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

(11) Publication number: **0 247 750**
A2

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: **87304090.1**

(22) Date of filing: **07.05.87**

(51) Int. Cl.⁴: **A 47 F 1/14**, A 47 B 87/02

(30) Priority: **07.05.86 GB 8611096**

(43) Date of publication of application: **02.12.87 Bulletin 87/49**

(84) Designated Contracting States: **AT BE CH DE ES FR GB IT LI NL SE**

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(54) **Modular system.**

(57) A modular system is described which uses the combination of frustums (30, 32, 34) of polygonal pyramids interlocked to form three-dimensional polyhedra. The polygonal pyramids are regular and have substantially identical unit base lengths (a) which permits a variety of three-dimensional display structures to be used by combining different frustums of polygonal pyramids. In a preferred application the frustums are hollow to permit a plurality of recesses (30, 40) inthe three-dimensional structure for displaying objects and the base units can be held together by clips (60) without the use of tools to permit rapid and easy assembly. In addition, the units can be easily disassembled and stacked or packed flat to facilitate transport and storage.

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MODULAR SYSTEM

The present invention relates to a modular system particularly, but not exclusively, to a modular system which can be arranged to form a variety of three-dimensional display structures.

A modular structure should satisfy a number of desirable criteria in addition to being relatively inexpensive and easy to construct. The structure should be able to be transported in a "flat pack" to minimise transport and storage costs, it should be easily and rapidly assembled and should include a variety of different shaped modules which can be interconnected to provide a variety of different shaped structures to suit different environments. The modular relevance should be easily interlocked and the interlocking should not require tools permitting on-site assembly. In the case of a display system the structure should permit a variety of display positions to facilitate viewing of objects to be displayed and, if desired, it should be able to provide the appearance of a solid three-dimensional structure.

The modular system should be capable of being used in a variety of different applications, for example, it could be used to construct modular furniture such as chairs, telephone booths and can be used as educational toys.

Existing modular structures have a number of disadvantages which do not fulfil one or more of the above mentioned criteria.

An object of the present invention is to provide an improved modular system which obviates or mitigates disadvantages associated with existing modular systems.

This is achieved by providing a modular system which uses the combination of frustums of polygonal pyramids interlocked to form three-dimensional polyhedra. The polygonal pyramids are regular and have substantially identical unit base lengths which permits a variety of three-dimensional display structures to be used by combining different frustums of polygonal pyramids.

In a preferred application the frustums are hollow to permit a plurality of recesses in the three-dimensional structure for displaying objects and the base units can be held together by clips without the use of tools to permit rapid and easy assembly. In addition, the units can be easily disassembled and stacked or packed flat to facilitate transport and storage.

Accordingly, in one aspect of the present invention there is provided a modular system comprising a plurality of frustums of regular polygonal pyramids adapted to be interlocked together to form a three-dimensional polyhedra, the length of the base of each frustum face being substantially identical.

Preferably, frustums of the regular polygonal pyramids are interlocked by fastening abutting frustum sides in a three-dimensional polyhedral structure together. Conveniently the frustums are hollow so that in a three-

dimensional polyhedra a plurality of recesses are provided which are adapted to receive items to be displayed.

Preferably also, the fastening means includes recess cover means for covering said display recess.

Preferably said polyhedra are adapted to be interlocked using said fastening means to create complex three-dimensional polyhedra shapes. Conveniently said fastening means is a resilient clip and preferably also said fastening means includes an M-shaped clip adapted to couple adjacent frustum faces to adjacent frustums together.

Preferably said polygonal pyramids are frustums of a regular three-sided polygon which has an equilateral triangular base, a four-sided pyramid which has a square base and a six-sided pyramid which has a hexagonal base, the base length of the equilateral triangle, and the square and the hexagon being substantially identical.

The angles between the faces of the side of the pyramid and the base plane are important and preferably the angle of the side of the frustum with the base and in the case of the triangle is 74^{o} 12' and in the case of the square is 70^{o} 32', and in the case of a hexagon for mating with the square is 54^{o} 44', and in the case of the hexagon joining with the triangle 35^{o} 16'.

Conveniently the modular system has a variety of applications. For example, the polygonal shapes can be

interconnected to provide a three-dimensional building such as booths, furniture such as chairs, loudspeaker cabinets, lampshades, educational toys and graphic displays, in addition to a modular display system.

These and other aspects of the invention will become apparent from the following description when taken in combination with the accompanying drawings in which:-

Figs. 1,2 and 3 are perspective views of frustums of hexagonal, square and triangular pyramids respectively which are combined to form modular three-dimensional structures.

Fig. 4 is a perspective and partly exploded away view of a three-dimensional polyhedra modular display system in accordance with the invention made using the frustums of the polygonal structures shown in Figs. 1, and 2;

Fig. 4a is a perspective view of a truncated tetrahedron made using the frustums of the polygonal structures shown in Figs. 1 and 3;

Figs. 5a,5b and 5c are respective plan, side and end views of the hexagonal frustum shown in Fig. 1 for use with the square frustum shown in Fig. 2;

Fig. 6 is an enlarged sectional view taken along the line B-b of Fig. 5a when showing parts of the hexagonal pyramid for interlocking with adjacent polygons;

Fig. 7a,7b,7c and 7d are respective plan, elevational and side views of a hexagonal pyramid for interlocking with triangular frustums.

Figs. 8a,8b and 8c are respective plan, and and enlarged side views of the square polygon shown in Fig. 2;

Figs. 9a,9b and 9c are views similar to Figs. 8a,8b and 8c for the triangular polygon;

Fig. 10 is an end view taken of ajoining frustums illustrating protrusions for receiving M-shaped clips for interlocking adjacent frustums together;

Fig. 11 illustrates a plan view taken in the direction of arrow 11 of Fig. 10 showing adjacent proturusions being coupled by an M-clip;

Figs. 12,13,14 and 15 are respective sectional views through adjacent faces of a square coupled to a hexagon for a truncate octahedron (mecon); through adjacent faces of a hexagon coupled to a hexagon for a mecon; a hexagon coupled to a triangle for a tetron; and through adjacent faces of the hexagons for a tetron structure;

Figs. 16a and 16b illustrates front and enlarged end views of an edge fixing clip for attachment of flat panels to a polygonal pyramid shown utilised in Fig. 6;

Fig. 17 depicts a hexagonal plate for fitting into a hexagonal frustum;

Fig. 18 shows an enlarged sectional view through a hexagonal frustum showing securement of the transparent plate on the edge fixing clip;

Fig. 19 shows a modification of two fixing clips to produce a hinged clip;

Fig. 20 shows a cross-sectional view taken on the line 20-20 of Fig. 19 showing the extent and method of the hinging action;

Fig. 21 shows the use of hinged clips to join two

polyhedra;

Figs 22 and 23 depict a modified hinge for attaching flat panels to a polyhedra structure;

Fig. 24 illustrates a perspective view of an example of a 3-dimensional display based on a truncated octahedron with flat panels (shown by cross-hatching) attached;

Fig. 25 shows a perspective view of half of a truncated octahedron having hinges as shown in Figs. 22 and 23 to receive a flat panel to produce a table; and

Fig. 26 shows a chair made of polygonal frustums.

Reference is first made to Figs. 1 to 3 of the drawings which illustrates respectively a hexagonal frustum 30, of a hexagonal pyramid, a square frustum 32 of the square pyramid and a triangular frustum 34 of a triangular pyramid. The hexagonal, square and triangular frustums are regular and have a base unit length, a, which is the same for each structure for permitting the frustums to be interconnected to form three-dimensional structures as will be later described. The face length, b, of each of the faces of the respective frustums is also the same to facilitate interconnection with the frustums in the three-dimensional structure.

