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(56) Documents Cited

**US 5048345 A US 4702515 A**

(58) Field of Search

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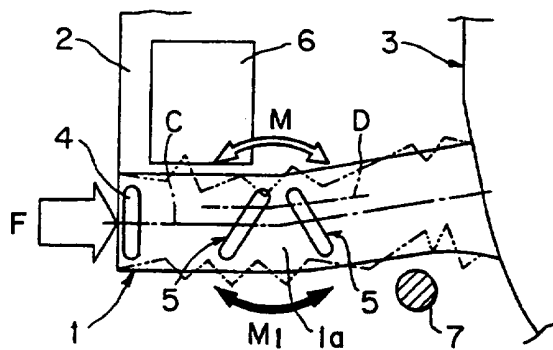
INT CL<sup>6</sup> **B62D 21/00 21/15 23/00 25/00 25/02 25/08**

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(54) **Motor vehicle structural member**

(57) A vehicle structural member 1 is formed with a hollow cross-section and has a pair of beads 5 formed in a V shape on a wall of the member. The member may be a longitudinal member formed at the side of a vehicle engine compartment. The structural member may have a convex portion 1a, eg to pass around an axle 7, or it may be straight. In the former case the beads are arranged such that a bending moment  $M_1$  generated at the convex portion by a impact load  $F$  is cancelled by a moment  $M$  generated by the beads. In the case of a straight member the beads serve to ensure the member will bend in a predetermined manner upon impact. The beads are arranged such that the space between them increases gradually from a compression side to a tension side of the bending moment  $M_1$ . Preventing a member with a convex portion from bending in a collision ensures that energy can be absorbed by buckling of the member. The beads operate by displacing the neutral axis (D fig 2) of the beam from its centre line (C fig 2) by a distance (L fig 2).



