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(54) **CUBIC LOGIC TOY**

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Description

[0001] This invention refers to the manufacturing of three - dimensional logic toys; which have the form of a normal geometric solid, substantially cubic, which has N layers per each direction of the three - dimensional rectangular Cartesian coordinate system, the centre of which coincides with the geometric centre of the solid. The layers consist of a number of smaller pieces, which in layers can rotate around the axes of the three - dimensional rectangular Cartesian coordinate system.

[0002] Such logic toys either cubic or of other shape are famous worldwide, the most famous being the Rubik cube, which is considered to be the best toy of the last two centuries.

[0003] This cube has three layers per each direction of the three - dimensional rectangular Cartesian coordinate system and it could otherwise be named as 3x3x3 cube, or even better as cube No 3, having on each face 9 planar square surfaces, each one coloured with one of the six basic colours, that is in total 6x9=54 coloured planar square surfaces, and for solving this game the user should rotate the layers of the cube, so that, finally, each face of the cube has the same colour.

[0004] The PCT application WO83/01203 (Torres Noel M.) also discloses a 3x3x3 cubic logic toy, consisting of a plurality of smaller separate pieces (cublets) which are able to rotate in layers (facets). Each of the cublets consists of three discernible parts, the internal surfaces of said cublets (i.e. the surfaces of the cublets which lie in the interior of the cubic puzzle when it is assembled) being formed by a combination of planar and concentric spherical surfaces, the centre of the latter coinciding with the geometric centre of the cube (see fig. 1 and 2/A-2/H of WO83/01203) These surfaces have been chosen so that a number of protrusions (tongues) and/or recesses (grooves) are formed on the cublets, whereby adjacent cublets are intercoupled (interlocked).

[0005] In order to hold the cublets together (and keep them from falling apart) a pattern of cooperating beads and grooves on the cublets is used. Thereby, the central three-dimensional supporting cross of Rubik's cube (central six-legged spider), upon which the center cublet of each facet is screwed, is rendered obsolete. The assembly of the cublets in order to form the puzzle is thus made easier and faster. The aforementioned technical problem which was solved by Torres is different from the technical problem solved by the present application, which consists in the manufacture of sturdier cubic logic toys of higher order, i.e. with more layers N per each direction of the three - dimensional rectangular Cartesian coordinate system than it has been possible until now (up to N=11, whereby an 11x11x11 cubic logic toy is derived). Since the solution to this problem is given in a general manner, it can of course also be applied to cubic logic toys with a smaller number of layers, like the classic Rubik cube (N=3). The solution, i.e. the invention itself, will be presented in detail in the description that follows.

[0006] From what we know up to now, except for the classic Rubik cube, that is the cube No 3, the 2x2x2 cube with two layers per direction, (or otherwise called cube No 2), the 4x4x4 cube with four layers per direction, (or otherwise called cube No 4) and the 5x5x5 cube with five layers per direction,(or otherwise called cube No 5) have also been manufactured.

[0007] However, with the exception of the well-known Rubik cube, that is the cube No 3, which does not present any disadvantages during its speed cubing, the other cubes have disadvantages during their speed cubing and the user should be very careful, otherwise the cubes risk having some of their pieces destroyed or being dismantled.

[0008] The disadvantages of the cube 2x2x2 are mentioned in the U.S. Rubik invention N4378117, whereas those of the cubes 4x4x4 and 5x5x5 on the Internet site www.Rubiks.com, where the user is warned not to rotate the cube violently or fast.

[0009] As a result, the slow rotation complicates the competition of the users in solving the cube as quickly as possible.

[0010] The fact that these cubes present problems during their speed Cubing is proved by the decision of the Cubing champion organization committee of the Cubing championship, which took place in August 2003 in Toronto Canada, according to which the main event was the users' competition on the classic Rubik cube, that is on cube No 3, whereas the one on the cubes No 4 and No 5 was a secondary event. This is due to the problems that these cubes present during their speed Cubing.

[0011] The disadvantage of the slow rotation of these cubes' layers is due to the fact that apart from the planar and spherical surfaces, cylindrical surfaces coaxial with the axes of the three - dimensional rectangular Cartesian coordinate system have mainly been used for the configuration of the internal surfaces of the smaller pieces of the cubes' layers. However, although the use of these cylindrical surfaces could secure stability and fast rotation for the

[0012] Rubik cube due to the small number of layers, N=3, per direction, when the number of layers increases there is a high probability of some smaller pieces being damaged or of the cube being dismantled, resulting to the disadvantage of slow rotation. This is due to the fact that the 4x4x4 and 5x5x5 cubes are actually manufactured by hanging pieces on the 2x2x2 and 3x3x3 cubes respectively. This way of manufacturing, though, increases the number of smaller pieces, having as a result the above-mentioned disadvantages of these cubes.

[0013] What constitutes the innovation and the improvement of the construction according to the present invention is that the configuration of the internal surfaces of each piece is made not only by the required planar and spherical surfaces that are concentric with the solid geometrical centre, but mainly by right conical surfaces. These conical surfaces are coaxial with the semi - axes of the three - dimensional rectangular Cartesian coordinate system, the number of which is $\underline{\kappa}$ per semi - axis, and consequently $\underline{\mathbf{2}\kappa}$ in each direction of the three dimensions.

[0014] Thus, when N=2κ even number, the resultant solid has N layers per direction visible to the toy user, plus one additional layer, the intermediate layer in each direction, that is not visible to the user, whereas when N=2κ+1, odd number, then the resultant solid has N layers per direction, all visible to the toy user.

[0015] We claim that the advantages of the configuration of the internal surfaces of every smaller piece mainly by conical surfaces instead of cylindrical, which are secondarily used only in few cases, in combination with the necessary planar and spherical surfaces, are the following:

A) Every separate smaller piece of the toy consists of three discernible separate parts. The first, outermost with regard to the geometric centre of the solid, part, substantially cubic in shape, the second, intermediate part, which has a conical sphenoid shape pointing substantially towards the geometric centre of the solid, its cross section being either in the shape of an equilateral spherical triangle or of an isosceles spherical trapezium or of any spherical quadrilateral, and the third, innermost with regard to the geometric centre of the solid, part, which is part of a sphere or of a spherical shell, delimited appropriately by conical or planar surfaces or by cylindrical surfaces only when it comes to the six caps of the solid. It is obvious, that the first, outermost part is missing from the separate smaller pieces as it is spherically cut when these are not visible to the user.

B) The connection of the corner separate pieces of each cube with the solid interior, which is the most important problem to the construction of three - dimensional logic toys of that kind and of that shape, is ensured, so that these pieces are completely protected from dismantling.

C) With this configuration, each separate piece extends to the appropriate depth in the interior of the solid and it is protected from being dismantled, on the one hand by the six caps of the solid, that is the central separate pieces of each face, and on the other hand by the suitably created recesses - protrusions, whereby each separate piece is intercoupled and supported by its neighbouring pieces, said recesses-protrusions being such as to create, at the same time, general spherical recesses-protrusions between adjacent layers. These recesses - protrusions both intercouple and support each separate piece with its neighbouring, securing, on the one hand, the stability of the construction and, on the other hand, guiding the pieces during the layers' rotation around the axes. The number of these recesses - protrusions could be more than one (1), i.e. two (2), when the stability of the construction requires it, as shown in the drawings of the present invention.

D) Since the internal parts of the several separate pieces are conical and spherical, they can easily rotate in and above conical and spherical surfaces, which are surfaces made by rotation and consequently the advantage of the fast and unhindered rotation, reinforced by the appropriate rounding of the edges of each separate piece, is ensured.

E) The configuration of each separate piece's internal surfaces by planar spherical and conical surfaces is more easily made on the lathe.

F) Each separate piece is self-contained, rotating along with the other pieces of its layer around the corresponding axis in the way the user desires.

G) According to the way of manufacture suggested by the present invention, two different solids correspond to each value of k. The solid with N=2κ, that is with an even number of visible layers per direction, and the solid with N=2κ+1 with the next odd number of visible layers per direction. The only difference between these solids is that the intermediate layer of the first one is not visible to the user, whereas the intermediate layer of the second emerges at the toy surface. These two solids consist, as it is expected, of exactly the same number of separate pieces, that is $T=6N^2+3$, where N can only be an even number, i.e. N=2κ. Therefore, the total number of separate pieces can also be expressed as $T = 6(2\kappa)^2+3$.

H) The great advantage of the configuration of the separate pieces internal surfaces of each solid with conical surfaces in combination with the required planar and spherical surfaces, is that whenever an additional conical surface is added to every semi - axis of the three - dimensional rectangular Cartesian coordinate system, then two new solids are produced, said solids having two more layers than the initial ones.

[0016] Thus, when κ=1, two cubes with N=2κ=2x1=2 and N=2κ+1=2x1+1=3 arise, that is the **cubic logic toys No2 and No3**, when κ=2, the cubes with N=2κ=2x2=4 and N=2κ+1=2x2+1=5 arise, that is the **cubic logic toys No4 and No5, e.t.c.** and, finally, when k=5 the cubes N=2κ=2x5=10 and N=2κ+1=2x5+1=11 are produced, that is the **cubic logic toys No 10 and No 11**, where the present invention stops.

[0017] The fact that when a new conical surface is added two new solids are produced is a great advantage as it makes the invention unified.

[0018] As it can easily be calculated, the number of the possible different places that each cube's pieces can take, during rotation, increases spectacularly as the number of layers increases, but at the same time the difficulty in solving the cube increases.

[0019] The reason why the present invention finds application up to the cube N=11, as we have already mentioned, is due to the increasing difficulty in solving the cubes when more layers are added as well as due to geometrical constraints and practical reasons.

[0020] The geometrical constraints are the following:

a) According to the present invention, in order to divide the cube into equal N layers we have already proved that N should verify the inequality $\sqrt{2}$ (a/2-a/N)<a/2.Having solved the inequality, it is obvious that the whole values of N are N<6,82.This is possible when N=2, N=3, N=4, N=5 and N=6 and as a result the cubic logic toys No2, No3, No4, No5 and No6, whose shape is ideally cubic, are produced.

b) The constraint in the value ofN<6,82 can be overcome if the planar faces of the cube become spherical parts of long radius. Therefore, the final solid with N=7 and more layers loses the classical geometrical cubic shape, that with six planar surfaces, but from N=7 to N=11 the six solid faces are no longer planar but spherical, of long radius compared to the cube dimensions, the shape of said spherical surfaces being almost planar, as the rise of the solid faces from the ideal level, is about 5% of the side length of the ideal cube.

[0021] Although the shape of the resultant solids from N=7 to N=11 is substantially cubic, according to the Topology branch the circle and the square are exactly the same shapes and subsequently the classic cube continuously transformed to substantially cubic is the same shape as the sphere. Therefore, we think that it is reasonable to name all the solids produced by the present invention **cubic logic toys No N**, as they are manufactured in exactly the same unified way, that is by using conical surfaces.

[0022] The practical reasons why the present invention finds application up to the cube N=11 are the following:

a) A cube with more layers than N=11 would be hard to rotate due to its size and the large number of its separate pieces.

b) When N>10, the visible surfaces of the separate pieces that form the acmes of the cube lose their square shape and become rectangular. That's why the invention stops at the value N=11 for which the ratio of the sides b/a of the intermediate on the acmes rectangular is1, 5.

[0023] Finally, we should mention that when N=6,the value is very close to the geometrical constraint N<6,82.As a result, the intermediate sphenoid part of the separate pieces, especially of the corner ones, will be limited in dimensions and must be either strengthened or become bigger in size during construction. That is not the case if the cubic logic toy No 6 is manufactured in the way the cubic logic toys with N≥7 are, that is with its six faces consisting of spherical parts of long radius. That's why we suggest two different versions in manufacturing the cubic logic toy No6; version No6a is of a normal cubic shape and version No6b is with its faces consisting of spherical parts of long radius. The only difference between the two versions is in shape since they consist of exactly the same number of separate pieces.

[0024] This invention has been possible since the problem of connecting the corner cube piece with the solid interior has been solved, so that the said corner piece can be self-contained and rotate around any semi - axis of the three - dimensional rectangular Cartesian coordinate system, be protected during rotation by the six caps of the solid, that is the central pieces of each face, to secure that the cube is not dismantled.

[0025] **I**. This solution became possible based on the following observations:

a) The diagonal of each cube with side length **a** forms with the semi-axes OX, OY, OZ, of the three - dimensional rectangular Cartesian coordinate system angles equal to $\tan\omega=\alpha\sqrt{2}/\alpha$, $\tan\omega=\sqrt{2}$, therefore $\omega=54{,}735610320°$ (figure 1.1).

b) If we consider three right cones with apex to the beginning of the coordinates, said right cones having axes the positive semi - axes OX, OY, OZ, their generating line forming with the semi - axes OX, OY, OZ an angle $\varphi>\omega$, then the intersection of these three cones is a sphenoid solid of continuously increasing thickness, said sphenoid solid's apex being located at the beginning of the coordinates (figure 1.2), of equilateral spherical triangle cross section (figure 1.3) when cut by a spherical surface whose centre coincides with the coordinates beginning. The length of the sides of the said spherical triangle increases as we approach the cube apex. The centre- axis of the said sphenoid solid coincides with the diagonal of the cube.

[0026] The three side surfaces of that sphenoid solid are parts of the surfaces of the mentioned cones and, as a result, the said sphenoid solid can rotate in the internal surface of the corresponding cone, when the corresponding cone axis or the corresponding semi - axis of the three - dimensional rectangular Cartesian coordinate system rotates.

[0027] Thus, if we consider that we have 1/8 of a sphere with radius **R**, the centre of said sphere being located at the coordinates beginning, appropriately cut with planes parallel to the planes XY, YZ, ZX, as well as a small cubic piece, whose diagonal coincides with the initial cube diagonal (figure 1.4), then these three pieces (figure 1.5) embodied into a separate piece give us the general form and the general shape of the corner pieces of all the present invention cubes (figure 1.6).

[0028] It is enough, therefore, to compare the figure 1.6 with the figures 2.1, 3.1, 4.1, 5.1, 6a.1, 6b.1 7.1, 8.1, 9.1, 10.1, 11.1, in order to find out the unified manufacturing way of the corner piece of each cube according to the present invention. In the above- mentioned figures one can clearly see the three discernible parts of the corner pieces; the first part which is substantially cubic, the second part which is of a conical sphenoid shape and the third part which is a part of a sphere. Comparing the figures is enough to prove that the invention is unified although it finally produces more than one solids.

[0029] The other separate pieces are produced exactly the same way and their shape that depends on the pieces' place in the final solid is alike. Their conical sphenoid part, for the configuration of which at least four conical surfaces are used, can have the same cross section all over its length or different cross-section per parts. Whatever the case, the shape of the cross-section of the said sphenoid part is either of an isosceles spherical trapezium or of any spherical quadrilateral. The configuration of this conical sphenoid part is such so as to create on each separate piece the above-mentioned recesses-protrusions whereby each separate piece is intercoupled and supported by its neighbouring pieces. At the same time, the configuration of the conical sphenoid part in combination with the third lower part of the pieces creates general spherical recesses-protrusions between adjacent layers, securing the stability of the construction and guiding the layers during rotation around the axes. Finally, the lower part of the separate pieces is a piece of a sphere or of spherical shell.

[0030] It should also be clarified that the angle $\underline{\varphi 1}$ of the first cone $\underline{k1}$ should be greater than 54,73561032° when the cone apex coincides with the coordinates beginning. However, if the cone apex moves to the semi-axis lying opposite to the semi-axis which points to the direction in which the conical surface widens, then the angle $\underline{\varphi 1}$ could be slightly less than 54,73561032° and this is the case especially when the number of layers increases.

[0031] We should also note that the separate pieces of each cube are fixed on a central three - dimensional solid cross whose six legs are cylindrical and on which we screw the six caps of each cube with the appropriate screws. The caps, that is the central separate pieces of each face, whether they are visible or not, are appropriately formed having a hole (figure 1.7) through which the support screw passes after being optionally surrounded with appropriate springs (figure 1.8). The way of supporting is similar to the support of the Rubik cube.

[0032] Finally, we should mention that after the support screw passes through the hole in the caps of the cubes, especially in the ones with an even number of layers, it is covered with a flat plastic piece fitted in the upper cubic part of the cap.

[0033] The present invention is fully understood by anyone who has a good knowledge of visual geometry. For that reason there is an analytic description of figures from 2 to 11 accompanying the present invention and proving that:

a) The invention is a unified inventive body.
b) The invention improves the up to date manufactured in several ways and by several inventor cubes, that is 2x2x2, 4x4x4 and 5x5x5 cubes, which, however, present problems during their rotation.
c) The classic and functioning without problems Rubik cube, i.e. the 3x3x3 cube, is included in that invention with some minor modifications.
d) It expands for the first time worldwide, from what we know up to now, the logic toys series of substantially cubic shape up to the number No 11, i.e. the cube with 11 different layers per direction.

[0034] Finally, we should mention that, because of the absolute symmetry, the separate pieces of each cube form groups of similar pieces, the number of said groups depending on the number $\underline{\kappa}$ of the conical surfaces per semi - axis of the cube, and said number being a triangle or triangular number. As it is already known, triangle or triangular numbers are the numbers that are the partial sums of the series $\Sigma = 1 + 2 + 3 + 4 + ... + v$, i.e. of the series the difference between the successive terms of which is 1. In this case the general term of the series is $v = \kappa + 1$. Hence, if the number of groups of similar pieces is denoted by G, it would be:

$$G = \sum_{i=1}^{\kappa+1} i\,.$$

[0035] In figures 2 to 11 of the present invention one can easily see:

a) The shape of all the different separate pieces each cube is consisted of.
b) The three discernible parts of each separate piece; the first, outermost part which is substantially cubic, the second, intermediate part which is of a conical sphenoid shape and the third, innermost part which is a part of a sphere or of a spherical shell.

c) The above-mentioned recesses-protrusions on the different separate pieces whenever necessary.

d) The above-mentioned between adjacent layers general spherical recesses-protrusions, which secure the stability of construction and guide the layers during rotation around the axes.

[0036] **II.** Thus, when κ=1 and N=2k=2x1=2, i.e. for the **cubic logic toy No 2,** we have only (3) three different kinds of separate pieces. The corner piece **1** (figure 2.1) and in total eight similar pieces, all visible to the toy user, the intermediate piece **2** (figure 2.2) and in total twelve similar pieces, all of non visible to the toy user and piece **3,** the cap of the cube, and in total six similar pieces all non visible to the toy user. Finally, piece **4** is the non-visible central, three - dimensional solid cross that supports the cube (figure 2.4).

[0037] In figures 2.1.1, 2.2.1, 2.2.2 and 2.3.1 we can see the cross sections of these pieces.

[0038] In figure 2.5 we can see these three different kinds of pieces of the cube, placed at their position along with the non-visible central three - dimensional solid cross that supports the cube.

[0039] In figure 2.6 we can see the geometrical characteristics of the cubic logic toy No 2 where **R** generally represents the radiuses of concentric spherical surfaces that are necessary for the configuration of the internal surfaces of the cube's separate pieces.

[0040] In figure 2.7 we can see the position of the separate central pieces of the intermediate non-visible layer in each direction on the non-visible central three - dimensional solid cross that supports the cube.

[0041] In figure 2.8 we can see the position of the separate pieces of the intermediate non-visible layer in each direction on the non-visible central three - dimensional solid cross that supports the cube.

[0042] In figure 2.9 we can see the position of the separate pieces of the first layer in each direction on the non-visible central three - dimensional solid cross that supports the cube.

[0043] Finally, in figure 2.10 we can see the final shape of the cubic logic toy No 2. The cubic logic toy No 2 consists of twenty- seven (27) separate pieces in total along with the non-visible central three - dimensional solid cross that supports the cube.

[0044] **III.** When κ=1 and N=2κ+1 = 2x1+1 = 3, i.e. **the cubic logic toy No 3,** we have again **(3)** three kinds of different, separate pieces. The corner piece **1,** (figure 3.1) and in total eight similar pieces, all visible to the toy user, the intermediate piece 2 (figure 3.2) and in total twelve similar pieces, all visible to the user, and finally piece **3**, (figure 3.3) the cube cap, and in total six similar pieces, all visible to the toy user. Finally, the piece 4 is the non-visible central three - dimensional solid cross that supports the cube (figure 3.4).

[0045] In figures 3.1.1, 3.2.1, 3.2.2, 3.3.1 we can see the cross-sections of these different separate pieces by their symmetry planes.

[0046] In figure 3.5 we can see these three different pieces placed at their position along with the non-visible central three - dimensional solid cross that supports the cube.

[0047] In figure 3.6 we can see the geometrical characteristics of the cubic logic toy No 3.

[0048] In figure 3.7 we can see the internal face of the first layer along with the non-visible central three - dimensional solid cross that supports the cube.

[0049] In figure 3.8 we can see the face of the intermediate layer in each direction along with the non-visible central three - dimensional solid cross that supports the cube.

[0050] In figure 3.9 we can see the section of that intermediate layer by an intermediate symmetry plane of the cube.

[0051] Finally, in figure 3.10 we can see the final shape of the cubic logic toy **No 3.** The cubic logic toy No 3 consists of twenty- seven (27) separate pieces in total along with the non-visible central three - dimensional solid cross that supports the cube.

[0052] By comparing the figures of the cubic logic toys No 2 and No 3, it is clear that the non-visible intermediate layer of the toy No 2 becomes visible in the toy No 3 while both the cubes consist of the same total number of separate pieces. Besides, this has already been mentioned as one of the advantages of the present invention and it proves that it is unified. At this point, it is useful to compare the figures of the separate pieces of the cubic logic toy No 3 with the figures of the separate pieces of the Rubik cube.

[0053] The difference between the figures is that the conical sphenoid part of the separate pieces of this invention does not exist in the pieces of the Rubik cube. Therefore, if we remove that conic sphenoid part from the separate pieces of the cubic logic toy No 3, then the figures of that toy will be similar to the Rubik cube figures.

[0054] In fact, the number of layers N=3 is small and, as a result, the conical sphenoid part is not necessary, as we have already mentioned the Rubik cube does not present problems during its speed cubing. The construction, however, of the cubic logic toy No 3 in the way this invention suggests, has been made not to improve something about the operation of the

[0055] Rubik cube but in order to prove that the invention is unified and sequent.

[0056] However, we think that the absence of that conical sphenoid part in the Rubik cube, which is the result of the mentioned conical surfaces introduced by the present invention, is the main reason why, up to now, several inventors could not conclude in a satisfactory and without operating problems way of manufacturing these logic toys.

[0057] Finally, we should mention that only for manufacturing reasons and for the easy assembling of the cubes when N=2 and N=3, the last but one sphere, i.e. the sphere with R_1 radius, shown in figures 2.6 and 3.6, could be optionally replaced by a cylinder of the same radius only for the configuration of the intermediate layer whether it is visible or not, without influencing the generality of the method.

[0058] **IV.** When κ=2 and N=2κ=2x2=4, i.e. for the **cubic logic toy No 4,** there are (6) six different kinds of separate pieces. Piece **1,** (figure 4.1) and in total eight similar pieces, all visible to the user, piece **2,** (figure 4.2) and in total twenty four similar pieces, all visible to the user, piece **3,** (figure 4.3) and in total twenty four similar pieces, all visible to the user, piece **4,** (figure 4.4) and in total twelve similar pieces, all non-visible to the user, piece **5,** (figure 4.5) and in total twenty four similar pieces, all non-visible to the user and piece **6,** (figure 4.6), the cap of the cubic logic toy No 4, and in total six similar pieces, all non-visible to the user. Finally, in figure 4.7 we can see the non-visible central three - dimensional solid cross that supports the cube.

[0059] In figures 4.1.1, 4.2.1, 4.3.1, 4.4.1, 4.4.2, 4.5.1, 4.6.1 and 4.6.2 we can see the cross sections of these different separate pieces.

[0060] In figure 4.8 we can see at an axonometric projection these different pieces placed at their positions along with the non-visible central three - dimensional solid cross that supports the cube No 4.

[0061] In figure 4.9 we can see the intermediate non-visible layer in each direction along with the non-visible central three - dimensional solid cross that supports the cube.

[0062] In figure 4.10 we can see the section of the pieces of the intermediate non-visible layer by an intermediate symmetry plane of the cube, as well as the projection of the pieces of the second layer of the cube on the said intermediate layer.

[0063] In figure 4.11 we can see at an axonometric projection the non-visible intermediate layer and the supported on it, second layer of the cube.

[0064] In figure 4.12 we can see at an axonometric projection the first and the second layer along with the intermediate non-visible layer and the non-visible central three - dimensional solid cross that supports the cube.

[0065] In figure 4.13 we can see the final shape of the cubic logic toy No 4.

[0066] In figure 4.14 we can see the external face of the second layer with the intermediate non-visible layer and the non-visible central three - dimensional solid cross that supports the cube.

[0067] In figure 4.15 we can see the internal face of the first layer of the cube with the non-visible central three - dimensional solid cross that supports the cube.

[0068] Finally, in figure 4.16 we can see the geometrical characteristics of the cubic logic toy No 4, for the configuration of the internal surfaces of the separate pieces of which, two conical surfaces per semi - direction of the three - dimensional rectangular Cartesian coordinate system have been used. The cubic logic toy No 4 consists of ninety- nine (99) separate pieces in total along with the non-visible central three - dimensional solid cross that supports the cube.

[0069] **V.** When κ=2 and N=2κ+1=2x2+1=5, i.e. for the **cubic logic toy No 5,** there are again (6) six different kinds of separate pieces, all visible to the user. Piece **1,** (figure 5.1) and in total eight similar pieces, piece **2,** (figure 5.2) and in total twenty four similar pieces, piece **3,** (figure 5.3) and in total twenty four similar pieces, piece **4,** (figure 5.4) and in total twelve similar pieces, piece **5,** (figure 5.5) and in total twenty four similar pieces, and piece **6,** (figure 4.6) the cap of the cubic logic toy No 5 and in total six similar pieces. Finally, in figure 5.7 we can see the non-visible central three - dimensional solid cross that supports the cube.

[0070] In figures 5.1.1, 5.2.1, 5.3.1, 5.4.1, 5.4.2, 5.5.1, 5.6.1, 5.6.2 we can see the cross sections of these different separate pieces.

[0071] In figure 5.8 we can see the geometrical characteristics of the cubic logic toy No 5, for the configuration of the internal surfaces of the separate pieces of which, two conical surfaces per semi - direction of the three - dimensional rectangular Cartesian coordinate system have been used.

[0072] In figure 5.9 we can see at an axonometric projection these six different pieces placed at their position along with the non-visible central three - dimensional solid cross that supports the cube. In figure 5.10 we can see the internal face of the first layer of the cubic logic toy No 5.

[0073] In figure 5.11 we can see the internal face of the second layer and in figure 5.14 its external face.

[0074] In figure 5.12 we can see the face of the intermediate layer of the cubic logic toy No 5 along with the non-visible central three - dimensional solid cross that supports the cube.

[0075] In figure 5.13 we can see the section of the pieces of the intermediate layer of the cube No 5 and the section of the non-visible central three - dimensional solid cross that supports the cube by an intermediate symmetry plane of the cube.

[0076] In figure 5.15 we can see the first and the second layer with the non-visible central three - dimensional solid cross that supports the cube.

[0077] In figure 5.16 we can see the first, the second and the intermediate layer with the non-visible central three - dimensional solid cross that supports the cube.

[0078] Finally, in figure 5.17 we can see the final shape of the cubic logic toy No 5.

[0079] The cubic logic toy No 5 consists of ninety- nine (99) separate pieces in total along with the non-visible central three - dimensional solid cross that supports the cube, the same number of pieces as in the cubic logic toy No 4.

[0080] VI.a When κ=3, that is when we use three conical surfaces per semi axis of the three-dimensional rectangular Cartesian coordinate system and N= 2κ=2x3=6 that is for the **cubic logic toy No 6a,** whose final shape is cubic, we have **(10)** different kinds of separate pieces, of which only the first six are visible to the user, whereas the next four are not.

[0081] Piece **1** (figure 6a.1) and in total eight similar pieces, piece **2** (figure 6a.2) and in total twenty-four similar pieces, piece **3** (figure 6a.3) and in total twenty-four similar pieces, piece **4** (figure 6a.4) and in total twenty-four similar pieces, piece **5** (figure 6a.5) and in total forty-eight similar pieces, which in pairs are mirror images, piece **6** (figure 6a.6) and in total twenty-four similar pieces, up to this point all visible to the user of the toy. The non-visible, different pieces that form the intermediate non visible layer in each direction of the cubic logic toy No 6a are: piece **7** (figure 6a.7) and in total twelve similar pieces, piece **8** (figure 6a.8) and in total twenty-four similar pieces, piece **9** (figure 6a.9) and in total twenty-four similar pieces and piece **10** (figure 6a.10) and in total six similar pieces, the caps of the cubic logic toy No 6a. Finally, in figure 6a.11 we can see the non- visible central three-dimensional solid cross that supports the cube No 6a.

[0082] In figure 6a.1.1., 6a.2.1, 6a.3.1, 6a.4.1, 6a.5.1, 6a.6.1, 6a.7.1, 6a.7.2, 6a.8.1, 6a.9.1, 6a.10.1 and 6a.10.2 we can see the cross-sections of the ten separate, different pieces of the cubic logic toy No 6a.

[0083] In figure 6a.12 we can see these ten different pieces of the cubic logic toy No 6a, placed at their position along with the non visible central three-dimensional solid cross that supports the cube.

[0084] In figure 6a.13 we can see the geometrical characteristics of the cubic logic toy No 6a, where for the configuration of the internal surfaces of its separate pieces three conical surfaces have been used per semi direction of the three-dimensional rectangular Cartesian coordinate system.

[0085] In figure 6a.14 we can see the internal face of the first layer of the cubic logic toy No 6a along with the non visible central three-dimensional solid cross that supports the cube.

[0086] In figure 6a.15 we can see the internal face and in figure 6a.16 we can see the external face of the second layer of the cubic logic toy No 6a.

[0087] In figure 6a.17 we can see the internal face and in figure 6a.18 we can see the external face of the third layer of the cubic logic toy No 6a.

[0088] In figure 6a.19 we can see the face of the non- visible intermediate layer in each direction along with the non -visible central three-dimensional solid cross that supports the cube.

[0089] In figure 6a.20 we can see the sections of the separate pieces of the intermediate layer as well as of the non visible central three dimensional solid cross that supports the cube by an intermediate symmetry plane of the cube, and we can also see the projection of the separate pieces of the third layer on this plane, said third layer being supported on the intermediate layer of the cubic logic toy No 6a.

[0090] In figure 6a.21 we can see at an axonometric projection the first three layers that are visible to the user, as well as the intermediate non visible layer in each direction and the non visible central three-dimensional solid cross that supports the cube.

[0091] Finally, in figure 6a.22 we can see the final shape of the cubic logic toy No 6a.

[0092] The cubic logic toy No 6a consists of two hundred and nineteen (219) separate pieces in total along with the non- visible central three-dimensional solid cross that supports the cube.

[0093] VI.b When κ=3, that is when we use three conical surfaces per semi axis of the three-dimensional rectangular Cartesian coordinate system and N= 2κ=2x3=6, that is for the **cubic logic toy No 6b**, whose final shape is substantially cubic, its faces consisting of spherical surfaces of long radius, we have **(10)** different kinds of separate pieces, of which only the first six are visible to the user, whereas the next four are not.

[0094] Piece **1** (figure 6b.1) and in total eight similar pieces, piece **2** (figure 6b.2) and in total twenty-four similar pieces, piece **3** (figure 6b.3) and in total twenty-four similar pieces, piece **4** (figure 6b.4) and in total twenty-four similar pieces, piece **5** (figure 6b.5) and in total forty eight similar pieces, which in pairs are mirror images, piece **6** (figure 6b.6) and in total twenty-four similar pieces, up to this point all visible to the user. The non visible different pieces that form the intermediate non visible layer in each direction of the cubic logic toy No 6b are: piece **7** (figure 6b.7) and in total twelve similar pieces, piece **8** (figure 6b.8) and in total twenty-four similar pieces, piece **9** (figure 6b.9) and in total twenty-four similar pieces and piece **10** (figure 6b.10) and in total six similar pieces, the caps of the cubic logic toy No 6b. Finally, in figure 6b.11 we can see the non-visible central three-dimensional solid cross that supports the cube No 6b.

[0095] In figure 6b.12 we can see the ten different pieces of the cubic logic toy No 6b, placed at their position along with the non visible central three-dimensional solid cross that supports the cube.

[0096] In figure 6b.13 we can see the geometrical characteristics of the cubic logic toy No 6b, for the configuration of the internal surfaces of the separate pieces of which three conical surfaces have been used per semi direction of the three-dimensional rectangular Cartesian coordinate system.

[0097] In figure 6b.14 we can see the internal face of the first layer of the cubic logic toy No 6b along with the non visible central three-dimensional solid cross that supports the cube.

[0098] In figure 6b.15 we can see the internal face and in figure 6a.16 we can see the external face of the second layer of the cubic logic toy No 6b.

[0099] In figure 6b.17 we can see the internal face and in figure 6b.18 we can see the external face of the third layer of the cubic logic toy No 6b.

[0100] In figure 6b.19 we can see the face of the non- visible intermediate layer in each direction along with the non-visible central three-dimensional solid cross that supports the cube.

[0101] In figure 6b.20 we can see the section of the separate pieces of the intermediate layer as well as of the non-visible central three- dimensional solid cross that supports the cube by an intermediate symmetry plane of the cube.

[0102] In figure 6b.21 we can see at an axonometric projection the first three layers that are visible to the user, as well as the intermediate non -visible layer in each direction and the non visible central s three-dimensional solid cross that supports the cube.

[0103] Finally, in figure 6b.22 we can see the final shape of the cubic logic toy No 6b.

[0104] The cubic logic toy No 6b consists of two hundred and nineteen (219) separate pieces in total along with the non-visible central three-dimensional solid cross that supports the cube.

[0105] We have already mentioned that the only difference between the two versions of the cube No6 is in their final shape.

[0106] __**VII.**__ When κ=3, that is when we use three conical surfaces per semi axis of the three-dimensional rectangular Cartesian coordinate system and N= 2κ+1=2x3+1=7, that is for the **cubic logic toy No 7**, whose final shape is substantially cubic, its faces consisting of spherical surfaces of long radius, we have again **(10)** different kinds of separate pieces, which are all visible to the user of the toy.