Reference is now made to Fig. 4 of the drawings which illustrates a three-dimensional display structure made using the hexagonal and square frustums shown in Figs. 1 and 2 respectively. For clarity part of the structure is shown in a partly exploded view to provide a better perspective on the composition of the structure.

The hexagonal and square frustums are hollow to define

respective recesses 38 and 40 before receiving items to be displayed and the adjacent hexagonal and square frustums are interlocked by exterior fastenings generally indicated by reference numeral 52 along an adjacent base line of the frustums and internal fasteners 44 engage with adjacent internal surfaces to permit the structure to be assembled as will be later described in detail.

Reference is now made to Fig. 4a which depicts a truncated tetrahedron made of triangular and hexagonal frustums shown in Figs. 1 and 3. The hexagonal frustums have angles of 35^{o} 16' as best seen in Fig. 7b. The frustums are secured in the same manner as the polyhedron shown in Fig. 4 using clips 52 and 44 as will be described.

Reference is now made to Figs. 5a,5b and 5c which illustrate an enlarged view of a hollow hexagonal frustum for use with the structure shown in Fig. 4. The frustum has a unit base length of 15 inches and the angle between the frustum base and face of the hexagon is 54^{o} 44'. This angle is very important in permitting the hexagonal frustum to be easily engaged with other hexagonal frustums or with square frustums. The hexagonal frustum 30 has a cut-out 46 for permitting the fasteners to be inserted and slid along adjacent surfaces for interlocking adjacent frustums as will be described.

Reference is now made to Fig. 6 of the drawings which is an enlarged view taken on the line B-b of Fig. 5a. It will be seen that the face 48 is deformed near to the base to create a flared portion generally indicated by

reference numeral 50. The flared portion 50 begins about ½ inch from the edge and subtends an angle substantially 15° from the plane of the face 48 and then returns along the base plane of the frustum to terminate when at the plane of the face 48. This shape when mated with adjacent complimentary flared portion of another frustum, shown in cross-hatching outline, aloows a resilient fastener generally indicated by reference numeral 52, and shown in broken outline, to be slid in through recess 46 over portions to provide an interlock between adjacent frustums. The surface 54 of the frustum 30 has a tubular portion 56 disposed therein. The tubular portion 56 is adapted to receive a leg 58 (shown in cross-section) of an M-shaped clamp 60 as best seen in Fig. 11 for coupling surfaces of adjacent frustums together internally.

Figs. 7a - 7c correspond to Figs. 5a - 5c and Fig. 7d corresponds to Fig. 6 in which like numerals refer to like parts. The angle between the frustum base and face of the hexagon is 35°16', and is combined with frustums of triangular pyramids to create polyhedral structures as shown in Fig. 4a.

Reference is now made to Figs. 8a and 8b of the drawings which illustrate enlarged plan and side views of the square frustum 32 shown in Fig. 2. As with the hexagonal frustum the unit length is 15 inches and in this case the angle between the base of each side face 62 is 70° 32'. This square 32 also includes a cut-out 64 for permitting an edge clip to be slid on in the same manner

as fastener 50 described in Fig. 6, and similarly the edge face 62 of the square is also deformed at the base in a similar manner to the flare 50 for receiving the fastener as seen in Fig. 8c.

The surface 66 also contains a tubular element at the mid-point of end side for receiving a leg of an M-shaped clamp for coupling to adjacent frustums.

Turning now to Figs. 9a and 9b the triangular frustum 34 is shown in more detail. The triangular frustum is an equilateral triangle in plan view and has a side of unit length 15 inches which is identical to that unit length of the square and the hexagon. The angle between the base of the frustum 34 and each face 70 is 74^{o} 12'.

Fig. 9c illustrates a section taken on the line A-a and it will be seen that each face 70 is deformed near the base portion to create a flared portion 72 in a manner similar to portion 50 for receiving a fastener in the manner already described. To this end a recess 74 is created at each apex 76 at each pair of side faces 70 of the triangular frustum 34.

Reference is now made to Figs. 10 and 11 of the drawings which illustrates a side view of hexagonal frustums 30 and square frustums 32 coupled together using M clips 60. It will be seen that tubular portions are arranged to define the distance 78 to which can be inserted clamps to interconnect adjacent surface 54 of respective hexagonal frustums together and hexagonal and square surfaces 56 together. In this embodiment, the hollow polygonal

frustums can be formed by vaccum moulding and the tubular portion created by grinding off the ends to allow the insertions of M clips. Conveniently the polygonal elements may be made of suitable plastic material such as styrene, polycarbonate, or metal such as aluminium or steel.

Reference is now made to Figs. 12,13,14 and 15 which are similar to Fig. 6. These figures illustrate sections through adjacent polygonal pyramids showing how the faces of the pyramids abut together. Fig. 12 depicts a section through adjacent faces of a square and hexognal pyramid. Fig. 13 depicts a section through adjacent faces of two hexagonal pyramids, Fig. 14 is a section through adjacent faces of a triangle and hexagon and Fig. 15 illustrates a section through an adjacent edge of two hexagonal pyramids for use with a tetron. It will be appreciated that with each of Figs. 12 to 15 the angle formed by the leg portions is approximately 30° in each case and the leg portions are about ½ inch in length.

It will be appreciated that with reference to Figs. 12 to 15 the polygonal pyramids are hollow to define recesses in which items to be displayed can be placed.

Reference is now made to Figs. 16a and 16b of the drawings which illustrate a edge fixing clip 52 shown in use in Fig. 6. The edge fixing clip 52 is elongate and is generally U-shape in cross-section. Either end 53 of the clip has a 32mm depth hole 55 to receive an L-shaped key 84 as best seen in Fig. 19. The clip has two legs 57 and 59 which define divergent recess 61 for receiving the

flared portions of respective face edges as shown in Figs. 12 through 15. The clip is made of a suitable plastic material and is designed to secure all combinations of adjacent frustums shown in Figs. 1 through 3.

Reference is now made to Fig. 17 of the drawings which illustrates how a recess can be covered by a transparent panel of hexagonal shape. A hexagonal panel 80 is proportioned to be fitted into the recess 38 or hexagonal frustum 30. With this arrangement a valuable display item can be displayed and protected by the panel 80. The transparent panel can also be used to give further depth to graphics for instance by placing lettering on the display panel 80 which tends to quote "float" above any pictorial matter displayed within the recess 38.

Fig. 18 is a side view through a structure having a hexagonal frustum when a display panel is secured therein by fixing clip 52. It will be seen that adjacent edges 48 flare to define a flared portion 50 which is received in recess 61 of the fixing clip 52. The end face 63 of the leg 59 abuts the edge 81 of the panel 80 to securely retain it in the recess.

Reference is now made to Fig. 19 of the drawings which illustrates two modified edge clips 82 arranged to form a hinge clip. The hinge clips are inverted and castellated to slot together as shown and are secured by an L-shaped key 84 which engages with aligned apertures 55 to produce the hinge.

Fig. 20 shows a section taken on line 20-20 of Fig. 19

and illustrates the degree of flexibility required to join adjacent polyhedra.

Fig. 21 is a perspective diagrammatic view of two polyhedra which are adapted to be joined by hinges 82 along the edges as shown. In this example a hexagonal face of a truncated tetrahedron is adapted to be coupled to a hexagonal face of a truncated octahedran.

Reference is now made to Figs. 22 and 23 of the drawings which illustrates a structure used for modifying the system to add various flat panels 88 to a variety of materials. This can be acheived by provided a hinged bar 86 on top of fixing edge 52 and the bar screwed to the panel 88. Am example of a finished structure is best seen in Fig. 24 where such flat panels are indicated by cross-hatching. Such flat panels can provide the flexibility for the display in that large items of graphic material such as posters can be displayed which may not fit into the recesses defined by the various frustums.

