(12) PATENT
(19) AUSTRALIAN PATENT OFFICE

(11) Application No. AU 199642689 B2
(10) Patent No. 709378

(54) Title
Anchorage assembly

(51)[6] International Patent Classification(s)
E04C 005/12

(21) Application No: 199642689

(22) Application Date: 1995.12.20

(87) WIPO No: WO96/20319

(30) Priority Data

(31) Number	(32) Date	(33) Country
9426239	1994.12.24	GB
9520399	1995.10.06	GB

(43) Publication Date : 1996.07.19
(43) Publication Journal Date : 1996.09.05
(44) Accepted Journal Date : 1999.08.26

(71) Applicant(s)
Ancon CCL Ltd

(72) Inventor(s)
David Robert Green; Michael Arthur Smith; David Phillips

(74) Agent/Attorney
CARTER SMITH and BEADLE,Qantas House,2 Railway Parade,CAMBERWELL VIC 3124

(56) Related Art
AT 251846
GB 887605

OPI DATE 19/07/96 APPLN. ID 42689/96
AOJP DATE 05/09/96 PCT NUMBER PCT/GB95/02980

AU9642689

(51) International Patent Classification 6 : E04C 5/12

A1

(11) International Publication Number: WO 96/20319

(43) International Publication Date: 4 July 1996 (04.07.96)

(21) International Application Number: PCT/GB95/02980

(22) International Filing Date: 20 December 1995 (20.12.95)

(30) Priority Data:

9426239.1	24 December 1994 (24.12.94)	GB
9520399.8	6 October 1995 (06.10.95)	GB

(71) Applicant (for all designated States except US): ~~CCL SYSTEMS LIMITED [GB/GB]; Cabco House, Elland Road, Leeds, West Yorkshire LS11 8BH (GB).~~ Ancon CCL Ltd.; President Way, President Park Sheffield S4 7UR United Kingdom

(72) Inventors; and

(75) Inventors/Applicants (for US only): GREEN, David, Robert [GB/GB]; 4 Prince Albert Road, Glasgow G12 9JX (GB). SMITH, Michael, Arthur [GB/GB]; 22 Highfields, Netherton, Wakefield WF4 4ST (GB). PHILLIPS, David [GB/GB]; 228 Wilton Street, Glasgow G20 6BJ (GB).

(74) Agents: SHERRARD-SMITH, Hugh et al.; Appleyard Lees, 15 Clare Road, Halifax, West Yorkshire HX1 2HY (GB).

(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TT, UA, UG, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, LS, MW, SD, SZ, UG).

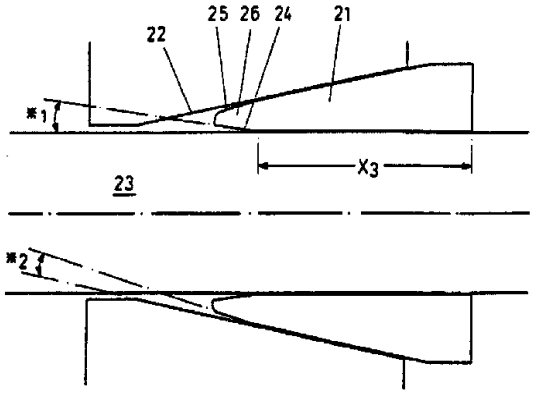
Published

With international search report.

Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

AUSTRALIAN PATENT OFFICE SEC 113

(54) Title: ANCHORAGE ASSEMBLY



(57) Abstract

The invention relates to anchorage assemblies and in particular to anchorage assemblies having a novel wedge arrangement, wedges for use with anchorage assemblies and an anchorage member. In order to improve wedge performance in an anchorage assembly, a wedge (21) is provided having both internally (24) and externally (25) relieved portions to give a nose area (26) which is tapered to a greater extent than the rest of the wedge (21). Under normal load conditions, the wedge (21) behaves like a short wedge having no nose relief and is highly efficient. However, under high load or load limit conditions, the nose portion (26) of the wedge (21) is arranged to deform plastically so that fretting of the stressing element (23) gripped by the wedge (21) does not occur. As well as the high performance wedge, an improved anchorage member for the anchorage assembly is provided, the anchorage member having a number of steps (34-74). The provision of steps (34-74) in the anchorage member reduces the tendency for anchorage members to be drawn into prestressed concrete structures and reduces the bursting forces within such structures. The combination of an anchorage assembly having the improved wedge and improved anchorage member is a particularly effective and advantageous one.

ANCHORAGE ASSEMBLY

The invention relates to anchorage assemblies and in particular to an anchorage assembly having a novel wedge arrangement and an anchorage member for use with an anchorage assembly in the field of construction of, for instance, pre-stressed concrete structures.

In more detail, the invention is particularly, but not exclusively, concerned with a so called live anchorage assembly for use with a multi-strand tendon of the kind comprising a bearing plate or similar, arranged to bear against a surface of a structure.

When constructing a prestressed reinforced concrete structure, a number of reinforcement bars need to be put under tension, following the application of the concrete. Typically, the construction process involves the steps of: making a form work from a number of metal bars, (into which form work the concrete will eventually be poured); securing anchorage members to the form work in opposed pairs; linking the opposed pairs of anchorage members by means of a multi-stranded tendon, by passing the tendon through a first anchorage member of each pair and through plastic ducting to connect with the second anchorage member of that pair; feeding the individual strands of the tendon through holes formed in a pair of bearing plates which are brought into abutment with a surface flange formed on each anchorage member; pouring concrete into the form work and pumping grouting or similar into the anchorage members and connecting duct so as to protect the individual strands of the tendon; tensioning the tendon and fixing the strands of the tendon into position whilst they are under tension, the fixing being carried out by

means of wedges driven into the holes of the bearing plates.

The above procedure is standard practice when producing prestressed concrete structures.

In a typical arrangement, the bearing plate of the structure is cylindrical in nature and has a plurality of openings formed therein. The openings are essentially of a truncated cone formation which taper towards the surface of the concrete structure and are arranged to receive a multi-strand tendon therein as well as a plurality of wedges. Each prestressing strand is made up from a number of wires, typically seven. The wedges are toothed and arranged so that, in use, when the tendon is under load they are drawn into the openings and forced into gripping engagement with their particular strands.