[0107] Piece **1** (figure 7.1) and in total eight similar pieces, piece **2** (figure 7.2) and in total twenty-four similar pieces, piece **3** (figure 7.3) and in total twenty-four similar pieces, piece **4** (figure 7.4) and in total twenty-four similar pieces, piece **5** (figure 7.5) and in total forty eight similar pieces, which in pairs are mirror images, piece **6** (figure 7.6) and in total twenty-four similar pieces, piece **7** (figure 7.7) and in total twelve similar pieces, piece **8** (figure 7.8) and in total twenty-four similar pieces, piece **9** (figure 7.9) and in total twenty-four similar pieces and piece **10** (figure 7.10) and in total six similar pieces, the caps of the cubic logic toy No 7.

[0108] Finally, in figure 7.11 we can see the non- visible central three-dimensional solid cross that supports the cube No 7.

[0109] In figures 7.1.1, 7.2.1, 7.3.1, 7.4.1, 7.5.1, 7.6.1, 7.7.1, 7.7.2, 7.8.1, 7.9.1, 7.10.1 and 7.10.2 we can see the cross-sections of the ten different, separate pieces of the cubic logic toy No 7.

[0110] In figure 7.12 we can see the ten different pieces of the cubic logic toy No 7 placed at their position along with the non-visible central three-dimensional solid cross that supports the cube.

[0111] In figure 7.13 we can see the geometrical characteristics of the cubic logic toy No 7, for the configuration of the internal surfaces of the separate pieces of which three conical surfaces per semi direction of the three-dimensional rectangular Cartesian coordinate system have been used.

[0112] In figure 7.14 we can see the internal face of the first layer per semi direction of the cubic logic toy No 7.

[0113] In figure 7.15 we can see the internal face of the second layer per semi direction along with the non -visible central three-dimensional solid cross that supports the cube and in figure 7.16 we can see the external face of this second layer.

[0114] In figure 7.17 we can see the internal face of the third layer per semi direction along with the non -visible central three-dimensional solid cross that supports the cube and in figure 7.18 we can see the external face of this third layer.

[0115] In figure 7.19 we can see the face of the intermediate layer in each direction along with the central three-dimensional solid cross that supports the cube.

[0116] In figure 7.20 we can see the section of the separate pieces of the intermediate layer and of the non-visible central three-dimensional solid cross that supports the cube by an intermediate symmetry plane of the cube.

[0117] In figure 7.21 we can see at an axonometric projection the three first layers per semi direction along with the intermediate layer in each direction, all of which are visible to the user of the toy along with the non- visible central three-dimensional solid cross, which supports the cube.

[0118] Finally, in figure 7.22 we can see the final shape of the cubic logic toy No 7.

[0119] The cubic logic toy No 7 consists of two hundred and nineteen (219) separate pieces in total along with the non- visible central three-dimensional solid cross that supports the cube, i.e. the same number of pieces as in the cubic logic toy No 6.

[0120] __**VIII.**__ When κ=4, that is when we use four conical surfaces per semi axis of the three-dimensional rectangular Cartesian coordinate system and N= 2κ=2x4=8, that is for the **cubic logic toy No 8** whose final shape is substantially cubic, its faces consisting of spherical surfaces of long radius, we have **(15)** fifteen different kinds of separate smaller pieces, of which only the first ten are visible to the user of the toy whereas the next five are non visible. Piece **1** (figure 8.1) and in total eight similar pieces, piece **2** (figure 8.2) and in total twenty-four similar pieces, piece **3** (figure 8.3) and in total twenty-four similar pieces, piece 4 (figure 8.4) and in total twenty-four similar pieces, piece **5** (figure 8.5) and in total forty-eight similar pieces, which in pairs are mirror images, piece **6** (figure 8.6) and in total twenty-four similar pieces, piece **7** (figure 8.7) and in total twenty-four similar pieces, piece **8** (figure 8.8) and in total forty- eight similar pieces, which in pairs are mirror images, piece **9** (figure 8.9) and in total forty- eight similar pieces, which in pairs are mirror images, and piece **10** (figure 8.10) and in total twenty-four similar pieces, all of which are visible to the user of the toy.

[0121] The non visible different pieces that form the intermediate non visible layer in each direction of the cubic logic toy No 8 are: piece **11** (figure 8.11) and in total twelve similar pieces, piece **12** (figure (8.12) and in total twenty-four similar pieces, piece **13** (figure 8.13) and in total twenty-four similar pieces, piece **14** (figure 8.14) and in total twenty-four similar pieces and piece **15** (figure 8.15) and in total six similar pieces, the caps of the cubic logic toy No 8. Finally, in figure 8.16 we can see the non -visible central three-dimensional solid cross that supports the cube No 8.

[0122] In figures 8.1.1, 8.2.1, 8.3.1, 8.4.1, 8.5.1, 8.6.1, 8.7.1, 8.9.1, 8.10.1, 8.11.1, 8.11.2, 8.12.1, 8.13.1, 8.14.1 and 8.15.1 we can see the cross-sections of the fifteen different, separate pieces of the cubic logic toy No 8.

[0123] In figure 8.17 we can see these fifteen separate pieces of the cubic logic toy No 8 placed at their position along with the non -visible central three-dimensional solid cross that supports the cube.

[0124] In figure 8.18 we can see the geometrical characteristics of the cubic logic toy No 8 for the configuration of the internal surfaces of the separate pieces of which four conical surfaces per semi direction of the three-dimensional rectangular Cartesian coordinate system have been used.

[0125] In figure 8.19 we can see the section of the separate pieces of the intermediate non visible layer per semi direction and of the central three-dimensional solid cross by an intermediate symmetry plane of the cube as well as the projection of the separate pieces of the fourth layer of each semi direction on this plane, said fourth layer being supported on the intermediate layer of this direction of the cubic logic toy No 8.

[0126] In figure 8.20 we can see the internal face of the first layer per semi direction of the cubic logic toy No 8 along with the non- visible central three-dimensional solid cross that supports the cube.

[0127] In figure 8.21 we can see the internal face and in figure 8.21.1 we can see the external face of the second layer per semi direction of the cubic logic toy No 8.

[0128] In figure 8.22 we can see the internal face and in figure 8.22.1 we can see the external face of the third layer per semi direction of the cubic logic toy No 8.

[0129] In figure 8.23 we can see the internal face and in figure 8.23.1 we can see the external face of the fourth layer per semi direction of the cubic logic toy No 8.

[0130] In figure 8.24 we can see the face of the non- visible intermediate layer in each direction along with the non-visible central three-dimensional solid cross that supports the cube.

[0131] In figure 8.25 we can see at an axonometric projection the four visible layers of each semi direction along with the non -visible intermediate layer of that direction and along with the non- visible central three-dimensional solid cross that supports the cube.

[0132] Finally, in figure 8.26 we can see the final shape of the cubic logic toy No 8.

[0133] The cubic logic toy No 8 consists of three hundred and eighty eight (387) pieces in total along with the non -visible central three-dimensional solid cross that supports the cube.

[0134] **IX.** When κ=4, that is when we use four conical surfaces per semi axis of the three-dimensional rectangular Cartesian coordinate system and $N= 2\kappa+1=2x4+1=9$, that is for the **cubic logic toy No 9** whose final shape is substantially cubic, its faces consisting of spherical surfaces of long radius, we have again (15) fifteen different and separate kinds of smaller pieces, all visible to the user of the toy. Piece **1** (figure 9.1) and in total eight similar pieces, piece **2** (figure 9.2) and in total twenty-four similar pieces, piece **3** (figure 9.3) and in total twenty-four similar pieces, piece **4** (figure 9.4) and in total twenty-four similar pieces, piece **5** (figure 9.5) and in total forty eight similar pieces, which in pairs are mirror images, piece **6** (figure 9.6) and in total twenty-four similar pieces, piece **7** (figure 9.7) and in total twenty-four similar pieces, piece **8** (figure 9.8) and in total forty eight similar pieces, which in pairs are mirror images, piece **9** (figure 9.9) and in total forty eight similar pieces, which in pairs are mirror images, and piece **10** (figure (9.10) and in total twenty-four similar pieces, piece **11** (figure 9.11) and in total twelve similar pieces, piece **12** (figure 9.12) and in total twenty-four similar pieces, piece **13** (figure 9.13) and in total twenty-four similar pieces, piece **14** (figure 9.14) and in total twenty-four similar pieces and finally, piece **15** (figure 9.15) and in total six similar pieces, the caps of the cubic logic toy No 9. Finally, in figure 9.16 we can see the non-visible central three-dimensional solid cross that supports the cube No 9.

[0135] In figures 9.1.1, 9.2.1, 9.3.1, 9.4.1, 9.5.1, 9.6.1, 9.7.1, 9.8.1, 9.9.1, 9.10.1, 9.11.1, 9.11.2, 9.12.1, 9.13.1, 9.14.1 and 9.15.1 we can see the cross-sections of the fifteen different, separate pieces of the cubic logic toy No 9.

[0136] In figure 9.17 we can see these separate fifteen pieces of the cubic logic toy No 9, placed at their position along with the non- visible central three-dimensional solid cross that supports the cube.

[0137] In figure 9.18 we can see the geometrical characteristics of the cubic logic toy No 9 for the configuration of the internal surfaces of the separate pieces of which four conical surfaces per semi direction of the three-dimensional rectangular Cartesian coordinate system have been used.

[0138] In figure 9.19 we can see the internal face of the first layer per semi direction of the cubic logic toy No 9 along with the non -visible central three-orthogonal solid cross that supports the cube.

[0139] In figure 9.20 we can see the internal face and in figure 9.20.1 the external face of the second layer per semi direction of the cubic logic toy No 9.

[0140] In figure 9.21 we can see the internal face and in figure 9.21.1 the external face of the third layer per semi direction of the cubic logic toy No 9.

[0141] In figure 9.22 we can see the internal face and in figure 9.22.1 the external face of the fourth layer per semi direction of the cubic logic toy No 9.

[0142] In figure 9.23 we can see the internal face of the intermediate layer in each direction of the cubic logic toy No 9 along with the non -visible central three-dimensional solid cross that supports the cube.

[0143] In figure 9.24 we can see the section of the separate pieces of the intermediate layer in each direction as well as of the non -visible central three-dimensional solid cross that supports the cube by an intermediate symmetry plane of the cubic logic toy No 9.

[0144] In figure 9.25 we can see at an axonometric projection the four layers in each semi direction along with the fifth intermediate layer of this direction and the non visible central three-dimensional solid cross that supports the cube.

[0145] Finally, in figure 9.26 we can see the final shape of the cubic logic toy No 9.

[0146] The cubic logic toy No 9 consists of three hundred and eighty eight (387) separate pieces in total along with the non -visible central three-dimensional solid cross that supports the cube, the same number of pieces as in the cubic logic toy No 8.

[0147] **X.** When κ=5, that is when we use five conical surfaces per semi axis of the three-dimensional rectangular Cartesian coordinate system and N= 2κ=2x5=10, that is for the **cubic logic toy No 10** whose final shape is substantially cubic, its faces consisting of spherical surfaces of long radius, we have (21) twenty one different kinds of smaller pieces, of which only the first fifteen are visible to the user of the toy, whereas the next six are non visible.

[0148] Piece **1** (figure 10.1) and in total eight similar pieces, piece **2** (figure 10.2) and in total twenty-four similar pieces, piece **3** (figure 10.3) and in total twenty-four similar pieces, piece **4** (figure 10.4) and in total twenty-four similar pieces, piece **5** (figure 10.5) and in total forty eight similar pieces, which in pairs are mirror images, piece **6** (figure 10.6) and in total twenty-four similar pieces, piece **7** (figure 10.7) and in total twenty-four similar pieces, piece **8** (figure 10.8) and in total forty eight similar pieces, which in pairs are mirror images, piece **9** (figure 10.9) and in total forty eight similar pieces which in pairs are mirror images, and piece **10** (figure 10.10) and in total twenty-four similar pieces, piece **11** (figure 10.11) and in total twenty-four similar pieces, piece **12** (figure 10.12) and in total forty eight similar pieces, which in pairs are mirror images, piece **13** (figure 10.13) and in total forty eight similar pieces, which in pairs are mirror images, piece **14** (figure 10.14) and in total forty eight similar pieces, which in pairs are mirror images, piece **15** (figure 10.15) and in total twenty-four similar pieces, up to this point all visible to the user of the toy. The non visible different pieces that form the intermediate non visible layer in each direction of the cubic logic toy No 10 are: piece **16** (figure 10.16) and in total twelve similar pieces, piece **17** (figure 10.17) and in total twenty-four similar pieces, piece **18** (figure 10.18) and in total twenty-four similar pieces, piece **19** (figure 10.19) and in total twenty-four similar pieces, piece 20 (figure 10.20) and in total twenty-four similar pieces, and, piece **21** (figure 10.21) and in total six similar pieces, the caps that of the cubic logic toy No 10.

[0149] Finally, in figure 10.22 we can see the non -visible central three-orthogonal solid cross that supports the cube No 10.

[0150] In figures 10.1.1, 10.2.1, 10.3.1, 10.4.1, 10.5.1, 10.6.1, 10.7.1, 10.8.1, 10.9.1, 10.10.1, 10.11.1, 10.12.1, 10.13.1, 10.14.1, 10.15.1, 10.16.1, 10.16.2, 10.17.1, 10.18.1, 10.19.1, 10.20.1 and 10.21.1 we can see the cross-sections of the twenty-one different separate pieces of the cubic logic toy No 10.

[0151] In figure 10.23 we can see these twenty-one separate pieces of the cubic logic toy No 10 placed at their position along with the non- visible central three-dimensional solid cross that supports the cube.

[0152] In figure 10.24 we can see the internal face of the first layer in each semi direction of the cubic logic toy No 10 along with the non- visible central three-dimensional solid cross that supports the cube.

[0153] In figure 10.25 we can see the internal face and in figure 10.25.1 we can see the external face of the second layer per semi direction of the cubic logic toy No 10.

[0154] In figure 10.26 we can see the internal face and in figure 10.26.1 we can see the external face of the third layer per semi direction of the cubic logic toy No 10.

[0155] In figure 10.27 we can see the internal face and in figure 10.27.1 we can see the external face of the fourth layer per semi direction of the cubic logic toy No 10.

[0156] In figure 10.28 we can see the internal face and in figure 10.28.1 we can see the external face of the fifth layer per semi direction of the cubic logic toy No 10.

[0157] In figure 10.29 we can see the face of the non -visible intermediate layer in each direction along with the non-visible central three-dimensional solid cross that supports the cube.

[0158] In figure 10.30 we can see the internal face of the intermediate layer in each direction and the internal face of the fifth layer per semi direction said fifth layer being supported on the intermediate layer, along with the non visible central three-dimensional solid cross that supports the cube.

[0159] In figure 10.31 we can see the section of the separate pieces of the intermediate layer in each direction and of the central non visible three-dimensional solid cross by an intermediate symmetry plane of the cube as well as the projection on it of the separate pieces of the fifth layer of this semi direction.

[0160] In figure 10.32 we can see the geometrical characteristics of the cubic logic toy No 10 for the configuration of the internal surfaces of the separate pieces of which, five conical surfaces per semi direction of the three-dimensional rectangular Cartesian coordinate system have been used.

[0161] In figure 10.33 we can see at an axonometric projection, the five visible layers per semi direction along with the non-visible central three-dimensional solid cross that supports the cube.

[0162] Finally, in figure 10.34 we can see the final shape of the cubic logic toy No 10.

[0163] The cubic logic toy No 10 consists of six hundred and three (603) separate pieces in total along with the non-visible central three-dimensional solid cross that supports the cube.

[0164] A careful examination of examples II, IV, VI.a, VI.b, VIII and X (regarding the even-numbered cubic logic toys No. 2, 4, 6a, 6b, 8 and 10 respectively) and particularly of the numbers of separate pieces which are visible (denoted by the symbol V) and non-visible (denoted by the symbol NV) to the user of the toy, shows that these numbers correlate with the number κ of right conical surfaces. The following formulas can be extracted:

$$V = 8 \cdot \left[6 \cdot \frac{\kappa \cdot (\kappa - 1)}{2} + 1 \right] \text{ and } NV = 6 \cdot \left(4\kappa - 1\right)$$

where κ = 1, 2, 3, 4 or 5 (and N is even, i.e. N = 2κ = 2, 4, 6, 8 or 10 respectively). A table of values of V and NV for the corresponding values of κ is given below, to prove the validity of these formulas and the conformity of their results with the numbers already mentioned in the examples:

κ	N	V	NV
1	2	8	18
2	4	56	42
3	6	152	66
4	8	296	90
5	10	488	114

[0165] <u>**XI.**</u> When κ=5, that is when we use five conical surfaces per semi axis of the three-dimensional rectangular Cartesian coordinate system and N= 2κ+1=2x5+1=11, that is for **the cubic logic toy No 11** whose final shape is substantially cubic its faces consisting of spherical surfaces of long radius, we have again (21) twenty-one different kinds of smaller pieces, all visible to the user of the toy.

[0166] Piece **1** (figure 11.1) and in total eight similar pieces, piece **2** (figure 11.2) and in total twenty-four similar pieces, piece **3** (figure 11.3) and in total twenty-four similar pieces, piece **4** (figure 11.4) and in total twenty-four similar pieces, piece **5** (figure 11.5) and in total forty eight similar pieces, which in pairs are mirror images, piece **6** (figure 11.6) and in total twenty-four similar pieces, piece **7** (figure 11.7) and in total twenty-four similar pieces, piece **8** (figure 11.8) and in total forty eight similar pieces, which in pairs are mirror images, piece **9** (figure 11.9) and in total forty eight similar pieces, which in pairs are mirror images, piece **10** (figure (11.10) and in total twenty-four similar pieces, piece **11** (figure 11.11) and in total twenty-four similar pieces, piece **12** (figure (11.12) and in total forty eight similar pieces, which in pairs are mirror images, piece **13** (figure 11.13) and in total forty eight similar pieces, which in pairs are mirror images, piece **14** (figure 11.14) and in total forty eight similar pieces, which in pairs are mirror images, piece **15** (figure 11.15) and in total twenty-four similar pieces, piece **16** (figure 11.16) and in total twelve similar pieces, piece **17** (figure 11.17) and in total twenty-four similar pieces, piece **18** (figure 11.18) and in total twenty-four similar pieces, piece **19** (figure 11.19) and in total twenty-four similar pieces, piece **20** (figure 11.20) and in total twenty-four similar pieces, and piece **21** (figure 11.21) and in total six similar pieces, the caps of the cubic logic toy No 11. Finally, in figure 11.22 we can see the non- visible central three-dimensional solid cross that supports the cube No 11.

[0167] In figures 11.1.1, 11.2.1, 11.3.1, 11.4.1, 11.5.1, 11.6.1, 11.7.1, 11.8.1, 11.9.1, 11.10.1, 11.11.1, 11.12.1, 11.13.1, 11.14.1, I1.15.1, 11.16.1, 11.16.2, 11.17.1, 11.18.1, 11.19.1, 11.20.1 and 11.21.1 we can see the cross- sections of the twenty-one different separate pieces of the cubic logic toy No 11.

[0168] In figure 11.23 we can see these twenty-one separate pieces of the cubic logic toy No 11 placed at their position along with the non-visible central three-dimensional solid cross that supports the cube.

[0169] In figure 11.24 we can see the internal face of the first layer per semi direction of the cubic logic toy No 11 along with the non- visible central three-dimensional solid cross that supports the cube.

[0170] In figure 11.25 we can see the internal face and in figure 11.25.1 we can see the external face of the second layer per semi direction of the three-dimensional rectangular Cartesian coordinate system of the cubic logic toy No 11.

[0171] In figure 11.26 we can see the internal face and in figure 11.26.1 we can see the external face of the third layer per semi direction of the three-dimensional rectangular Cartesian coordinate system of the cubic logic toy No 11.

[0172] In figure 11.27 we can see the internal face and in figure 11.27.1 we can see the external face of the fourth layer per semi direction of the three-dimensional rectangular Cartesian coordinate system of the cubic logic toy No 11.

[0173] In figure 11.28 we can see the internal face and in figure 11.28.1 we can see the external face of the fifth layer per semi direction of the three-dimensional rectangular Cartesian coordinate system of the cubic logic toy No 11.

[0174] In figure 11.29 we can see the intermediate layer per direction along with the non -visible central three-dimensional solid cross that supports the cube.

[0175] In figure 11.30 we can see the section of the separate pieces of the intermediate layer per direction along with the non -visible central three-dimensional solid cross that supports the cube by an intermediate symmetry plane of the cube No 11.

[0176] In figure 11.31 we can see the geometrical characteristics of the cubic logic toy No 11 for the configuration of the internal surfaces of the separate pieces of which five conical surfaces per semi direction of the three-dimensional rectangular Cartesian coordinate system have been used.

[0177] In figure 11.32 we can see at an axonometric projection, the five layers in each semi direction and the sixth layer in each direction, as well as the intermediate layer along with the non- visible central three-dimensional solid cross that supports the cube.

[0178] Finally, in figure 11.33 we can see the final shape of the cubic logic toy No 11.

[0179] The cubic logic toy No 11 consists of six hundred and three (603) separate pieces in total along with the non-visible central three-dimensional solid cross that supports the cube, the same number of pieces as in the cubic logic toy 10.

[0180] As already explained, when N is odd, i.e. $N=2\kappa+1$, all the separate smaller rotatable pieces are visible to the user of the toy. Only the central three-dimensional supporting cross is non-visible. Since the total number of pieces (including said cross) is $T = 6(2\kappa)^2+3$, the number of the (visible) separate smaller rotatable pieces is obviously $6(2\kappa)^2+2$, where $\kappa = 1, 2, 3, 4$ or 5 (and N is odd, i.e. $N = 2\kappa+1 = 3, 5, 7, 9$ or 11 respectively).

[0181] It is suggested that the construction material for the solid parts can be mainly plastic of good quality, while for N=10 and N= 11 it could be replaced by aluminum.

[0182] Finally, we should mention that up to cubic logic toy No 7 we do not expect to face problems of wear of the separate pieces due to speed cubing.

[0183] The possible wear problems of the corner pieces, which are mainly worn out the most during speed cubing, for the cubes No 8 to No 11, can be dealt with, if during the construction of the corner pieces, their conical sphenoid parts are reinforced with a suitable metal bar, which will follow the direction of the cube's diagonal. This bar will start from the lower spherical part, along the diagonal of the cube and it will stop at the highest cubic part of the corner pieces.

[0184] Additionally, possible problems due to speed cubing for the cubes No 8 to No 11 may arise only because of the large number of the separate parts that these cubes are consisting of, said parts being 387 for the cubes No 8 and No 9, and 603 for the cubes No 10. These problems can only be dealt with by constructing the cubes in a very cautious way.

Claims

1. A cubic logic toy which has the shape of a normal geometric solid, substantially cubic,
said solid having N layers visible to the user of the toy per each direction of the three-dimensional, rectangular Cartesian coordinate system whose centre coincides with the geometric centre of the solid and whose axes pass through the centre of the solid's external surfaces and are vertical to the latter,
said layers consisting of a plurality of separate pieces, the sides of said pieces which form part of the solid's external surface being substantially planar,
said pieces being able to rotate in layers around the axes of said rectangular Cartesian coordinate system,
the surfaces of said pieces which are visible to the user of the toy being coloured or bearing shapes or letters or numbers,
each of said pieces consisting of three discernible separate parts, i.e.

- ■ a first, outermost with regard to the geometric centre of the solid, part, the outer surfaces of said part being either substantially planar, when they form part of the solid's external surface and are visible to the user, or spherically cut, when they are not visible to the user,
- ■ a second, intermediate part and
- ■ a third, innermost with regard to the geometric centre of the solid, part, which is part of a sphere or of a

spherical shell,

each of said pieces bearing recesses and/or protrusions, whereby, on one hand, each piece is intercoupled with and supported by its neighbouring pieces, and, on the other hand, one or two spherical recesses / protrusions between adjacent layers are created,
the edges of each of said pieces, whether linear or curved, being rounded,
the assembly of said pieces being held together to form said substantially cubic geometric solid on a central three-dimensional supporting cross, located at the centre of the solid and having six cylindrical legs, the axes of symmetry of said legs coinciding with the semi-axes of said three-dimensional, rectangular Cartesian coordinate system,
the assembly of said pieces being held on said central three-dimensional supporting cross by six caps, i.e. the six central pieces of each face of said substantially cubic geometric solid, each of said caps having a cylindrical hole coaxial with the semi-axes of said three-dimensional, rectangular Cartesian coordinate system, each of said six caps being screwed to a corresponding leg of said central three-dimensional supporting cross via a supporting screw passing through said cylindrical hole, said caps either being visible to the user and having a flat plastic piece covering said cylindrical hole or being non-visible to the user,
the internal surfaces of each of said pieces, i.e. the surfaces of said pieces which lie in the interior of said substantially cubic geometric solid, being formed by a combination of:

- ■ planar surfaces
- ■ concentric spherical surfaces, whose centre coincides with the geometric centre of the solid
- ■ cylindrical surfaces, the latter applying only to the third, innermost part of the six said caps

said cubic logic toy being **characterised in that:**

for the configuration of the internal surfaces of each of said pieces, apart from said planar surfaces, said concentric spherical surfaces and said cylindrical surfaces, a minimum number of κ right conical surfaces per semi-axis of said three-dimensional, rectangular Cartesian coordinate system are used,
the axis of said right conical surfaces coinciding with the corresponding semi-axis of said three-dimensional, rectangular Cartesian coordinate system,
the generating angle φ_1 of the first and innermost of said right conical surfaces either being greater than 54,73561032° when the apex of said first conical surface coincides with the geometric centre of the solid, or starting from a value less than 54,73561032°, when the apex of said first conical surface lies on the semi-axis opposite to the semi-axis which points to the direction in which said first conical surface widens,
the generating angle of the subsequent conical surfaces gradually increasing, i.e. $\varphi_\kappa > \varphi_{\kappa-1} > ..... > \varphi_1$,
the number of layers N correlating with the number of right conical surfaces κ, so that:

- ■ either N=2κ and the substantially cubic geometric solid has an even number of N visible to the user layers per direction, plus one additional layer in each direction, the intermediate layer, which is not visible to the user,
- ■ or N=2κ+1 and the substantially cubic geometric solid has an odd number of N layers per direction, all visible to the user,

the second, intermediate part of each of said pieces having thereby a conical sphenoid shape, pointing substantially towards the geometric centre of the solid, its cross-section, when the second, intermediate part is sectioned by spherical surfaces concentric with the geometric centre of the solid, having the shape either of an equilateral spherical triangle or of an isosceles spherical trapezium or of a spherical quadrilateral or, more precisely, of any triangle or trapezium or quadrilateral on a sphere, said cross-section being either similar or differentiated in shape along the length of said second, intermediate part.

2. A cubic logic toy, according to claim 1, **characterised by** the fact that, for values of N between 2 and 5, i.e. when N = 2, 3, 4 or 5, the external surfaces of the geometric solid are planar.

3. A cubic logic toy, according to claim 1, **characterised by** the fact that, for values of N between 7 and 11, i.e. when N = 7, 8, 9, 10 or 11, the external surfaces of the geometric solid are substantially planar, i.e. spherical surfaces of a radius significantly long in comparison to the dimensions of the toy.

4. A cubic logic toy, according to claim 1, **characterised by** the fact that, when N = 6, the external surfaces of the geometric solid are planar.

5. A cubic logic toy, according to claim 1, **characterised by** the fact that, when N = 6, the external surfaces of the geometric solid are substantially planar, i.e. spherical surfaces of a radius significantly long in comparison to the dimensions of the toy.

6. A cubic logic toy, according to claim 1, **characterised in that** the number of right conical surfaces κ = 1, 2, 3, 4 or 5 and the number of layers N per each direction of said three-dimensional, rectangular Cartesian coordinate system which are visible to the user of the toy is even, i.e. N = 2κ = 2, 4, 6, 8 or 10 respectively, thereby:

■ the total number of the pieces which are able to rotate in layers around the axes of said rectangular Cartesian coordinate system, with the addition of the central three-dimensional supporting cross, being equal to: $T = 6 (2\kappa)^2+3$
■ the number of groups of said pieces with similar shape and dimensions being equal to:

$$G = \sum_{i=1}^{\kappa+1} i$$

■ the number of said pieces which are visible to the user of the toy being equal to:

$$V = 8 \cdot \left[6 \cdot \frac{\kappa \cdot (\kappa - 1)}{2} + 1 \right]$$

■ the number of said pieces which are non-visible to the user of the toy and belong to said additional, intermediate layer in each direction, being equal to: $NV = 6 \cdot (4\kappa-1))$

7. A cubic logic toy, according to claim 1, **characterised in that** the number of right conical surfaces κ = 1, 2, 3, 4 or 5 and the number of layers N per each direction of said three-dimensional, rectangular Cartesian coordinate system which are visible to the user of the toy is odd, i.e. N = 2K+1 = 3,5, 7, 9 or 11 respectively, thereby:

■ the total number of the pieces which are able to rotate in layers around the axes of said rectangular Cartesian coordinate system, with the addition of the central three-dimensional supporting cross, being equal to: $T = 6 (2\kappa)^2+3$
■ the number of groups of said pieces with similar shape and dimensions being equal to:

$$G = \sum_{i=1}^{\kappa+1} i$$

■ all of said pieces, their number being equal to $6(2\kappa)^2+2$, being visible to the user of the toy.

8. A cubic logic toy, according to any of the preceding claims, **characterised in that** the supporting screws are surrounded by springs.

Patentansprüche

1. Kubisches logisches Spielzeug, welches die Form eines normalen, im Wesentlichen kubischen geometrischen Körpers besitzt, wobei der Körper N Schichten aufweist, welche für den Benutzer des Spielzeugs in jeder Richtung des dreidimensionalen, rechtwinkligen kartesischen Koordinatensystems, dessen Mitte mit der geometrischen Mitte des Körpers zusammenfällt und dessen Achsen durch die Mitte der äußeren Flächen des Körpers hindurchgehen und zu den letzteren senkrecht stehen, sichtbar sind,
wobei die Schichten aus einer Vielzahl separater Stücke bestehen, deren Seiten Teil der äußeren Oberfläche des Körpers bilden und im Wesentlichen eben sind,
wobei die Stücke in der Lage sind, sich in Schichten um die Achsen des rechtwinkligen kartesischen Koordinatensystems zu drehen,

wobei die Oberflächen der Stücke, die für den Benutzer des Spielzeugs sichtbar sind, farbig sind oder Formen oder Buchstaben oder Zahlen tragen,
wobei jedes der Stücke aus drei unterscheidbaren separaten Teilen besteht, d.h.

- einem ersten, in Bezug auf die geometrische Mitte des Körpers äußersten Teil, wobei die äußeren Oberflächen des Teils entweder im Wesentlichen eben sind, wenn sie Teil der äußeren Oberfläche des Körpers bilden und für den Benutzer sichtbar sind, oder kugelförmig geschnitten sind, wenn sie für den Benutzer nicht sichtbar sind,
- einem zweiten mittleren Teil und
- einem dritten, in Bezug auf die geometrische Mitte des Körpers innersten Teil, der Teil einer Kugel oder einer Kugelschale ist,

wobei jedes der Stücke Vertiefungen und/oder Vorsprünge trägt, wobei einerseits jedes Stück mit seinen benachbarten Stücken verbunden ist und von ihnen getragen wird und andererseits zwischen benachbarten Schichten eine oder zwei kugelförmige Vertiefungen/Vorsprünge erzeugt werden,
wobei die Kanten jedes der Stücke, ob geradlinig oder gekrümmt, abgerundet sind,
wobei der Aufbau der Stücke zusammengehalten wird, um den im Wesentlichen kubischen geometrischen Körper auf einem zentralen, dreidimensionalen Trägerkreuz zu bilden, welches in der Mitte des Körpers liegt und sechs zylindrische Beine besitzt, wobei die Symmetrieachsen der Beine mit den Halbachsen des dreidimensionalen rechtwinkligen katesischen Koordinatensystems zusammenfallen,
wobei der Aufbau der Stücke auf dem zentralen dreidimensionalen Trägerkreuz von sechs Deckel gehalten wird, d.h. sechs zentralen Stücken jeder Seite des im Wesentlichen kubischen geometrischen Körpers, wobei jeder der Deckel ein mit den Halbachsen des dreidimensionalen rechtwinkligen katesischen Koordinatensystems koaxiales zylindrisches Loch aufweist, wobei jeder der sechs Deckel mit einer durch das zylindrische Loch hindurchgehenden Trägerschraube an einem entsprechenden Bein des zentralen dreidimensionalen Trägerkreuzes angeschraubt ist,
wobei die Deckel entweder für den Benutzer sichtbar sind und ein flaches Kunststoffstück besitzen, das das zylindrische Loch abdeckt, oder für den Benutzer unsichtbar sind,
wobei die inneren Oberflächen jedes der Stücke, d.h. die Oberflächen der Stücke, die im Inneren des im Wesentlichen kubischen geometrischen Körpers liegen, aus einer Kombination von:

- ebenen Oberflächen;
- konzentrischen kugelförmigen Oberflächen, deren Mitte mit der geometrischen Mitte des Körpers zusammenfällt,
- zylindrischen Oberflächen, wobei letzteres lediglich für den dritten innersten Teil der sechs Deckel gilt

geformt sind
wobei das kubische logische Spielzeug **dadurch gekennzeichnet ist, dass**:

für die Gestaltung der inneren Oberflächen jedes der Stücke mit Ausnahme der ebenen Oberflächen, der konzentrischen kugelförmigen Oberflächen und der zylindrischen Oberflächen eine minimale Anzahl von κ geradkegligen Oberflächen pro Halbachse des dreidimensionalen rechtwinkligen kartesischen Koordinatensystems verwendet werden,

wobei die Achse der geradkegligen Oberflächen mit der entsprechenden Halbachse des dreidimensionalen rechtwinkligen kartesischen Koordinatensystems zusammenfällt,
wobei der Erzeugungswinkel φ_1 der ersten und innersten der geradkegligen Oberflächen entweder größer als 54,73561032° ist, wenn die Spitze der ersten konischen Oberfläche mit der geometrischen Mitte des Körpers zusammenfällt, oder von einem Wert von weniger als 54,73561032° beginnt, wenn die Spitze der ersten kegligen Oberfläche auf der Halbachse liegt, die der Halbachse gegenüberliegt, welche in die Richtung zeigt, in der sich die erste keglige Oberfläche aufweitet,
wobei der Erzeugungswinkel der nachfolgenden kegligen Oberflächen allmählich zunimmt, d.h. $\varphi_\kappa > \varphi_{\kappa 1} > ... > \varphi_1$, wobei die Anzahl der Schichten N mit der Anzahl der geradkegligen Oberflächen κ korreliert, sodass:

- entweder $N = 2\kappa$ und der im Wesentlichen kubische geometrische Körper eine gerade Anzahl von N für den Benutzer sichtbaren Schichten pro Richtung besitzt, zuzüglich einer zusätzlichen Schicht in jeder Richtung, der mittleren Schicht, die für den Benutzer nicht sichtbar ist,
- oder $N = 2\kappa+1$ und der im Wesentlichen kubische geometrische Körper eine ungerade Anzahl von N Schichten pro Richtung besitzt, die alle für den Benutzer sichtbar sind,

wobei der zweite mittlere Teil jedes der Stücke **dadurch** eine keglige keilförmige Form besitzt, die im Wesentlichen zur geometrischen Mitte des Körpers zeigt, wobei sein Querschnitt, wenn der zweite mittlere Teil von zur geometrischen Mitte des Körpers konzentrischen kugelförmigen Oberflächen geschnitten wird, die Form entweder eines gleichseitigen sphärischen Dreiecks oder eines gleichschenkligen sphärischen Trapezes oder eines sphärischen Vierecks besitzt oder genauer die Form eines beliebigen Dreiecks oder Trapezes oder Vierecks auf einer Kugel hat, wobei der Querschnitt entweder eine ähnliche oder unterschiedliche Form entlang der Länge des zweiten mittleren Teils besitzt.