Fig. 25 illustrates a further example of half of a truncated octahedran adapted to receive a flat panel 90 to provide a table like structure. Such a configuration provides added strength when inverted as indicated by reference numeral 92 and can be used in a complex construction of polyhedra as seen in Fig. 24 to provide articles such as furniture as well as the display.

Fig. 26 illustrates a chair made using the frustums of the hexagon and square as illustrated in Figs. 1 and 2. Cushions can be located in the interior and attached to be

secured therein by the M-shaped clips.

Various modifications may be made to the system hereinbefore described without departing from the scope of the invention. For example, although only hexagonal square and triangular frustums have been depicted, it will be appreciated that frustums such as pentagonal and octagonal could be used to provide a plurality of three-dimensional shapes such as a dodecahedron, truncated icosahedron and a truncated dodecahedron. It will be also appreciated that although the angles in each face and the base is preferably the value given hereinbefore slight variations in these angles can be made without effecting the structure, particularly if the materials used are resilient so that slight variations can be readily tolerated without effecting the overall three-dimensional structure or its assembly.

Furthermore, although the frustums hereinbefore described have been made by vaccum forming they can be made by any other suitable procedure such as extruding or by pressing and can be made of any other suitable material such as wood, fiberglass and metal that can be pressed into shape or assembled as desired. Furthermore, the frustums can be fastened by any other suitable means consistent with the objective of providing a rapidly and easily assembled structure. The panels can be made in any suitable size depending on design requirements and a variety of different elements can be used as desired to create any suitable shape for aesthetic purposes or for

functional requirements, such as a chair or a telephone booth. All of the frustums need not necessarily be recessed but only those requiring to display elements and in the case of other applications the frustums can be recessed or made solid as desired. It will also be appreciated that devices can be used for back or internal projection of slides, incorporation of computer and visual display units. Furthermore the use of certain units as covering canopies over displays, or elongation of individual units by vertical and horizontal columns made up of flat panels of some rigid material can readily be provided.

Advantages of the invention are that the structure can be stored in a flat pack because similar frustums can nest to minimise volume and hence transport and storage costs. The structure can be easily and rapidly assembled without the use of any tools except when suspended from above or similarly raised from the floor or fixed walls and the elements permit a variety of structures to be readily made on site such as display items, furniture and occasional toys and the like. Materials may be made relatively inexpensively using vaccum forming techniques and a variety of sizes can be accommodated depending on the application.

CLAIMS:

1. A modular system comprising a plurality of frustums (30,32,34) of regular polygonal pyramids adapted to be interlocked together to form a three-dimensional polyhedra, the length of the base (a) of each frustum face being substantially identical.

2. A modular system as claimed in claim 1 characterised in that frustums of the regular polygonal pyramids are interlocked by fastening abutting frustum sides in a three-dimensional polyhedra structure together.

3. A modular system as claimed in claim 1 or claim 2 characterised in that the frustums are hollow so that in a three-dimensional polyhedra a plurality of recesses (38,40) are provided which are adapted to receive items to be displayed.

4. A modular system as claimed in any preceding claim characterised in that the fastening means includes recess cover means for covering said display recess.

5. A modular system as claimed in any preceding claim characterised in that said polyhedra are adapted to be interlocked using said fastening means to create complex three-dimensional polyhedra shapes.

6. A modular system as claimed in any preceding claim characterised in that said fastening means is a resilient clip (52) and preferably also said fastening means includes an M-shaped clip (60) adapted to coupled adjacent frustum faces to adjacent frustums together.

7. A modular system as claimed in any preceding claim

characterised in that said polygonal pyramids are frustums of a regular three-sided polygon which has an equilateral triangular base, a four-sided pyramid which has a square base and a six-sided pyramid which has a hexagonal base, the base length of the equilateral triangle, and the square and the hexagon being substantially identical.

8. A modular system as claimed in any preceding claim characterised in that the angles between the faces of the side of the pyramid and the base plane are important and the angle of the side of the frustum with the base and in the case of the triangle is 74° 12' and in the case of the square is 70° 32', and in the case of a hexagon for mating with the square is 54° 44', and in the case of the hexagon joining with the triangle 35° 16'.

9. A modular system as claimed in any preceding claim for use as a modular display system.

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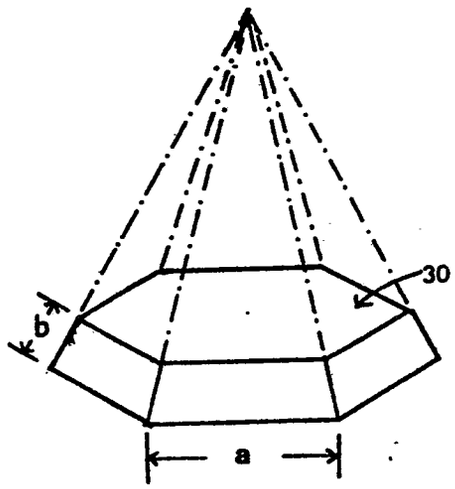