In fact, the openings in the bearing plate generally have a two part structure comprising a first truncated cone (frusto-conical) portion leading into a cylindrical portion at the area of the bearing plate nearest to the surface of the concrete structure.

Wedges, as well as finding application in anchorage assemblies for multi-strand tendons (having typically between 4 to 37 strands or more) may also find application where individual wires are to be gripped.

Wedge performance has been found to be increased in efficiency if there is an amount of "nose relief". A wedge with nose relief is shown in Figures 1A and 1B. Figure 1A shows the wedge 1 in a normal working position. In this working position, the wedge extends only into the frusto-conical portion 2 of the opening and grips the wire

or multi-wire strand 3 as shown over an effective length X_1. Under such normal load conditions, the relieved nose portion 4 of the wedge 1 is not really acting to provide any wedging action itself but under fatigue conditions, fretting can occur at the relieved portion 4 of the wedge 1 where the sharp internal teeth of the wedge which are formed along length X_1, change into flattened teeth. At the limit state shown in Figure 1B, the relieved portion of the nose is still fully enclosed within the tapered portion of the opening, but now under heavier load is supported by (i.e. in contact with) the multi-wire strand over a length X_2 which is approximately its full internal length.

It should be noted as stated above that the internal length of the wedges are toothed for engagement with the multi-wire strand 3. Efficiency of the wedge is defined as (breaking load of strand in wedge)/(breaking load of strand) and this is reduced in cases where there is no nose relief.

From the above discussion, it will be apparent that for fatigue applications, the best wedges have no nose relief due to the fact that fatigue failure of a strand gripped by a wedge usually occurs due to fretting at a point near to where the strand emerges from the wedge at the nose end. The fretting initiates fatigue cracks which then grow under cyclical loading until failure occurs. For fretting to occur there are two essential conditions. Firstly, there must be a high contact pressure between the components at the potential site of fretting, but not high enough to prevent relative movement and secondly, there must be relative movement between the components. When those conditions apply, pressure between the components causes cold welding to occur and the relative movement

fractures the weld. Repeated forming and fracturing of welds between the components is what causes the damage which initiates the fatigue cracks. In a short wedge with no nose relief, the mechanical lock which occurs between the strand and the wedge at the point where the strand emerges from the wedge prevents relative movement. Unfortunately, such a wedge is not suitable for most applications, as the stress gradients formed in the strand under highly loaded conditions are severe, and the efficiency of the wedges reduced. For a high efficiency a wedge needs to create a gradual transition of transfer of force from the strand into the wedge and this is achieved conventionally, as described above, by having a wedge which is relatively longer and which has internal nose relief - just the opposite of what is required for good fatigue performance.

Austrian patent application AT-A-251846 discloses a wedge having bevelled ends, but this wedge does not solve the fundamental problems as outlined above.

According to the present invention, there is provided an anchorage assembly for a pre-stressed concrete structure, the assembly comprising: a bearing plate having at least one transverse opening, and a plurality of tapered wedges, wherein, the or each transverse opening has at least a frusto-conical portion with a central axis generally transverse to the bearing plate and adapted to receive, in use, a stressing element and said plurality of wedges, the wedges each being shaped such that an internal part thereof is arranged to co-operate with said stressing element and an external part thereof is arranged to co-operate with said opening, said plurality of wedges and said opening being arranged, in use, so that the wedges grip the stressing element when stressed to inhibit

movement of the element, each of said wedges being provided with both internally and externally relieved portions at a tapered or narrow end region thereof to form a nose portion which tapers to a greater extent than the rest of said wedge, the assembly being characterised in that the internally relieved portion is angled away from a general extent of said internal part of said wedge by approximately 2 to 4 degrees and that the externally relieved portion is angled away from a general extent of said external part of said wedge by approximately 1 to 1.5 degrees.

Preferably, the internal part of each wedge is provided with a toothed region for gripping the stressing element.

Preferably, the nose portion of the wedge is arranged such that under normal load conditions the wedge has a shorter active length than under heavily loaded conditions.

Preferably, under normal load conditions the nose portion of the wedge is unsupported and substantially not in contact with either said stressing element or said bearing plate.

Preferably, in heavily loaded conditions, the nose portion deforms plastically to be fully supported and in contact with both said stressing element and the bearing plate.

For a better understanding of the various aspects of the invention, specific embodiments will now be described with reference to the accompanying drawings, in which:

Figure 2A shows an embodiment of a wedge in accordance with aspects of the present invention under normal working conditions;

Figure 2B shows the wedge of Figure 2A under limit conditions;

Figures 3 to 7 are cross-sectional plan views of five different anchorage assemblies;

Figure 8 is an exemplary end view of an anchorage member showing hidden detail; and

Figures 9A and 9B illustrate a typical arrangement of an anchorage member of the type shown in Figure 7, in use within a prestressed reinforced concrete structure.

Referring in more detail to Figure 2A, a wedge 21 with both internal 24 and external 25 nose relief is illustrated. It can be seen that under normal load conditions, the nose of the wedge 21 shown generally at 26, is unsupported as it does not come into contact with either the frusto-conical portion of the opening 22 or the tendon 23. This prevents the flattened teeth which are present in the region of the internal nose relief 24 from pressing onto the wire or strand and reduces the probability of fretting so as to enhance fatigue life. In other words, the wedge behaves like a short wedge without internal nose relief. The "active length" of the wedge being shown by dimension "X_3".

Referring now to Figure 2B, which shows the wedge at the load limit state, both the internal 24 and external 25 reliefs on the nose come into play. The material of both the wedge 21 and the opening 22 deform plastically and the

wedge is now fully supported, but with graduated pressure from the nose of the wedge to the point of full engagement of wedge teeth creating ideal conditions for high efficiency. The active length of the wedge is now dimensioned "X_4".

The angles of nose relief as shown in the drawings are exaggerated. In fact, external nose relief of the order of 1 to 1.5 degrees has found to be sufficient for $*_2$, which is the angular relief of portion 25, when there is an internal nose relief of around 3 degrees for $*_1$, which is the angular relief of portion 24.

It can therefore be seen that the use of wedges 21 of the type show in Figures 2A and 2B provide an anchorage assembly which is both of high efficiency and demonstrates good fatigue performance under both normal and limit load conditions.