2. Kubisches logisches Spielzeug nach Anspruch 1, **dadurch gekennzeichnet, dass** für Werte von N zwischen 2 und 5, d.h. wenn N = 2, 3, 4 oder 5, die äußeren Oberflächen des geometrischen Körpers eben sind.

3. Kubisches logisches Spielzeug nach Anspruch 1, **dadurch gekennzeichnet, dass** für Werte von N zwischen 7 und 11, d.h. wenn N = 7, 8, 9, 10 oder 11, die äußeren Oberflächen des geometrischen Körpers im Wesentlichen eben sind, d.h. dass es sich um sphärische Oberflächen mit einem im Vergleich zu den Abmessungen des Spielzeugs wesentlich langen Radius handelt.

4. Kubisches logisches Spielzeug nach Anspruch 1, **dadurch gekennzeichnet, dass** wenn N =6, die äußeren Oberflächen des geometrischen Körpers eben sind.

5. Kubisches logisches Spielzeug nach Anspruch 1, **dadurch gekennzeichnet, dass** wenn N = 6, die äußeren Oberflächen des geometrischen Körpers im Wesentlichen eben sind, d.h., dass es sich um sphärische Oberflächen mit einem im Vergleich zu den Abmessungen des Spielzeugs wesentlich langen Radius handelt.

6. Kubisches logisches Spielzeug nach Anspruch 1, **dadurch gekennzeichnet, dass** die Anzahl der geradkegligen Oberflächen κ = 1, 2, 3, 4 oder 5 ist, und die Anzahl der Schichten N für jede Richtung des dreidimensionalen rechtwinkligen kartesischen Koordinatensystems, die für den Benutzer des Spielzeuges sichtbar sind, gerade ist, d.h., dass N = 2κ = 2, 4, 6, 8 bzw. 10, wodurch:

- die Gesamtzahl der Stücke, die in der Lage sind, sich in Schichten um die Achsen des rechtwinkligen kartesischen Koordinatensystems zu drehen, unter Hinzufügung des zentralen dreidimensionalen Trägerkreuzes gleich dem Wert: $T = 6(2\kappa)^2 + 3$ ist
- die Anzahl der Gruppen der Stücke mit ähnlicher Form und Abmessungen gleich dem Wert:

$$G = \sum_{i=1}^{\kappa+1} i$$

- die Anzahl der Stücke, die für den Benutzer des Spielzeugs sichtbar sind, gleich dem Wert:

$$V = 8 \cdot \left[6 \cdot \frac{\kappa \cdot (\kappa - 1)}{2} + 1\right]$$

ist
- die Anzahl der Stücke, die für den Benutzer des Spielzeugs nicht sichtbar sind und zu der zusätzlichen mittleren Schicht in jeder Richtung gehören, gleich dem Wert $NV = 6 * (4\kappa\text{-}1))$ ist.

7. Kubisches logisches Spielzeug nach Anspruch 1, **dadurch gekennzeichnet, dass** die Anzahl der geradkegligen Oberflächen κ = 1, 2, 3, 4 oder 5 und die Anzahl der Schichten N für jede Richtung des dreidimensionalen rechtwinkligen kartesischen Koordinatensystems, die für den Benutzer des Spielzeugs sichtbar sind, ungerade ist, d.h. dass N = 2κ+1 = 3,5, 7, 9 bzw. 11, wodurch:
die Gesamtzahl der Stücke, die in der Lage sind, sich in Schichten um die Achsen des rechtwinkligen kartesischen Koordinatensystems zu drehen, unter Hinzufügung des zentralen dreidimensionalen Trägerkreuzes gleich dem Wert $T = 6^* (2\kappa)^2 +3$ ist

- die Anzahl der Gruppen der Stücke mit ähnlicher Form und Abmessungen gleich dem Wert

$$G = \sum_{i=1}^{\kappa+1} i \text{ ist,}$$

- alle Stücke, deren Anzahl gleich $6*(2\kappa)^2 + 2$ ist, für den Benutzer des Spielzeugs sichtbar sind.

8. Kubisches logisches Spielzeug nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** die Trägerschrauben von Federn umgeben sind.

Revendications

1. Un jouet cubique de casse-tête ayant la forme d'un solide géométrique régulier, essentiellement cubique, ayant N couches visibles par l'utilisateur du jouet par rapport à chaque direction du système d'axes cartésiens orthonormés, dont le repère coïncide avec le centre géométrique du solide et dont les axes passent au travers du centre des faces extérieures du solide et sont perpendiculaires auxdites faces extérieures,
lesdits couches étant composés de plusieurs pièces distinctes, dont les faces, qui forment une partie de la surface extérieure du solide, sont essentiellement plates,
lesdites pièces ayant la possibilité de pivoter couche par couche autour des axes dudit système de axes orthonormés, les surfaces desdites pièces, qui sont visibles par l'utilisateur du jouet, étant colorées, ou portant de dessins, des lettres ou des chiffres,
chacune desdites pièces étant composée de trois parties distinctes, c.à.d. :

■ une première partie extérieure par rapport au centre géométrique du solide, dont les faces extérieures quand elles forment une partie de la surface extérieure du solide et sont visibles par l'utilisateur, elles sont essentiellement plates, tandis que si elles ne sont pas visibles par l'utilisateur, leur surface fait partie d'une surface sphérique,
■ une deuxième partie intermédiaire, et
■ une troisième partie intérieure la plus proche au centre géométrique du solide, qui fait partie d'une sphère ou d'une coque sphérique,

chacune desdites pièces portant des cavités et/ou des saillies, par lesquelles chaque pièce est d'une part reliée aux pièces voisines et soutenue par elles, et d'autre part une ou deux cavités /saillies sphériques sont créées entre les couches voisines,
les arêtes desdites pièces, étant linéaires ou incurvées de forme arrondie,
l'ensemble desdites pièces étant supporté afin de former ledit solide géométrique essentiellement cubique sur une croix centrale tridimensionnelle de support, qui se trouve au centre du solide et qui possède six pieds cylindriques, dont les axes coïncident avec les axes dudit système d'axes cartésiens orthonormés,
l'ensemble desdites pièces étant retenue sur ladite croix tridimensionnelle de support par six couverts, c.à.d. les six parties centrales de chaque face dudit solide géométrique essentiellement cubique, chacun desdits couverts ayant un trou cylindrique coaxial aux axes dudit système d'axes cartésiens orthonormés, chacun desdits six couverts étant vissé au pied respectif de ladite croix centrale tridimensionnelle de support par le biais d'une vis de support pénétrant dans ladite trou cylindrique, lesdits couverts étant soit visibles par l'utilisateur et ayant une pièce plastique plate couvrant ladite trou cylindrique, soit non visibles par l'utilisateur,
les faces intérieures de chacune desdites pièces, c.à.d. les faces desdites pièces qui se trouvent à l'intérieur dudit solide géométrique essentiellement cubique, étant composées d'une combinaison de:

■ surfaces plates
■ surfaces sphériques concentriques, dont les centres coïncident avec le centre géométrique du solide
■ surfaces cylindriques, seulement au cas de la troisième partie la plus interne desdits six couverts

ledit jouet cubique de casse-tête étant **caractérisé par le fait que**:

un nombre minimum de surfaces coniques droites κ par semi axe dudit système d'axes cartésiens orthonormés est utilisé pour la configuration des surfaces intérieures de chacune desdites pièces, à l'exception desdites

surfaces planaires, desdites surfaces sphériques concentriques et desdites surfaces cylindriques,
l'axe desdites surfaces coniques droites coïncidant avec le semi axe respectif dudit système d'axes cartésiens orthonormés,
l'angle génératrice φ_1 de la première et la plus interne desdites faces coniques droites soit étant supérieure à 54,73561032° quand le sommet de ladite première surface conique coïncide avec le centre géométrique du solide, soit ayant une valeur inférieure à 54,73561032°, quand le sommet de ladite première surface conique se trouve sur le semi axe vis-à-vis du semi axe qui est orienté à la direction d'élargissement de ladite surface conique,
l'angle génératrice des surfaces coniques conséquentes s'augmentant graduellement, c.à.d. $\varphi_\kappa > \varphi_{\kappa-1} > ..... > \varphi_1$, le nombre de couches N se dépendant du nombre des surfaces coniques droites κ, de façon que:

■ soit $N=2\kappa$ et le solide géométrique essentiellement cubique ayant un nombre pair de couches N par direction visibles par l'utilisateur, et une couche supplémentaire dans chaque direction, la couche intermédiaire, n'étant pas visible par l'utilisateur,
■ soit $N=2\kappa+1$ et le solide géométrique essentiellement cubique ayant un nombre impair de couches N, toutes visibles par l'utilisateur,

la deuxième partie intermédiaire de chacune desdites pièces ayant par conséquent une forme conique sphénoïde, rétrécissant vers le centre géométrique du solide, sa coupe transversale, ayant la forme soit d'une triangle sphérique équilatérale, soit d'un trapèze sphérique isocèle soit d'un quadrilatère sphérique soit, plus précisément, de toute triangle ou trapèze ou quadrilatère sur une sphère, quand la deuxième partie intermédiaire est découpée par des surfaces sphériques concentriques au centre géométrique du solide, ladite section transversale étant soit similaire ou ayant une forme variable au long de ladite deuxième partie intermédiaire.

2. Un jouet cubique de logique selon la revendication 1, **caractérisé par le fait que**, pour des valeurs de N entre 2 et 5, c.à.d. N =2, 3, 4 ou 5, les surfaces extérieures du solide géométrique sont plates.

3. Un jouet cubique de logique selon la revendication 1, **caractérisé par le fait que** pour des valeurs de N entre 7 et 11, c.à.d. N = 7, 8, 9, 10 ou 11, les surfaces extérieures du solide géométrique sont essentiellement plates, c.à.d. des surfaces sphériques d'un rayon important par rapport aux dimensions du jouet.

4. Un jouet cubique de casse-tête selon la revendication 1, **caractérisé par le fait que** quand N = 6, les surfaces extérieures du solide géométrique sont plates.

5. Un jouet cubique de casse-tête selon la revendication 1, **caractérisé par le fait que** quand N = 6, les surfaces extérieures du solide géométrique sont essentiellement plates, c.à.d. des surfaces sphériques d'un rayon important par rapport aux dimensions du jouet.

6. Un jouet cubique de casse-tête selon la revendication 1, **caractérisé par le fait que** le nombre de surfaces coniques droites κ = 1, 2, 3, 4 ou 5 et le nombre de couches N à chaque direction dudit système d'axes cartésiens orthonormés qui sont visibles par l'utilisateur du jouet est pair, c.à.d. N = 2κ = 2, 4, 6, 8 ou 10 respectivement, de façon que:

■ le nombre total des pièces qui peuvent pivoter couche par couche autour des axes dudit système d'axes cartésiens soit égal à: $T = 6(2\kappa)^2+3$, compte tenu de la croix centrale tridimensionnelle de support,
■ le nombre de groupes desdites pièces ayant une forme et des dimensions pareilles soit égal à:

$$G = \sum_{i=1}^{\kappa+1} i$$

■ le nombre desdites pièces qui sont visibles par l'utilisateur du jouet soit égal à:

$$V = 8 \cdot \left[6 \cdot \frac{\kappa \cdot (\kappa - 1)}{2} + 1 \right]$$

■ le nombre desdites pièces non visibles par l'utilisateur du jouet et appartenant audit couche intermédiaire supplémentaire dans chaque direction, soit égal à: NV =6·(4κ-1))

7. Un jouet cubique de casse-tête selon la revendication 1, **caractérisé par le fait que** le nombre des surfaces coniques droites κ = 1, 2, 3, 4 ou 5 et le nombre de couches N à chaque direction dudit système d'axes cartésiens orthonormés qui sont visibles par l'utilisateur du jouet est impair, c.à.d. N = 2κ+1 = 3, 5, 7, 9 ou 11 respectivement, de façon que:

■ le nombre total des pièces qui peuvent pivoter couche par couche autour des axes dudit système d'axes cartésiens soit égal à: T = $6(2\kappa)^2+3$, compte tenu de la croix centrale tridimensionnelle de support,
■ le nombre de groupes desdites pièces ayant une forme et des dimensions pareilles soit égal à:

$$G = \sum_{i=1}^{\kappa+1} i$$

■ l'ensemble desdites pièces, leur nombre étant égal à $6(2\kappa)^2+2$, soient visibles par l'utilisateur du jouet.

8. Un jouet cubique de casse-tête selon l'une des revendications précédentes, **caractérisé par le fait que** les vis de support sont entourées de ressorts.

FIGURE 1

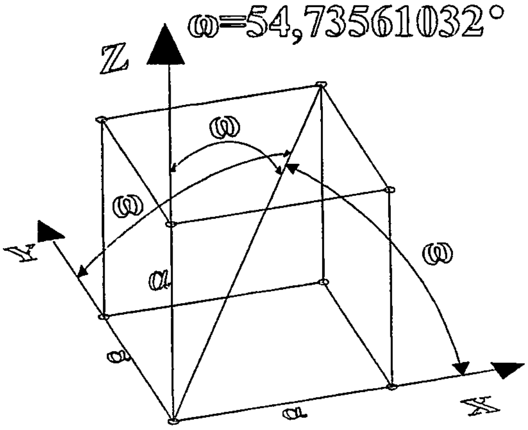


Fig.1.1

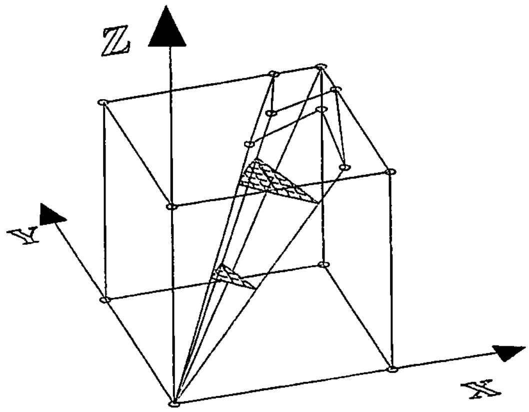


Fig.1.2

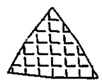


Fig.1.3

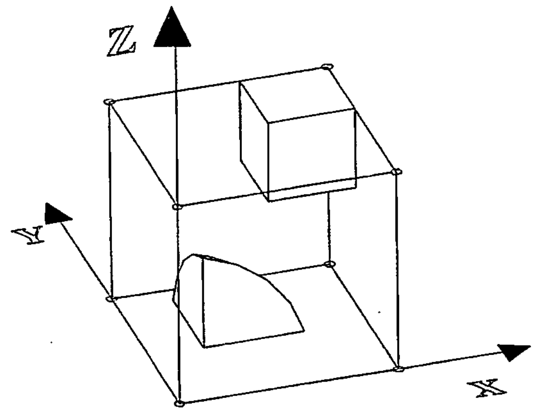
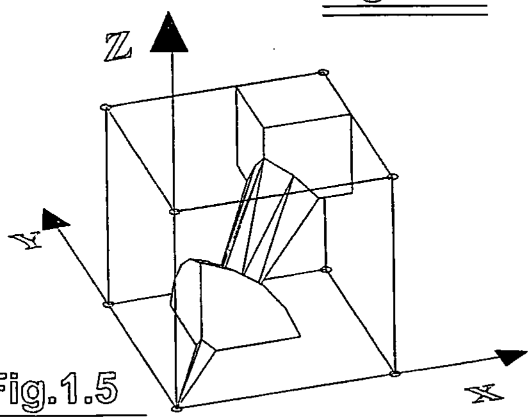


Fig.1.4



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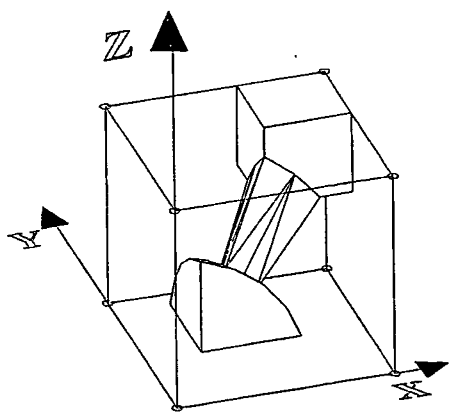


Fig.1.6

Fig.1.8

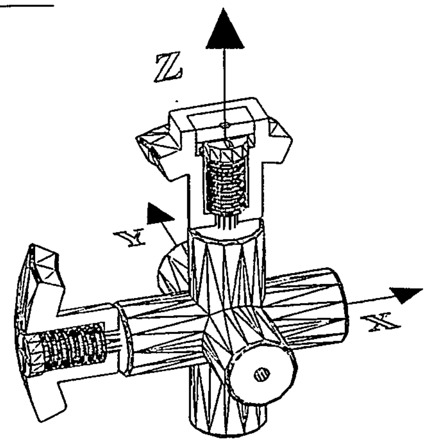


Fig.1.7

FIGURE 2

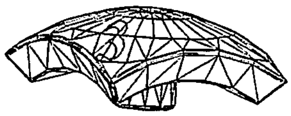


Fig.2.3

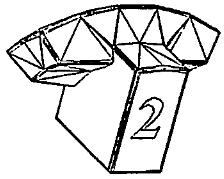
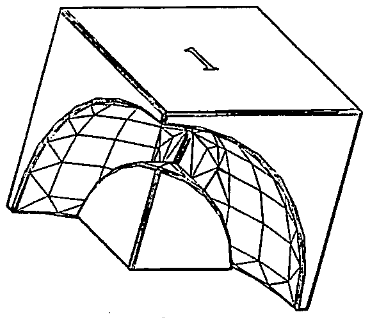


Fig.2.2



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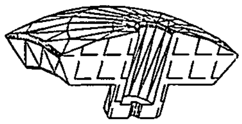

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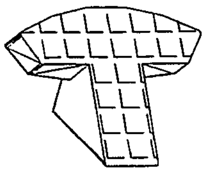

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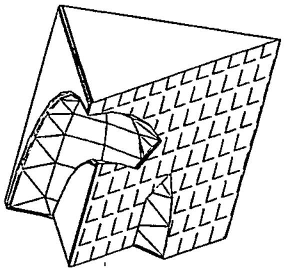

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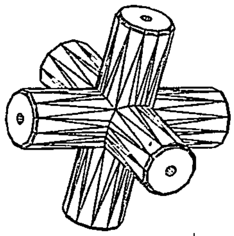

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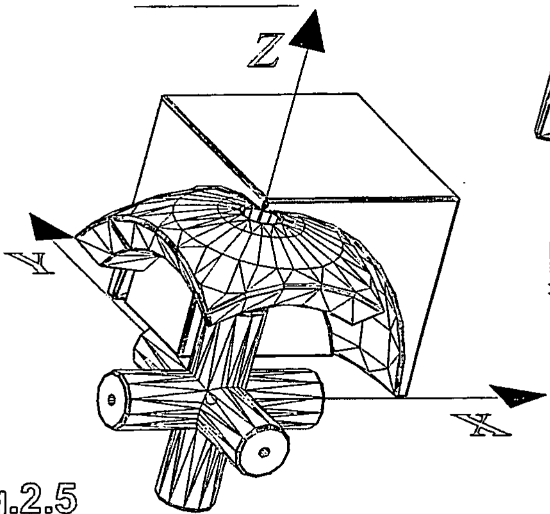

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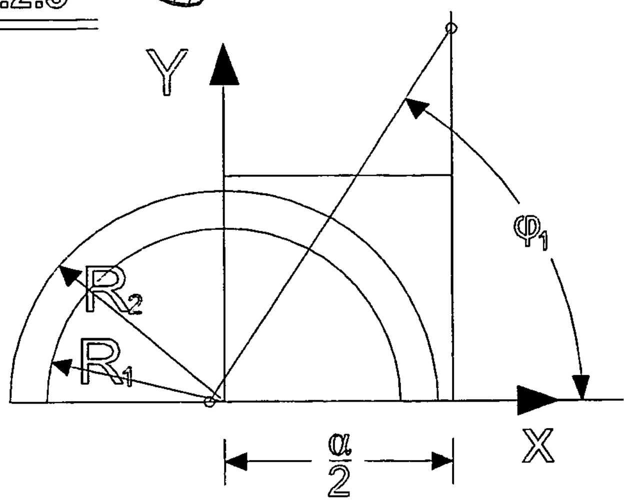
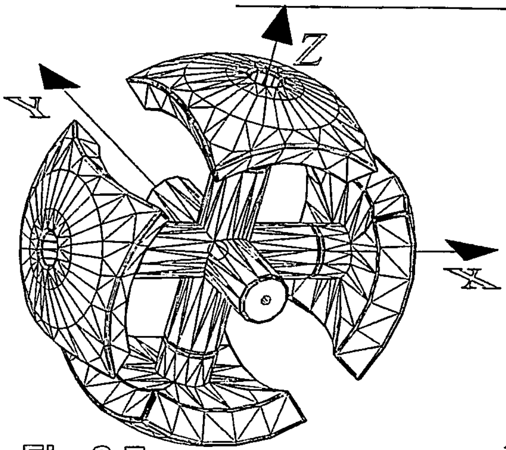


Fig.2.6

FIGURE 2



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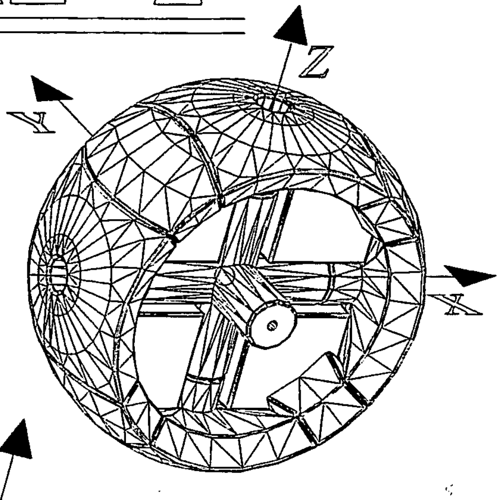

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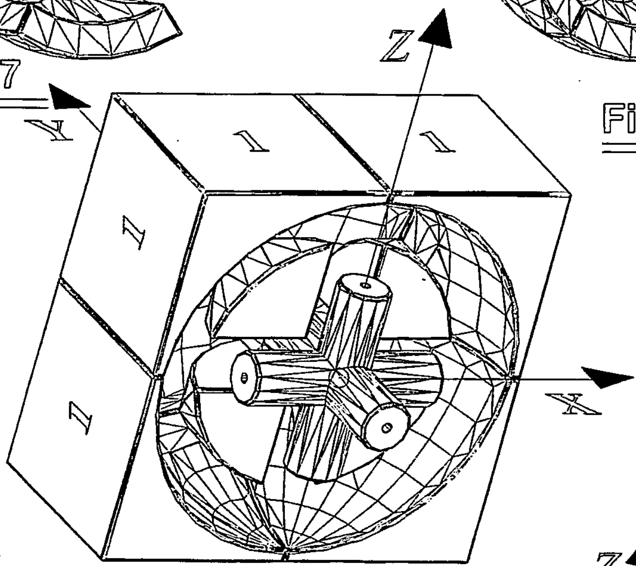


Fig.2.9

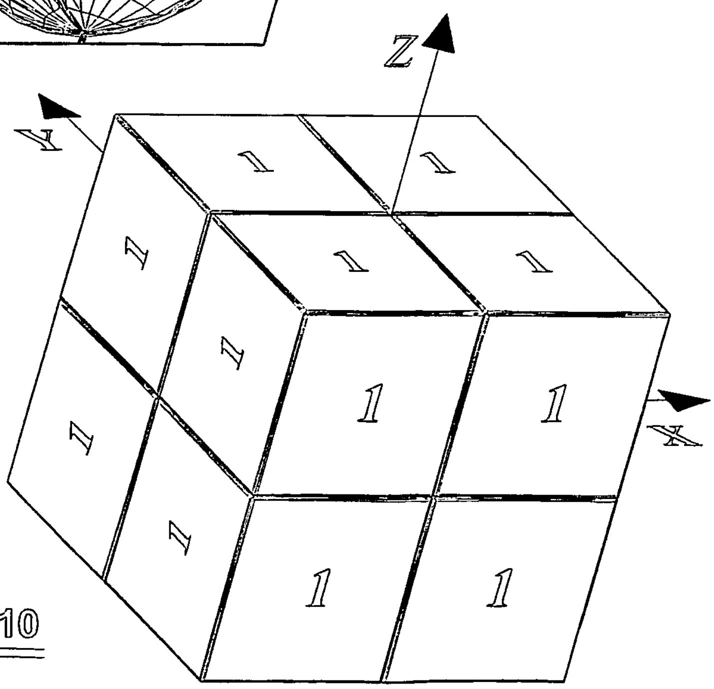


Fig.2.10

FIGURE 3

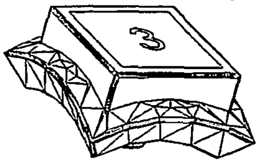


Fig.3.3

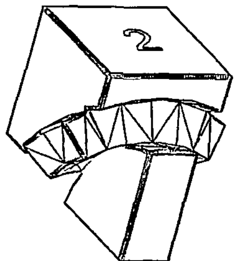


Fig.3.2

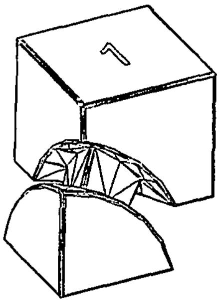
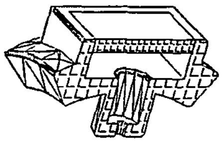


Fig.3.1



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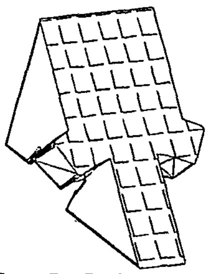

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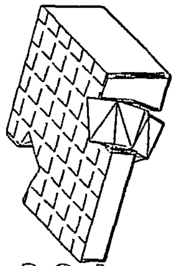

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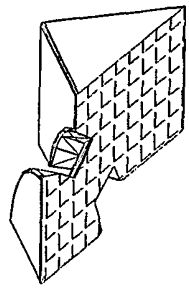

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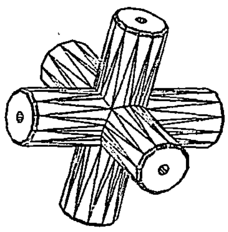

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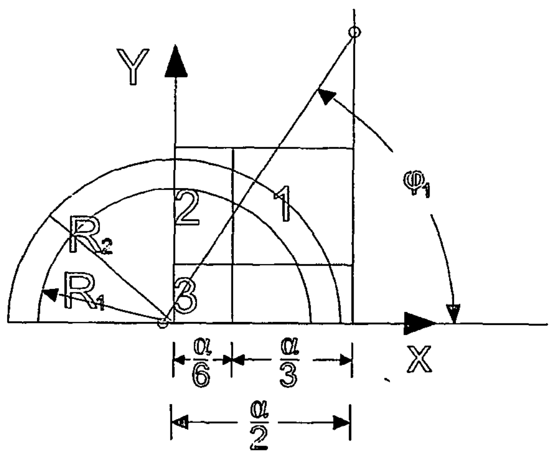

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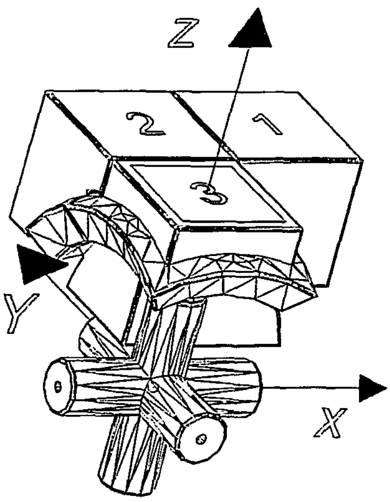
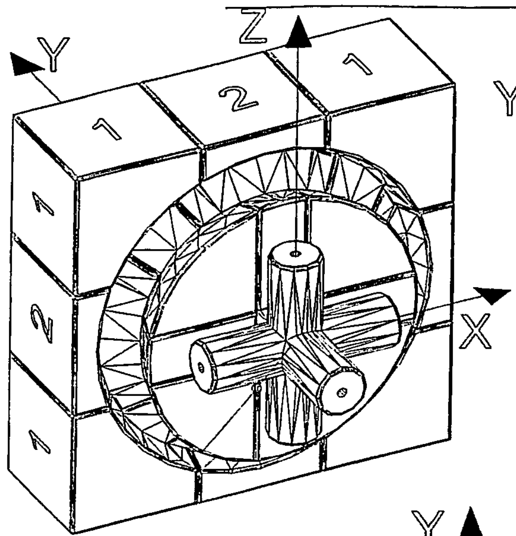


Fig.3.5

FIGURE 3



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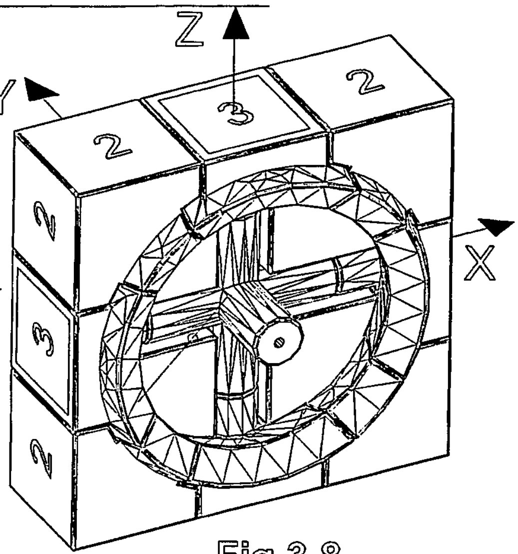

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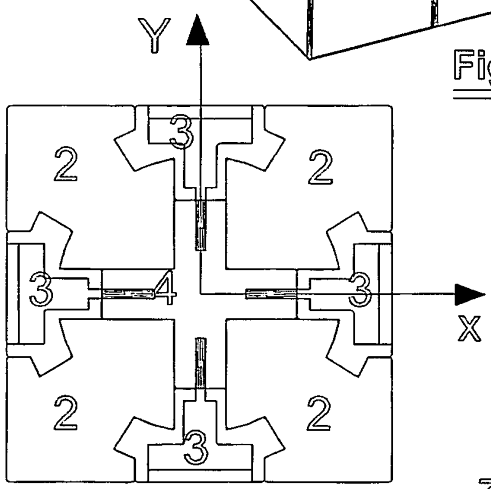

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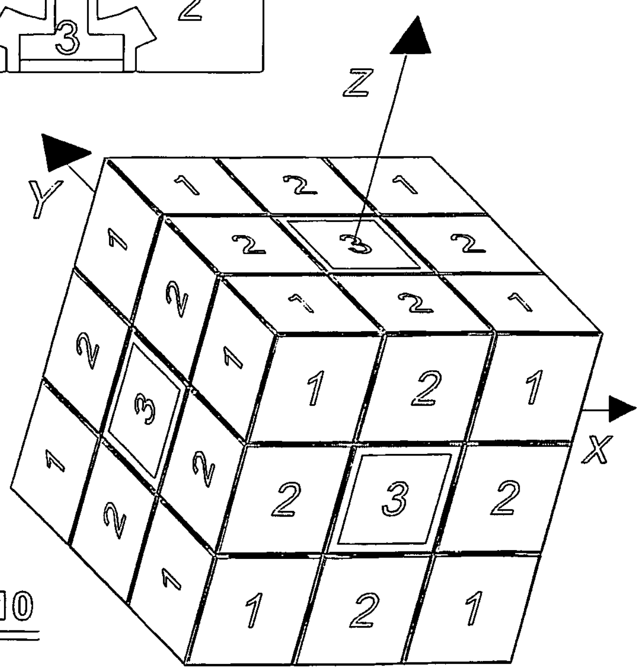


Fig.3.10

FIGURE 4

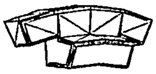
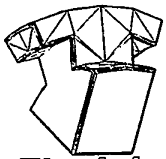


Fig.4.5



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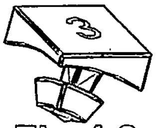

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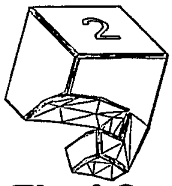
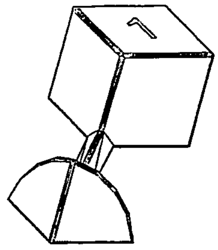


Fig.4.2



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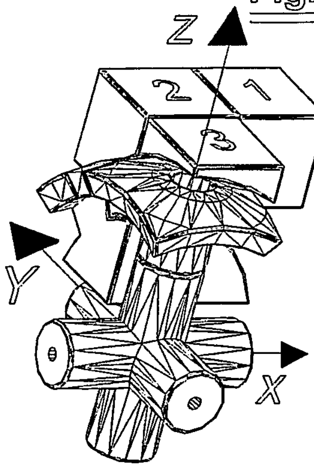

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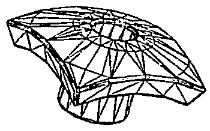
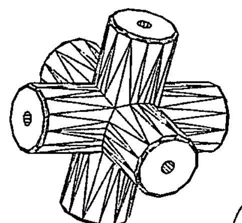