fig 1

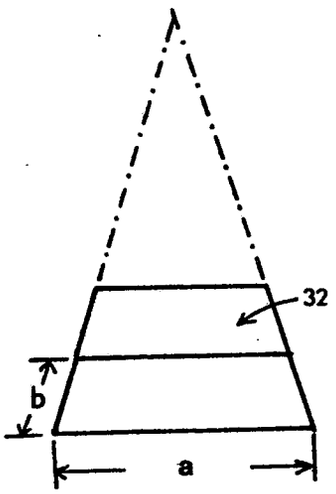

fig 2

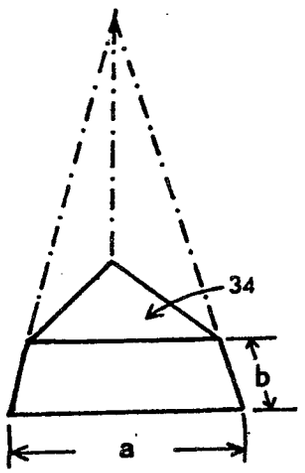

fig 3

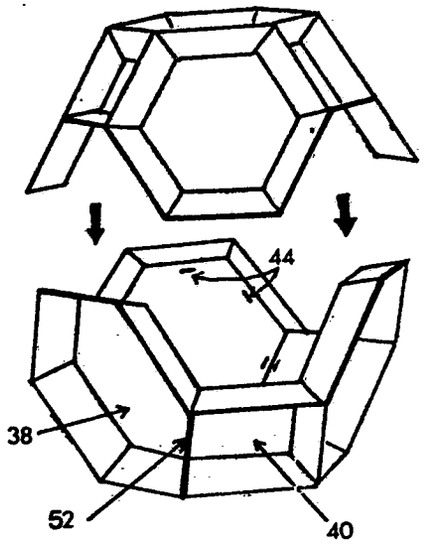

fig.4

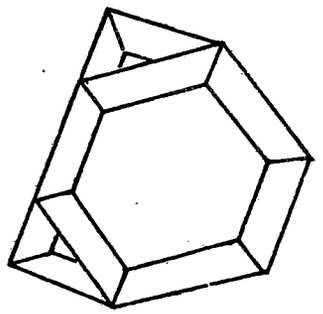

fig 4a

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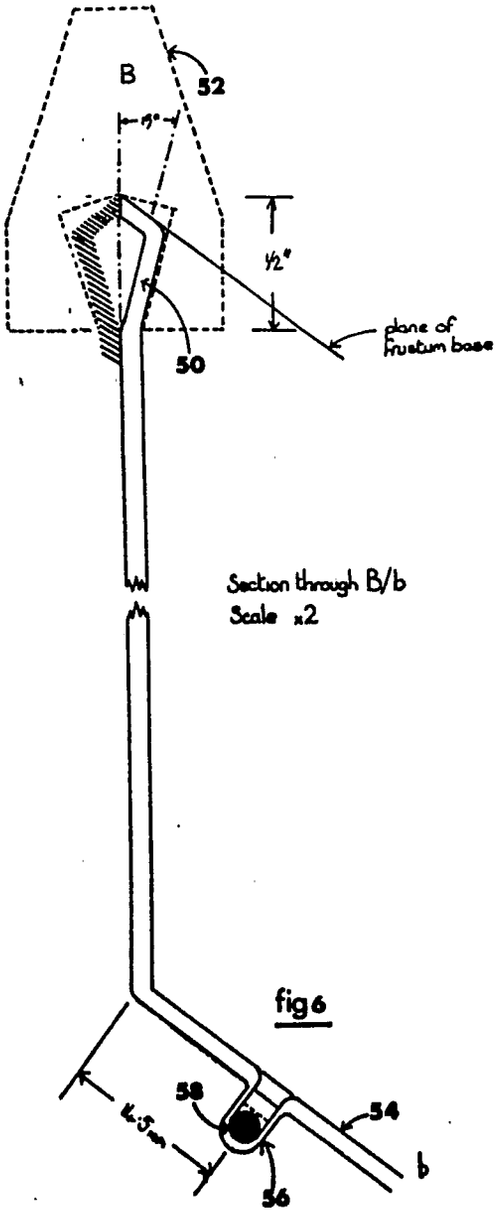