Referring now to Figures 3 to 7, five different exemplary embodiments of an anchorage member shown.

Each of the anchorage members comprises a barrel portion, shown generally at 31, 41, 51, 61, 71 having a central axis A-A' and a surface flange 32, 42, 52, 62, 72 to which a bearing plate may be connected in use (as will be explained later).

Each of the anchorage members comprises a tapering hollow interior 33 - 73 into which a plastic connecting ducting (not shown) may be placed, and through which a multistranded tendon may be passed.

Each of the anchorage members feature a plurality of steps 34 - 74, which provide them with an externally tapering shape.

In the case of the embodiments shown in Figures 3 and 4, the steps 34, 44 are effectively tapered in a reverse direction to that of the barrel. It should be noted that an upstanding portion 35 - 75 linking a second end 36 - 76 of a preceding step to a first end 37 - 77 of its succeeding step effectively provides a surface giving resistance against the anchorage member being pulled inwardly towards the interior of the concrete block and will, as a consequence, produce the effect of anchoring the member in position.

In all of the embodiments shown, the first end 37 -77 of each step 34 is displaced perpendicularly from the central axis A-A' by a distance X_5 which is less than (Figures 3, 4, 6, 7), or substantially equal to (Figure 5) the perpendicular displacement X_6 of the second end 36 - 76 of that step from the same axis.

Providing a main portion 38 - 78 of the step 34 - 74, which is reverse tapered with respect to the tapering of the barrel, is thought to reduce the amount of bursting forces generated within the prestressed block.

The embodiment shown in Figure 5, does not feature reverse tapering of the main portion 59 of each step, but instead has a series of descending plateaus, each of which is substantially parallel to the central axis A-A' of the anchorage member.

This arrangement, has also been shown in tests to provide advantageous results, in terms of reduced bursting force within the block.

Arrangements shown in Figures 6 and 7 have been found to provide particularly effective results, the provision of a large upstanding flange 69, 79 situated towards the second end 66, 76 of each step provides excellent resistance against movement of the anchorage member and, the tapering reverse side 60, 70 of the flange 69, 78 coupled with an essentially non-tapered main portion 8 of each step, have been found to reduce bursting forces generated within the block, still further.

Referring now to Figures 8 and 9, a particular arrangement of the internal parts of an anchorage member of the type such as shown in Figure 7 will be described.

In Figure 8, the anchorage member as well as having a generally tapering interior portion 73, also has a slotted end region with relieved interior portions 71 (see Figure 7) produced by slots 82 formed in the surface flange 72 (Figure 7).

These relieved portions 71, give the interior of the anchorage member a funnel like appearance, when viewed in cross-section taken between a pair of slots 82 along line B-B'.

The end view of Figure 8 is shown from the surface flange end 72, which surface flange it should be noted is circular in outline, contrary to normal prior art practice. It has been found by the applicants that a circular flange of correct dimensions is as strong as prior art non-circular flanges and has the further

advantage of using minimal materials. The surface flange 72 has a bearing surface 84 (onto which a bearing plate 95 (see Figure 9) is adapted to fit) which circumferentially surrounds the hollow barrel portion 73.

The slots or cutaway portions 82 are adapted so as to extend generally beyond the bearing surface 84 part of flange 72. For illustrative purposes the bearing surface 84 part of the surface flange 72 is shown as bounded by the hatched lines (-·-·).

Grout or other flexible filling material may be pumped into the slots 82 once the bearing plate 95 has been put into position mating with the surface 84 and, as the bearing plate 95 is of such a radius that it fully covers the main interior portion 73 of the anchorage member, (but does not fully cover the slots 82), the slots act so as to effectively funnel the material into the anchorage member.

Also shown on Figure 8, is hidden detail revealing mounting holes 83, by which the anchorage member may be mounted to the form work.

Line B-B' shows the line on which the cross-sectional view of Figure 7 is taken.

Referring now to Figures 9A and 9B, a typical application of the anchorage member will now be described.

In Figure 9A, the anchorage member is shown as being of a type such as that illustrated in Figure 7, but the general description which will now be given would equally apply to other types of anchorage member, such as those shown in Figures 5 or 6.

The process of fixing anchorage members into position within a form work and applying concrete and prestressing, is as described in relation to the prior art. In other words, following construction of the form work and attachment of opposed pairs of anchorage members thereto, ducting 96 is used to connect the anchorage members of each pair together, strands 97 of the tendon 98 are passed into a first of the anchorage members, through the ducting 96 and into the second of the anchorage members, then bearing plates 95 are positioned at either end. Each bearing plate 95 has a plurality of holes formed therein for passage of the individual strands 97 of the tendon 98, and the plates 95 are carefully passed over the strands 97 of the tendon 98, and brought into abutment with the bearing surface 84 of the surface flange 72 of the anchorage members. Concrete is then poured into the assembly, the strands 97 of the tendon 98 are stressed by putting them into tension, and then wedges 99 of the type shown in Figure 2 are driven into the holes of the bearing plate 95 around each strand 97, to prevent further movement of the tendon. Grouting is pumped around the strands, so as to protect the individual strands.

The method of applying the grouting to the anchorage member will now be described with reference to Figure 9B. In Figure 9B there is shown a plastic grout cap which is placed over the end of the anchorage assembly/bearing plate and a temporary steel grout cap 101. The steel grout cap is arranged to receive grout from an external grouting source and to allow grout to pass through it through holes 101A. The grouting thereafter passes through holes in the plastic grout cap and through grout slots 82 in the anchorage member. Once the grout has set, the steel cap may be removed. The plastic cap 100 may be left in place permanently. This has been found to provide

a particularly advantageous means of applying such a grout or flexible filler.

The well known form work, by which the anchorage members are originally held in position, is not shown in Figure 9, for ease of illustration.

A spiral of reinforcing steel 91, which is attached to the form work, is shown as surrounding the anchorage member. This spiral reinforcement, helps to counteract bursting forces generated within the block.

As well as reducing peak bursting forces within the block, the design of the anchorage members also helps to move that peak away from the surface flange region and further into the block. This is also advantageous, as, in general, the surface regions of the block will be able to withstand less bursting force than the interior and so by moving this peak away from the surface area, greater reliability is achieved.