Fig.4.6



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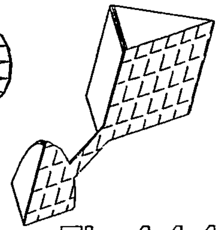

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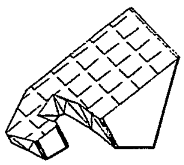

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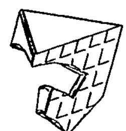

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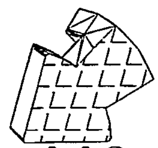

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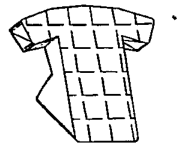
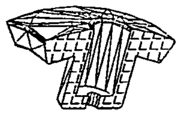


Fig.4.4.1

Fig.4.5.1



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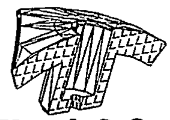

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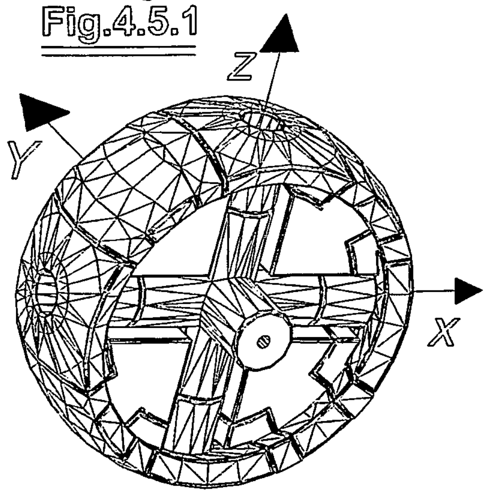

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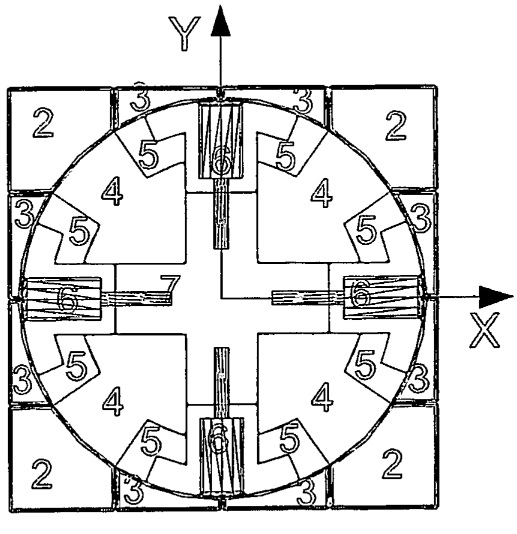
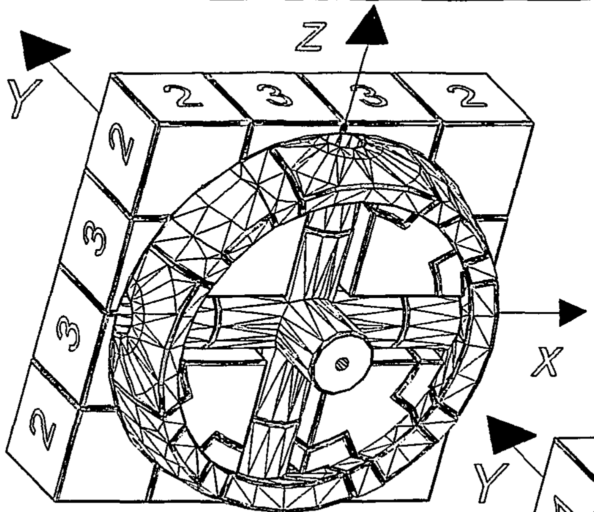


Fig.4.10

FIGURE 4



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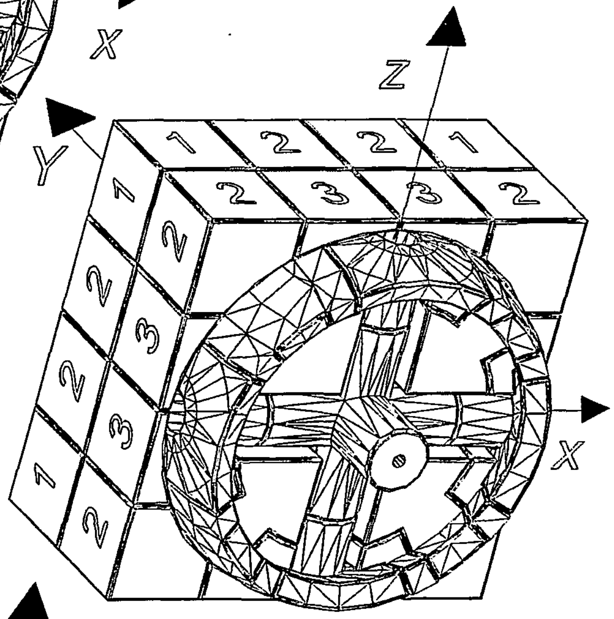


Fig.4.12

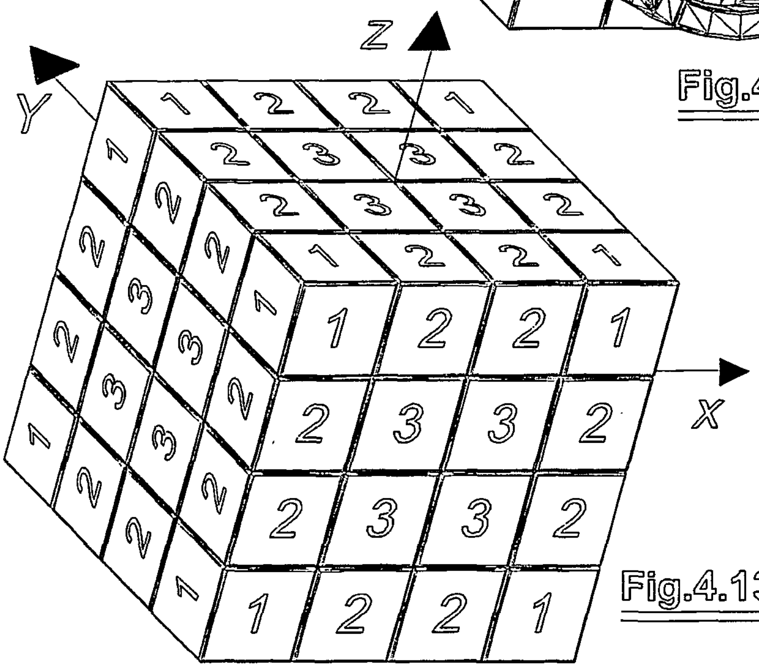
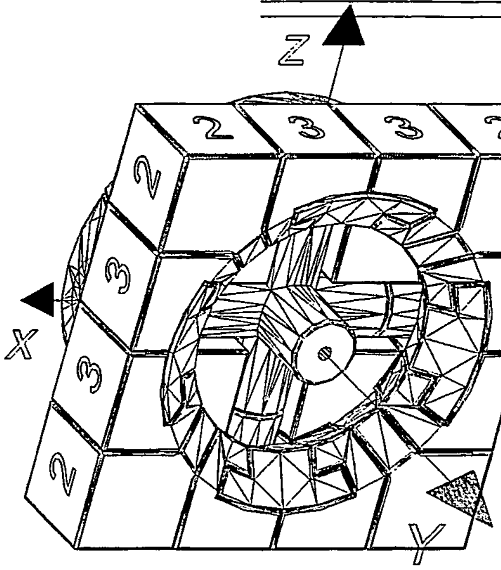


Fig.4.13

FIGURE 4



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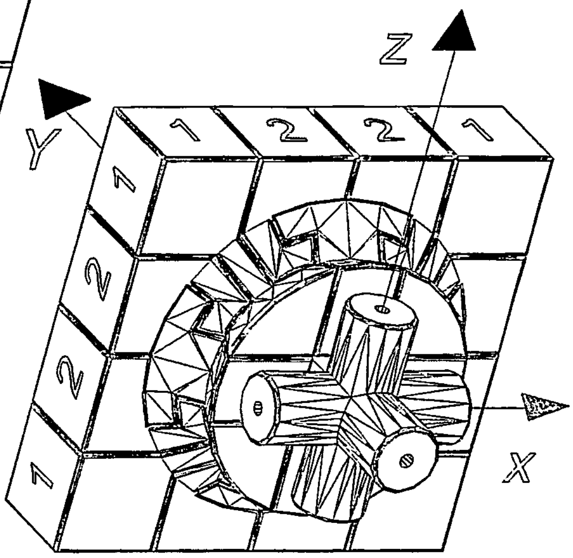

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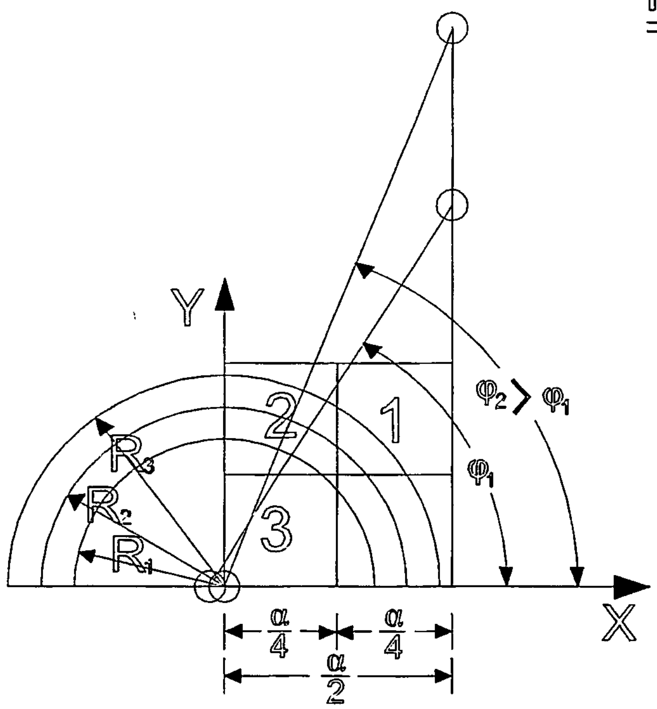


Fig.4.16

FIGURE 5

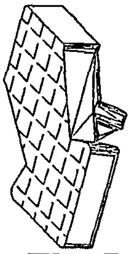


Fig.5.4.1

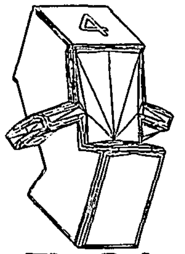


Fig.5.4

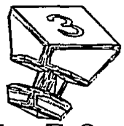
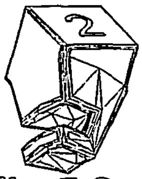


Fig.5.3



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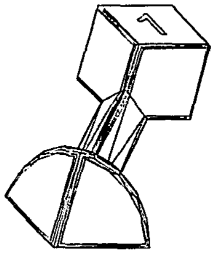
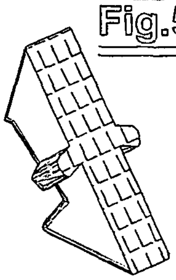


Fig.5.1



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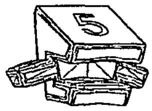


Fig.5.5

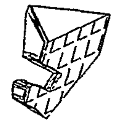


Fig.5.3.1

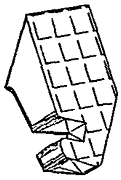


Fig.5.2.1

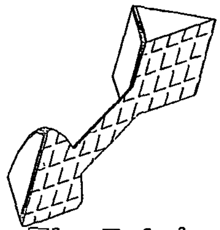


Fig.5.1.1

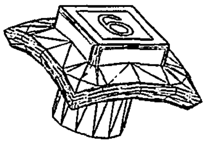


Fig.5.6

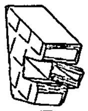


Fig.5.5.1

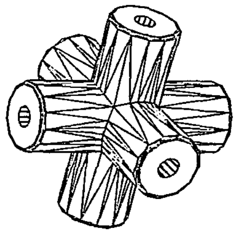
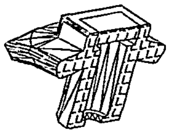


Fig.5.7



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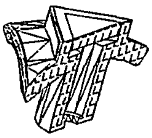


Fig.5.6.2

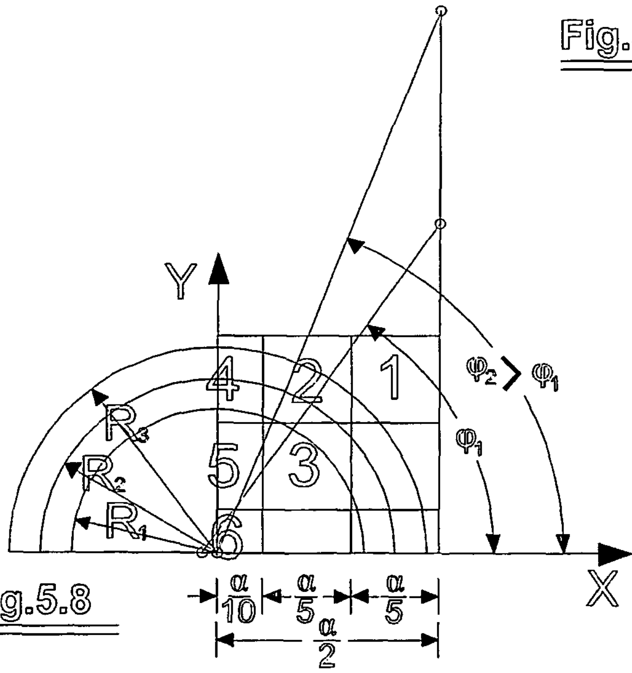
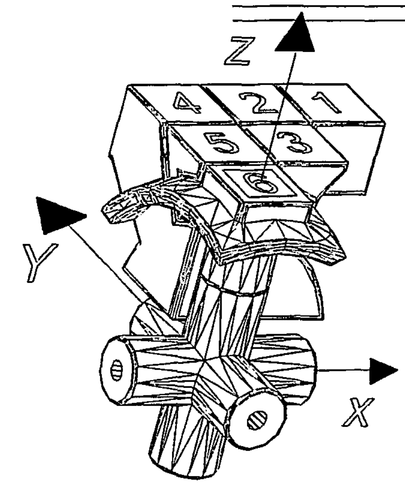


Fig.5.8

FIGURE 5



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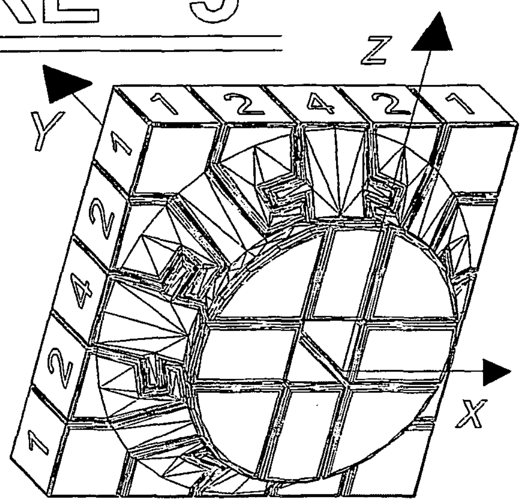

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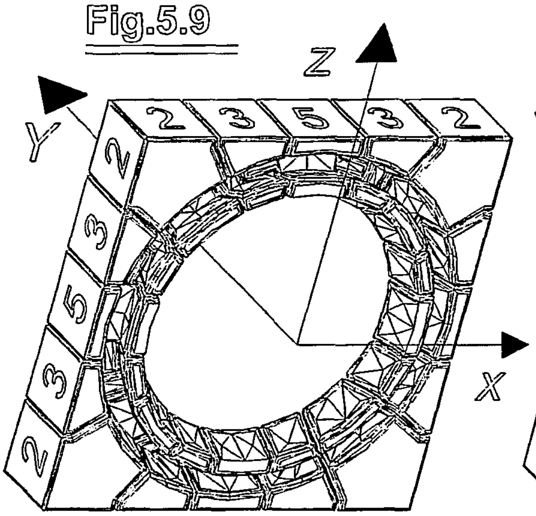

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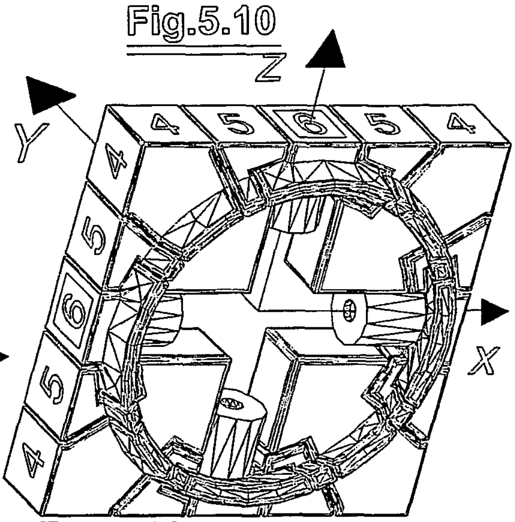

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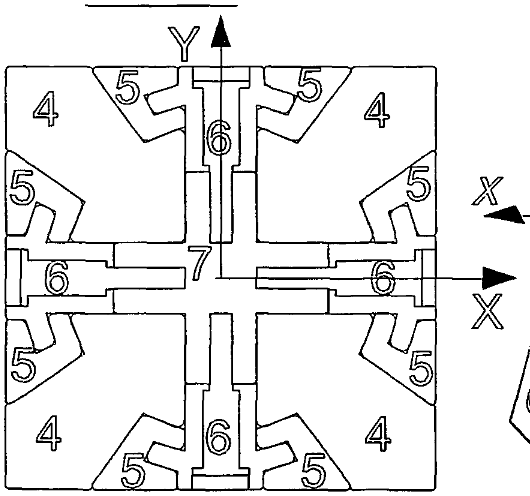


Fig.5.13

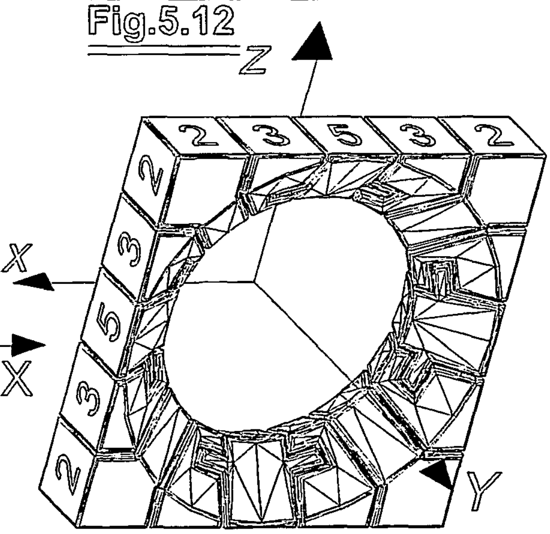
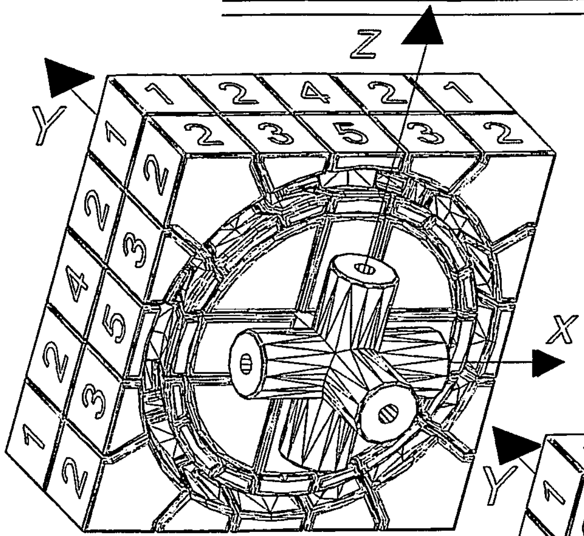


Fig.5.14

FIGURE 5



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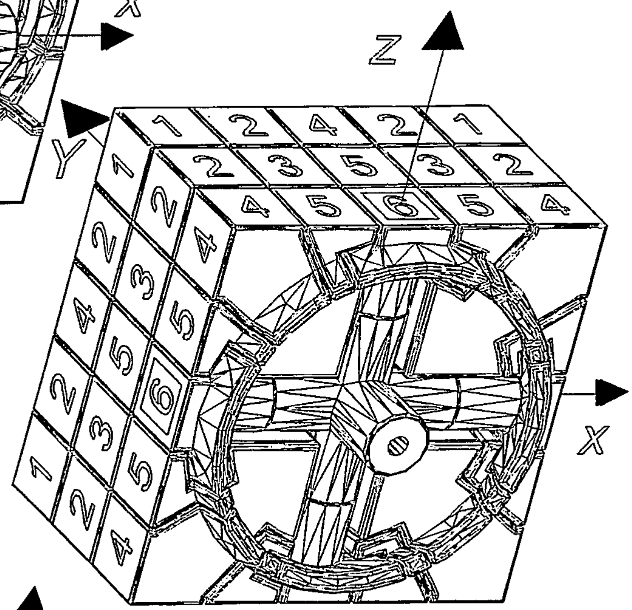

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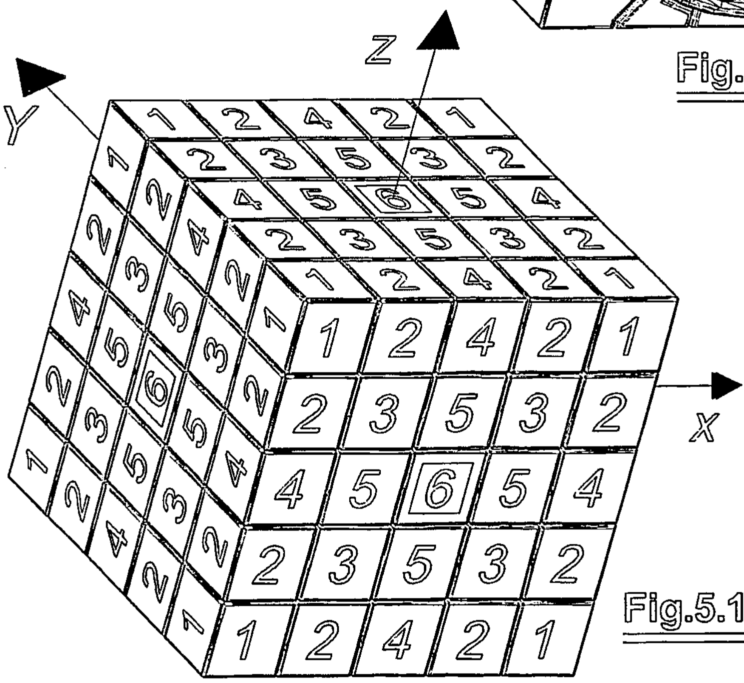

Fig.5.17

FIGURE 6a

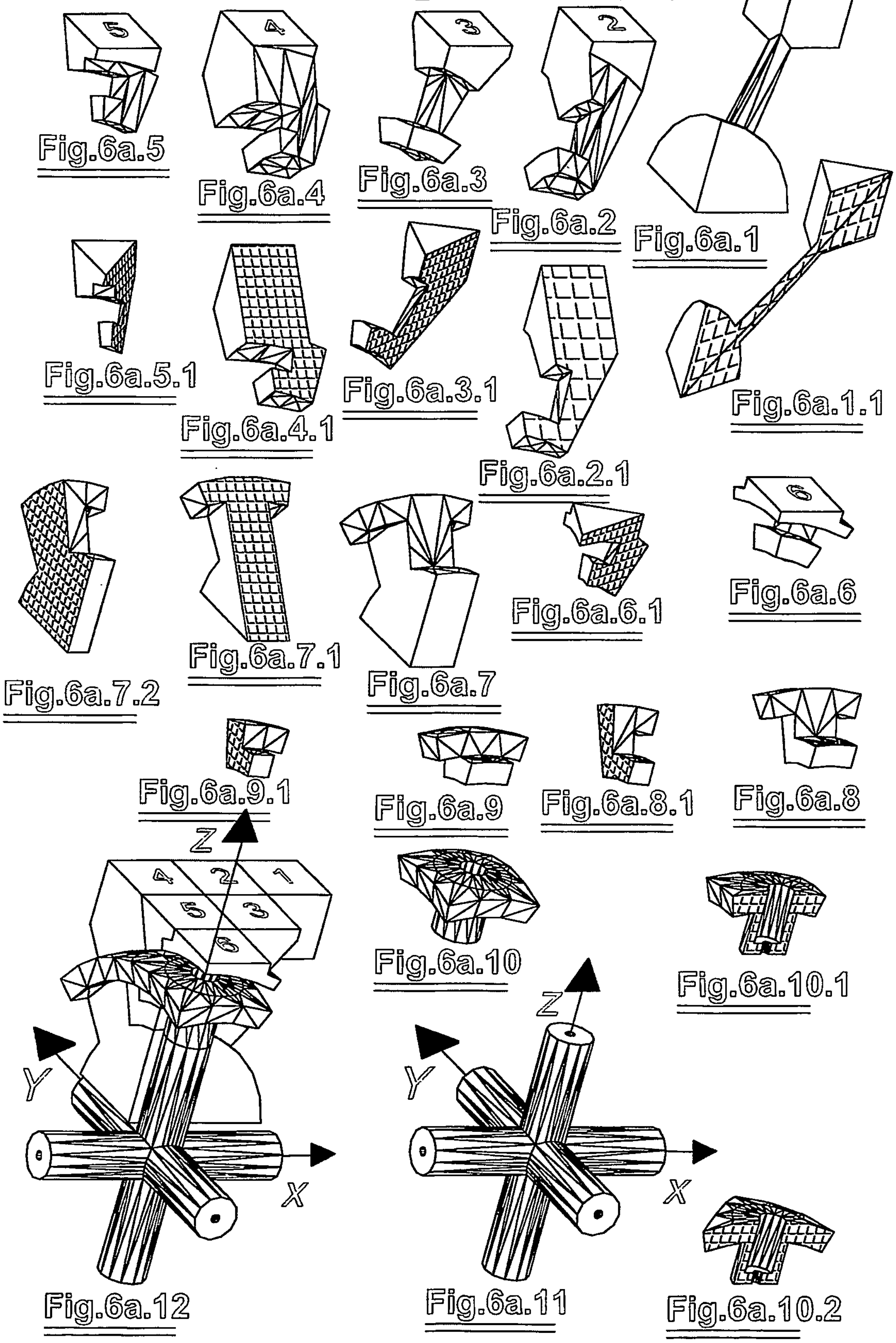
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Fig.6a.11
Fig.6a.10.2

FIGURE 6a

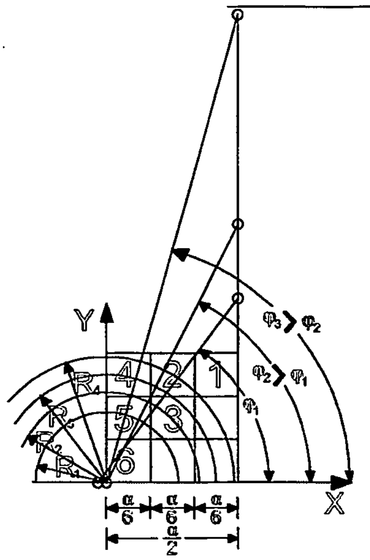
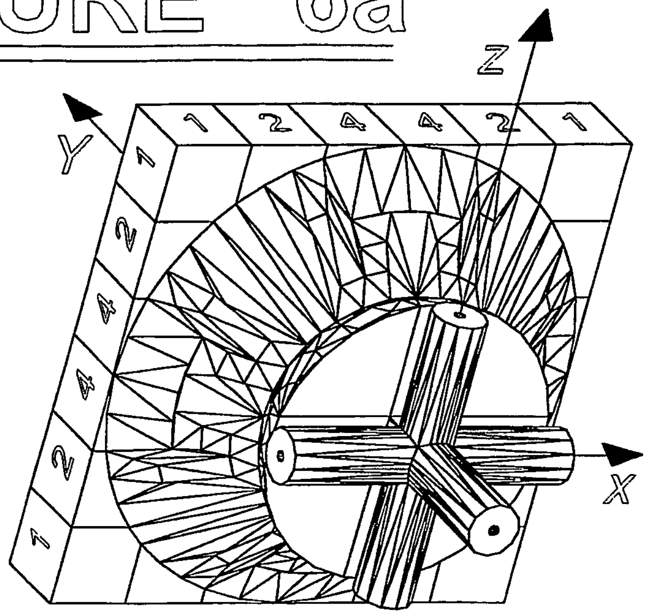


Fig.6a.13



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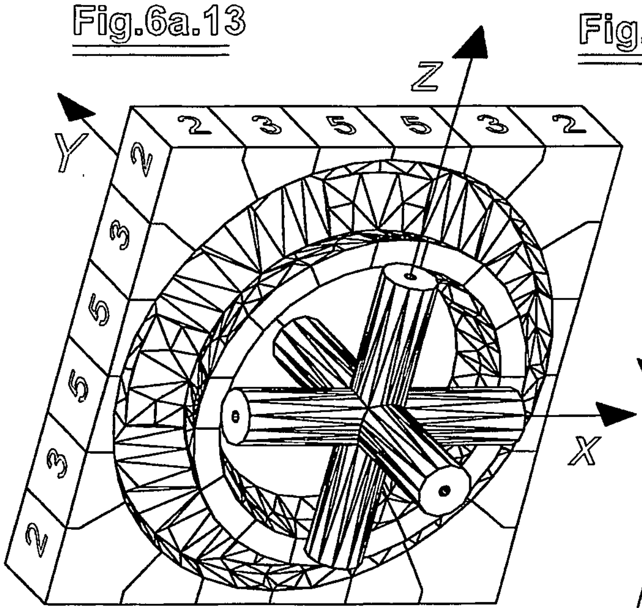


Fig.6a.15

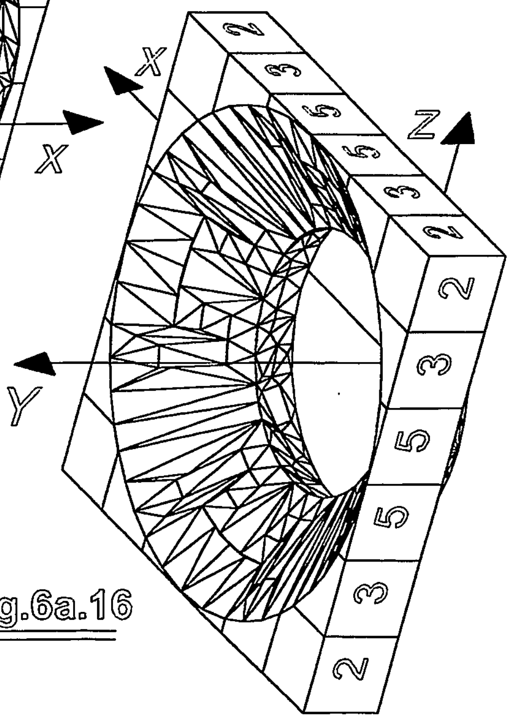
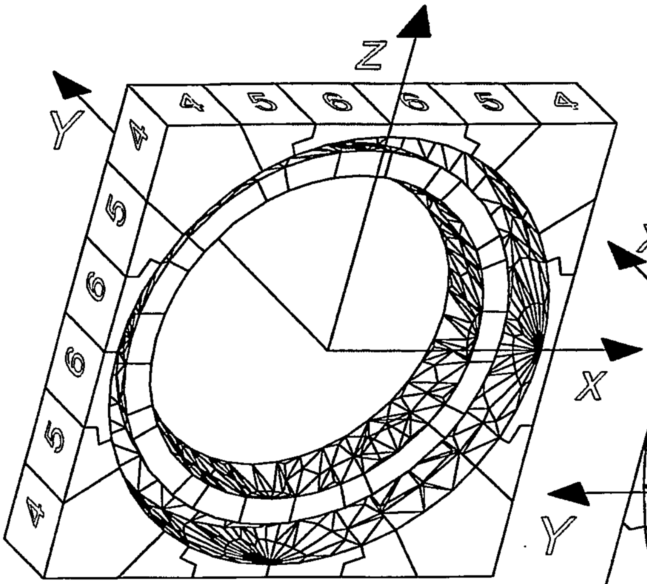


Fig.6a.16

FIGURE 6a



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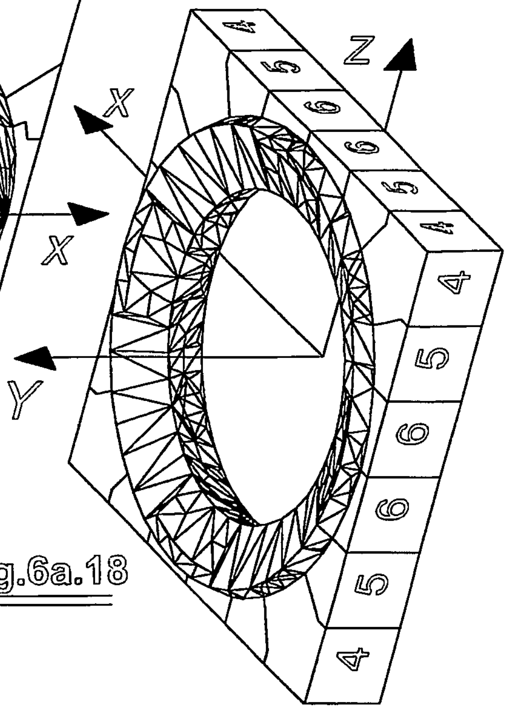