fig 6

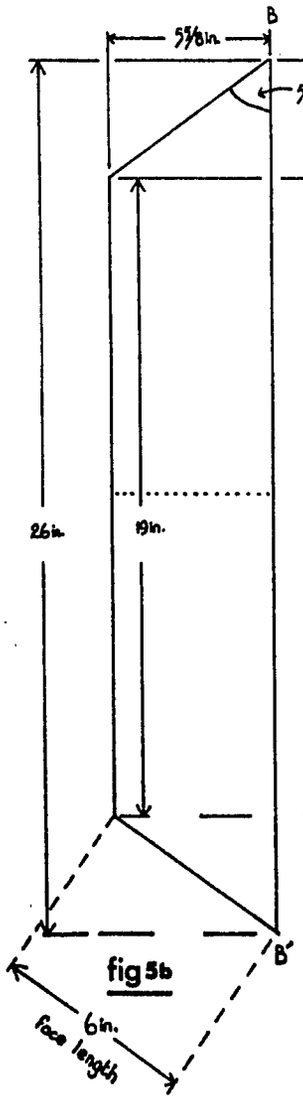

fig 5b

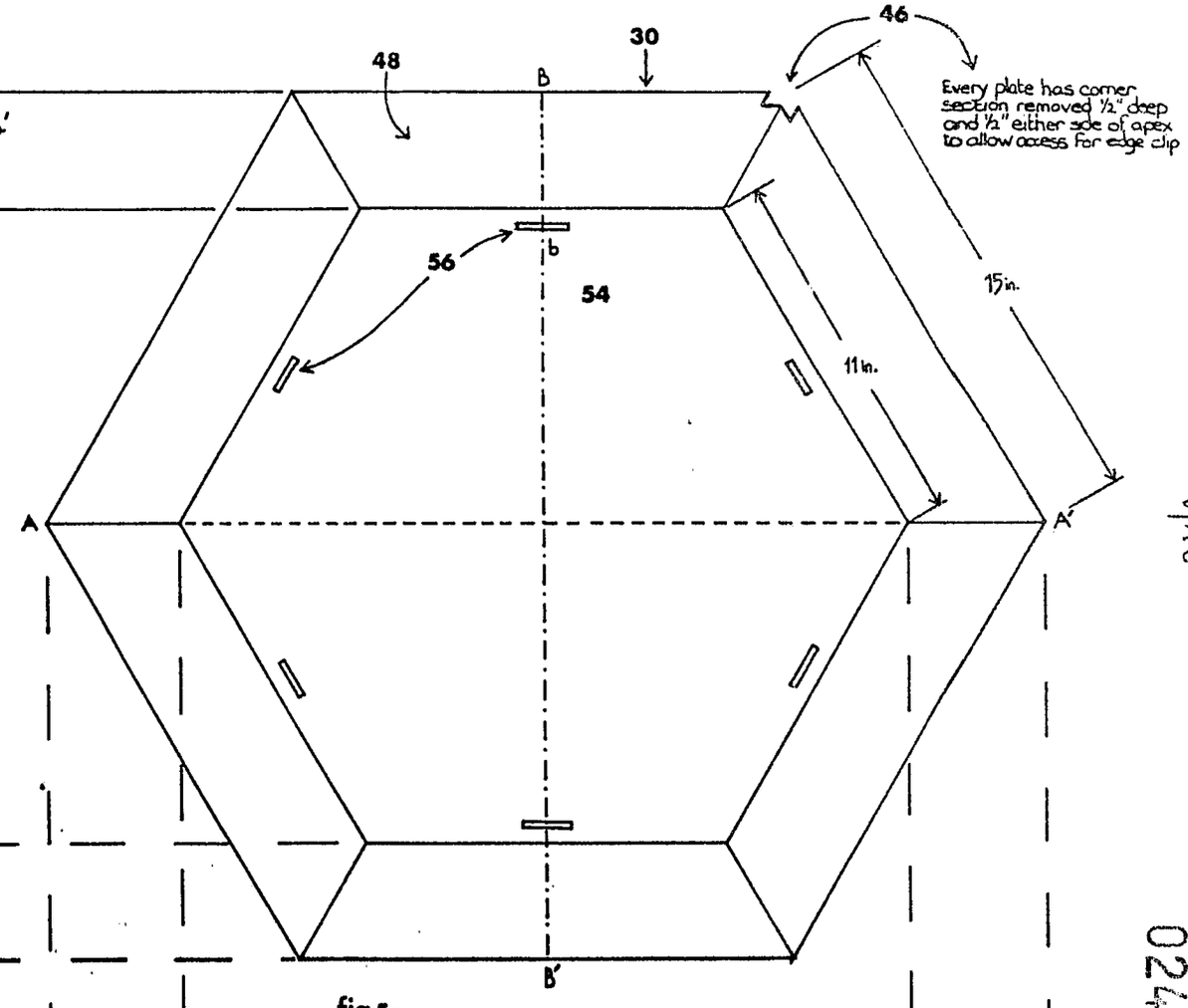

fig 5a

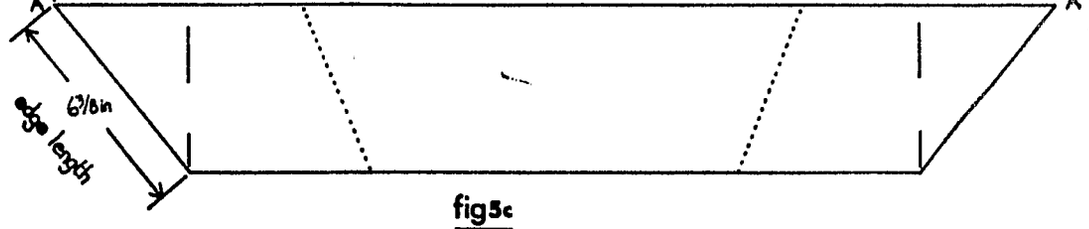

fig 5c

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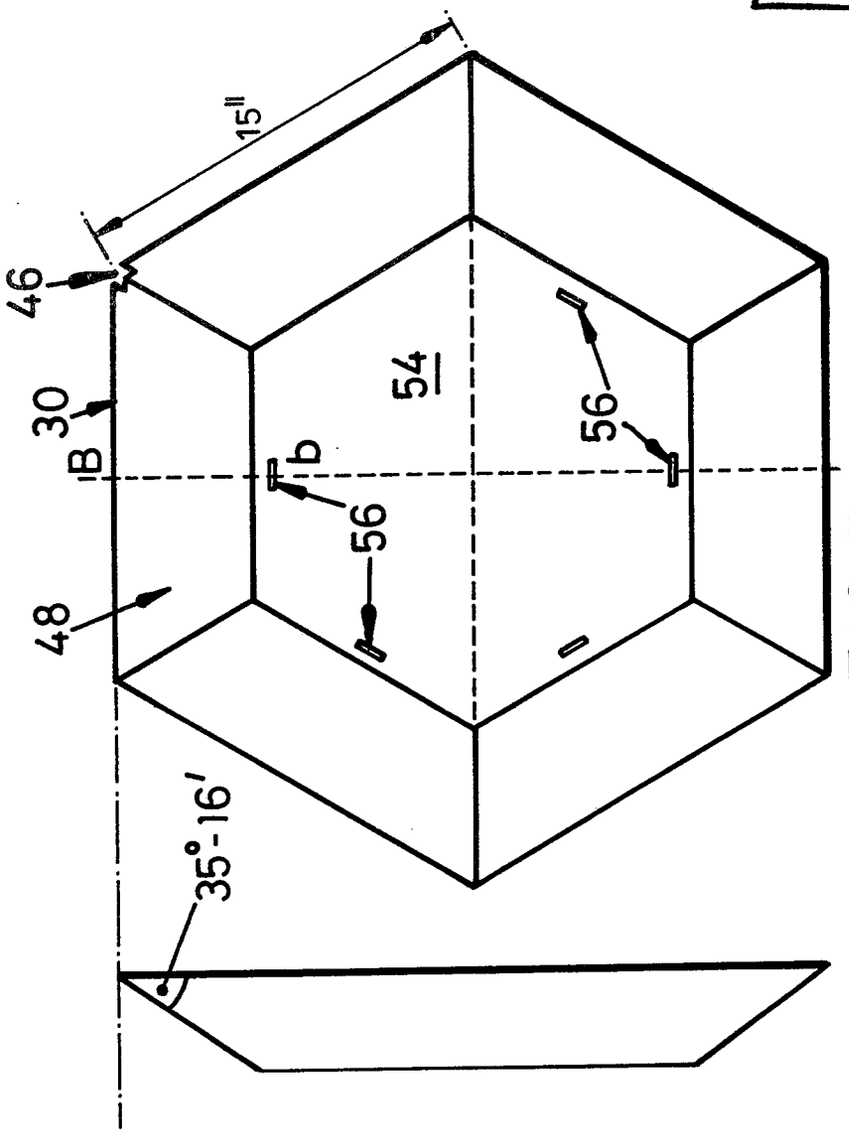

FIG.7a

FIG.7b

FIG.7c

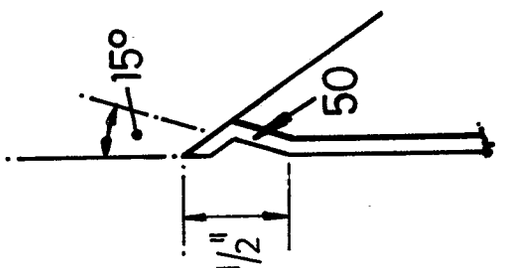

FIG.7d

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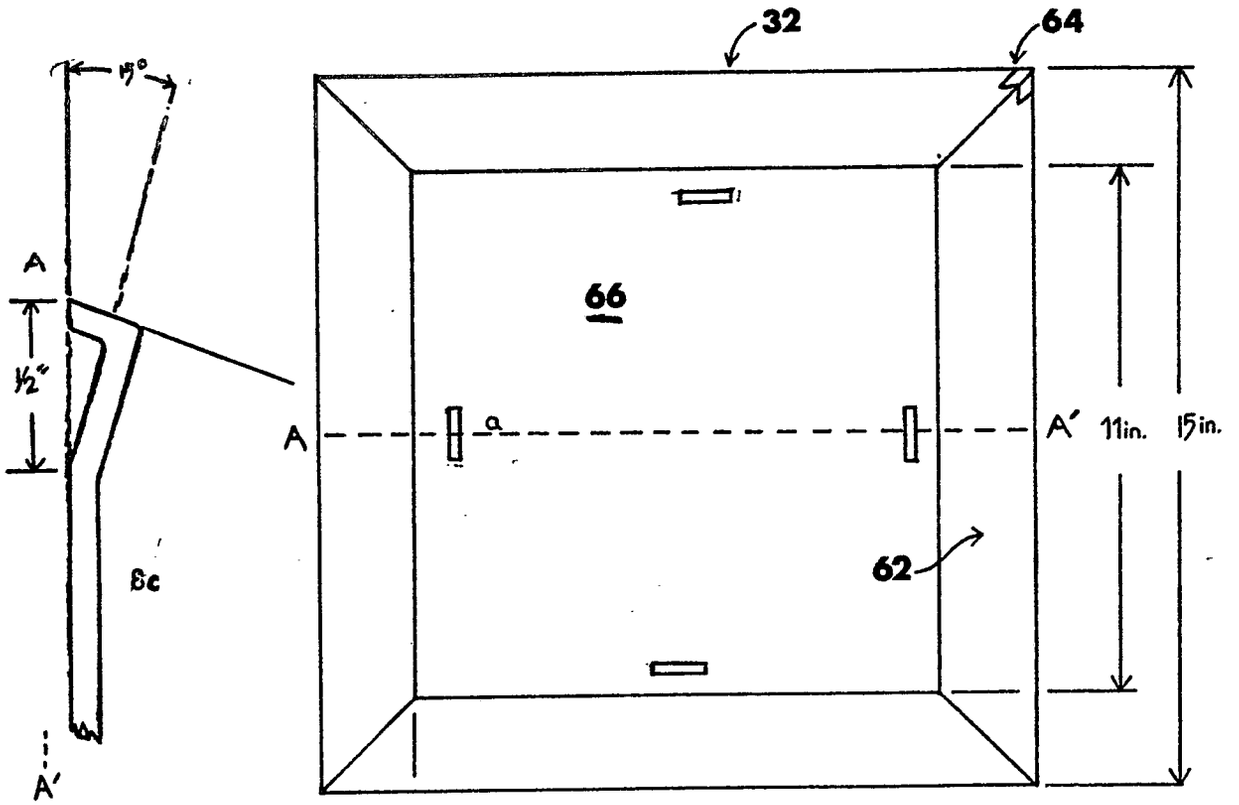

fig 8a

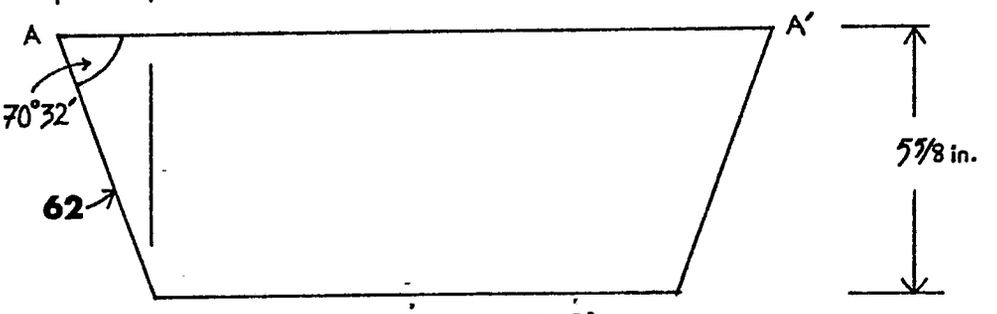

fig 8b

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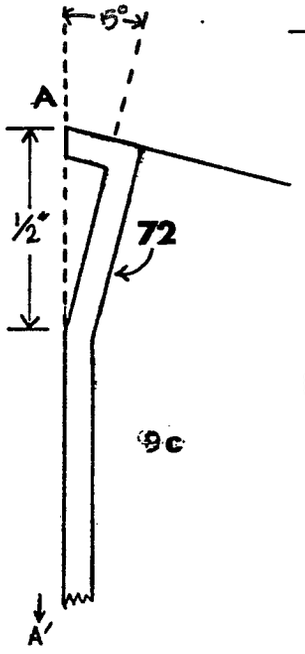