In view of the improvements in strength which result from the reduced bursting force, as a consequence it may be possible to use less concrete in a given structure.

Further, anchorage assemblies incorporating wedges with internal and external nose relief have been found to be particularly effective as they produce a high-performance, high-efficiency set-up having the benefits of reduced costs and easy application of concrete.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. An anchorage assembly for a pre-stressed concrete structure, the assembly comprising:

a bearing plate having at least one transverse opening, and

a plurality of tapered wedges,

wherein, the or each transverse opening has at least a frusto-conical portion with a central axis generally transverse to the bearing plate and adapted to receive, in use, a stressing element and said plurality of wedges, the wedges each being shaped such that an internal part thereof is arranged to co-operate with said stressing element and an external part thereof is arranged to co-operate with said opening, said plurality of wedges and said opening being arranged, in use, so that the wedges grip the stressing element when stressed to inhibit movement of the element, each of said wedges being provided with both internally and externally relieved portions at a tapered or narrow end region thereof to form a nose portion which tapers to a greater extent than the rest of said wedge, the assembly being characterised in that the internally relieved portion is angled away from a general extent of said internal part of said wedge by approximately 2 to 4 degrees and that the externally relieved portion is angled away from a general extent of said external part of said wedge by approximately 1 to 1.5 degrees.

2. An anchorage assembly according to claim 1, wherein the internal part of each wedge is provided with a toothed region for gripping the stressing element.

3. An anchorage assembly according to claim 1 or 2, wherein the nose portion of the wedge is arranged such that under normal load conditions the wedge has a shorter active length than under heavily loaded conditions.

4. An anchorage assembly according to claim 3, wherein under normal load conditions the nose portion of the wedge is unsupported and substantially not in contact with either said stressing element or said bearing plate.

5. An anchorage assembly according to claim 3 or 4, wherein in heavily loaded conditions, the nose portion deforms plastically to be fully supported and in contact with both said stressing element and the bearing plate.

6. An anchorage assembly for a pre-stressed concrete structure, substantially as hereinbefore described with reference to Figures 2A and 2B or any one of Figures 3 to 6, or Figures 7,8 and 9 of the accompanying drawings.

DATED: 8 February, 1999

CARTER SMITH & BEADLE

Patent Attorneys for the Applicant:

CCL SYSTEMS LIMITED

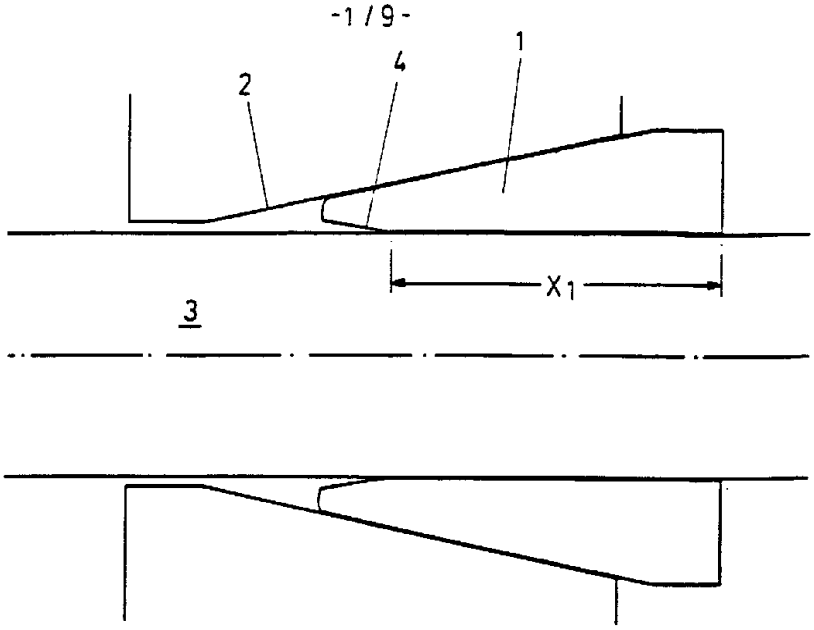


FIG. 1A

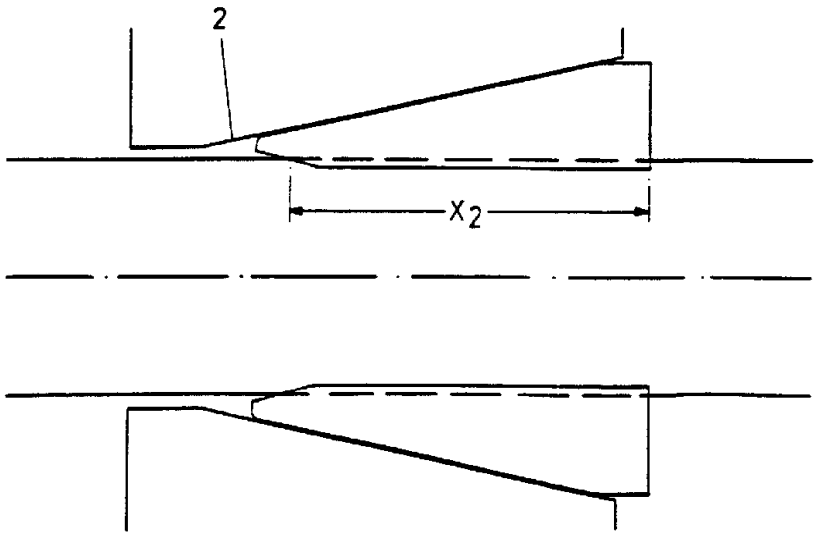


FIG. 1B

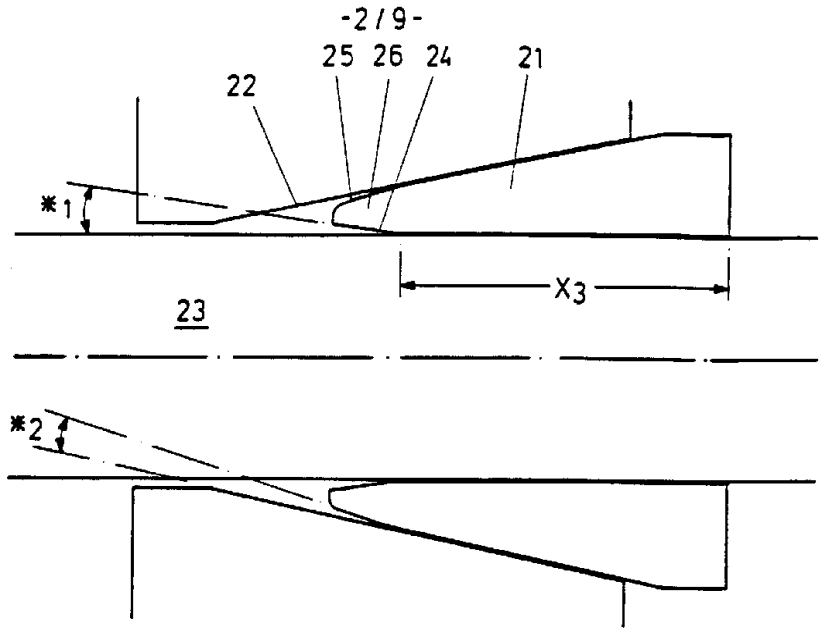