**FIG. 1**

**GB 2 318 552 A**

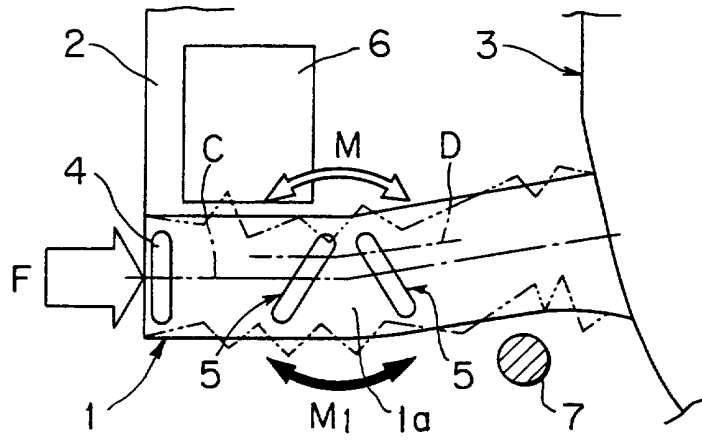


FIG. 1

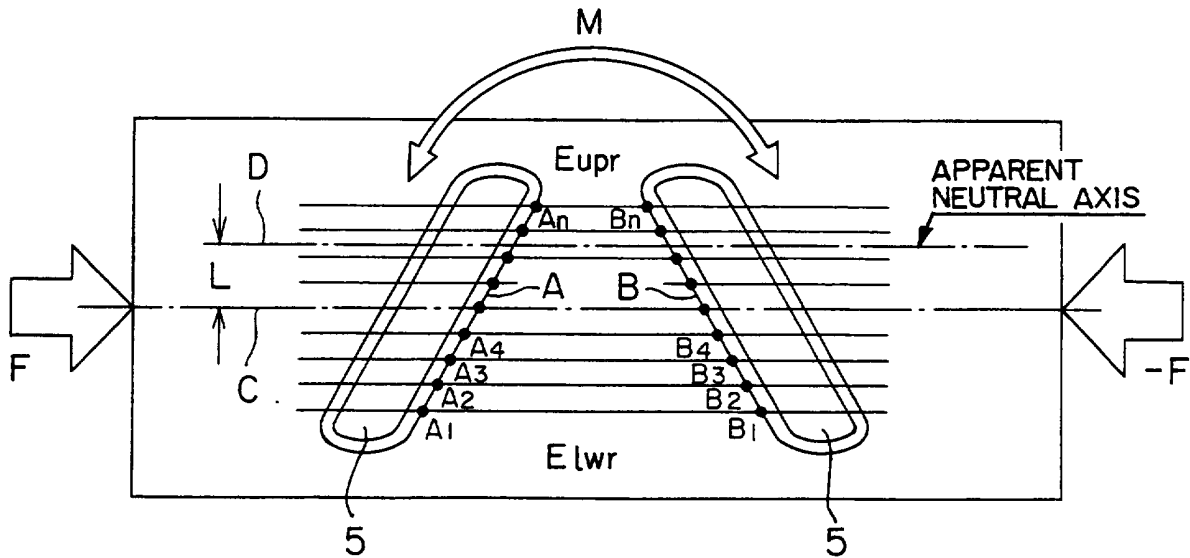


FIG. 2

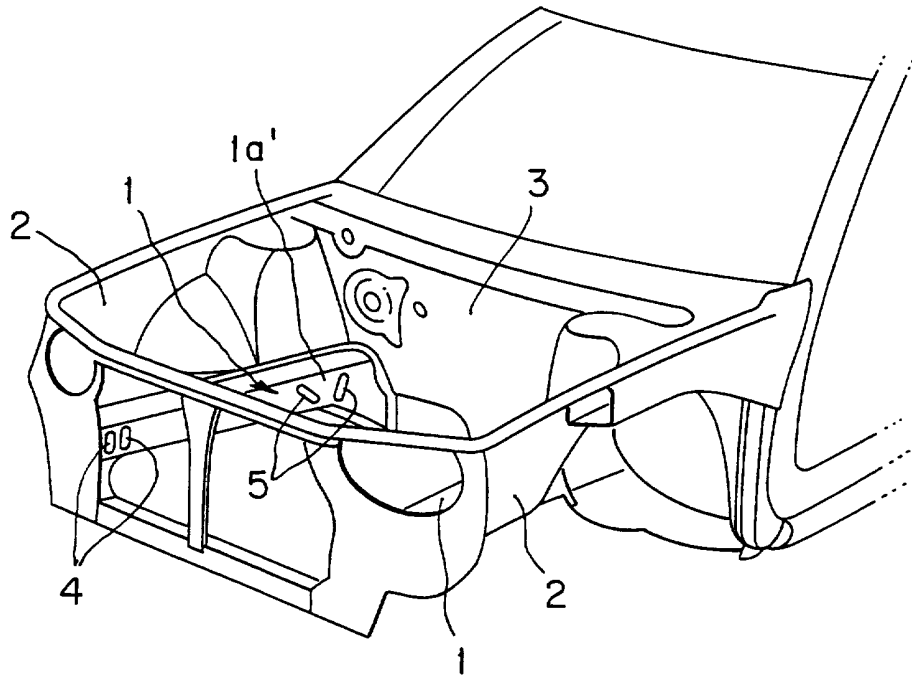


FIG. 3

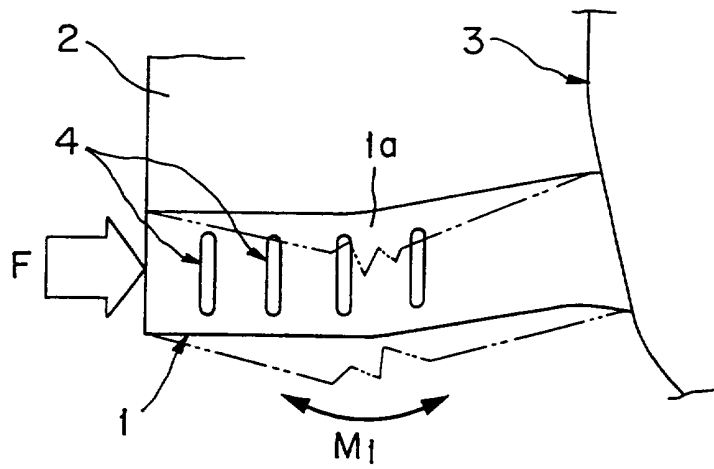


FIG. 4  
PRIOR ART

## FRAME STRUCTURE FOR VEHICLE BODY

5           The present invention relates to a frame structure used  
for a vehicle body.

10           In general, the front frame structure of a vehicle body  
is composed of right and left front frames and a lower  
radiator frame. Here, each of the right and left front  
frames is formed into a box-shaped cross section so as to  
extend in the longitudinal (front to rear) direction of the  
vehicle along the inner side of each of right and left  
front wheel aprons both constructing side walls of an  
engine compartment. On the other hand, the lower radiator  
frame is used to join the front ends of the right and left  
front frames. Further, the rear ends of the right and left  
front frames are usually butt-joined to a toe board for  
partitioning the engine compartment from a vehicle compart-  
ment.

