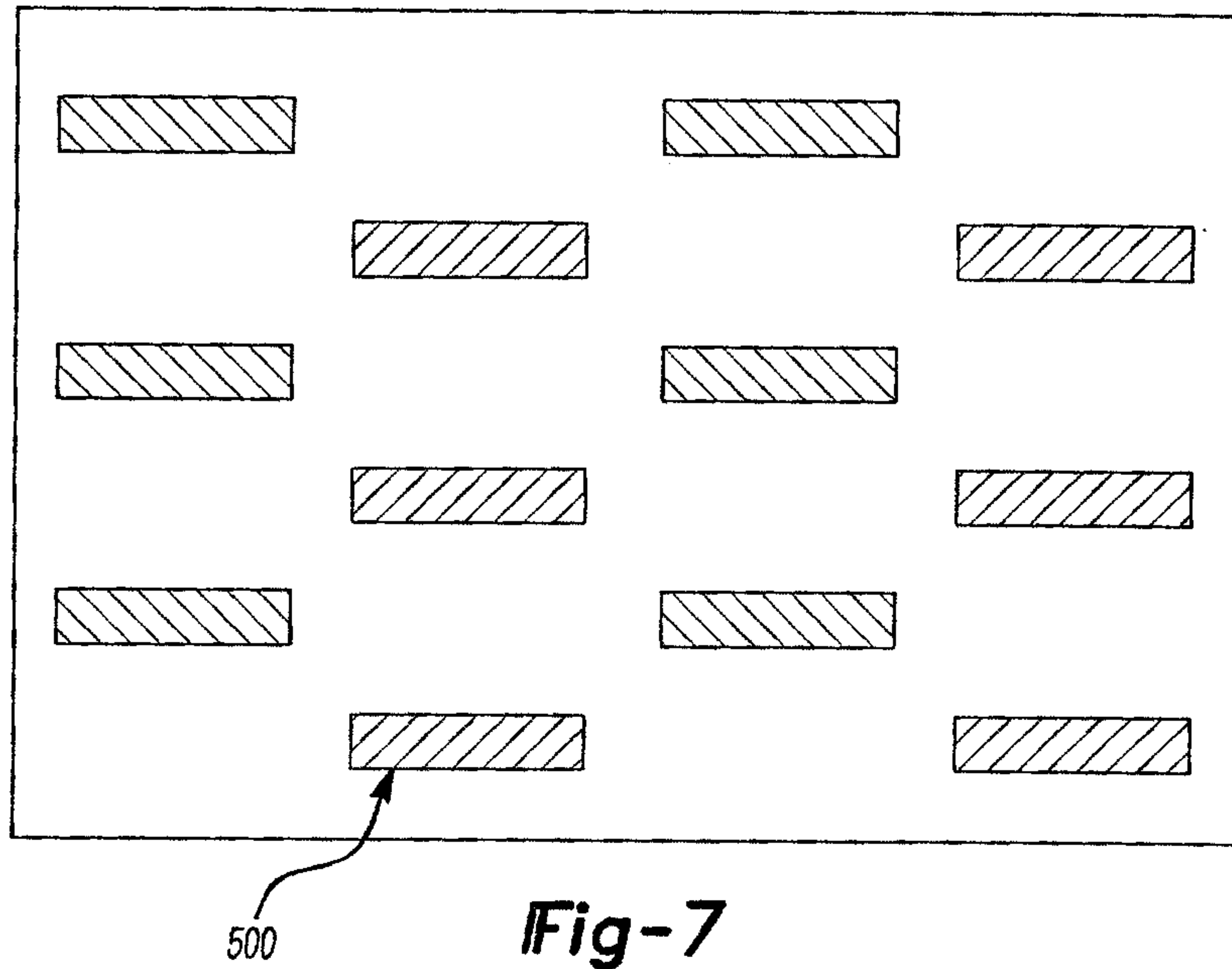


Fig-6

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