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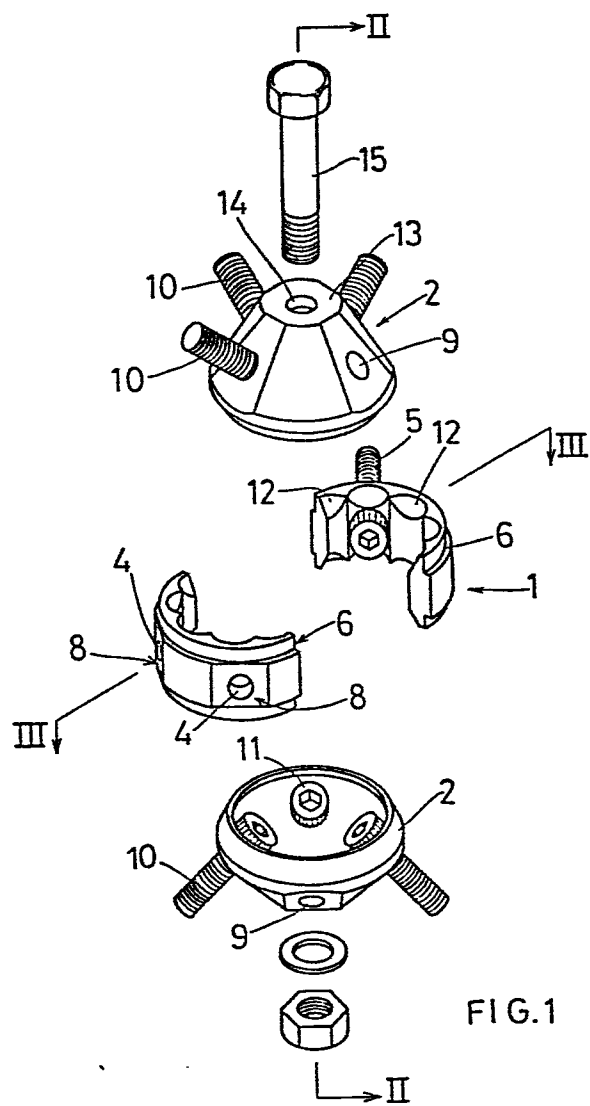
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(54) **Improvements in or relating to space frame connector elements.**

(57) A space frame connector element for interconnecting frame members of a space frame is provided wherein the connector element is composed of a first ring shaped part (1), a second part (2) having a convergent wall section and, in most cases, but not necessarily all, an oppositely directed third part (2) usually identical to the second part. The first ring shaped part may optionally be split (3) diametrically and has angularly spaced holes (4) adapted to accommodate co-planar fasteners (5) attached, in use, to frame members. The second and third parts (12) each have angularly spaced holes (9) also for receiving fasteners (10) but in this case the fasteners extend at an incline, usually 45°, to the plane of the fasteners associated with the first part. The two or three parts are clamped together using a common bolt (15) the like and circumferential formations (12) on the parts interengage to properly locate the parts and, where the ring shaped first part is split, to hold these parts together in the radial direction.

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"IMPROVEMENTS IN OR RELATING TO
SPACE FRAME CONNECTOR ELEMENTS"

THIS INVENTION relates to space frame components and assemblies thereof wherein the space frame is defined by a plurality of generally tubular frame members having their ends connected to free ends of other frame members by means of suitable connector elements.

Space frames of the above general type are usually assembled to form quadripoids (ie. pyramids) coupled together to form a frame suitable for supporting a roof or the like and having an extended area in plan view. Such a space frame requires few or no columns to support the central region thereof and, thus, are employed where large areas of "column-free" space are required.

Such space frames have been made for many years and all have the common feature of having connector elements to which the free ends of a number of frame members can be attached in order to

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connect them together. Such connector elements are not only required to connect co-planar frame members, but also, frame members extending at an incline to the plane which contains some of them to define the above mentioned quadripoids. The frame members defining the quadripoids could be co-incedent with, or offset from, the co-planar frame members in plan view as may be required.

Some examples of the way in which frame members have been connected together heretofore include the following:-

(a) The ends of tubular frame members are flattened, drilled and then bolted to an "octopus" assembly as a connector.