FIG. 2A

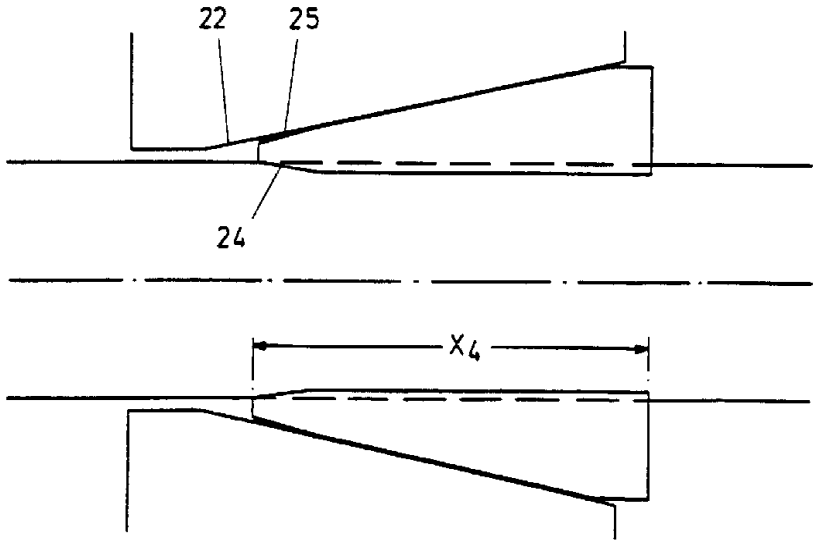


FIG. 2B

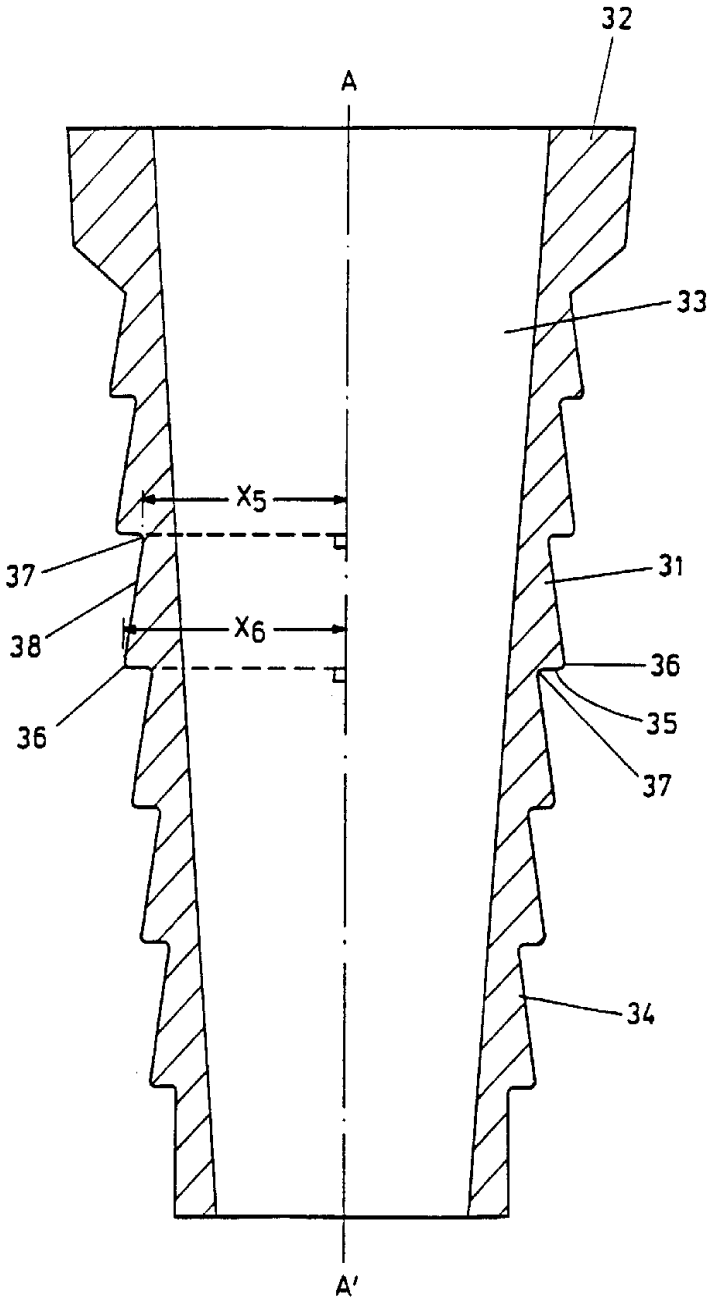


FIG. 3

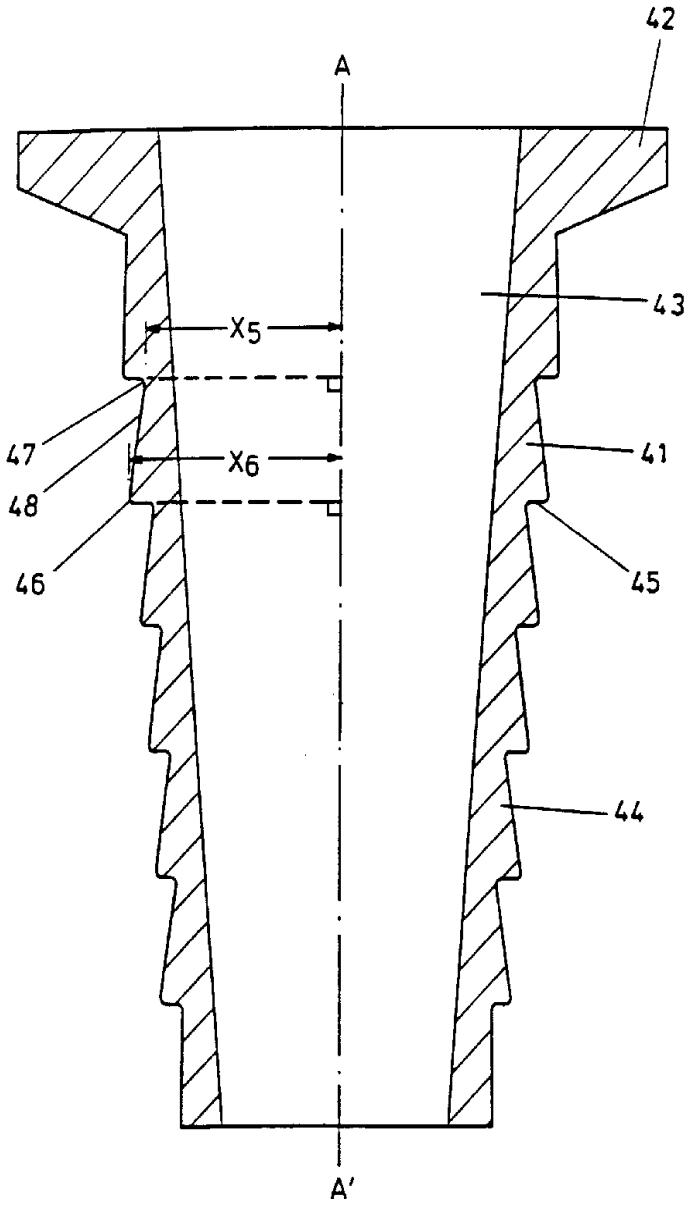