20           In the conventional vehicle front frame structure as  
described above, in case of vehicle collision, it is  
necessary to effectively absorb shock energy by allowing  
the two front frames to be deformed in buckling mode. For  
this purpose, conventionally, in order to allow the front  
frames to be deformed in buckling mode in case of vehicle  
collision, a measure has been adopted to form a plurality  
of bead portions extending in the vertical direction on at  
least one side surface of the box-shaped front frame, as  
disclosed in Japanese Patent Application Laid-Open Publica-  
tion No. 3-94137 or in Japanese Utility Model Application  
Laid-Open Publication No. 3-16580, for instance.

30           Here, it is basically ideal to form each of the two  
front frames as a straight part extending in the front to  
rear direction, in the practical vehicle design. However,  
the shape of the front frames is severely restricted due  
35

to various parts to be arranged in the engine compartment, so that the front frames 1 are inevitably formed with a bent portion 1a roughly midway portion thereof, as shown in Fig. 4. Further, in Fig. 4, each front frame 1 is fixed  
5 between a front wheel apron 2 and a toe board 3, and the front frame 1 is further formed with a plurality of vertical bead portions 4.

In the conventional front frame structure as described above, having a plurality of bead portions 4 extending in  
10 the vertical direction and formed on the side surface of the front frame with the bent portion 1a formed roughly midway thereof, in case a collision load  $F$  is applied to the front end of the front frame 1 and thereby a bending moment  $M_1$  is generated at the bent portion 1a, the vertical  
15 bead portions 4 cannot effectively suppress the bending deformation at the bent portion 1a, depending on the way of arrangement of the bead portions, with the result that there exists a problem in that collision energy cannot be absorbed effectively. In other words, in the conventional  
20 front frames, there exists a problem in that it is difficult to determine how the vertical bead portions 4 are arranged.

25 It is an aim of embodiments of the present invention to provide a frame structure for a vehicle body, which can absorb a collision load effectively in buckling deformation mode.

According to one aspect of the present invention, there is provided a frame structure for a vehicle body with a frame  
30 having a box-shaped cross section and formed with a portion bendable when a collision load is applied in a longitudinal direction of the frame in case of a vehicle collision, comprising a pair of bead portions arranged in a roughly V shape and formed on at least one of two opposite surfaces  
35 of the frame, in such a direction that a bending moment generated at the bendable portion of the frame can be canceled out by an additional moment generated by the pair

of the bead portions in case of a vehicle collision.

Here, it is preferable that a space between a pair of the bead portions arranged roughly in V shape increases gradually from a compression side to a tension side of the bending moment generated at the bendable portion of the frame.

Further, it is preferable that the bendable portion of the frame is of a downwardly convex shape so that in case of a vehicle collision an upper side of the bendable portion is compressed and a lower side thereof is extended, and that the bead portions are arranged in a roughly inverted V shape.

Further, it is preferable that the bendable portion of the frame is of an upwardly convex shape so that in case of a vehicle collision a lower side of the bendable portion is compressed and an upper side thereof is extended, and that the bead portions are arranged in a roughly V shape. According to a second aspect, there is provided a frame structure

for a vehicle body with a straight frame having a box-shaped cross section without forming any bendable portion, wherein a pair of bead portions arranged in a roughly V shape or in a roughly inverted V shape are formed on at least one of the two opposite surfaces of the box-shaped cross-sectional frame so that a bending moment will be generated to positively bend the frame in case of a vehicle collision.