(b) The simple welding of a metal box to the free ends of a plurality of tubes forming the quadripoids is another commonly used method.

(c) Steel discs with a series of holes at the perimeter have been employed to bolt flattened tube-ends thereto.

(d) Certain clamping methods have been employed and these include the

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clamping of the head of a grub screw
or the like in corresponding, co-
operating recesses between the two
members which can be clamped together
by means of a nut and bolt.

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All the above suffer from some
disadvantage or another which are generally apparent
during erection or construction of the space frame.
Thus, in many cases, the means of connecting the
frame members to the connector elements is
inconvenient and requires that more than one person
be present to hold the frame members in the correct
positions. Also, for example, where the head of a
grub or socket headed screw is clamped between two
members in co-operating recesses, all the grub
screws which are to be clamped between the same two
members must be located loosely in their recesses
prior to the two members being secured together.
This is often inconvenient and also requires more
hands than a workman may have available.

It is the object of this invention to
provide a connector element and co-operating frame

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members which, it is envisaged will be easier to install in an operative position and, in addition, will provide flexibility as to its application in use. It is a secondary and optional object of the invention to decrease the physical size and thus the cost of connector elements.

In accordance with this invention there is provided a space frame connector element comprising at least a first and second part whereof the first part is in the form of a ring (which may be split) having angularly spaced holes in the wall thereof to receive co-planar fasteners associated with frame members, the second part has at least a convergent wall section provided with holes therethrough at suitably angularly spaced positions with the axes of the holes being at substantially right angles to the convergent wall sections in which they are located, co-operating formations on the two parts (and, in the case where the ring is split, for retaining the parts of the ring together,) and means for holding the two parts in fixed association with each other.

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Further features of the invention provide for the first part to be a ring shaped member split at diammetrically opposed positions on the periphery of the ring; for a third part to be provided and having formations co-operating with the end of the ring opposite the second part for maintaining the parts of the ring in association with each other; for the said third part to be identical to said second part with the convergent wall sections extending in the opposite direction; and for said means for holding the parts together to be a fastener passing through the first, second and, where present, the third parts to clamp them together.

It is preferred that bolts be installed to extend from the interior of the connector outwardly in order to secure the ends of frame members having screw threaded nut formations fixed relative thereto. Such bolts conveniently have the form of a grub screw with a knurled outer surface and hexagonal shaped socket head operable by means of a conventional Allen-key. The splitting of the ring

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enables such an Allen-key to be employed on the socket of a bolt without too much interference from the remainder of the ring even though there may only be little space available.

5 The employment of bolts to extend outwardly from the interior of the connector element enables the element to be made very much smaller than in the case where nuts have to be tightened on the inside of the connector element which would
10 necessitate that the element be made fairly large. However, such a variant is intended to fall within the scope of this invention.

 Where the first mentioned arrangement is employed, the element can be made so small that the
15 peripheries of the heads of bolts passing through the holes in the second and where present, the third parts, co-operate with specially provided notches in the inner periphery of the ring in order firstly, to accommodate the heads, and, secondly to orientate
20 the second and third parts angularly relative to the first part and the axis of the connector element.

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In order to enable the co-planar and quadripoid frame members to be of equal length there may be lugs formed on the outside surface of the ring where the frame members are connected thereto. Alternatively, the whole connector element could be made to be substantially spherical in shape in the operative condition.

In order to avoid the employment of additional lock nuts on the bolts on the exterior of the connector it is preferred that means be embodied within the connector for holding the head substantially in engagement with its adjacent surface surrounding the hole through which it extends. Such means could take any suitable form and may, in fact, be in the form of specially manufactured and shaped inserts co-operating with the bolt heads and also, for example, a bolt passing through the connector element in order to secure the parts thereof together. It is also envisaged that the bolts could be provided with a circumferentially extending groove in the surface thereof on the exterior of the connector element and a circlip and washer arrangement could be employed to maintain the bolts in position axially with respect to their holes.

A further alternative is to provide a suitable deformable sleeve, the ends of which are arranged to maintain the heads of the quadripoid bolts in position and the central region of which is adapted to deform outwardly as the bolt securing the parts of the connector element together is tightened. This is a well known principle of circumferential expansion of an element.