Edge detail section A A'
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SCALE 1:4

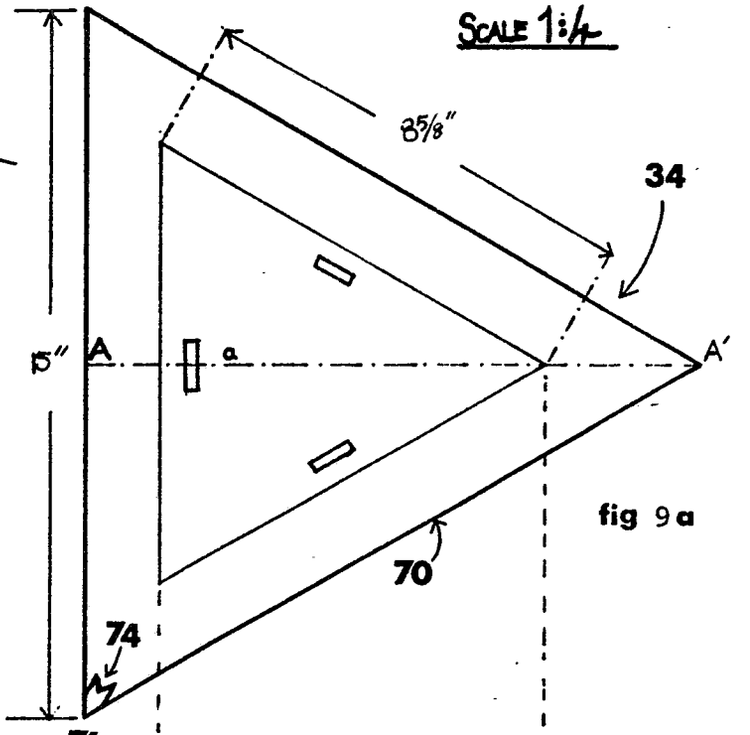

fig 9a

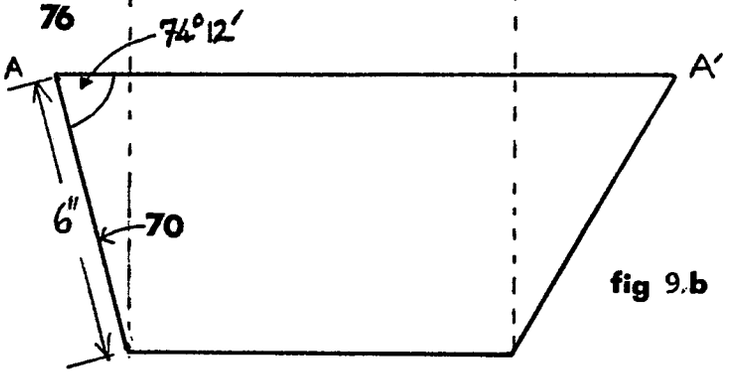

fig 9.b

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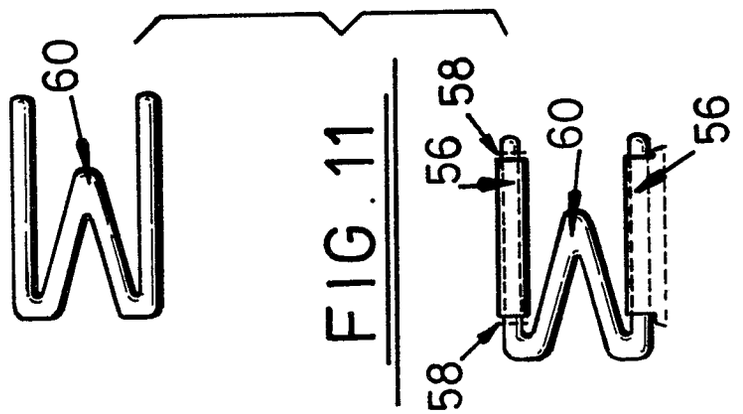

FIG. 11

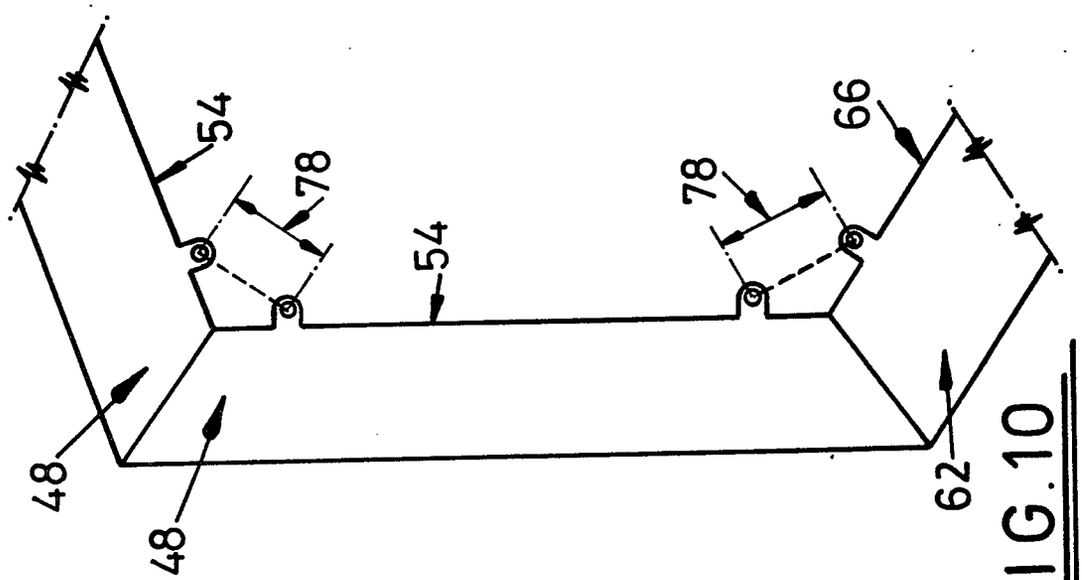

FIG. 10

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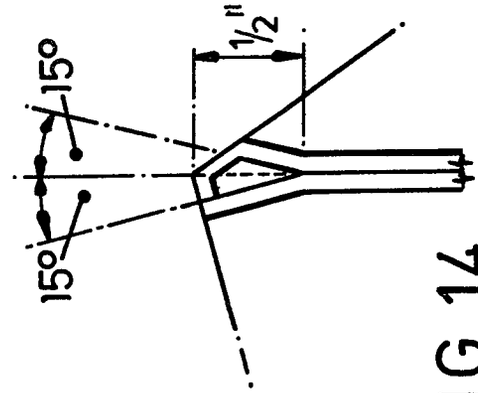