In the frame structure for a vehicle body embodying the present invention, it may be possible to cancel the bending moment generated at the bendable portion by another moment generated by a pair of the bead portions arranged in the roughly V-shape or inverted V-shape in case of a vehicle collision, so that the resistance to the frame bending deformation is increased, whereby the deformation mode can be changed from the bending mode to a nearly buckling mode in case of a vehicle collision. As a result, it may be possible to improve the effect of absorbing the collision energy.

Further, in the frame structure for a vehicle body, preferably, a pair of bead portions arranged in a roughly V shape or roughly inverted V shape are formed on the side surface of a straight frame, so that it is possible to positively generate a bending moment by the pair of the bead portions at any desired position and in any desired direction of the straight frame. As a result, the frame may be bend positively in case of a collision.

10 For a better understanding of the present invention and as to how the same may be carried into effect, reference will now be made by way of example to the accompanying drawings in which:

Fig. 1 is a side view showing a first embodiment of the frame structure for a vehicle body embodying the present invention;

15 Fig. 2 is an illustration for assistance in explaining the principle of the frame structure embodying the present invention;

Fig. 3 is a perspective view showing a second embodiment of the frame structure for a vehicle body embodying the present invention; and

20 Fig. 4 is a side view showing an example of the prior art front frame structure of a vehicle body.

25 Preferred embodiments of the present invention will be understood from the following detailed description referring to the accompanying drawings.

In the side view shown in Fig. 1, in the same way as with the case of the prior art front frame, a front frame 1 is formed into a box-shaped cross section so as to extend in the longitudinal direction of the vehicle along the inner side of a front wheel apron 2. Further, the rear end portion of the front frame 1 is butt-welded to the toe board 3.

35 Here, it is basically ideal that the two front frames 1 are each formed as a straight part extending in the front

to rear direction. In practice, however, the shape of the front frames are severely restricted by various parts (e.g., a battery 6, an axle shaft 7, etc.) all to be arranged in the engine compartment, so that the front frame 1 is inevitably formed with a slightly bent portion 1a roughly midway of the front frame. Further, in Fig. 1, the front frame 1 is formed in such a way that the rear end portion thereof is bent upward relative to the front portion thereof at the bent portion 1a of the front frame 1. Therefore, in case a collision load  $F$  is applied to the front frame 1, the front frame 1 is deformed in such a way that the upper portion of the bent portion 1a becomes a compression side and the lower portion thereof becomes a tension side, so that a bending moment  $M_1$  is generated in such a way that the bent portion 1a is deformed into a convex shape toward the lower side.

In the front frame 1 formed with the bent portion 1a as described above, in embodiments of the present invention, a pair of bead portions 5 are formed on the side surface of the bent portion 1a in such a way that the space between the two adjacent bead portions 5 increases gradually from the upper side (compression side) to the lower side (tension side), that is, in a roughly inverted V shape with a space at the apex thereof. Owing to this roughly inverted V-shaped arrangement of a pair of the bead portions 5, it is possible to generate a moment  $M$  in such a direction as to cancel out the bending moment  $M_1$  generated at the bent portion 1a due to the shape factor of the front frame 1.

The reason why the moment  $M$  can be generated by a pair of the bead portions 5 arranged roughly in the inverted V shape will be explained in further detail below with reference to Fig. 2.

Here, in Fig. 2, the assumption is made that the two opposing bead lines A and B of a pair of the front and rear bead portions 5 arranged in the roughly inverted V shape have such a sufficient rigidity as to restrict the dis-



placements at points  $A_n$  and  $B_n$  in X, Y and Z directions, respectively, where X denotes the front to rear direction; Y denotes the right to left direction; and Z denotes the vertical direction. Further, the origin of the three dimensional coordinates differs according to the vehicle. Under these conditions, it is possible to assume that the segments between  $A_n$  and  $B_n$  are a plurality of beam elements simply supported at both ends thereof.

Therefore, when Euler's buckling theory is adopted, the following relationship can be established between the buckling load  $P_E$  applied to the beam element formed between  $A_n$  and  $B_n$  and the beam length  $L_n$ :

$$P_E \propto 1 / L_n \quad (\text{the segment } A_n - B_n = L_n) \quad \dots (1)$$

In the plane on which the two front and rear beads are arranged roughly in the inverted V shape, the beam length  $L_n$  on the lower side is longer than that on the upper side. Therefore, the buckling load  $P_E$  on the lower side (where the beam length is longer) is lower than that on the upper side (where the beam length is shorter), and further the apparent Young's modulus E can be defined on the basis of the above formula (1) as follows:

$$E_{\text{upr}} > E_{\text{lwr}} \quad \dots (2)$$

where  $E_{\text{upr}}$  denotes the upper side Young's modulus and  $E_{\text{lwr}}$  denotes the lower side Young's modulus.