Fig.6a.18

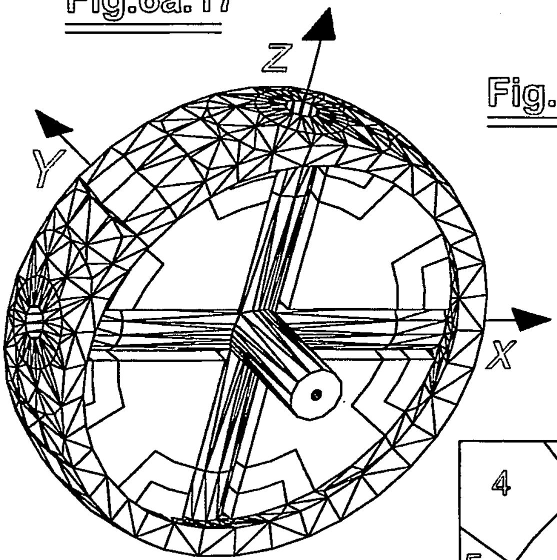


Fig.6a.19

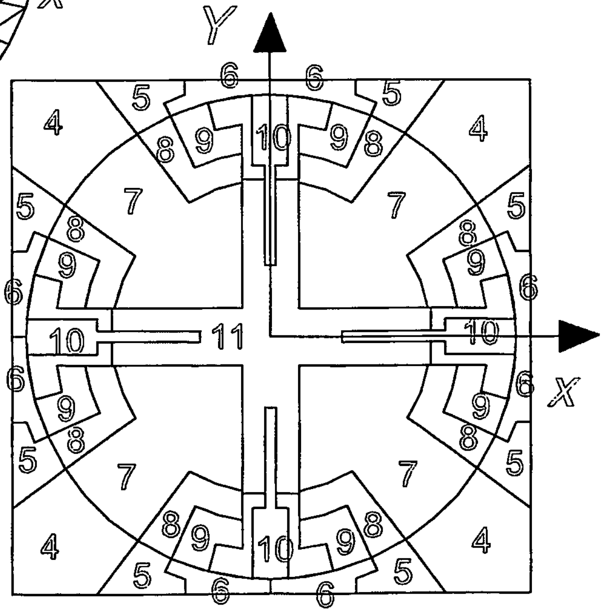
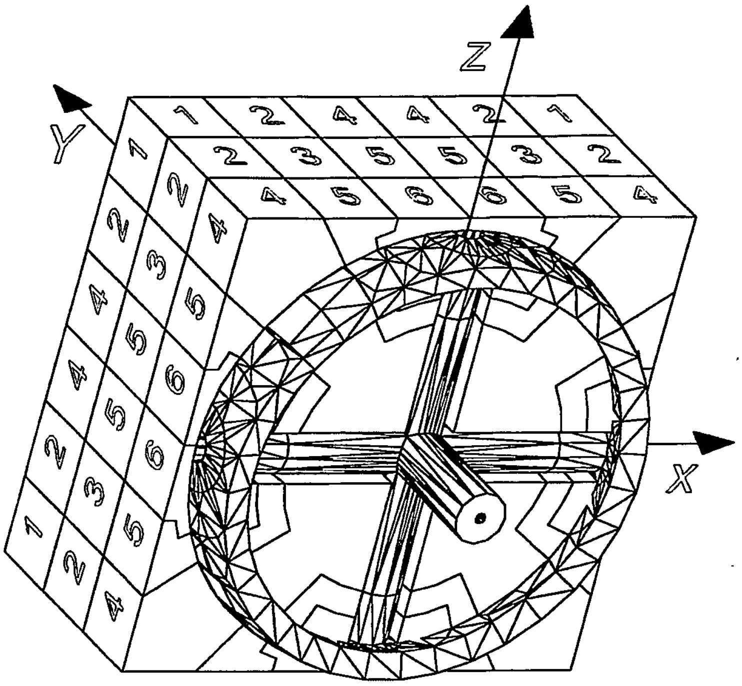


Fig.6a.20

FIGURE 6a



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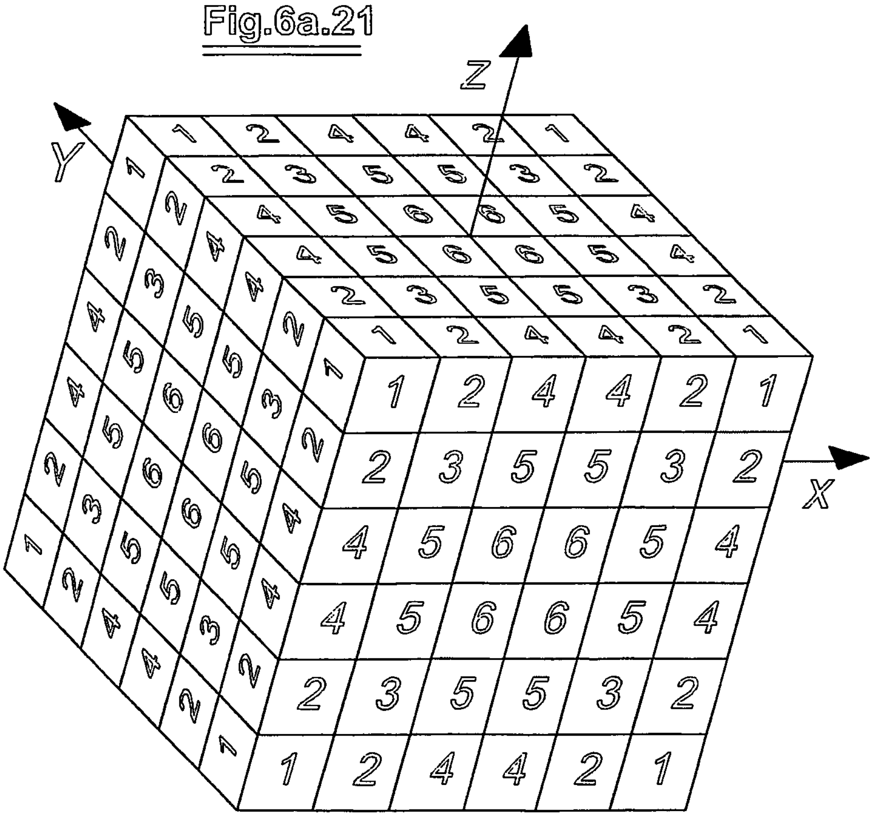


Fig.6a.22

FIGURE 6b

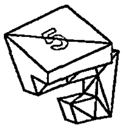


Fig.6b.5

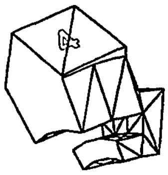


Fig.6b.4

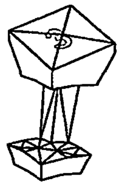


Fig.6b.3

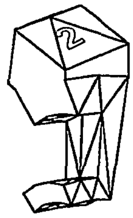


Fig.6b.2

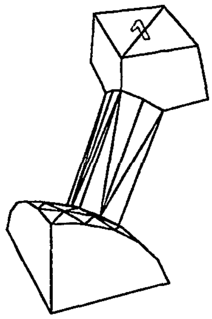


Fig.6b.1

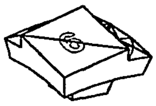


Fig.6b.6

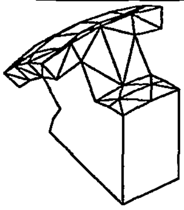
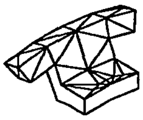


Fig.6b.7



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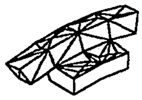

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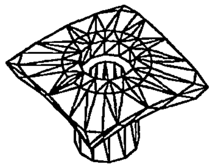

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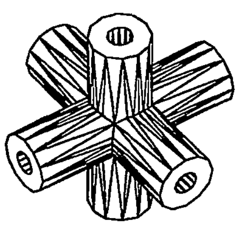

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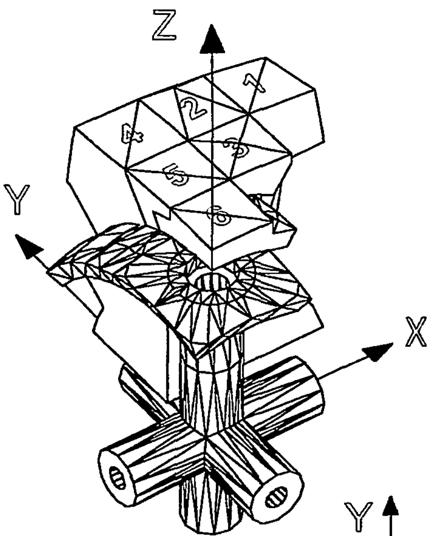

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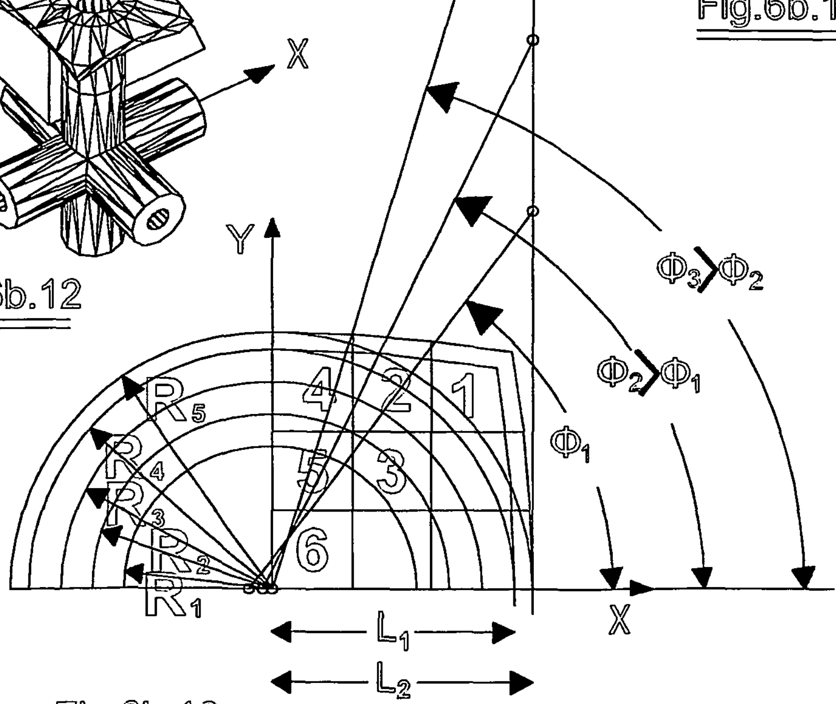
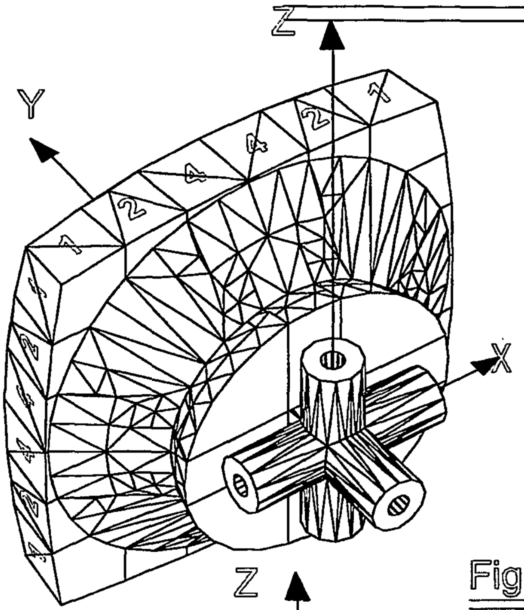


Fig.6b.13

FIGURE 6b



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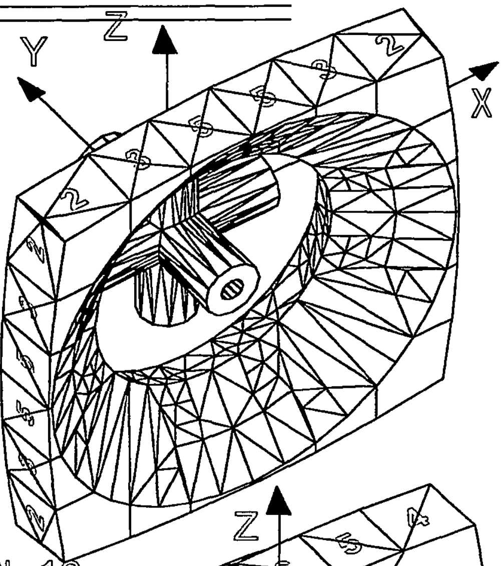
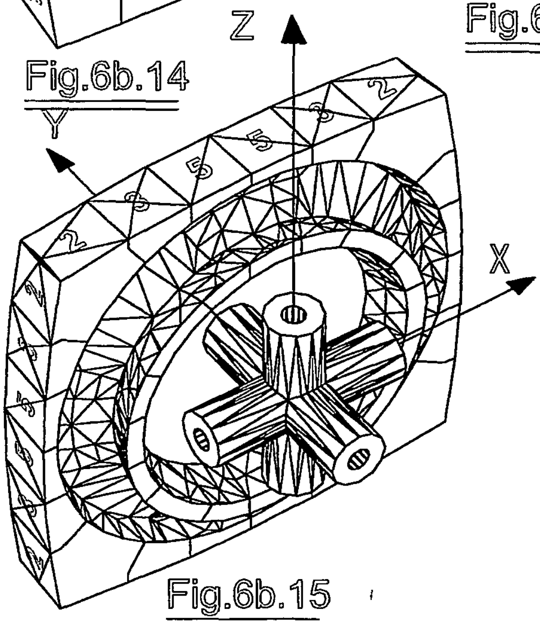


Fig.6b.16



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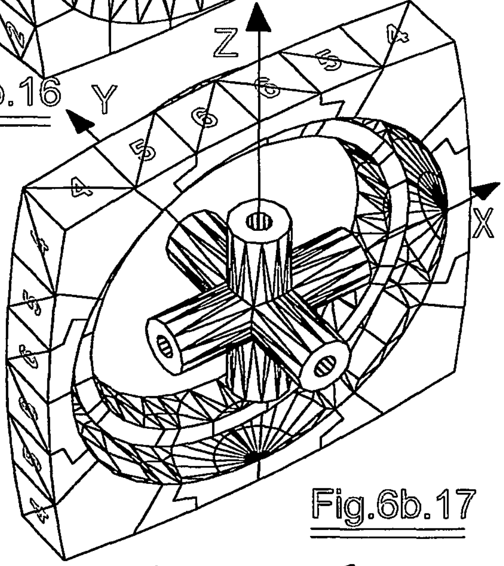

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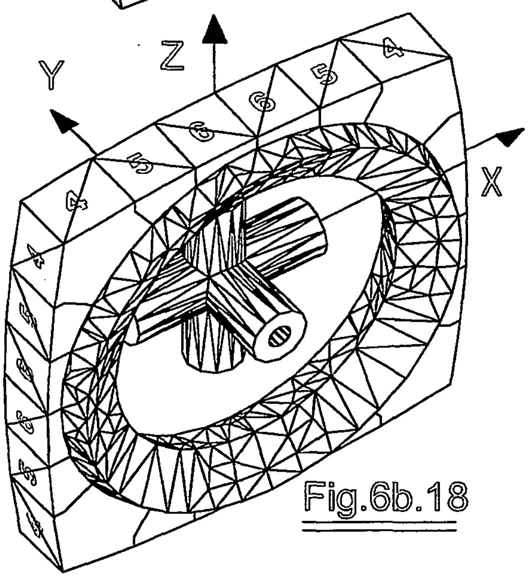
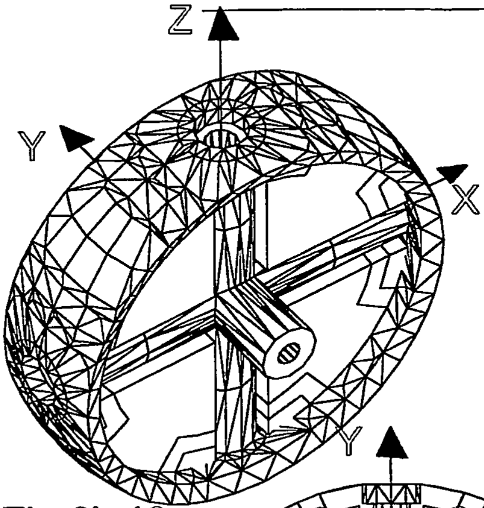


Fig.6b.18

FIGURE 6b



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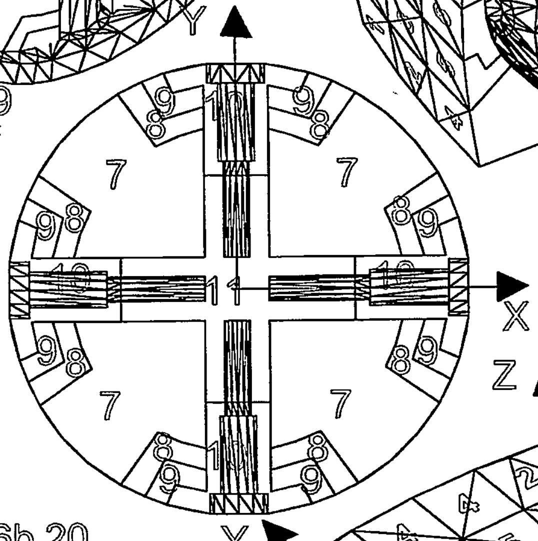

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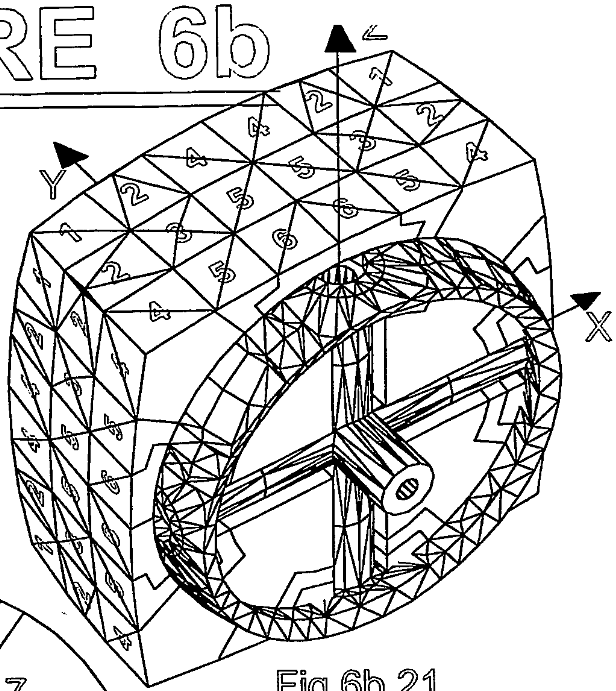

Fig.6b.21

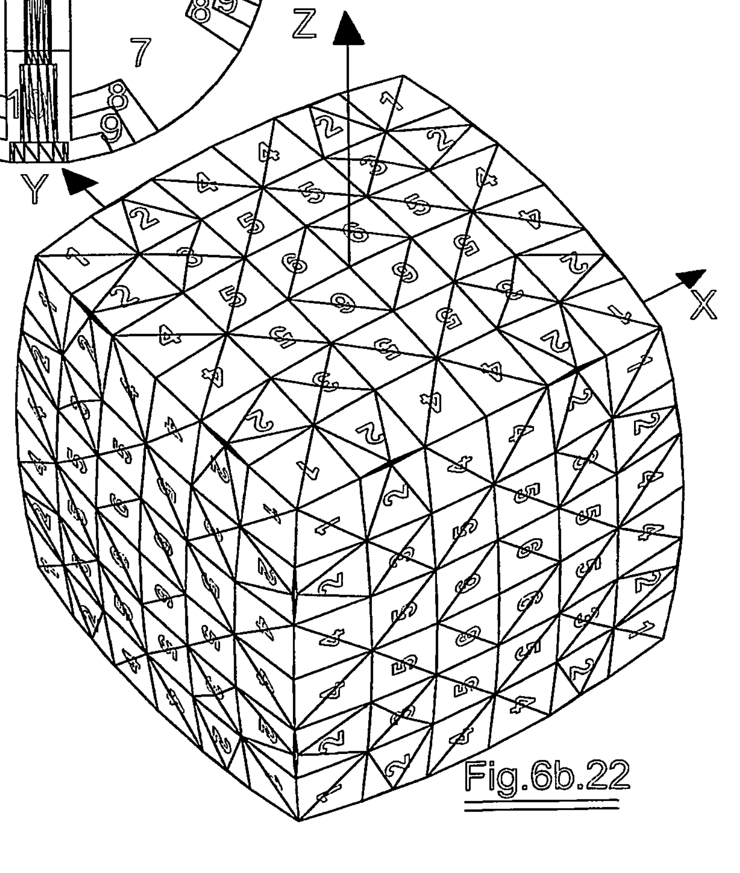

Fig.6b.22

FIGURE 7

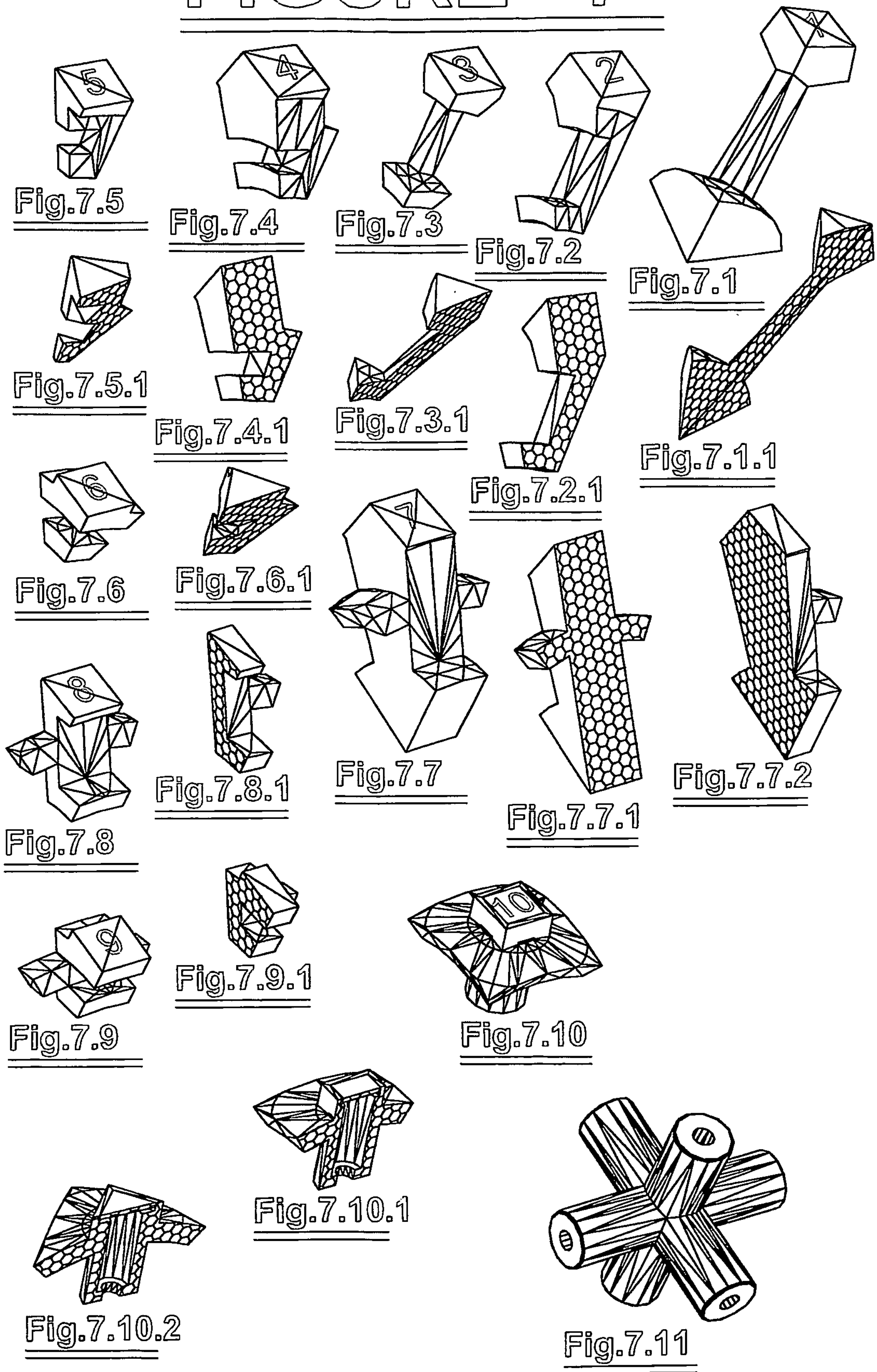
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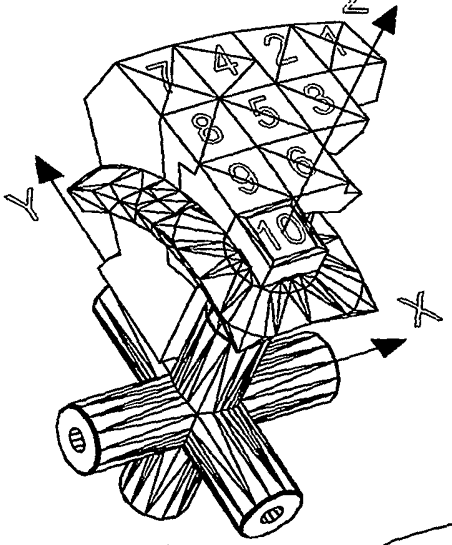
Fig.7.11

FIGURE 7



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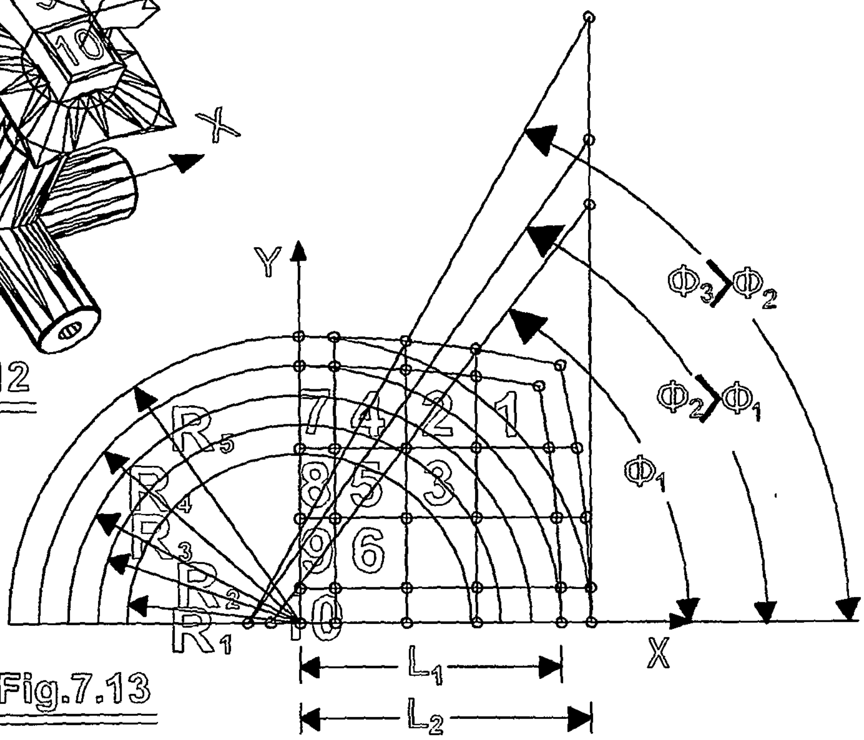

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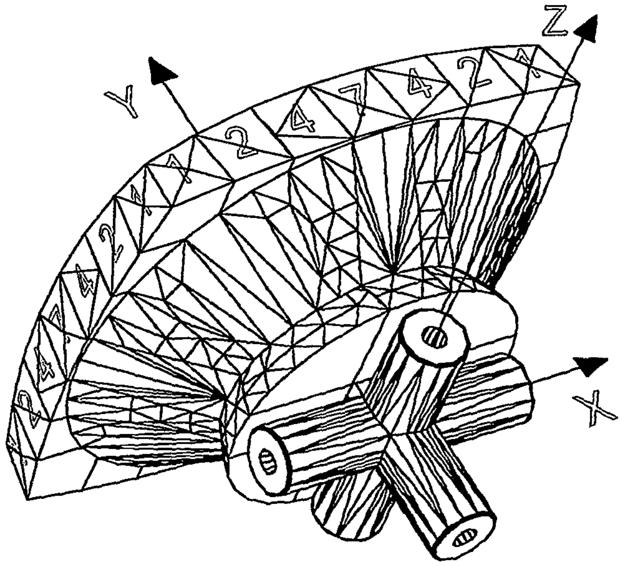
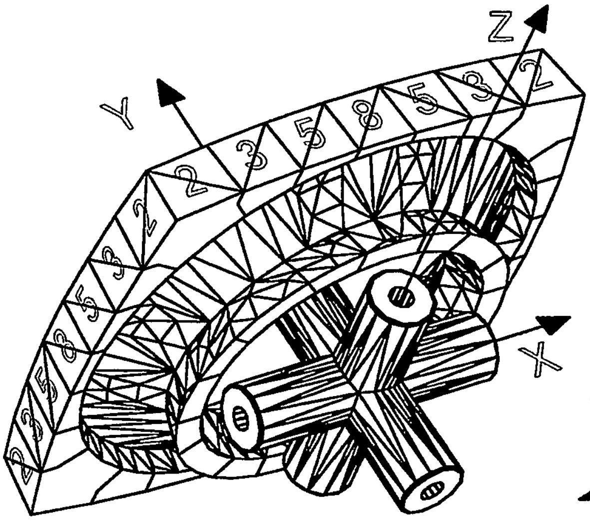


Fig.7.14

FIGURE 7



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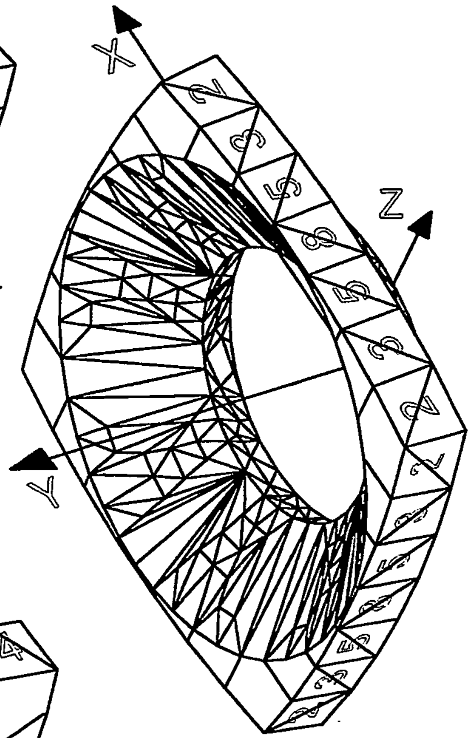

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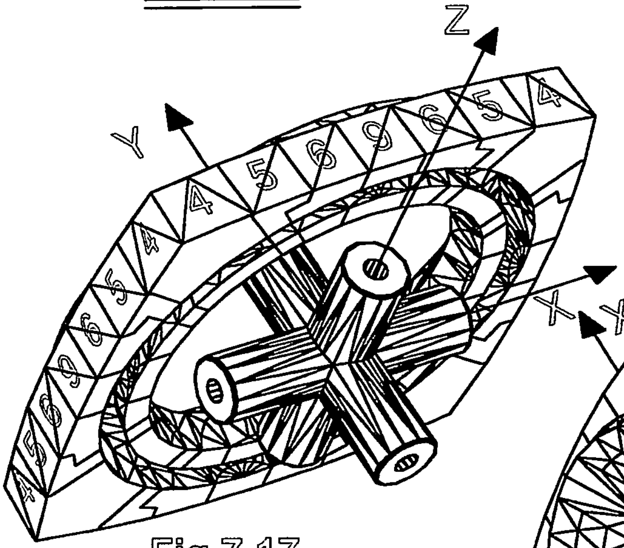

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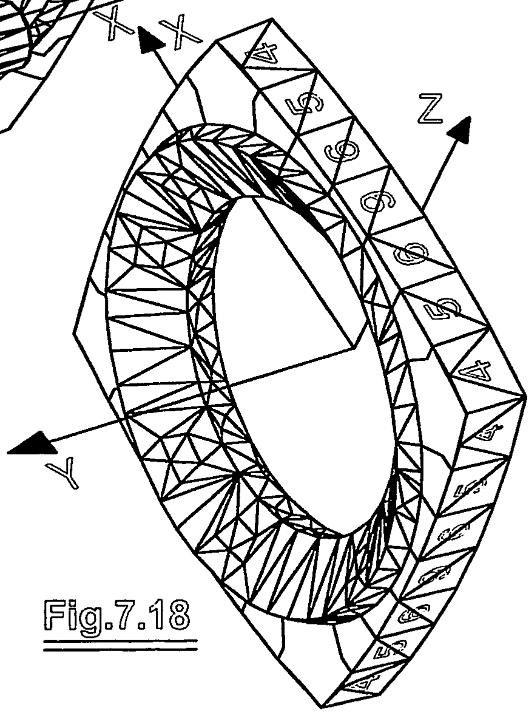
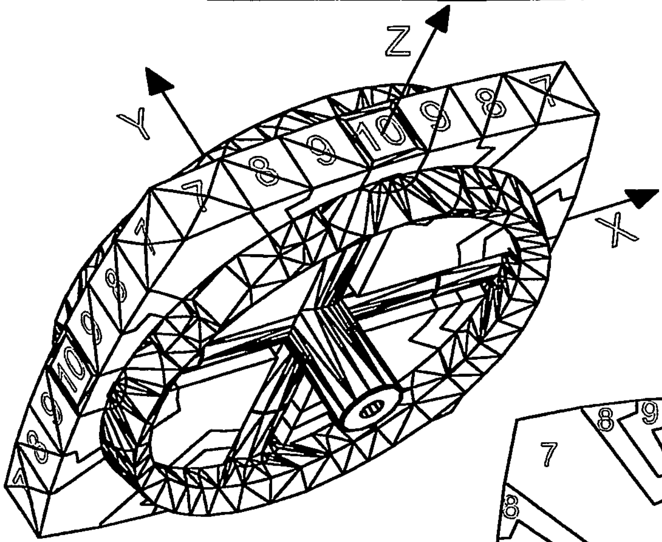


Fig.7.18

FIGURE 7



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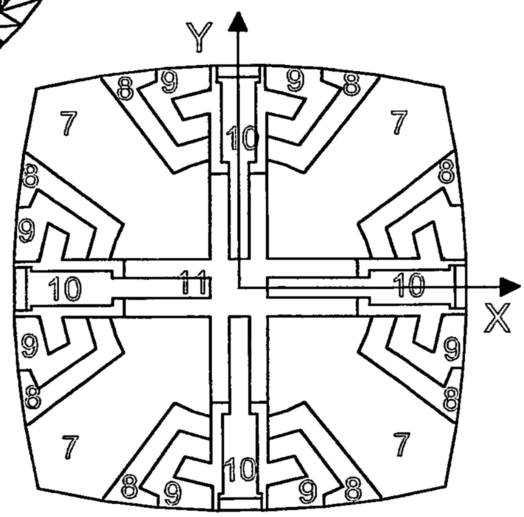