In order that the invention may be more fully understood one embodiment thereof will be described with reference to the accompanying drawings in which:-

Fig. 1 is an exploded view of a connector element according to this invention;

Fig. 2 is a sectional elevation taken along line II - II in Fig. 1 but with the connector element in an assembled condition; and,

Fig. 3 is a sectional plan view taken along line III - III in Fig. 1, and also in an assembled condition.

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In this embodiment of the invention the connector element comprises three parts, namely, a split ring 1 and two roughly conical shaped parts 2, one of which is adapted to be associated with each end of the ring 1.

The portions 3 of the ring are defined by diammetrically opposed cuts therein and each of the portions accommodates two symmetrically located holes 4 for receiving socket headed bolts 5 passing therethrough in co-planar manner. Thus the four bolts will extend in directions angularly spaced by 90° from each other.

The ring is provided with a rebate 6 at each end thereof in the outer end surface of the ring, this rebate defining a formation for co-operation with a encircling lip 7 of the adjacent conical part 2. These lips therefore maintain the parts of the ring in proper association with each other in use by co-operation with each of the rebated ends.

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The outer surface of the ring is flattened as indicated by numeral 8 in the region of each hole 4 so that an end of a frame member can be clamped firmly up against such flattened surface.

5 It will be understood that, as a result of the splitting of the ring, the ring can be made extremely small as access by an Allen-key to the socket heads of the bolts can easily be achieved without interference. In fact, the ring can be made
10 so small that very little space exists between the bolt heads and the shank of a bolt used to secure the parts of the connector element together. This can be seen most clearly in Figs. 2 and 3. If, however, the ring is large enough, it need not be
15 split at all.

Turning now to the conical parts 2 of the connector element, each of these is provided with four holes 9 in the walls thereof so that four bolts
10 can be passed through these holes in a substantially "quadripoid" relationship relative to each other. That is to say that the bolts will extend at approximately 45° to the plane in which the four bolts of the ring are located and will, in
20 plan view, be offset from each other by 90°.

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5 The heads 11 of these bolts will, when the
ring is dimensioned as indicated above, generally
foul the inner edge of the ring 1 and, this feature
is employed to positively locate the conical parts
relative to the ring part in certain fixed angular
positions. Thus, the inner edge of the ring part is
recessed as indicated by numeral 12 with recesses
adapted to co-operate with the round external
surface of the head 11 of each of the bolts 10. In
10 general the recesses are orientated such that the
bolts 10 can either, in plan view, be coincident
with the bolts extending from the ring or can be
offset angularly therefrom by 45°.

15 The apex of each cone member is flattened
as indicated by numeral 13 and perforated with a
hole 14 to receive a bolt 15 passing axially
therethrough.

20 It will be understood that, in use, the
bolts 5 or 10 associated with a part of the
connector can be attached to an end 16 of a tubular
frame member 17 (see Fig. 3) the end having, for
this purpose, an internally screw threaded fitting
18 welded to the frame member. It will be

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understood that each half of the ring shaped part can be attached to two frame members whilst each conical shaped part can be attached to four of such frame members. Once all these attachments have been made and the degree to which each bolt extends into its screw threaded fitting adjusted as required, the ring can be assembled and the conical shaped parts associated therewith preparatory to tightening the bolt 15 connecting all the parts together.

10 Whilst it may be possible to dimension the parts of the connector element such that the bolt itself engages all the heads of the socket headed bolts to prevent them from moving inwardly where the end of a frame member is not abutted against the
15 outer surface of the connector element, it may alternatively be necessary to provide some other means to ensure that the heads remain in their required position.

20 As indicated above fittings could be made to bear against the bolt 15 connecting the parts together and also against the heads of the socket headed bolts.

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Such fittings could be somewhat deformable to ensure that the bolt heads are urged against the inner surface of the connector element to a desired extent. Alternatively a deformable sleeve arrangement of the type outlined above could be employed at which each end of the sleeve co-operates with the bolts 10 of a conical part of the connector element whilst the central region is adapted to bulge outwardly during tightening of the assembly bolt 15 to engage the heads of the bolts 5 associated with the ring.

It will be understood that many variations may be made to the abovedescribed embodiment of the invention without departing from the scope hereof.