The above relationship (2) indicates that when a pair of the front and rear bead portions are arranged in the roughly inverted V shape, an apparent neutral axis D can be newly produced in addition to the neutral axis C defined on the simple plane. Therefore, synthesizing the above assumption and the theory, when a load F is applied to a panel (the front frame 5) as shown in Fig. 2, a moment M can be generated due to an offset L between the original neutral axis C (the load application point) and the apparent neutral axis D.

When the above phenomenon is used under consideration

of the deformation mode (bending characteristics) generated on the basis of the shape factor of the front frame; that is, when a pair of the front and rear bead portions 5 are arranged in the roughly inverted V shape in such a way that  
5 the newly generated moment M can cancel the bending moment M1 generated at the bent portion 1a of the front frame as shown in Fig. 1, it is possible to change the deformation mode of the front frame 1 due to a collision load F to the buckling mode (as shown by chain lines in Fig. 1) without  
10 limit. As a result, it is possible to allow the front frame 1 to have a high resistance against an applied collision load; in other words, it is possible to improve the effect of absorbing collision energy.

Further, in the first embodiment shown in Fig. 1, in  
15 order to reduce the peak resistance generated at the initial stage of the frontal collision and thereby to allow the buckling deformation to be started smoothly, a vertical bead portion 5, is formed at the front end portion of the front frame 1 in the same way as with the case of the prior  
20 art front frame. However, without being limited only to this example shown in Fig. 1 (in which the vertical bead portion is formed toward the front end portion of the front frame 1), it is possible to form the vertical bead portions 4 at any portions except near the bent portion 1a according  
25 to the necessity.

Further, in the first embodiment shown in Fig. 1, a pair of the inverted V-shape arranged bead portions 5 are formed at the bent portion 1a in such a way that the convex deformation can be produced downward (the upper side  
30 compression side and the lower side tension side). Without being limited only thereto, however, it is possible to form a pair of V-shape arranged bead portions 5, as shown in Fig. 3. In this second embodiment as shown in Fig. 3, a pair of the V-shape arranged bead portions 5 are formed on  
35 a front frame 1 having a bent portion 1a' in such a way that the convex deformation can be produced upward (the upper side tension side and the lower side compression

side). In more detail, a pair of bead portions 5 are formed on the side surface of the front frame in such a way that the space between the two adjacent bead portions increases gradually from the lower side (compression side) to the upper side (tension side), that is, the two bead portions 5 are formed in a roughly V shape with a space at the apex thereof. Owing to this roughly V-shaped arrangement of a pair of the bead portions 5, it is possible to generate a new moment M in such a direction as to cancel out the bending moment M1 generated at the bent portion 1a' of the front frame 1 due to the shape factor. Further, in Fig. 3, the same reference numerals have been retained for the similar parts or elements having the same functions as with the case of the first embodiment shown in Fig. 1.

Further, in the first and second embodiments, the V-shaped bead portions have been applied to the front frame formed with the portions 1a and 1a' which are bendable in the vertical direction. Without being limited thereto, the bead portions used in embodiments of the present invention can be applied to the front frame formed with the portions bendable in the horizontal direction. In the case of the front frame formed with the horizontally bent portion, a pair of bead portions are formed on the side surface of the bent portion in such a way that the space between the two adjacent bead portions increases gradually from the lower or upper side (compression side) to the upper or lower side (tension side) in roughly the V shape or inverted V shape with a space at the apex thereof. In these cases, the same effect as above can be obtained.

In the above embodiments, the front frame formed with the bent portion can prevent the bending deformation in case of frontal vehicle collision and further the deformation mode of the front frame due to a collision load F can be changed to the mode similar to the buckling mode without limit. Without being limited thereto, embodiments of the present invention can be applied to a straight front frame. That is,

when it is necessary to control the position and the direction of the bending deformation positively in case of vehicle frontal collision in the straight front frame, it is possible to obtain the same effect as above, by appropriately forming a pair of the bead portions arranged in roughly inverted V shape or in roughly inverted V shape according to the required bending position and direction.