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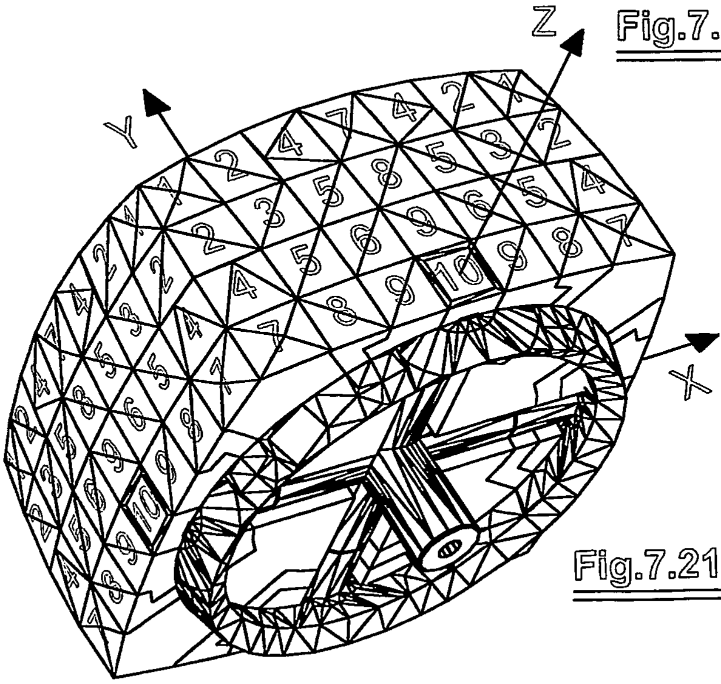

Fig.7.21

FIGURE 7

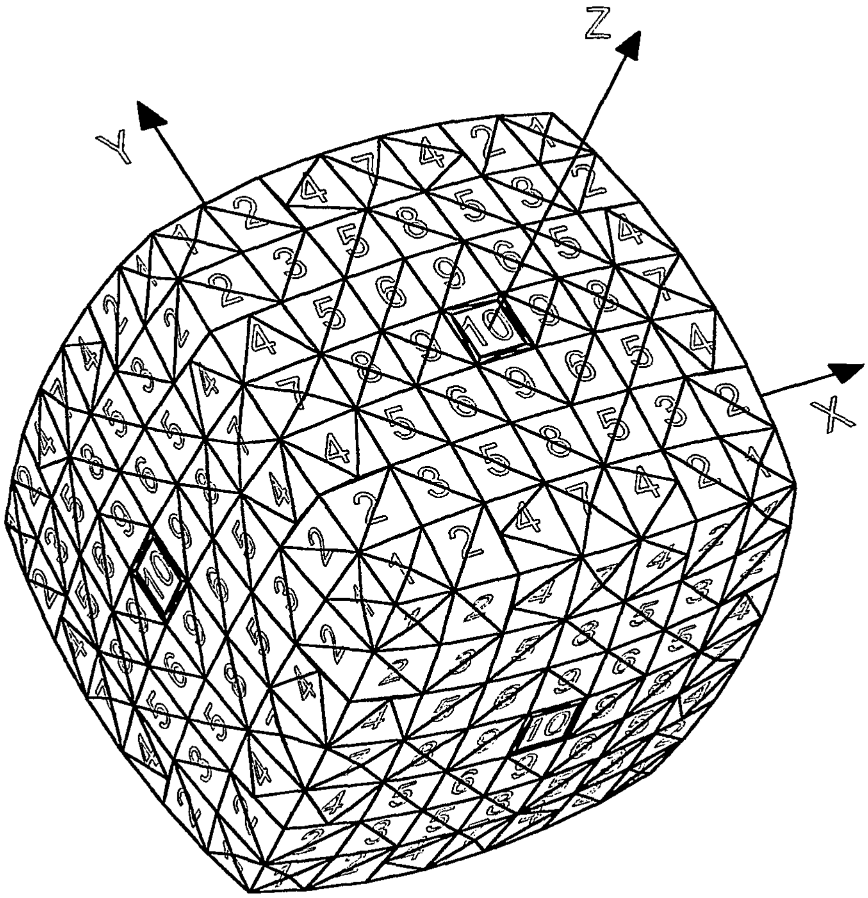

Fig.7.22

FIGURE 8

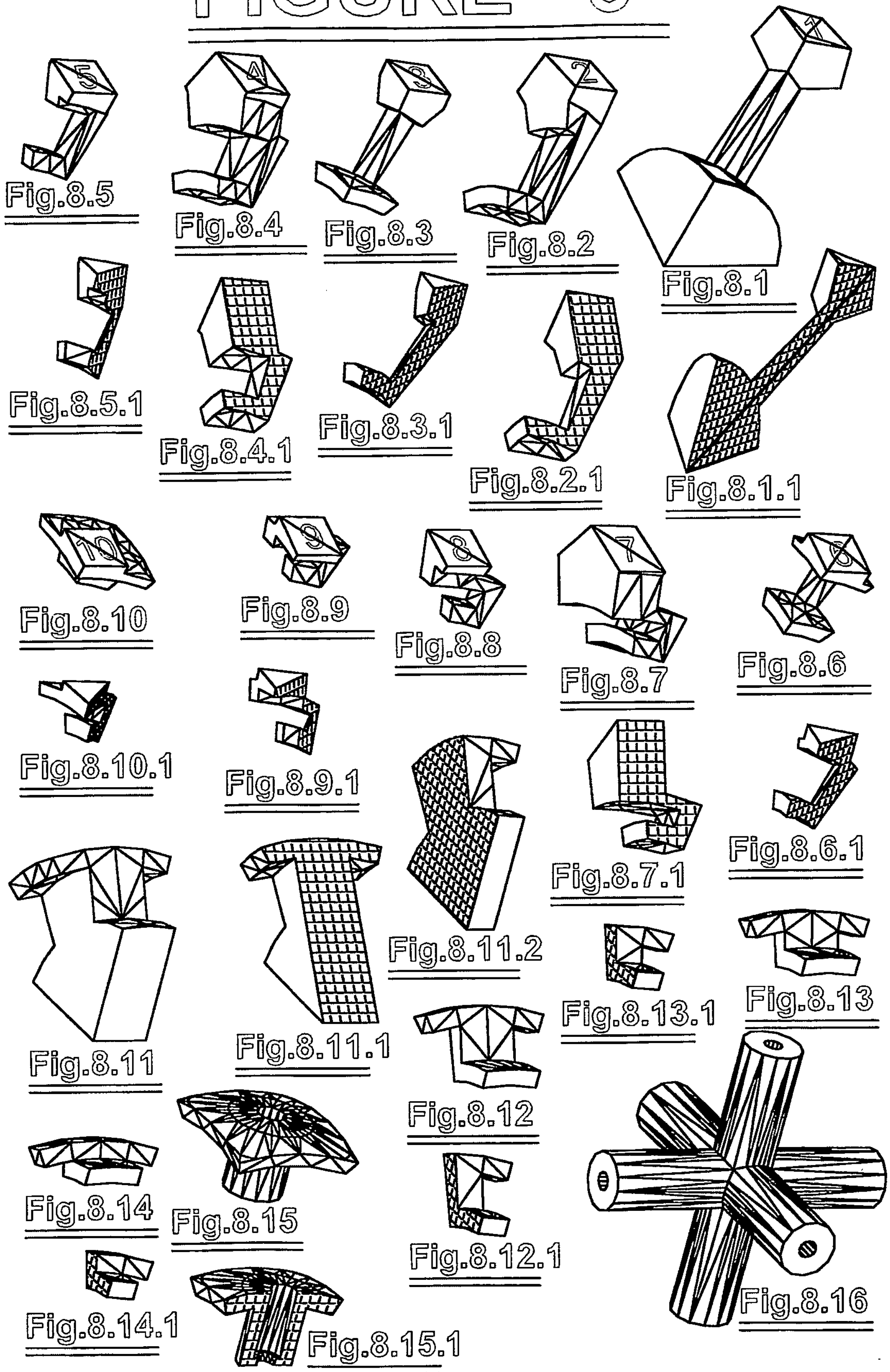
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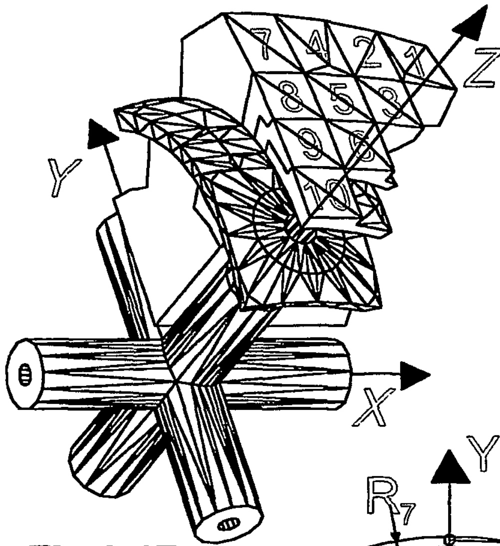
FIGURE 8



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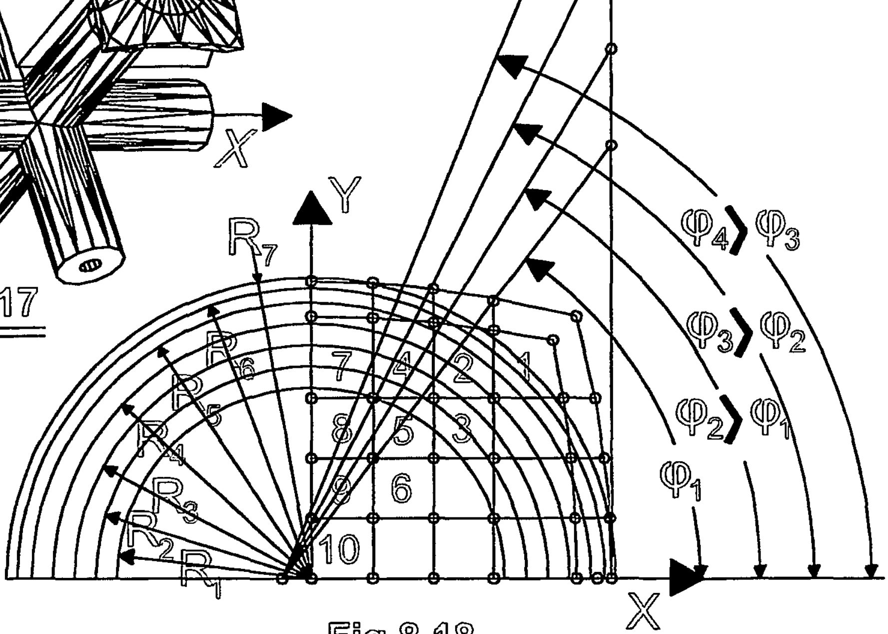

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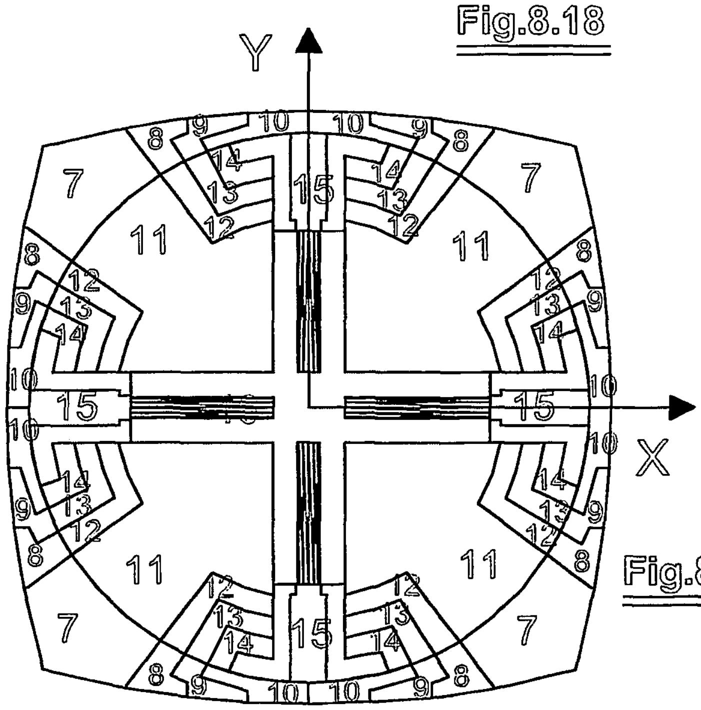
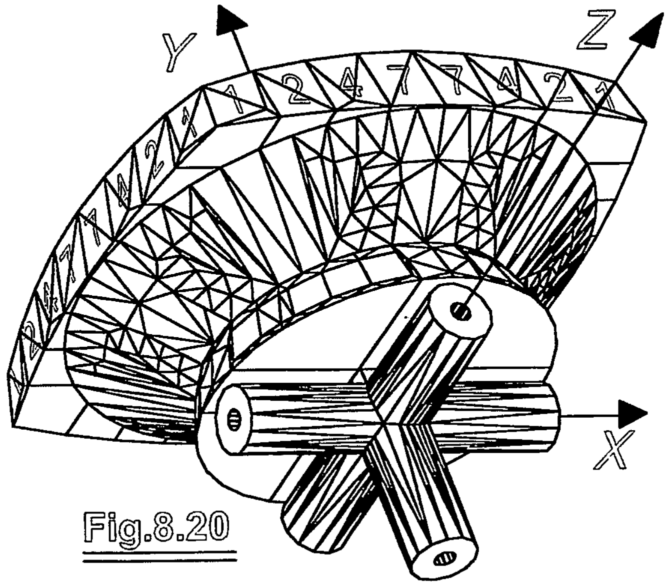


Fig.8.19

FIGURE 8



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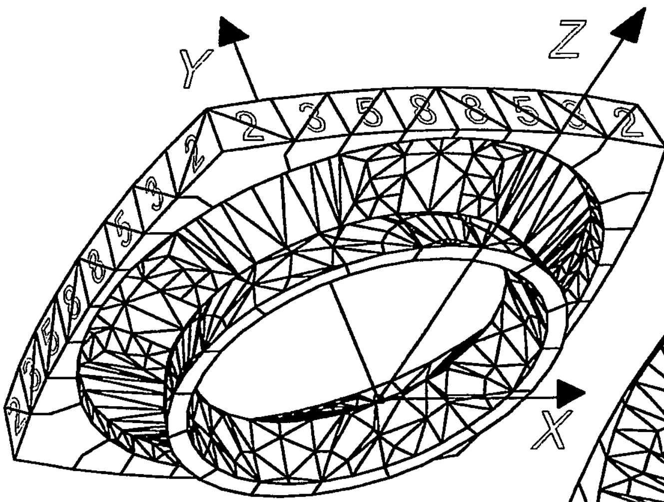

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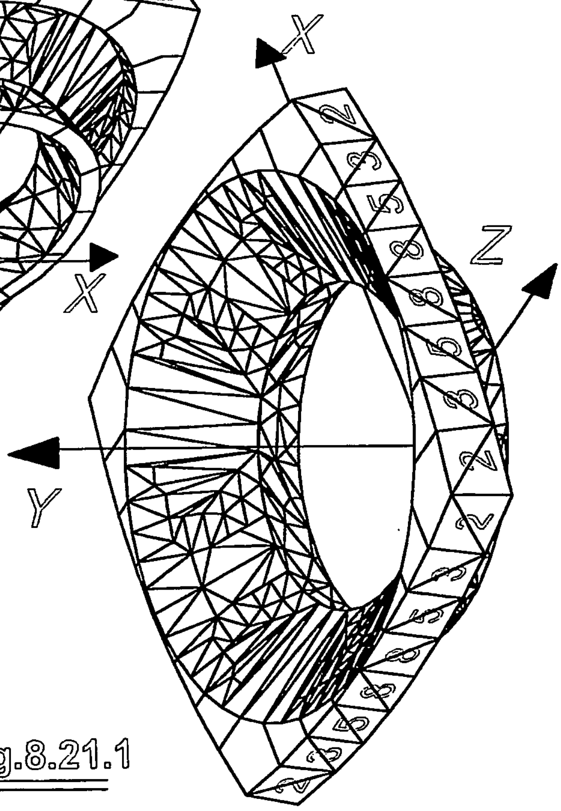
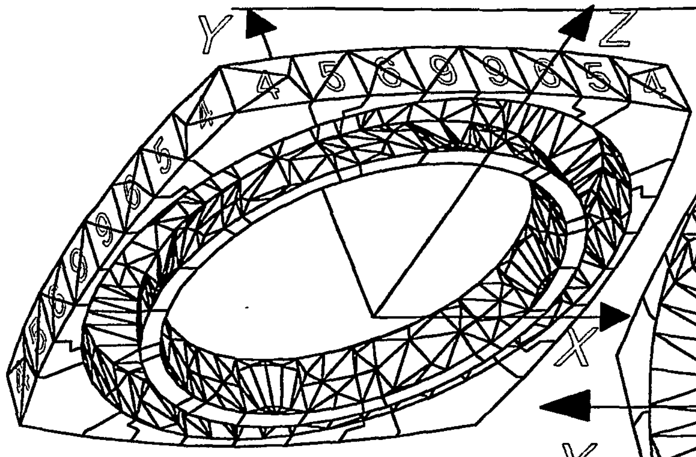


Fig.8.21.1

FIGURE 8



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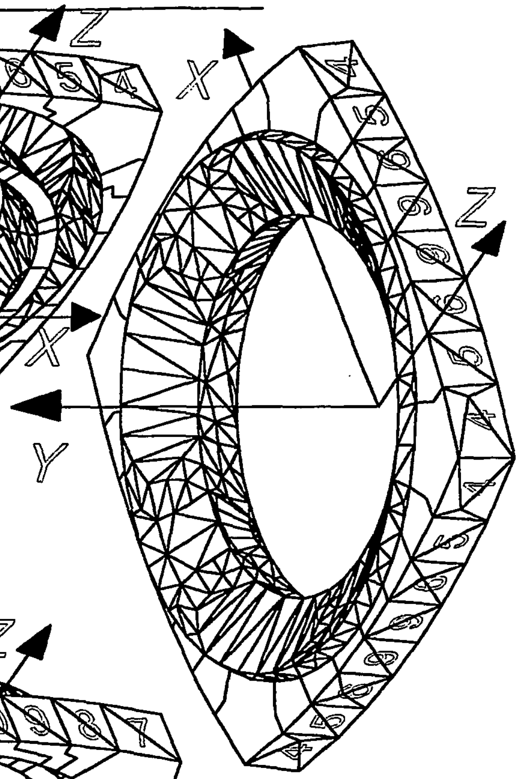
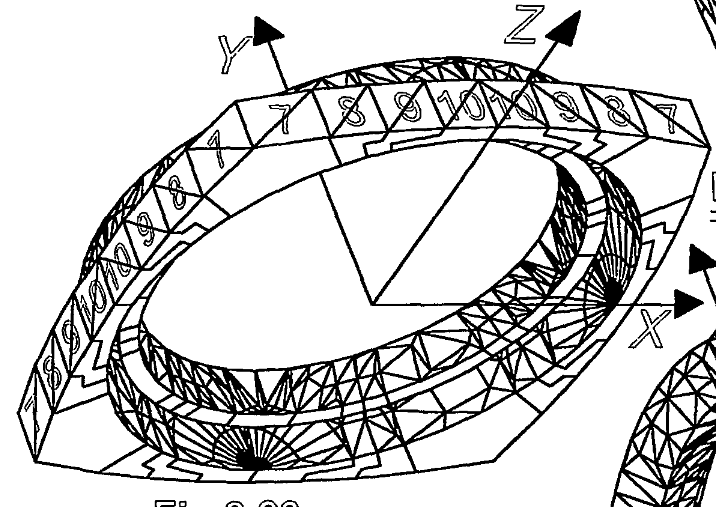


Fig.8.22.1



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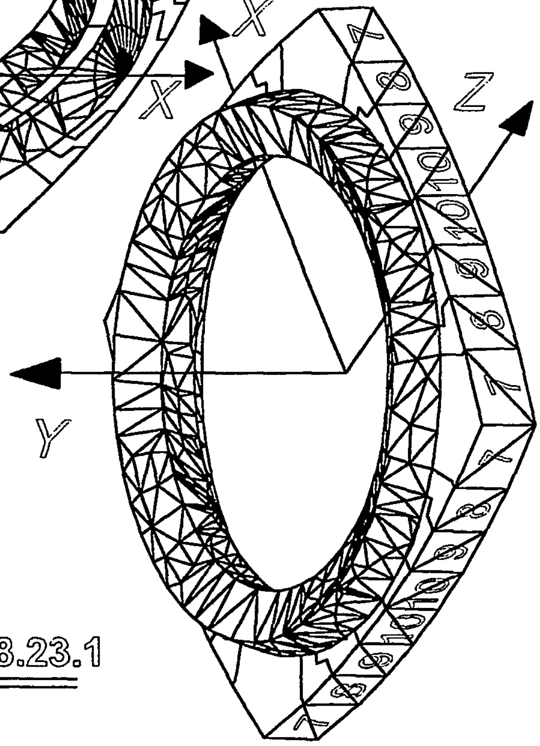
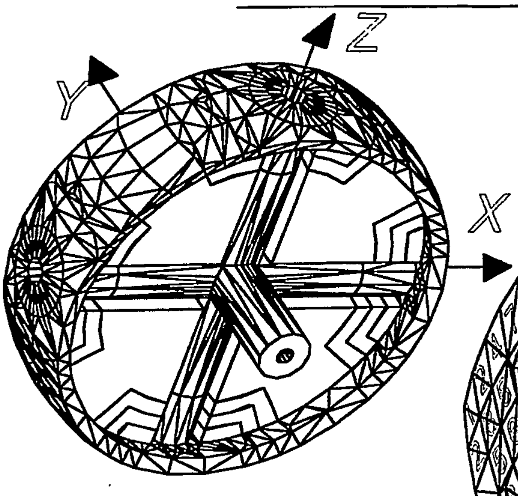


Fig.8.23.1

FIGURE 8



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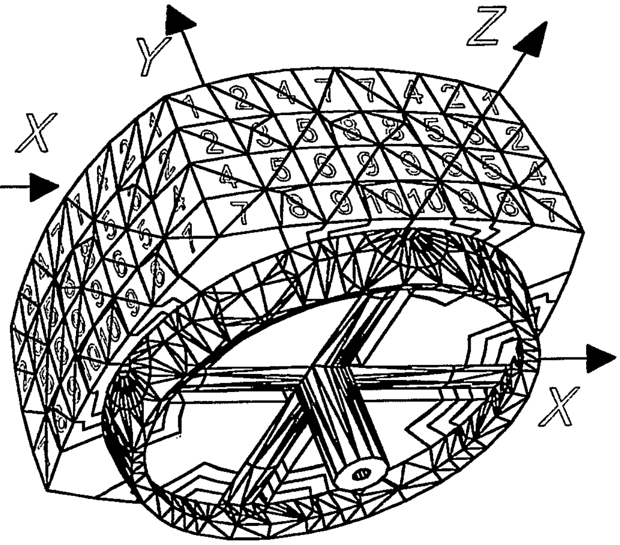

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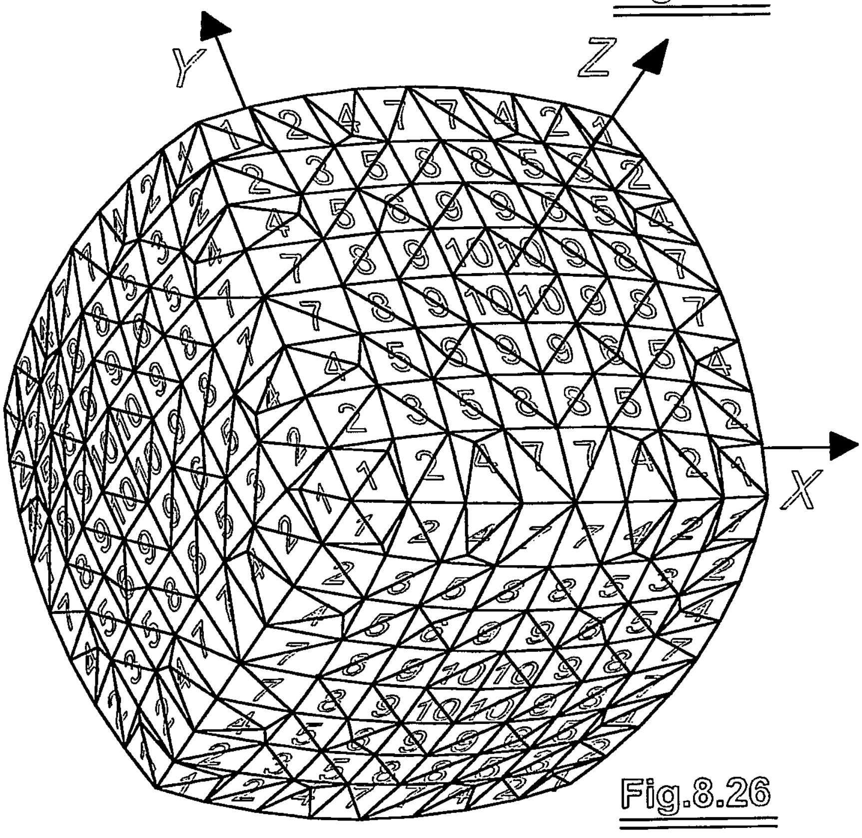


Fig.8.26

FIGURE 9

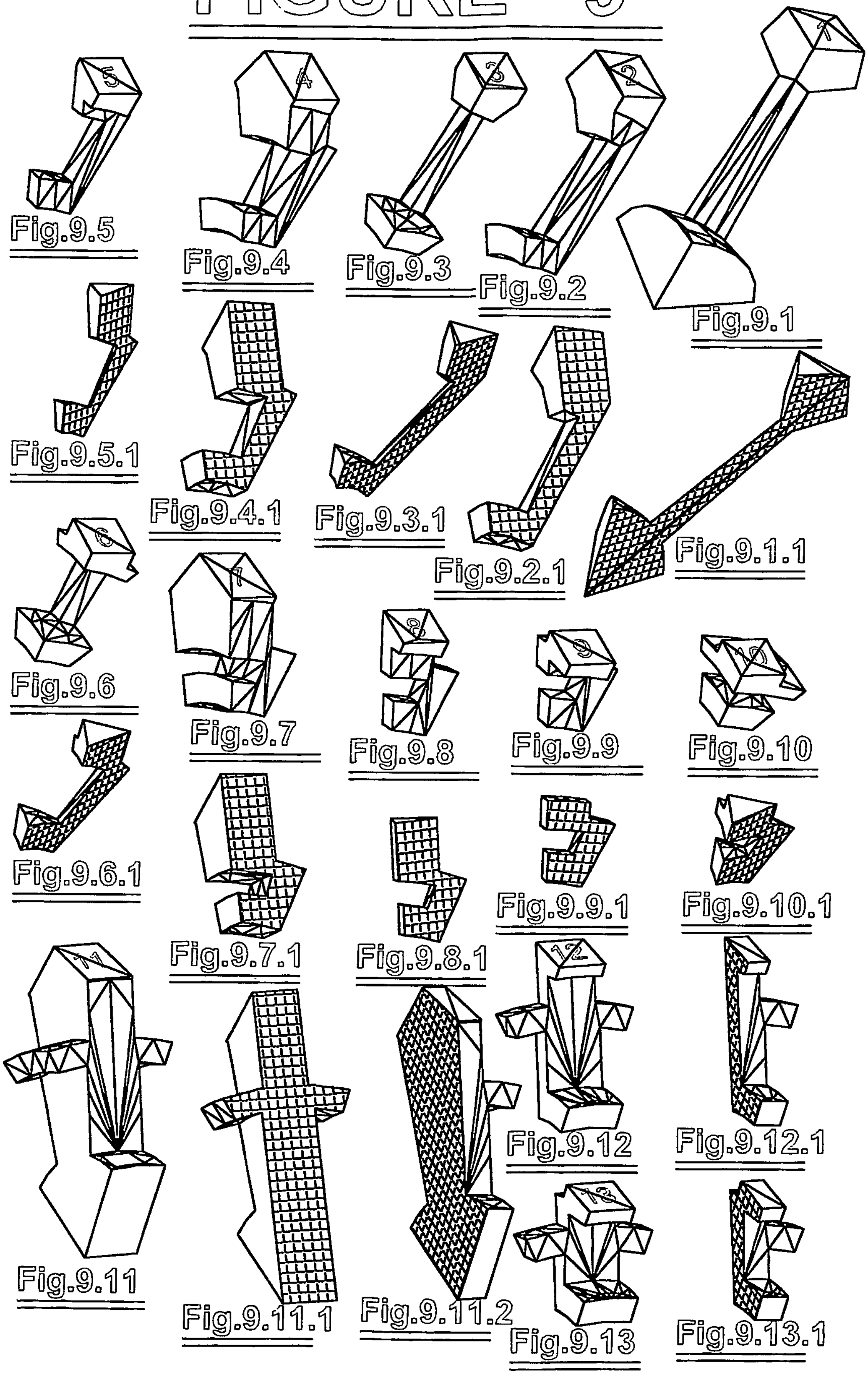


Fig.9.1 Fig.9.2 Fig.9.3 Fig.9.4 Fig.9.5

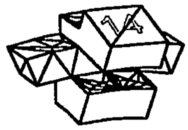
Fig.9.1.1 Fig.9.2.1 Fig.9.3.1 Fig.9.4.1 Fig.9.5.1

Fig.9.6 Fig.9.7 Fig.9.8 Fig.9.9 Fig.9.10

Fig.9.6.1 Fig.9.7.1 Fig.9.8.1 Fig.9.9.1 Fig.9.10.1

Fig.9.11 Fig.9.11.1 Fig.9.11.2 Fig.9.12 Fig.9.12.1 Fig.9.13 Fig.9.13.1

FIGURE 9



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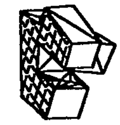

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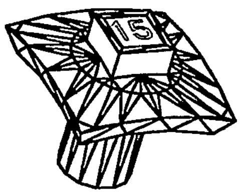

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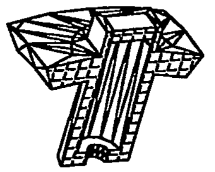

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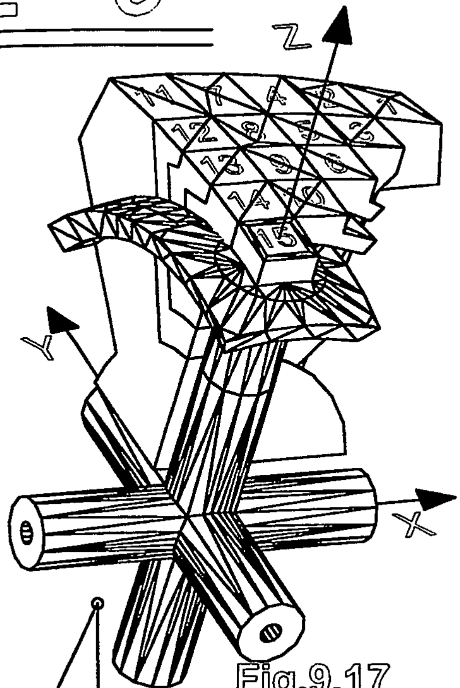

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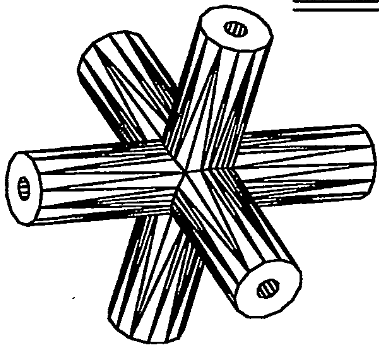

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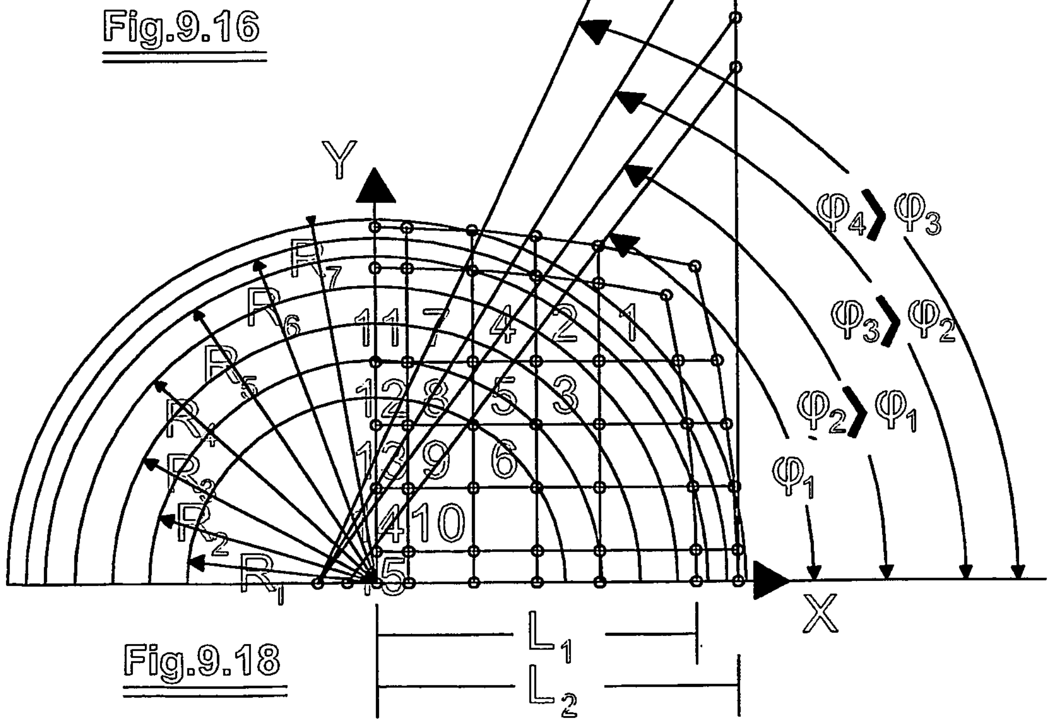
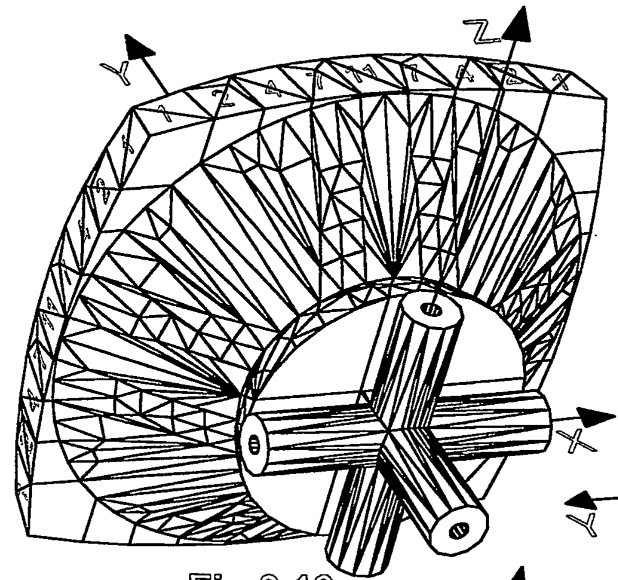