In particular, the ring could, if necessary, be made as one piece or, indeed, could be made as three or more pieces. However, it must be borne in mind that the more pieces there are the less advantageous is the connector element when compared to certain prior art connector elements. This is particularly so when considering the assembly of the parts of a connector into their final condition.

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Also, the bolts could have conventional shaped heads but, again, this is disadvantageous from the point of view of manipulation of such heads, a socket being very much preferred. Finally
5 the formations for locating the conical members in desired angular orientations relative to the ring could be of any other form and could, in fact, be formations specially provided on the conical members and ring.

10 It is to be remembered that as stated above, if an even length of frame members is required the whole assembled connector element may be of a spherical shape. Alternatively, the ring may have lugs on the outside to make up the
15 shortfall.

It is envisaged that a connector element and frame members made according to the invention will be very much superior in use to the prior art types of assemblies and, in addition, the
20 manufacturing costs are low.

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CLAIMS:

1. A space frame connector element comprising at least a first and second part whereof the first part is in the form
5 of a ring having angularly spaced holes in the wall thereof to receive co-planar fasteners associated with frame members, the second part has at least a convergent wall section provided with holes therethrough at suitably
10 angularly spaced positions with the axes of the holes being at substantially right angles to the convergent wall sections in which they are located, co-operating formations on the two parts, and means for holding the two
15 parts in fixed association with each other.

2. A space frame connector element as claimed in claim 11 wherein the ring is a split
20 ring and co-operating formations are provided on said two parts for retaining the parts of the ring together in said fixed association with each other.

3. A space frame connector element as claimed in claim 2 in which the first part is ring shaped and split at diametrically opposed positions on the ring.
- 5 4. A space frame connector element as claimed in either of claims 1 or 2 in which a third part is provided and has formations co-operating with the end of the ring opposite the second part.
- 10 5. A space frame connector element as claimed in anyone of claims 1 to 4 in which the second part, and where present the third part, receive a bolt passing therethrough whereby they are clamped to an end of the first part, the bolt defining said means for holding the parts in fixed associated with each other.
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6. A space frame connector element as claimed in either of claims 4 or 5 in which the third part is identical to the second part with the convergent wall sections extending in the opposite direction.
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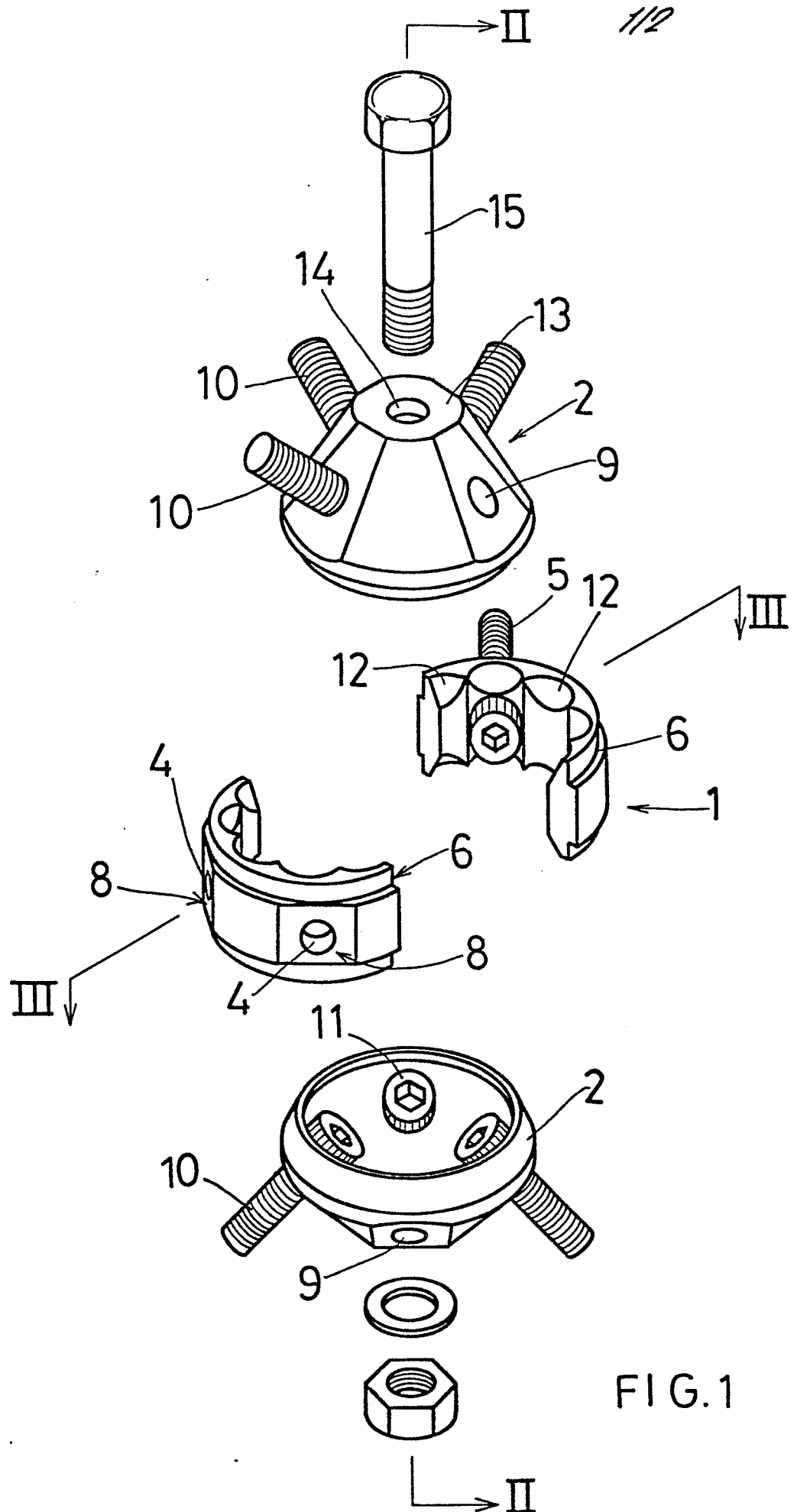
7. A space frame connector element as claimed
in any one of the preceding claims in
which the connector has, or is adapted to
have, bolts extending outwardly from the
interior of the connector to co-operate
with screw threaded nuts or holes in the
ends of the frame members.