5  
10 In addition, the gist of the present invention can be applied to any frames such as rear frames, without being limited to the front frames.

According to embodiments of the present invention, in the vehicle frame formed with a bent portion which can be deformed by allowing one side to be compressed and the other side to be extended, a pair of bead portions arranged in roughly V shape are formed in such a way that the space between the two adjacent bead portions increases gradually from the compression side to the extension side, whereby it is possible to cancel the bending moment  $M$  generated at the bent portion by the additional moment  $M_1$  newly generated by a pair of the bead portions arranged in the roughly V shape, so that the frame deformation mode can be changed from the bending mode to an approximately buckling mode. As a result, the effect of absorbing the collision energy can be improved.

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20  
25 Further, in a straight front frame without a bent portion, if the front frame is required to be bent positively at a predetermined position and in a predetermined direction in case of vehicle collision, a pair of the bead portions arranged in a V-shape are formed at the position where the front frame is required to be bent or deformed. In this case, since the moment can be easily generated at the bead portions in the desired direction in case of vehicle collision, it is possible to improve the effect of absorbing collision energy.

30  
35 While the presently preferred embodiments of the present invention have been shown and described, it is to be understood that these disclosures are for the purpose

of illustration and that various changes and modifications may be made without departing from the scope of the invention as set forth in the appended claims.

WHAT IS CLAIMED IS:

1. A frame structure for a vehicle body with a frame having a box-shaped cross section and a portion bendable when a collision load is applied in a longitudinal direction of the frame in case of a vehicle collision, comprising:

a pair of bead portions arranged in a roughly V shape and formed on at least one of two opposite surfaces of the frame, in such a direction that a bending moment generated at said bendable portion of the frame can be canceled by an additional moment generated by said pair of the bead portions in case of a vehicle collision.

2. The frame structure for a vehicle body according to claim 1, wherein:

said frame has a space between the bead portions arranged roughly in a V shape, which increases gradually from a compression side to a tension side of the bending moment generated at said bendable portion of the frame.

3. The frame structure for a vehicle body according to claim 1 or 2, wherein:

said bendable portion of the frame is of a downwardly convex shape so that in case of a vehicle collision an upper side of the bendable portion is compressed and a lower side thereof is extended and wherein the bead portions are arranged in a roughly inverted V-shape.

4. The frame structure for a vehicle body according to claim 1 or 2, wherein:

said bendable portion of the frame is of an upwardly convex shape so that in case of a vehicle collision a lower side of the bendable portion is compressed and an upper side thereof is extended and wherein the bead portions are arranged in a roughly V-shape.

5. A frame structure for a vehicle body with a straight frame having a box-shaped cross section, comprising:

a pair of bead portions arranged in a roughly V shape and formed on at least one of two opposite surfaces of the frame, such that a bending moment will be generated on said frame to positively bend the frame in case of a vehicle collision.

6. A frame structure for a vehicle body with a straight frame having a box-shaped cross section, comprising:

a pair of bead portions arranged in a roughly inverted V shape and formed on at least one of two opposite surfaces of the frame, such that a bending moment will be generated on said frame to positively bend the frame in case of a vehicle collision.

7. A frame structure substantially as hereinbefore described with reference to Figures 1 and 2, or Figure 3 of the accompanying drawings.



**Application No:** GB 9722587.4  
**Claims searched:** 1 to 6

**Examiner:** Karl Whitfield  
**Date of search:** 12 January 1998

**Patents Act 1977**  
**Search Report under Section 17**

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:  
UK CI (Ed.P): B7B (BCL, BCM, BSES)  
Int CI (Ed.6): B62D 21/00, 21/15, 23/00, 25/00, 25/02, 25/08, 25/20, 39/00  
Other: Online database: Derwent World Patents Index accessed via Questel

**Documents considered to be relevant:**

Category	Identity of document and relevant passage	Relevant to claims
A	US 5048345 (HAGIWARA et al.) especially fig 3	
A	US 4702515 (KATO et al.) especially figs 1-5	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.