Fig.9.18

FIGURE 9



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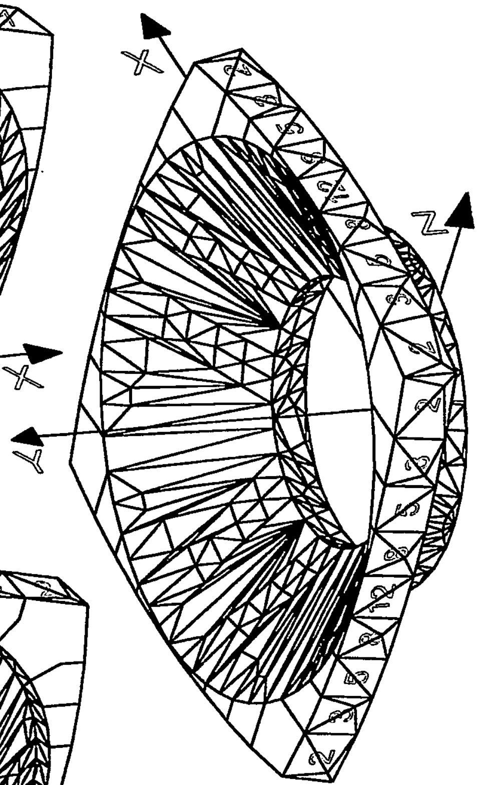

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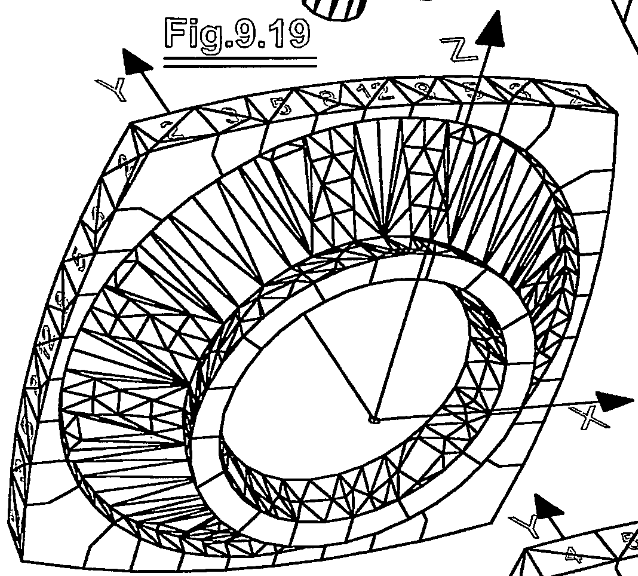

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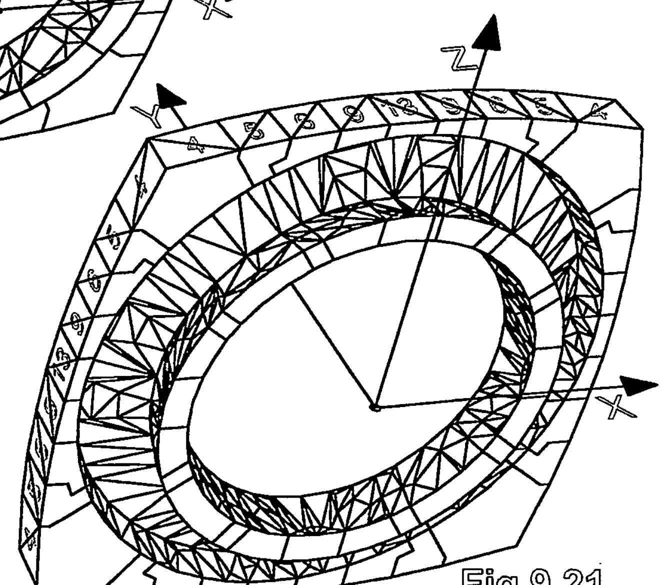


Fig.9.21

FIGURE 9

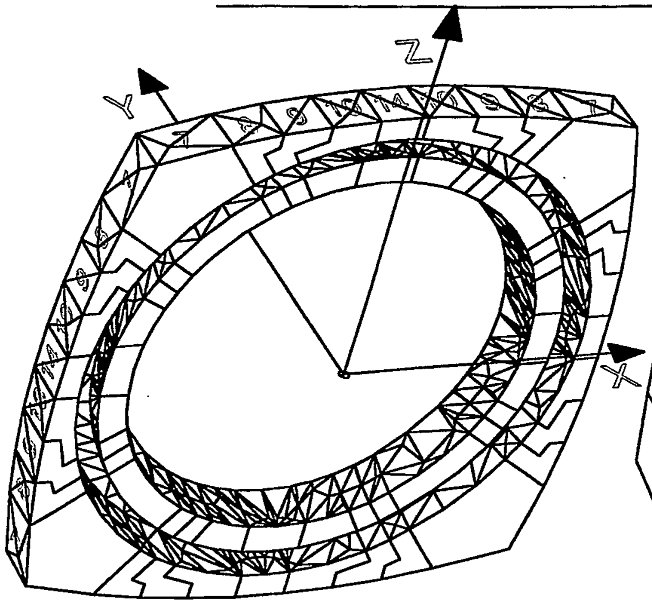
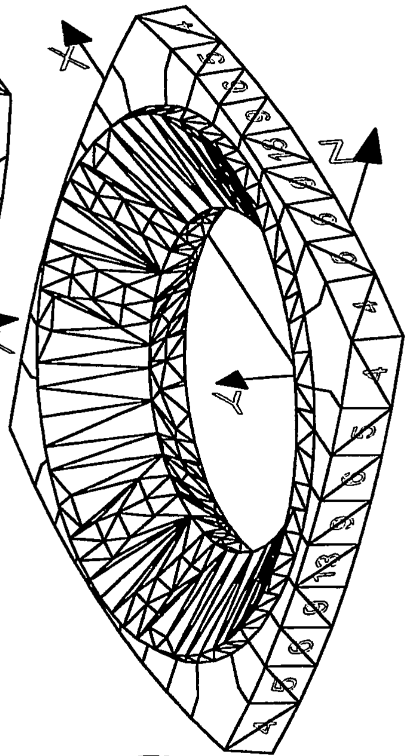


Fig.9.22



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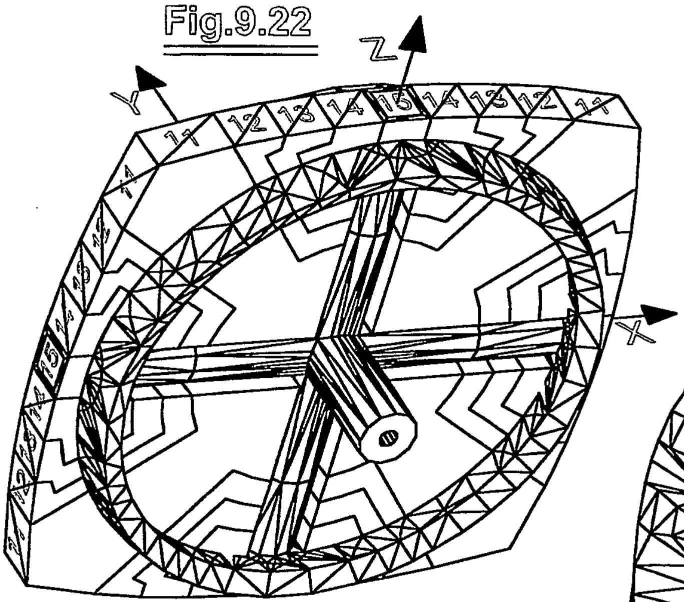

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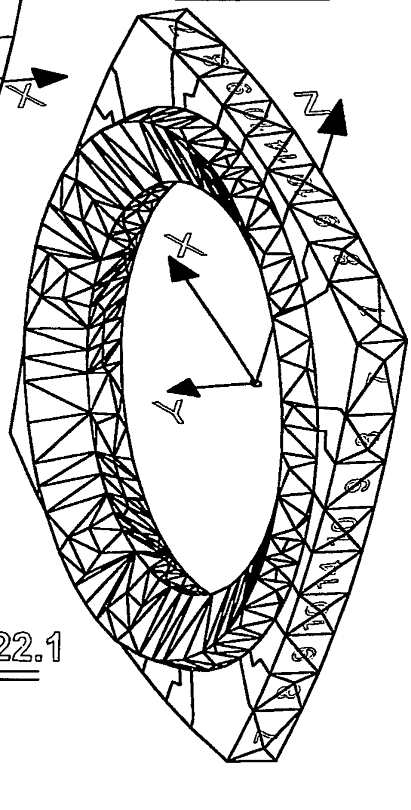
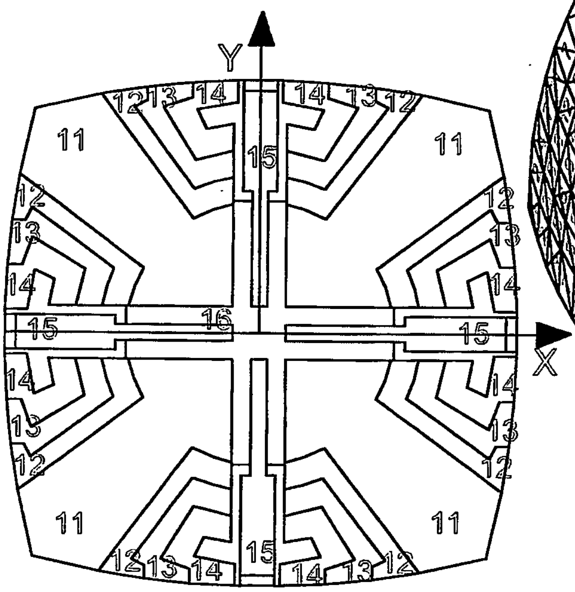


Fig.9.22.1

FIGURE 9



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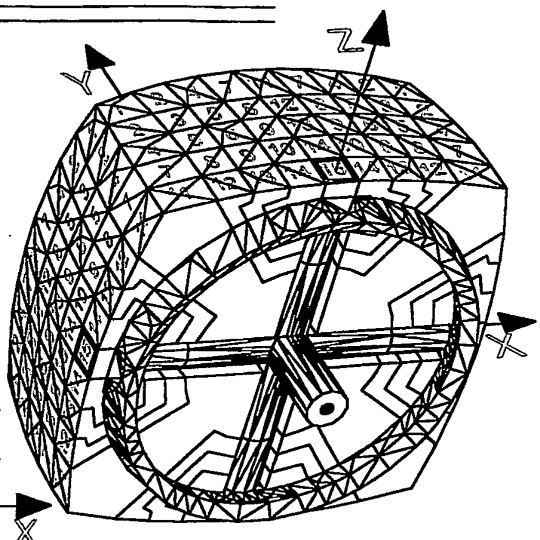

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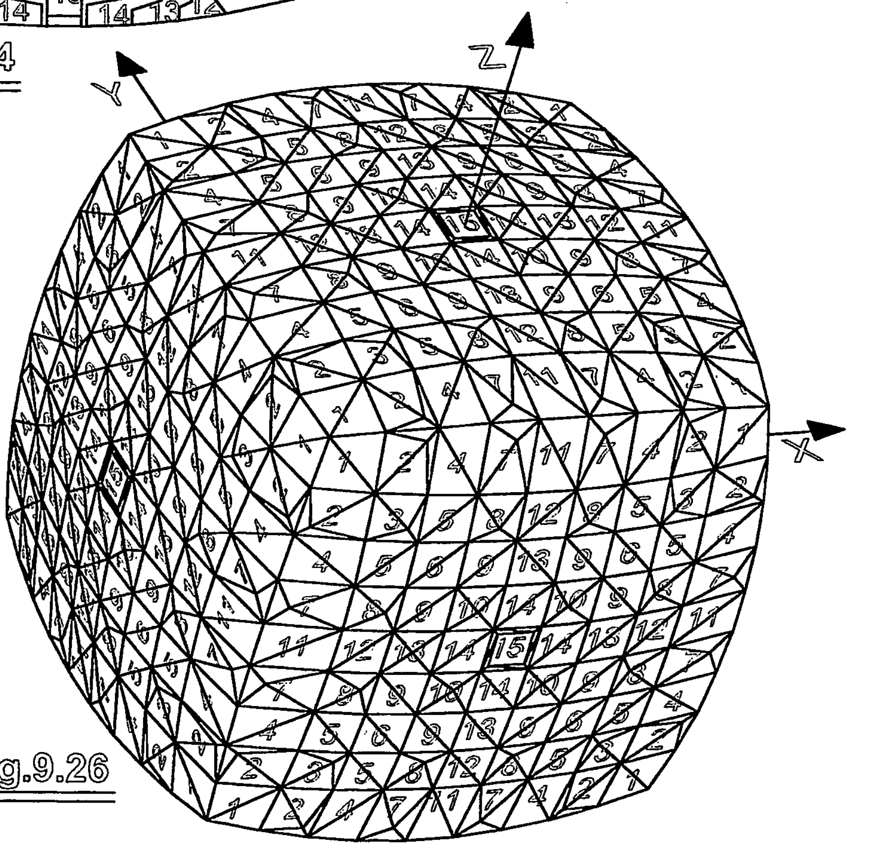

Fig.9.26

FIGURE 10

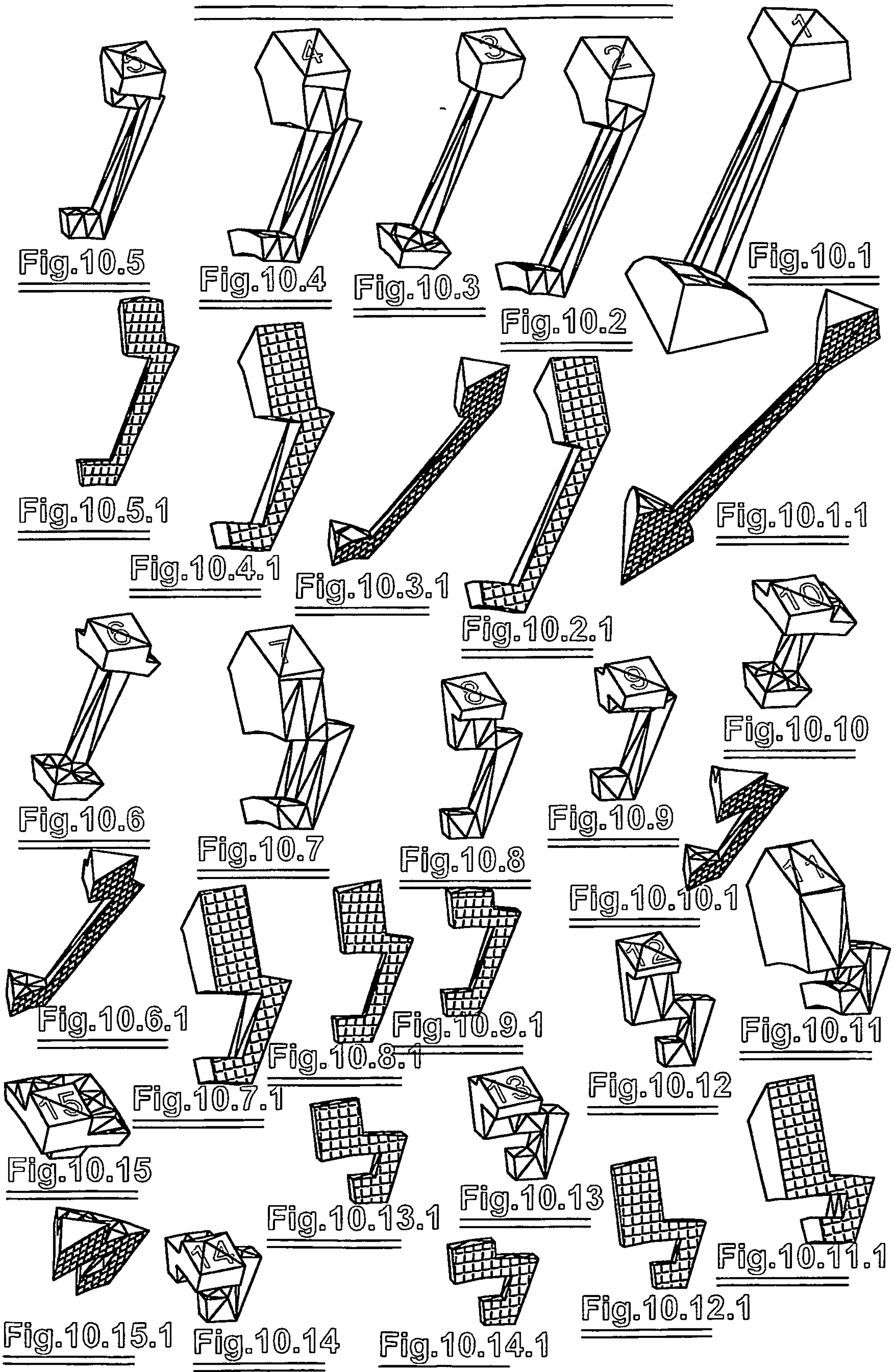
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Fig.10.15
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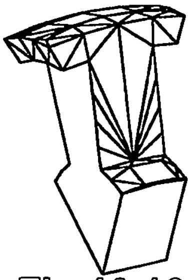
Fig.10.14
Fig.10.14.1

FIGURE 10



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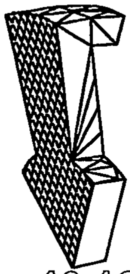

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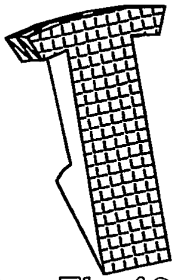

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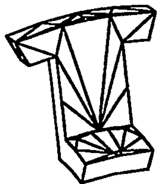

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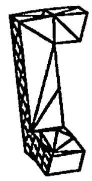

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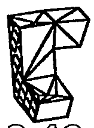

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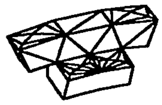

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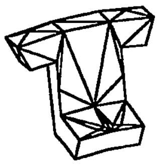

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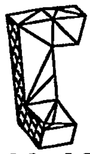

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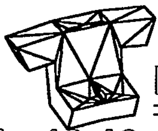

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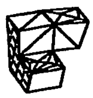

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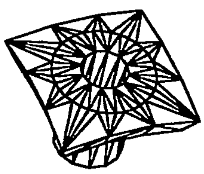

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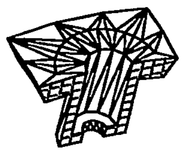

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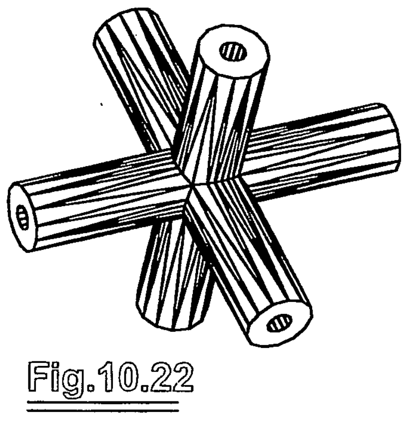

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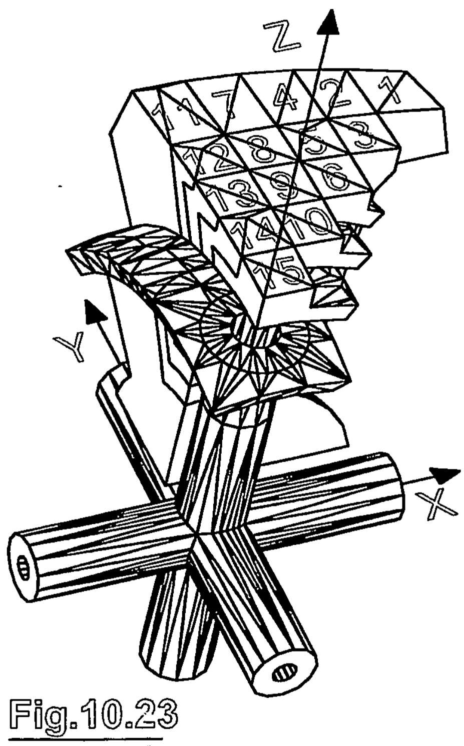
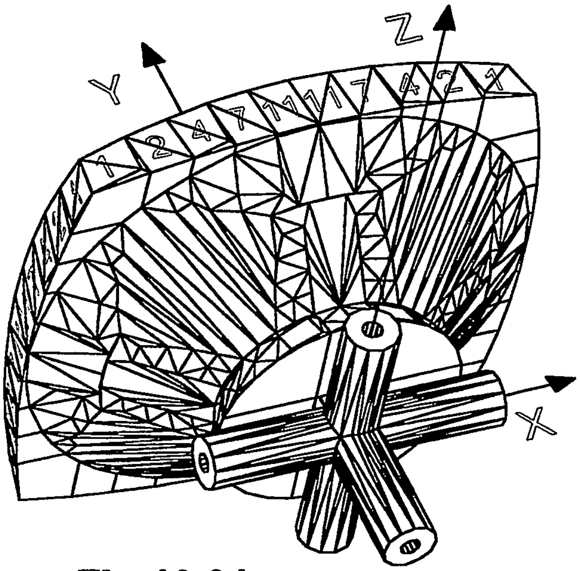


Fig.10.23

FIGURE 10



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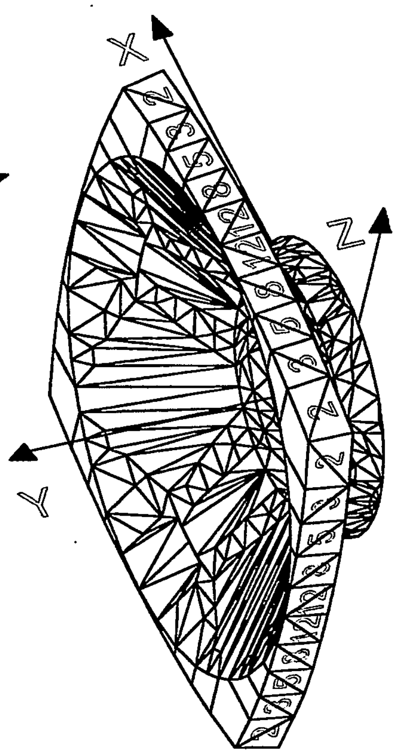

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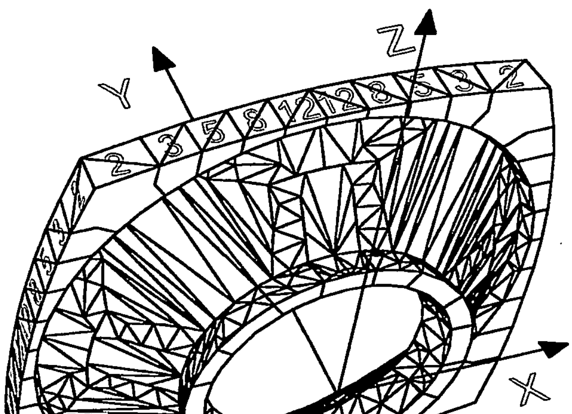
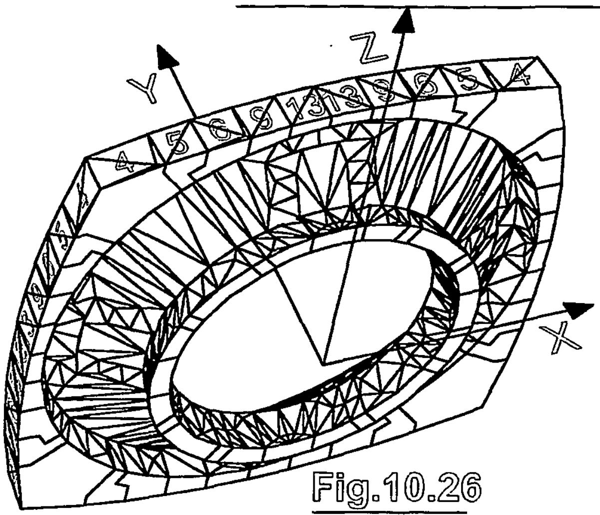


Fig.10.25

FIGURE 10



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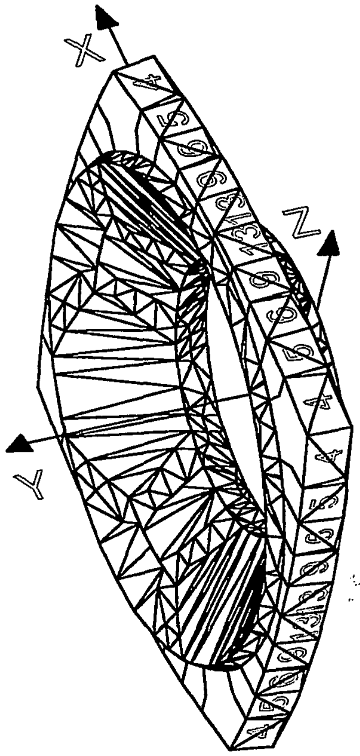

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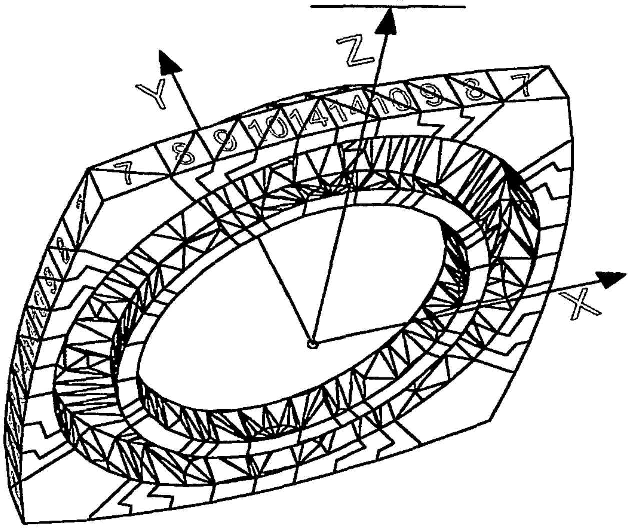

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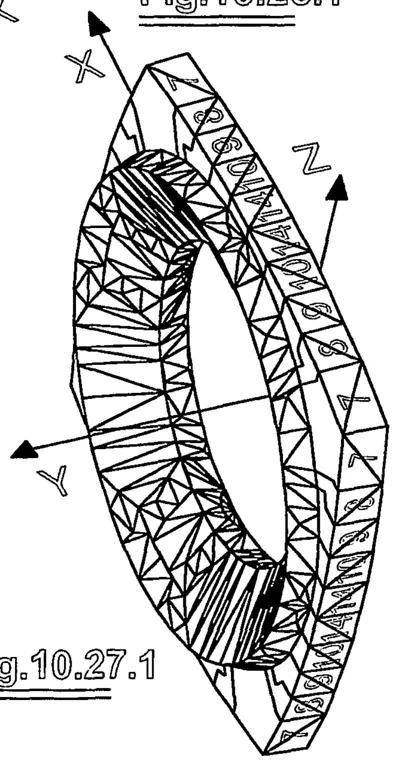
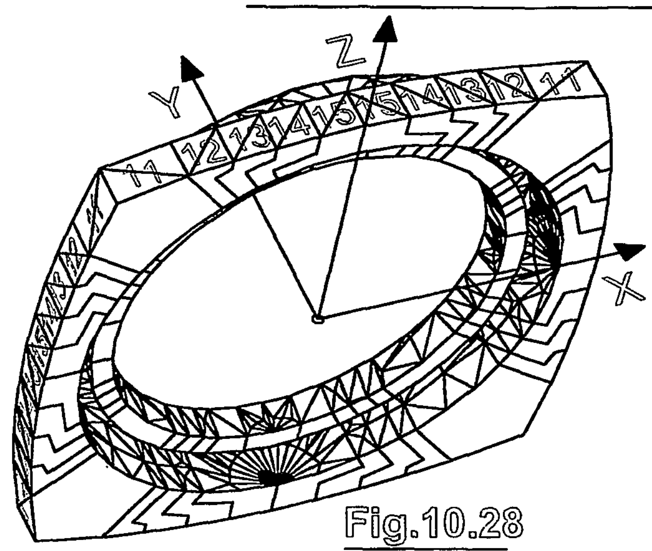


Fig.10.27.1

FIGURE 10



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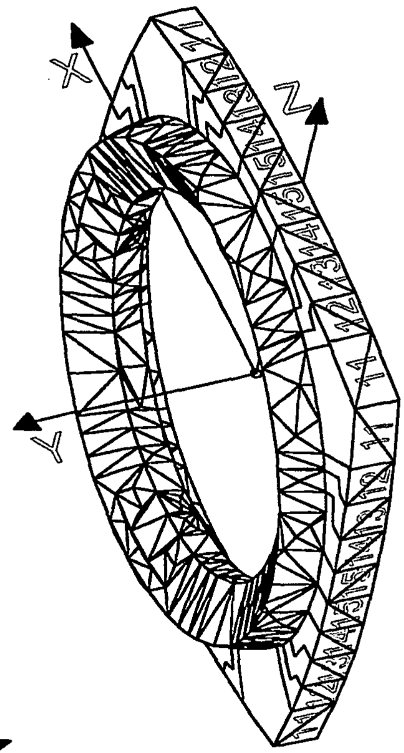

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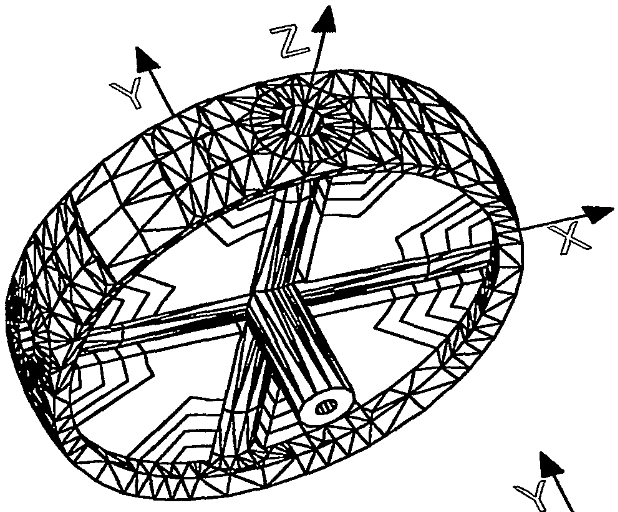

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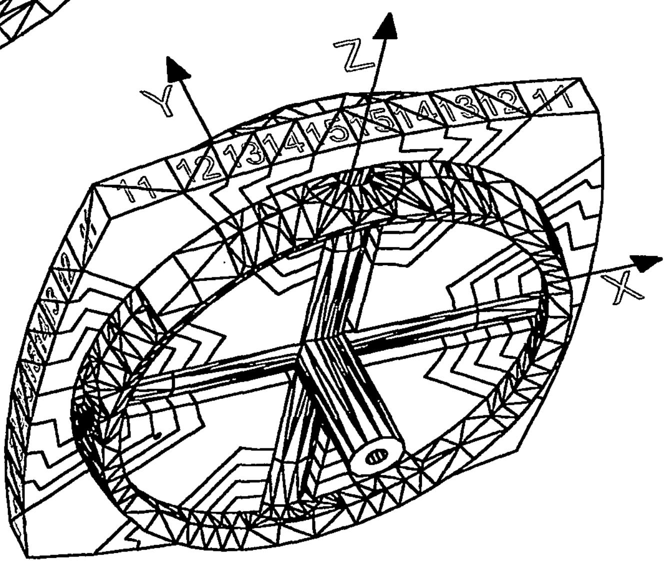
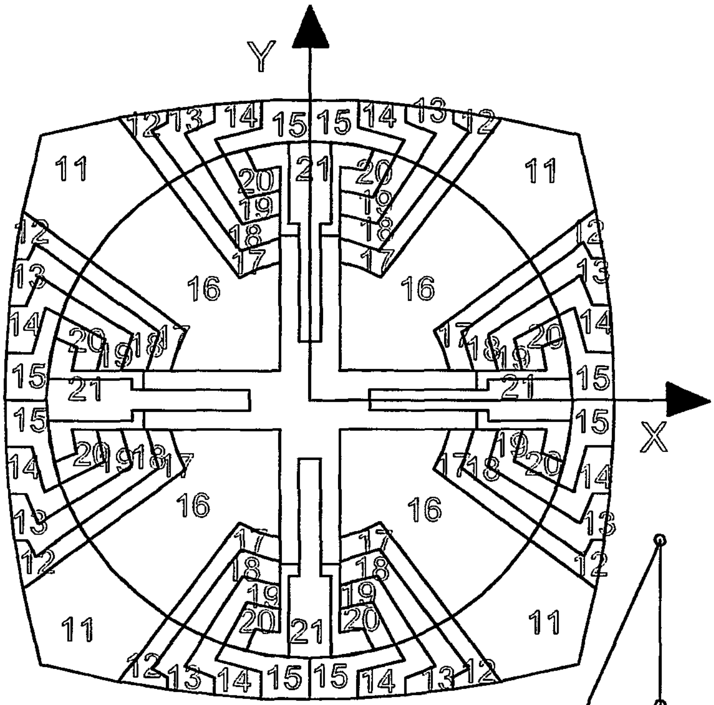