8. A space frame connector element as claimed
in any one of the preceding claims in
which notches in the inner periphery of
the ring are provided to accomodate parts
of the heads of outwardly directed
fasteners or bolts and to angularly locate
the ring relative to the second and, where
applicable third parts of the element.

9. A space frame connector element as claimed
in any one of the preceding claims in
which the first, second and, where
applicable third, parts are made to form a
composite element of substantially
spherical shape.

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10. A space frame connector element as claimed
in any one of claims 1 to 8 in which the
second and, where present the third part,
are made to a hollow roughly truncated,
5 conical shape.
11. A space frame connector element as claimed
in any one of claimed 1 to 8 or 10 in which
lobes or protrusions are provided on the
first part on the outer surface thereof to
10 enable frame members of the same length to
be employed in the use of all of said
fasteners.
12. A space frame wherever embodying a
connector element or elements as claimed
in any one of claims 1 to 11.



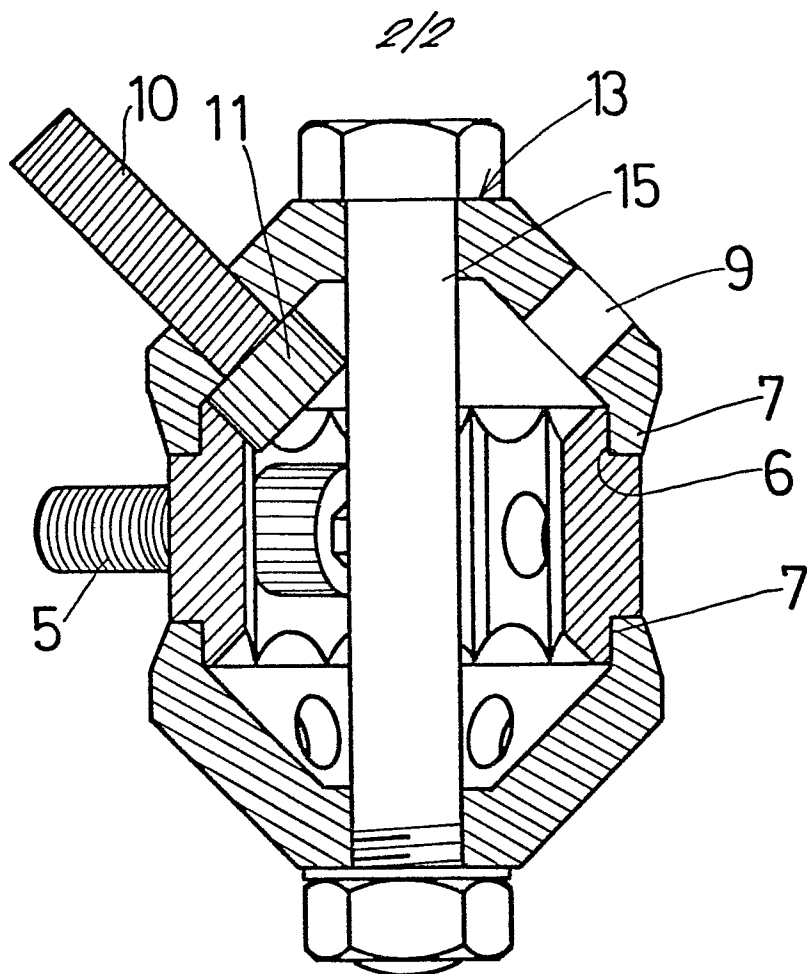


FIG. 2

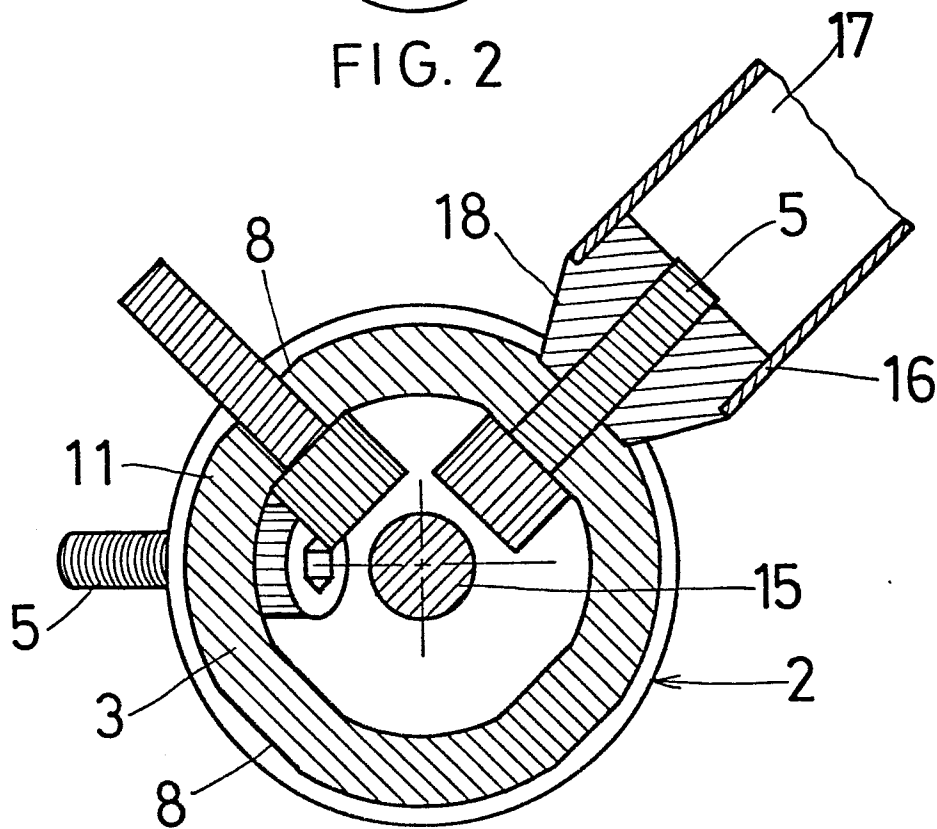


FIG. 3



European Patent
Office

EUROPEAN SEARCH REPORT

0154060

Application number

EP 84 30 1291

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	PATENTJOERNAAL, March 1984, page 234; & ZA - A - 83 4078 (P.E. HERR) * abstract * -----	1-12	E 04 B 1/19
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			E 04 B
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 23-10-1984	Examiner SCHOLS W.L.H.
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			
T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			