FIG. 4

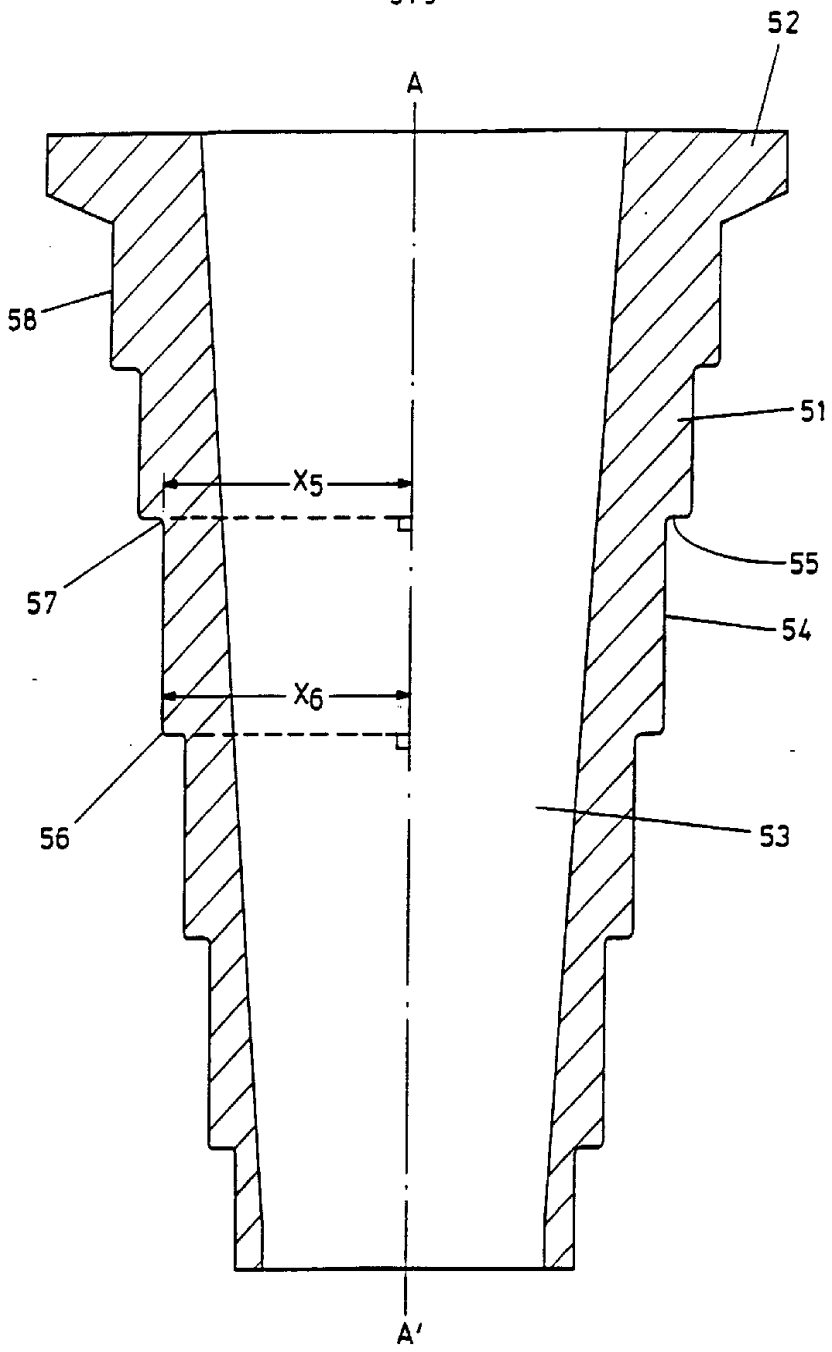


FIG. 5

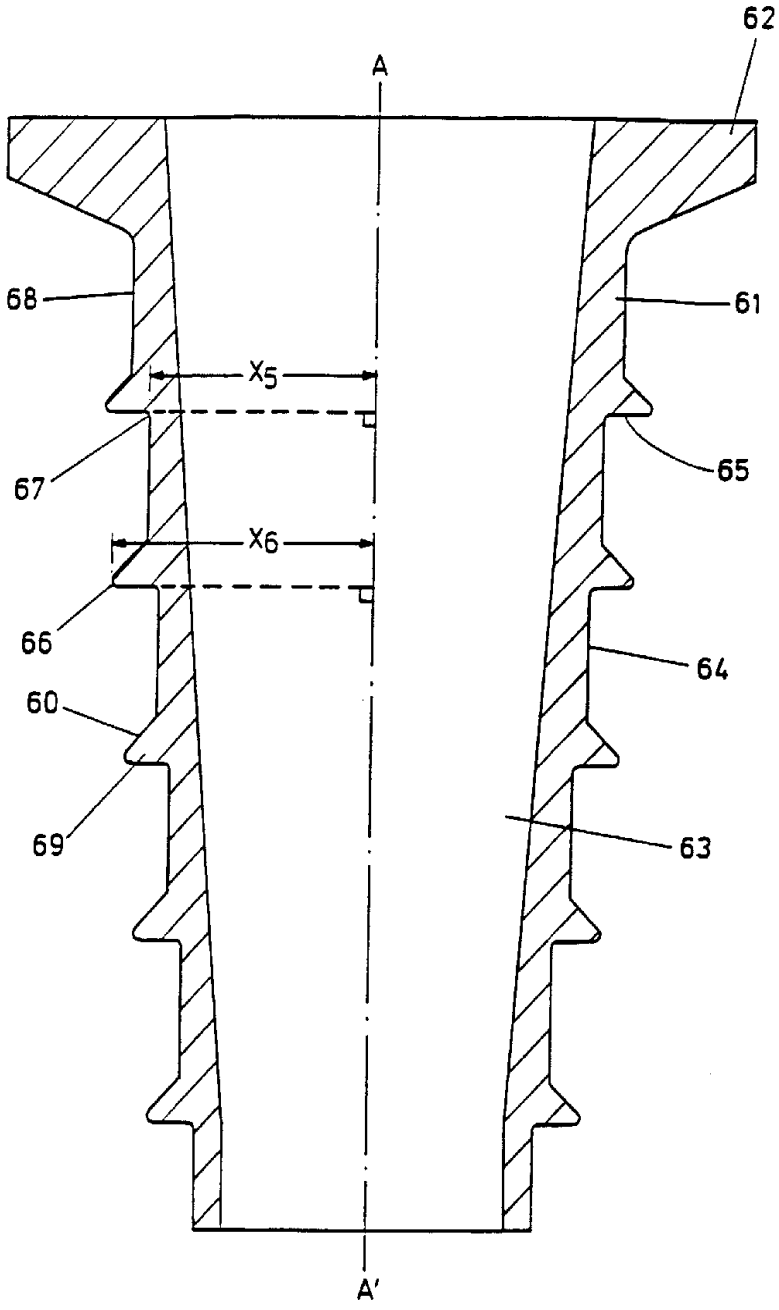


FIG. 6

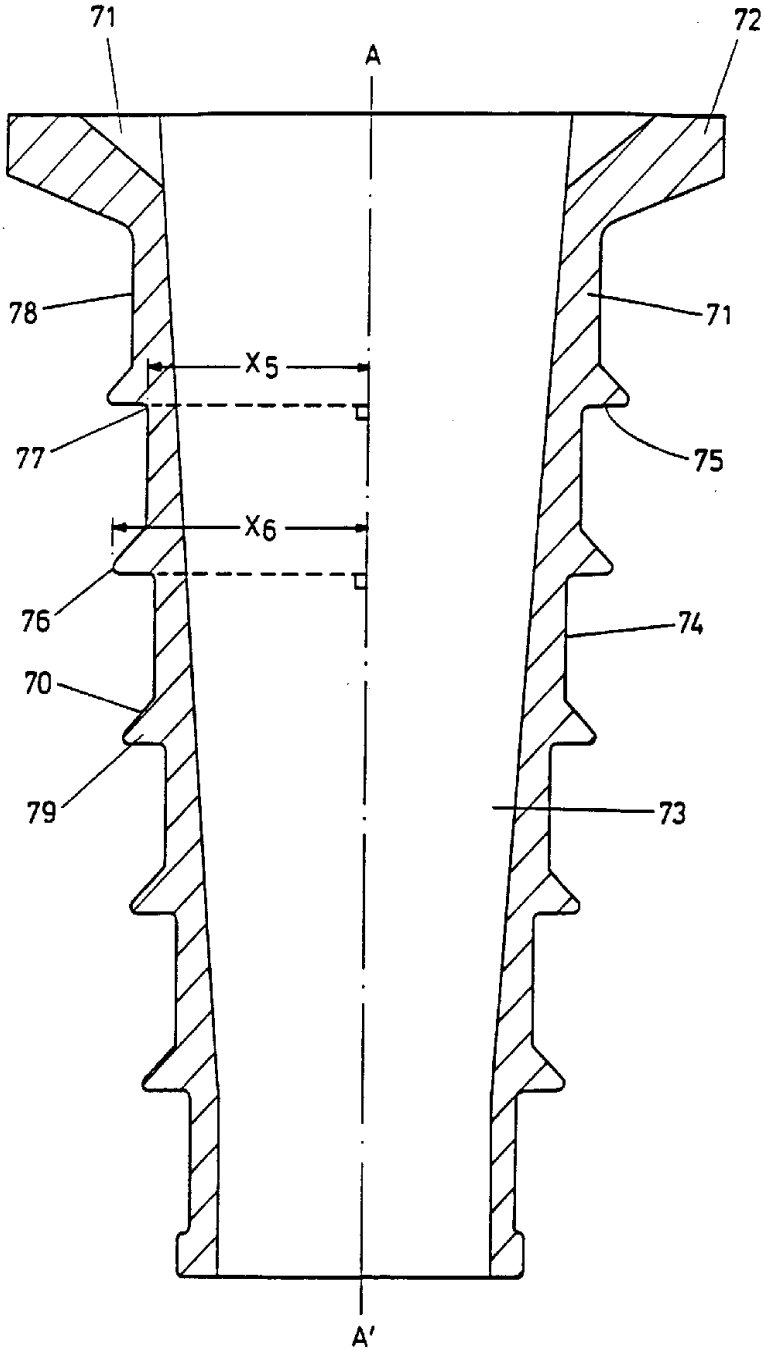