Fig.10.30

FIGURE 10



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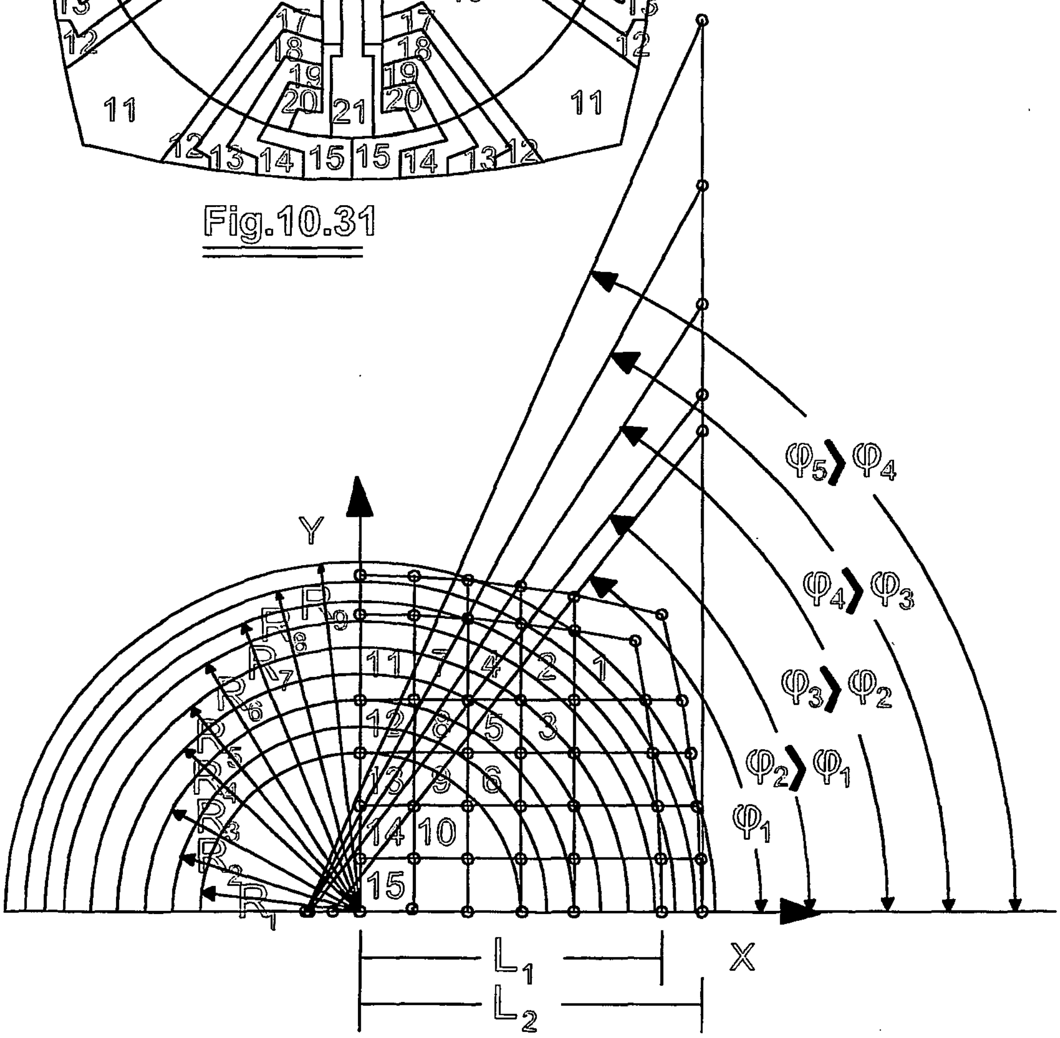
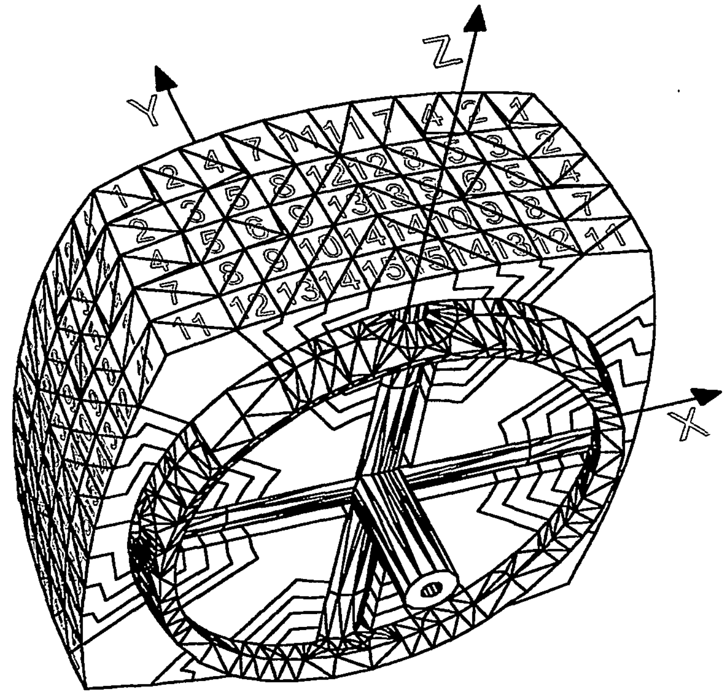


Fig.10.32

FIGURE 10



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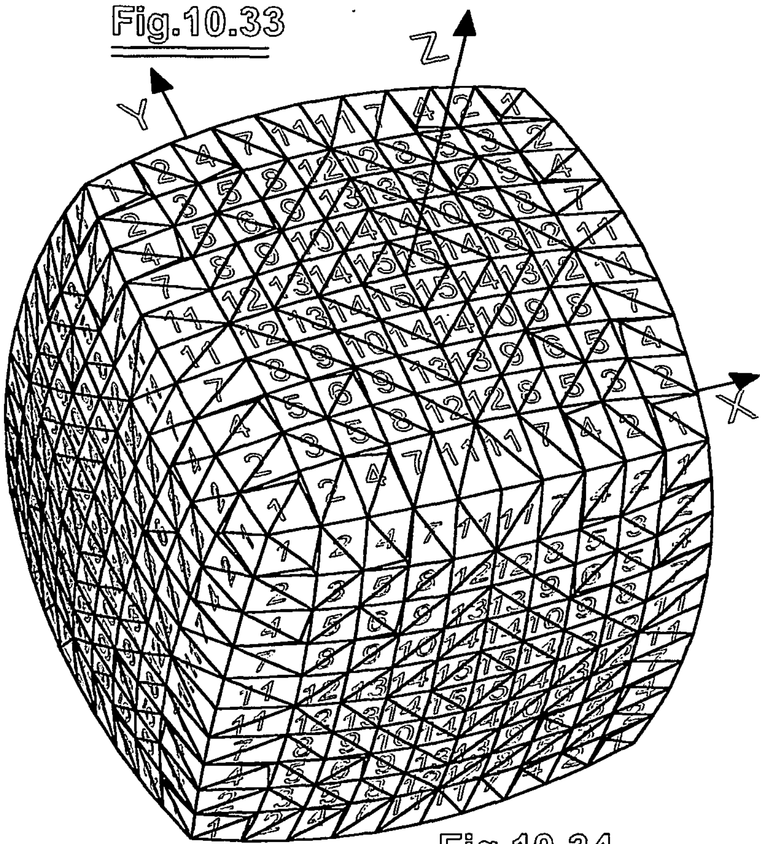

Fig.10.34

FIGURE 11

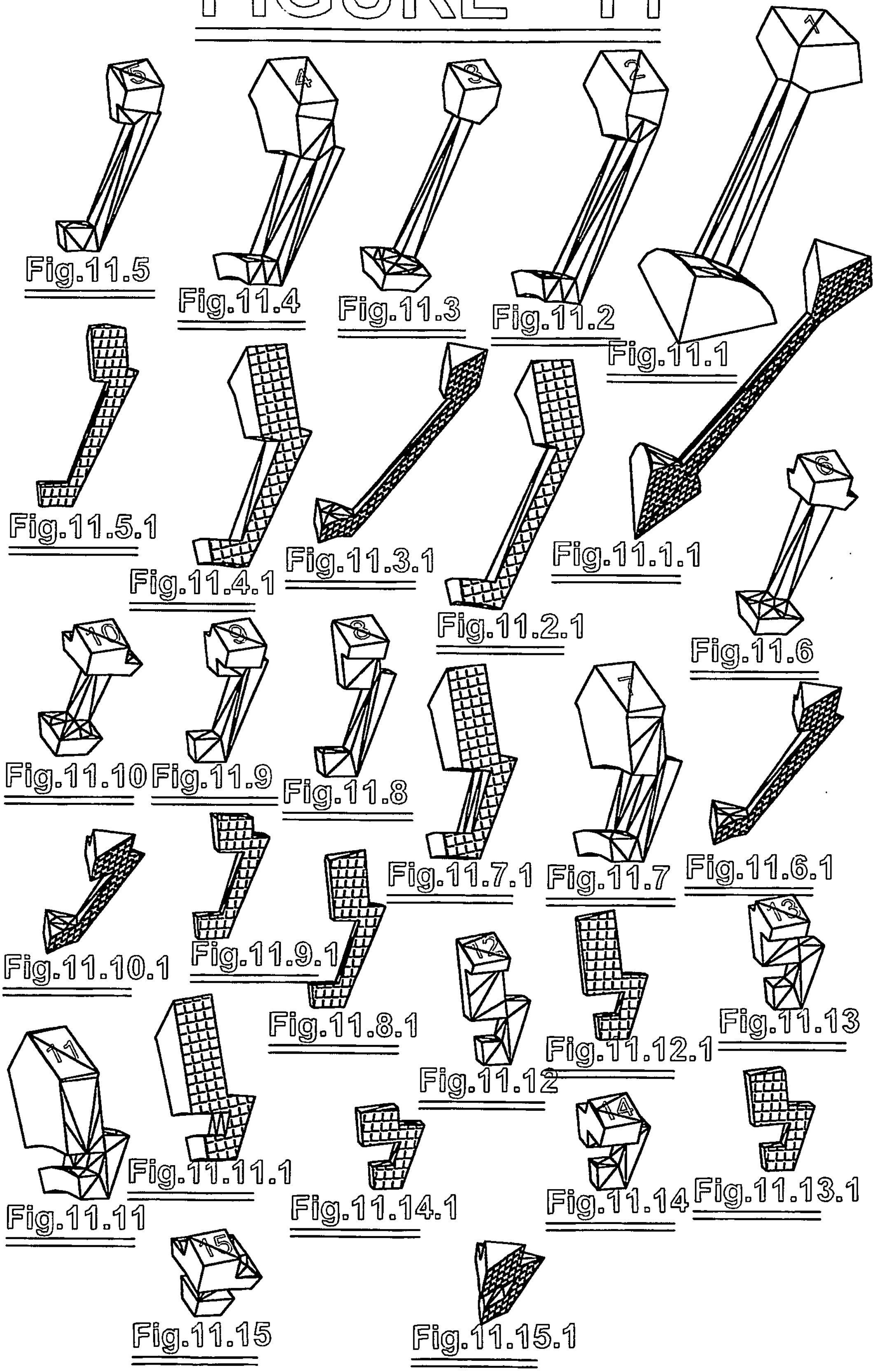
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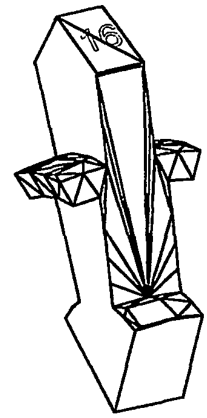
Fig.11.15.1

FIGURE 11



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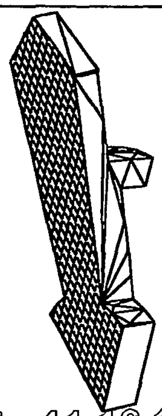

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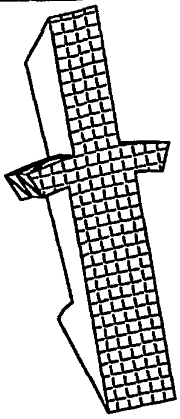

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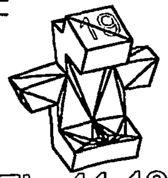

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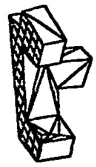

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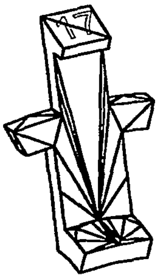

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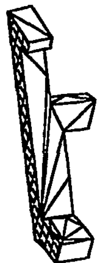

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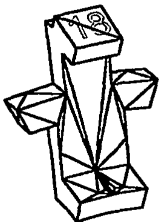


Fig.11.18

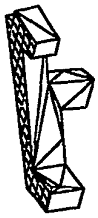


Fig.11.18.1

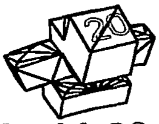
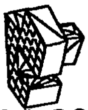


Fig.11.20



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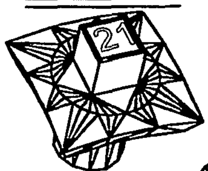
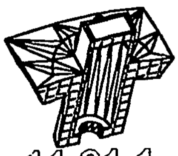


Fig.11.21



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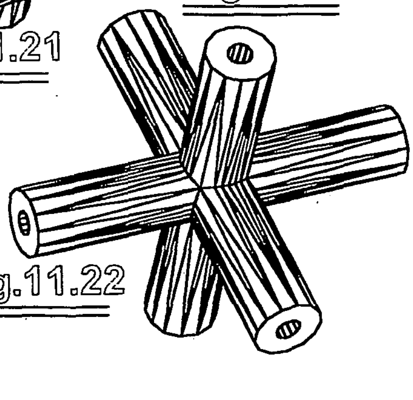


Fig.11.22

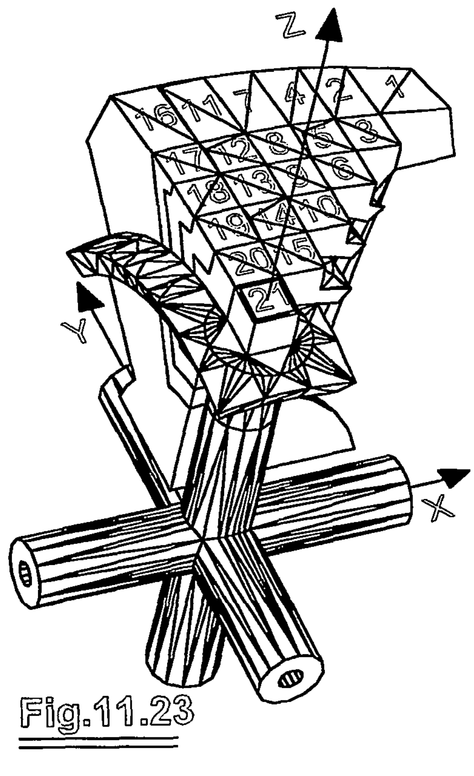


Fig.11.23

FIGURE 11

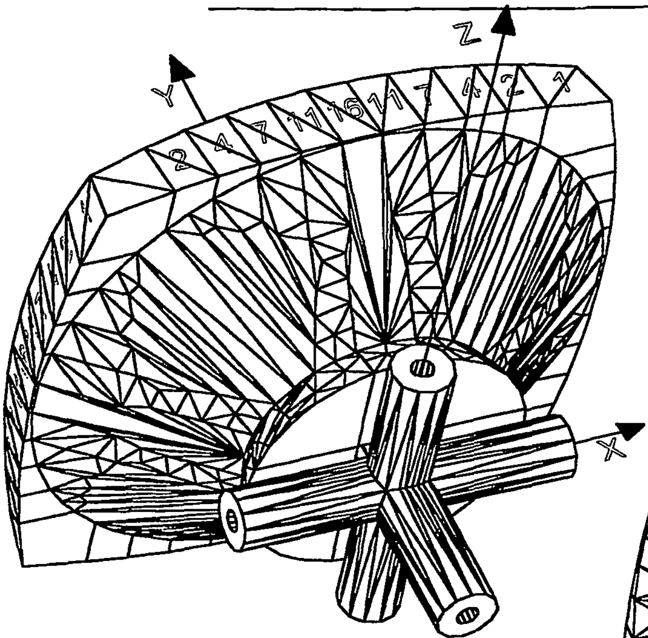
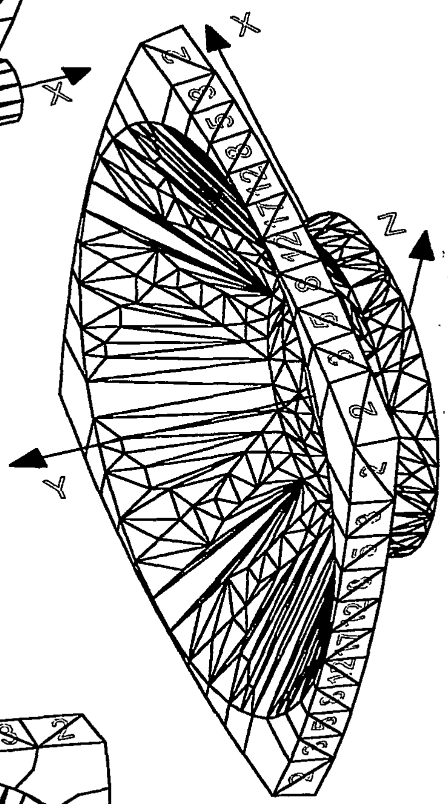


Fig.11.24



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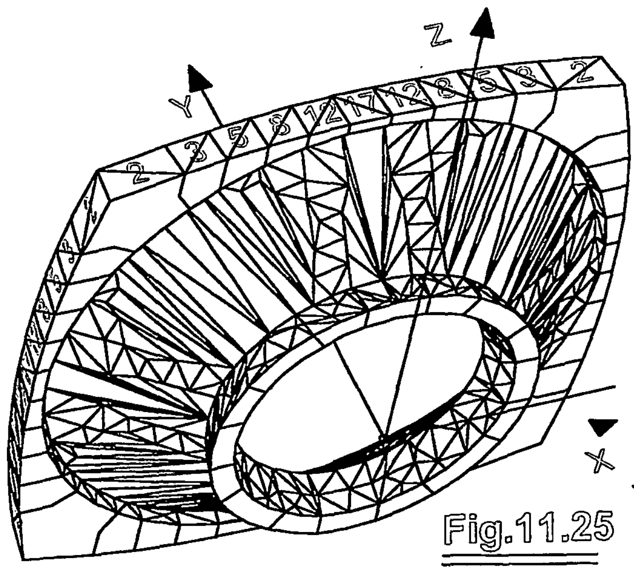

Fig.11.25

FIGURE 11

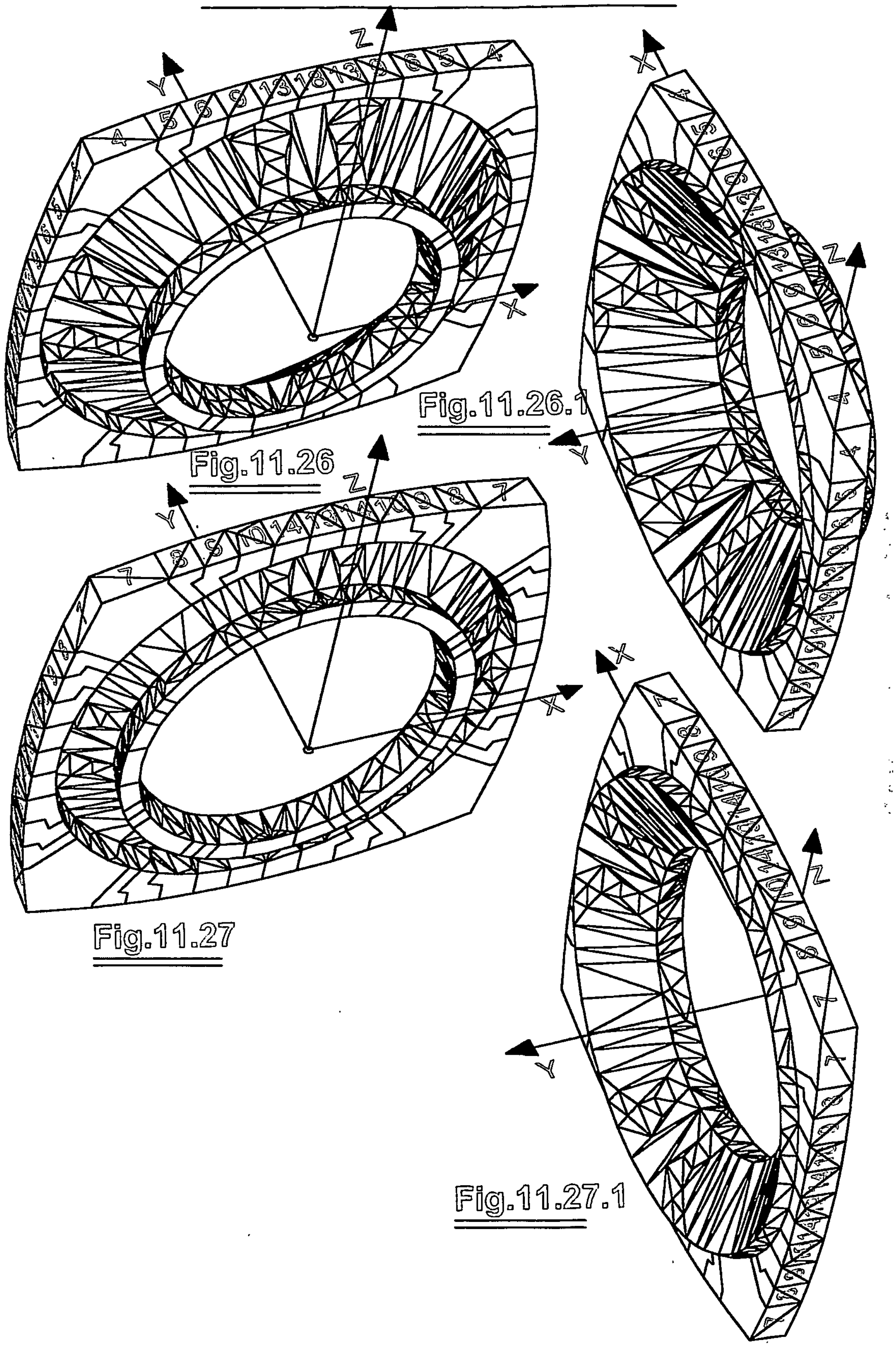

Fig.11.26

Fig.11.26.1

Fig.11.27

Fig.11.27.1

FIGURE 11

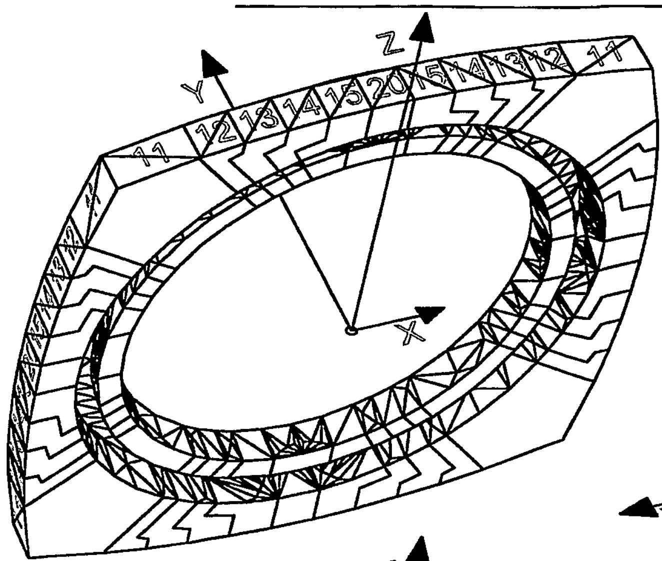

Fig.11.28

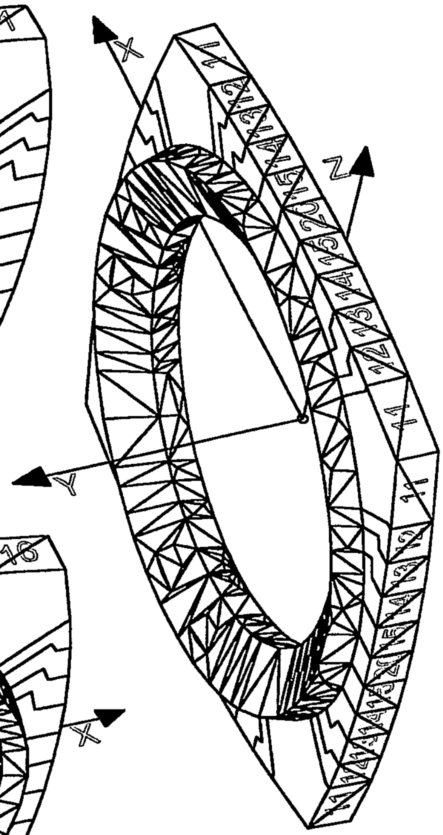

Fig.11.28.1

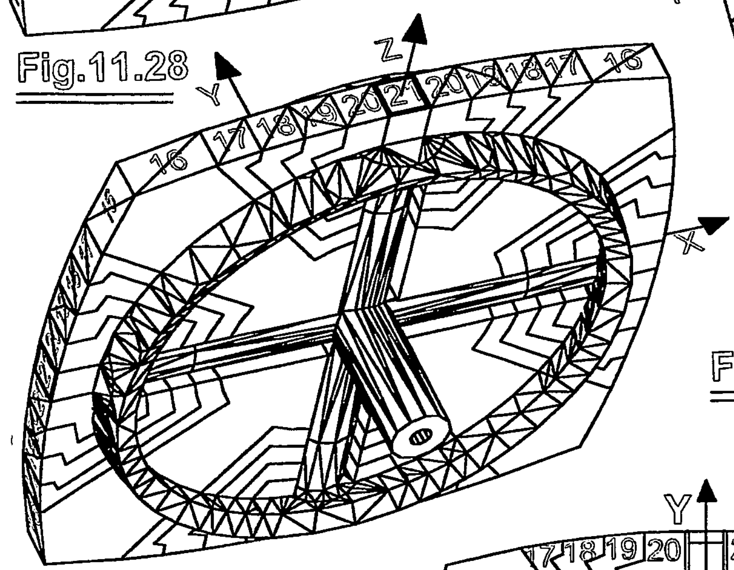

Fig.11.29

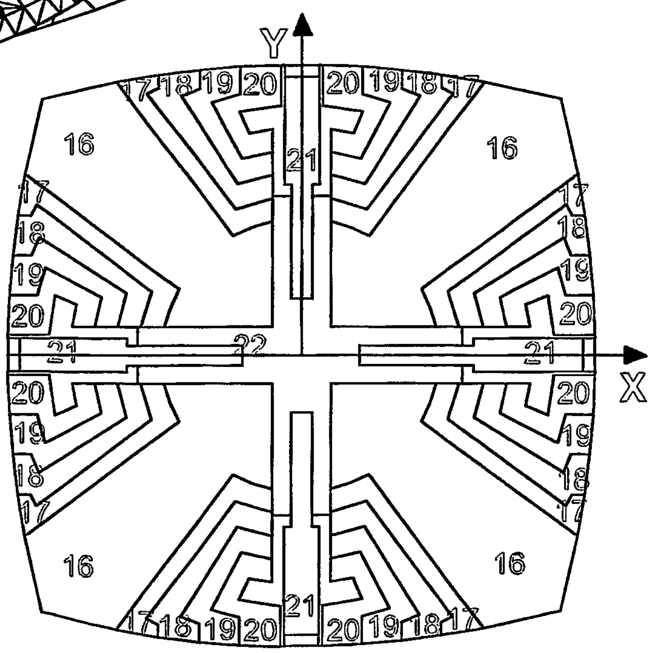

Fig.11.30

FIGURE 11

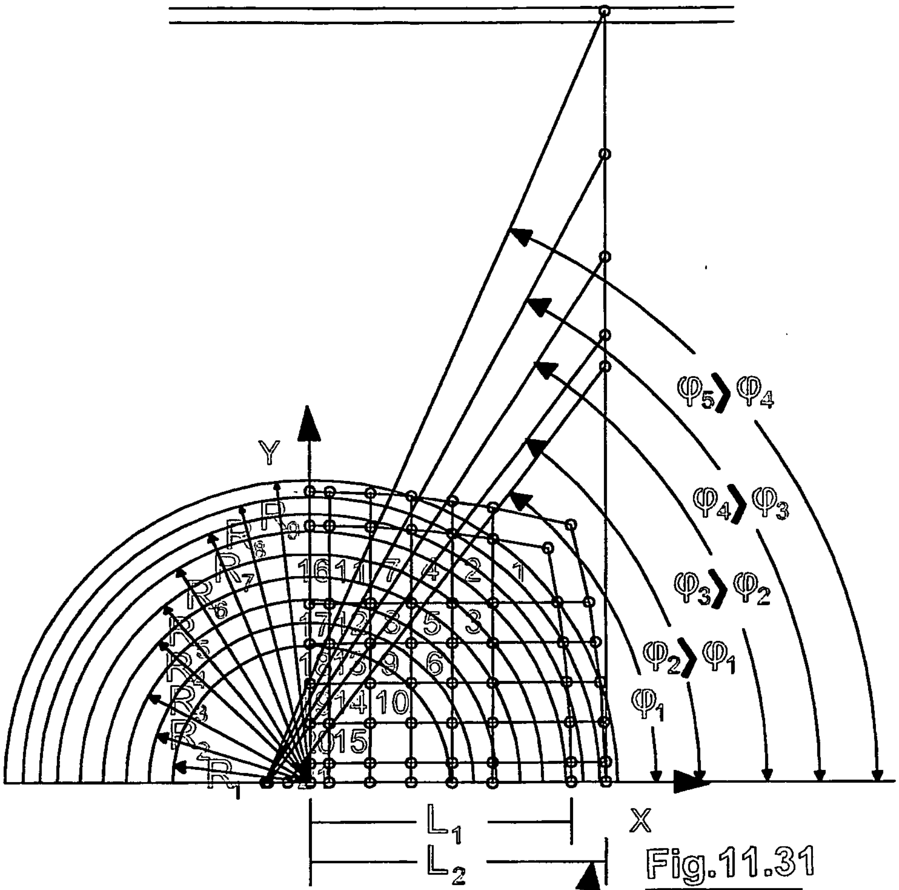

Fig.11.31

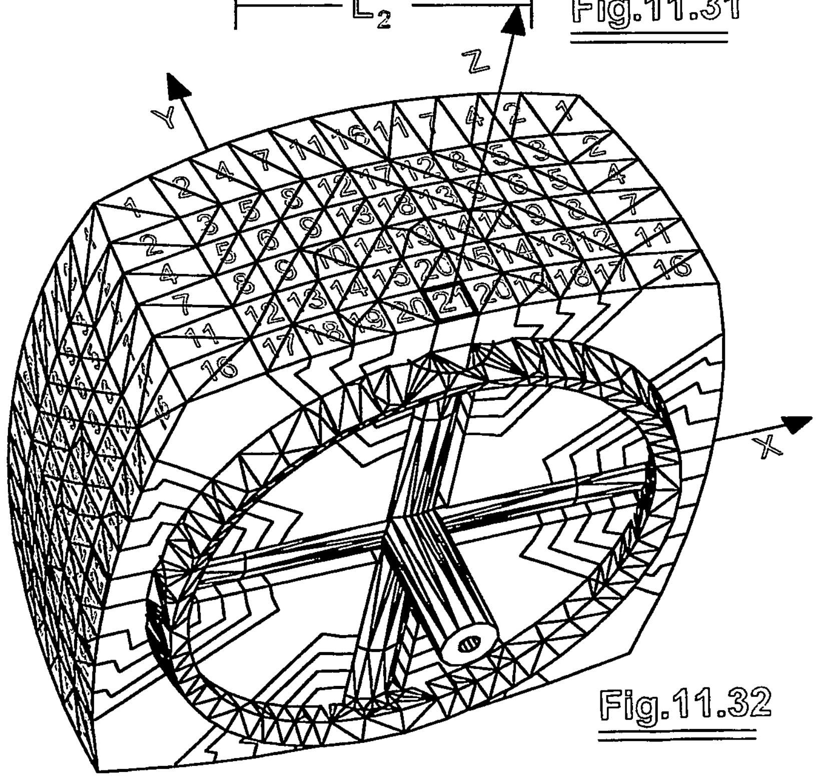

Fig.11.32

FIGURE 11

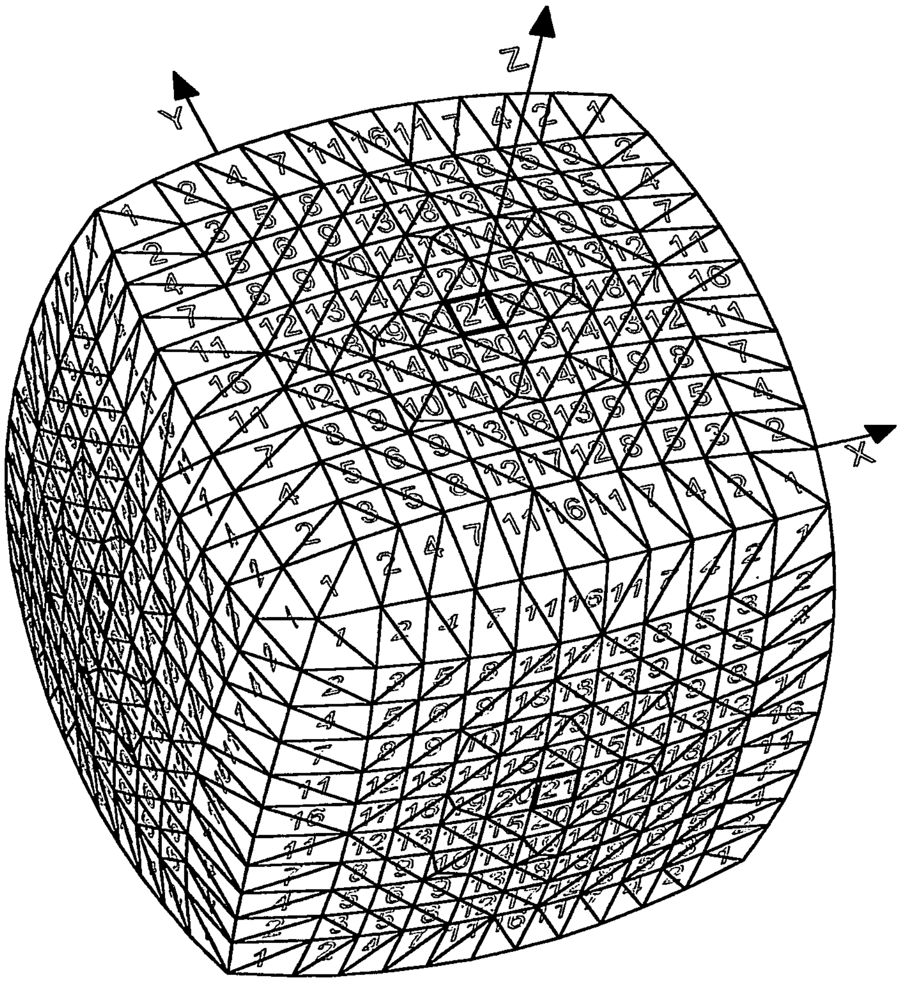

Fig.11.33

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 8301203 A **[0004] [0004]**