FIG.14

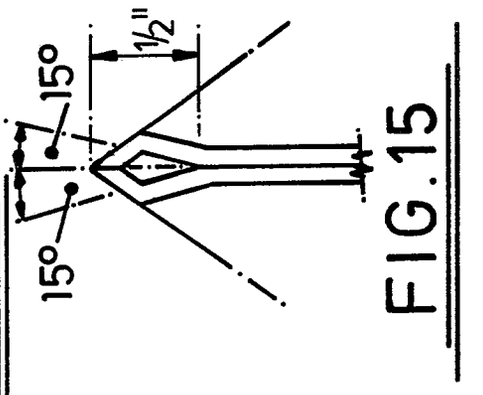

FIG.15

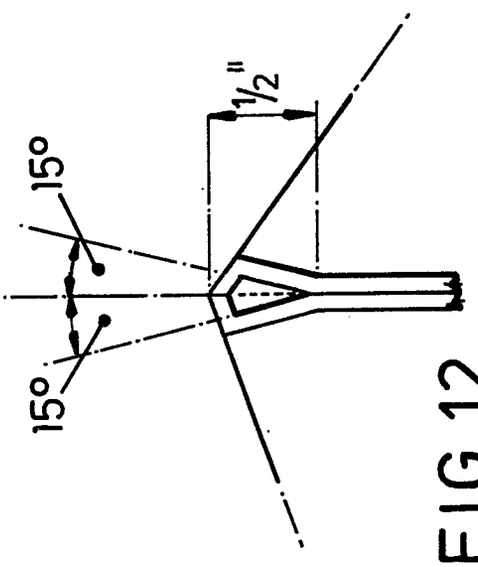

FIG.12

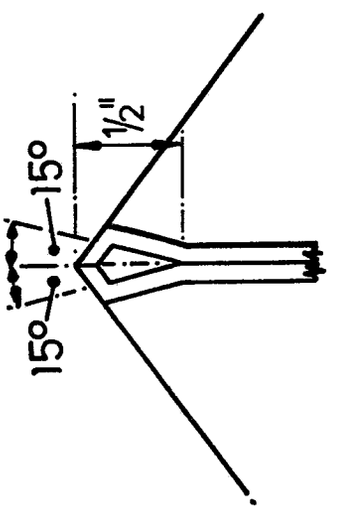

FIG.13

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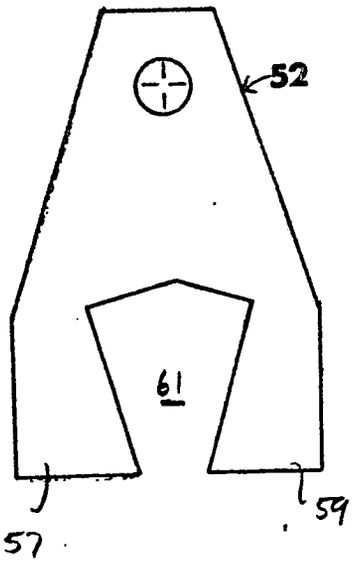
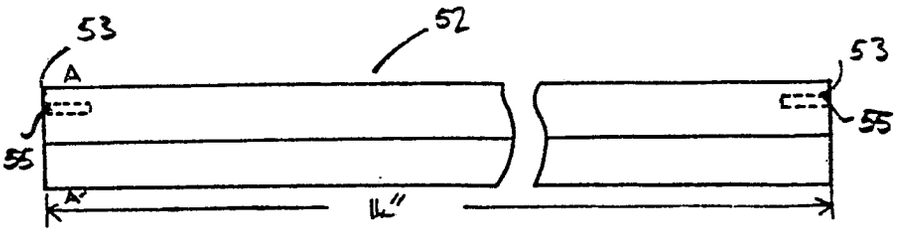