FIG. 7

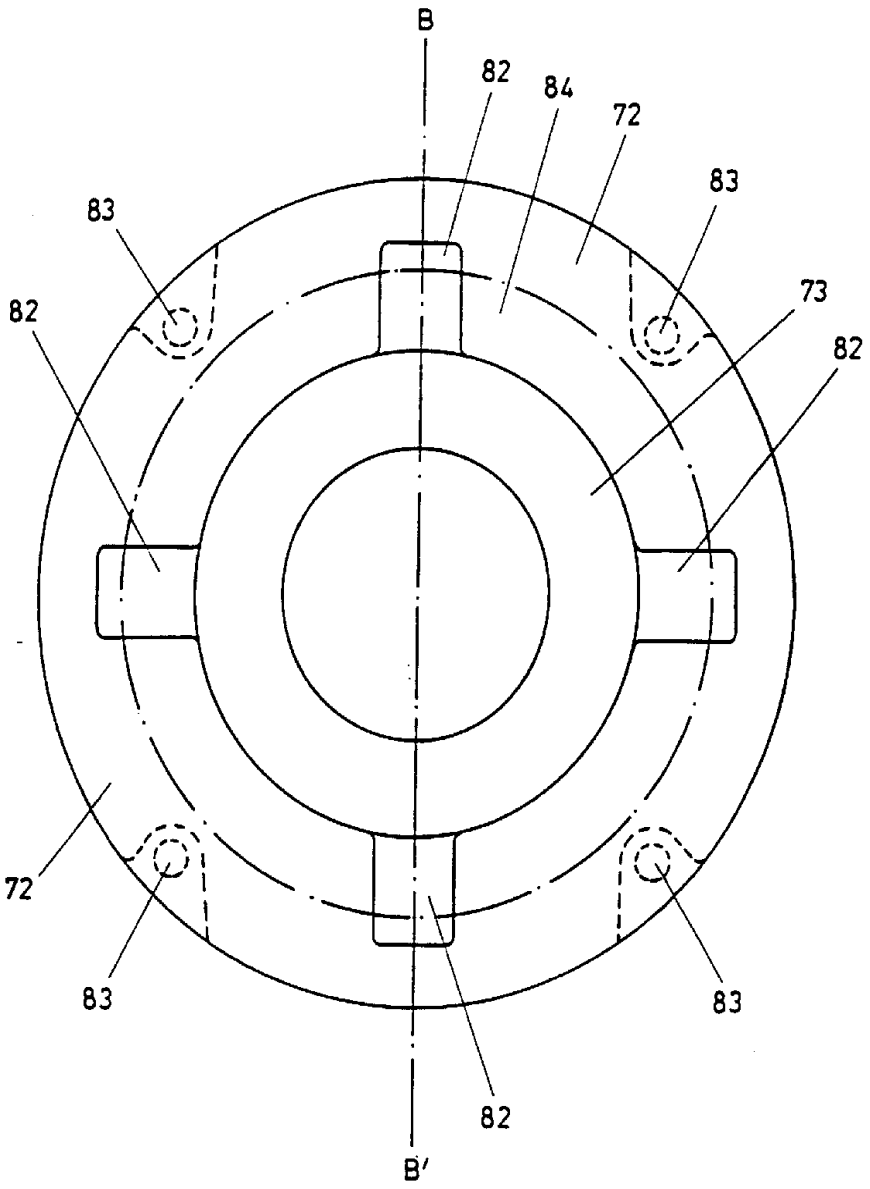


FIG. 8

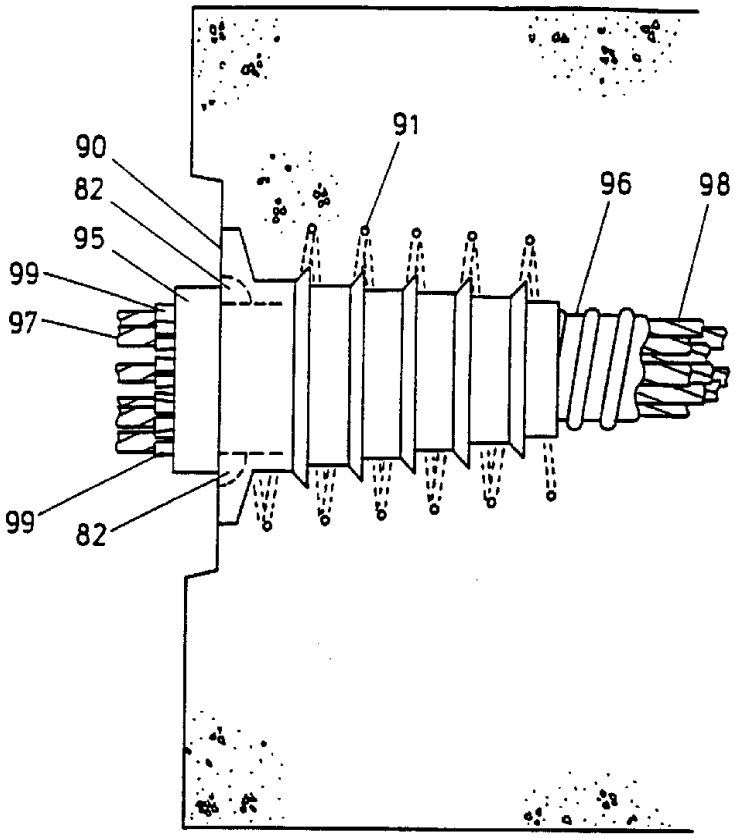


FIG. 9A

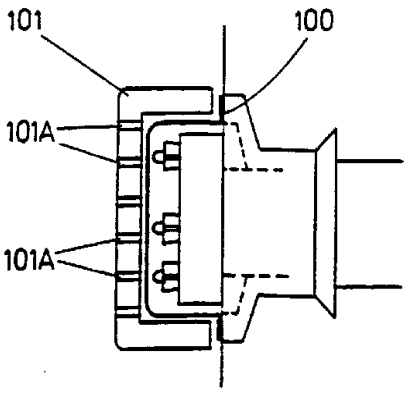


FIG. 9B