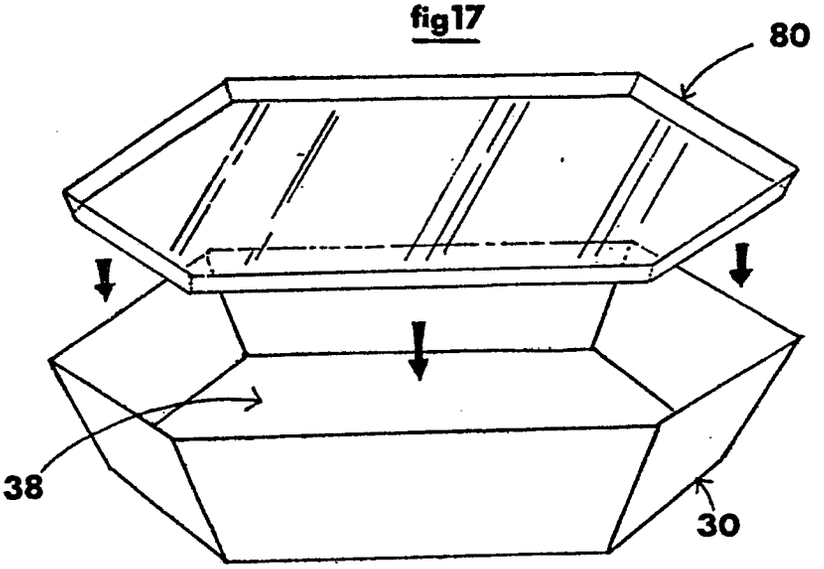
fig 16b

fig 16a



elevation of fixing clip

fig17



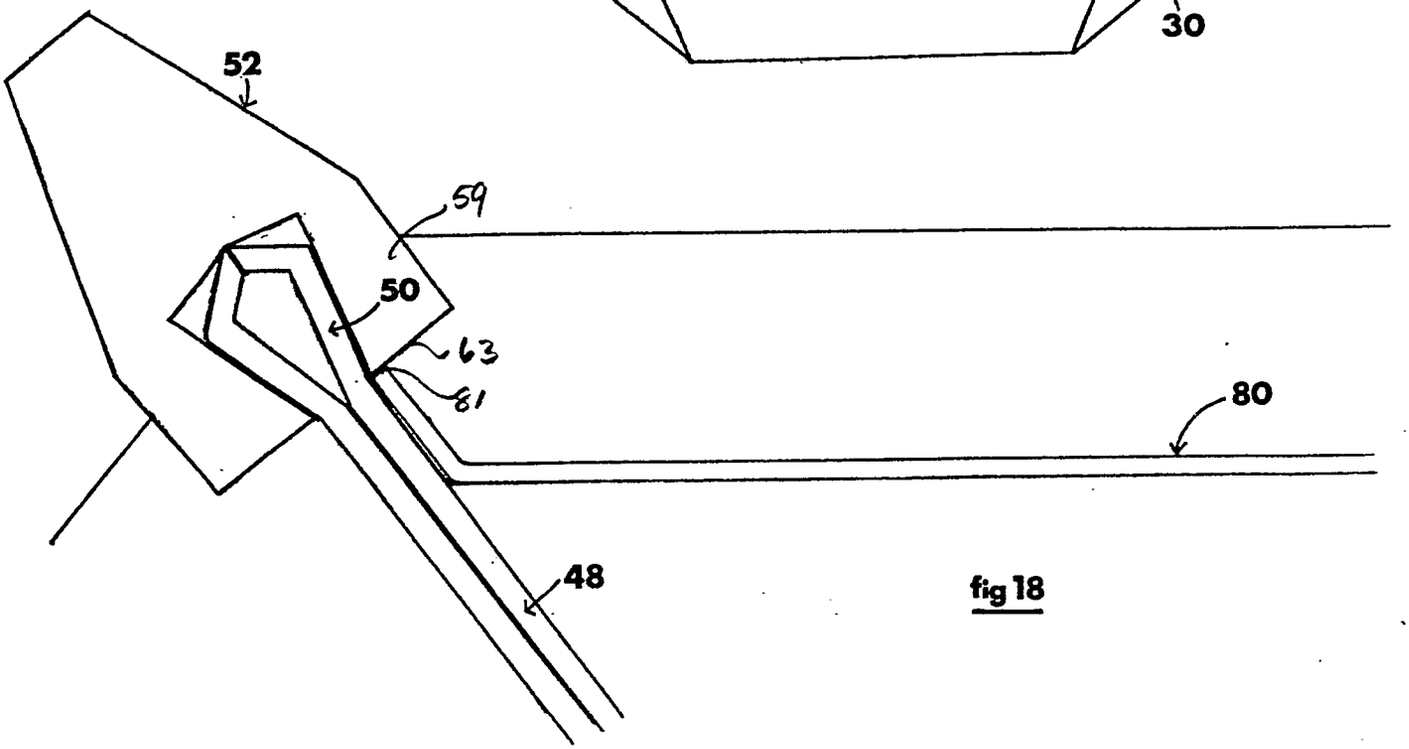


fig 18

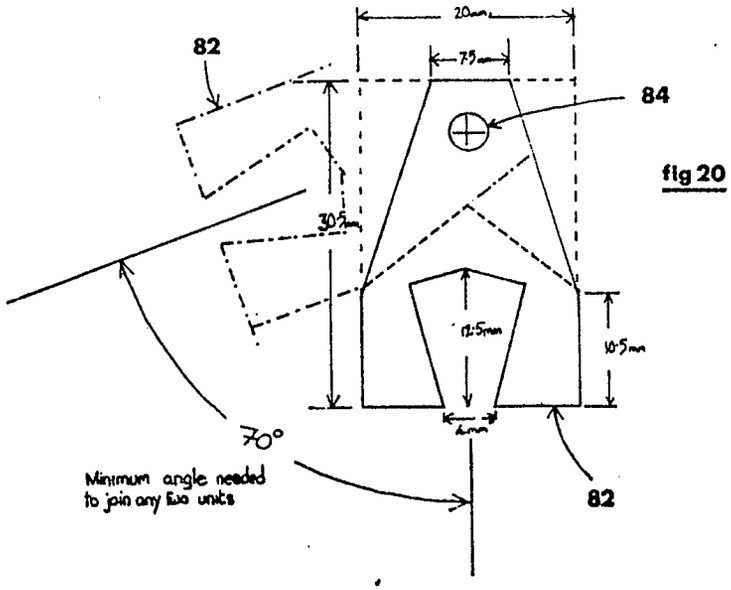


fig 20

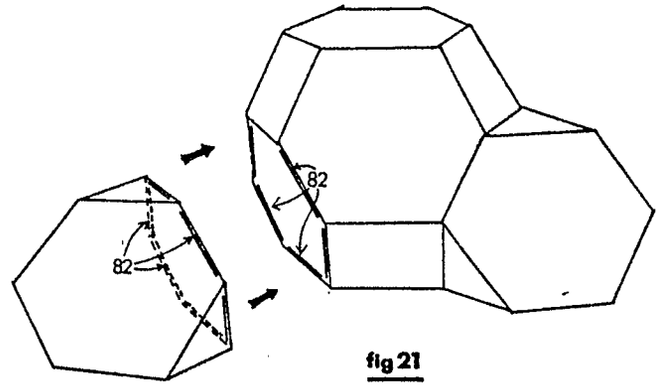


fig 21

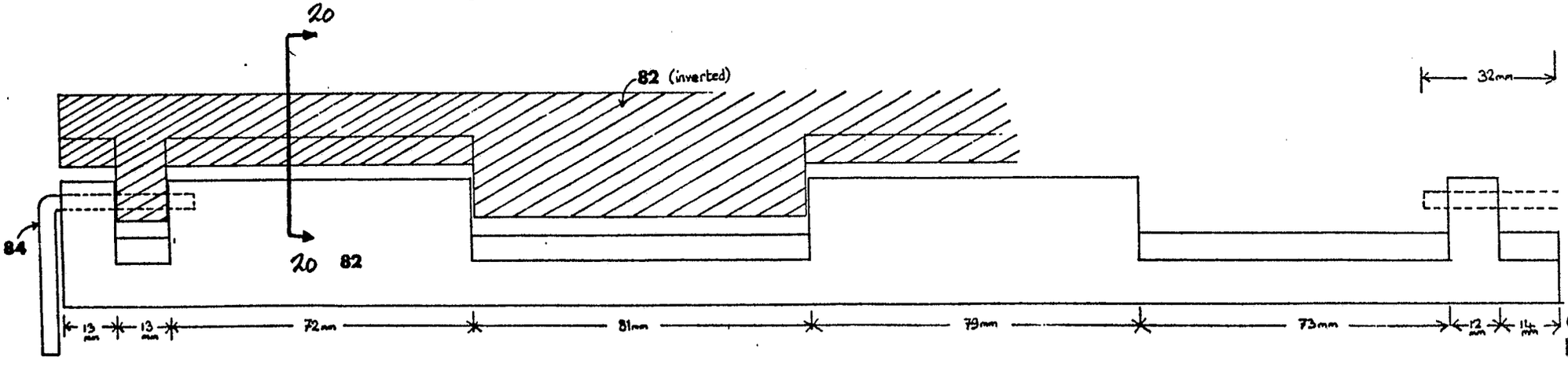


fig 19

9/10

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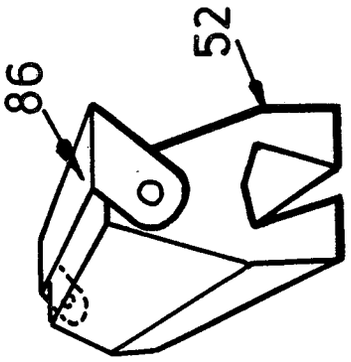

FIG.23

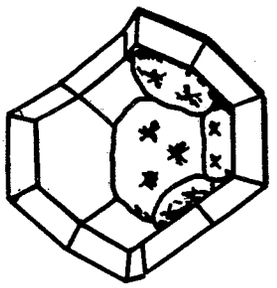

FIG.26

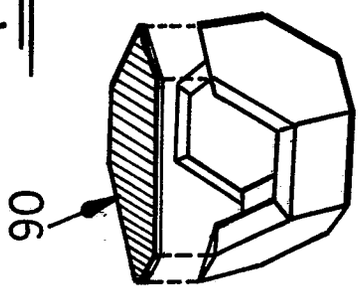

FIG.25

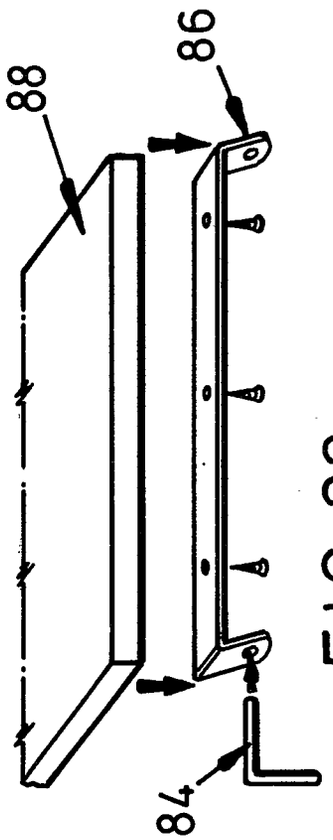

FIG.22

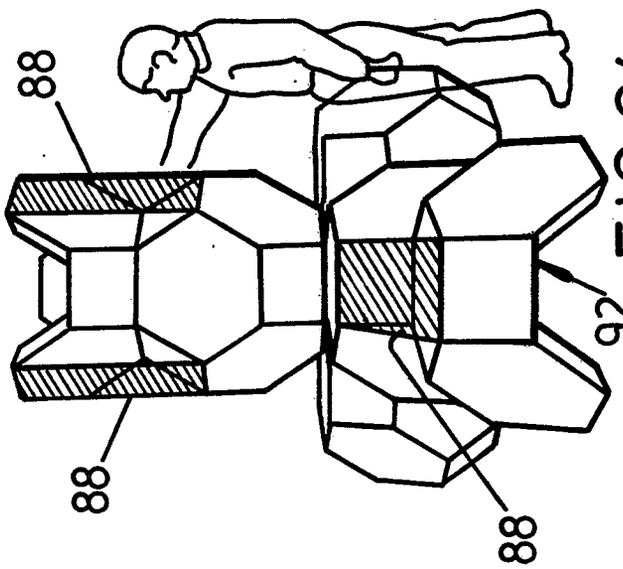

FIG.24