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(71) Applicant:
Cooper Industries Italia S.p.A.
20124 Milano (IT)

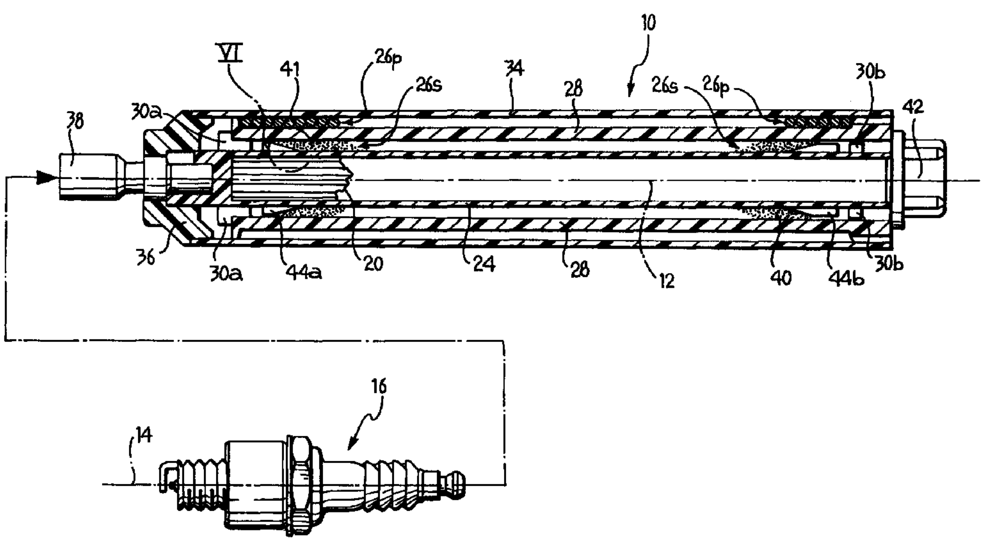
(72) Inventors:
- **Rossi, Daniele**
40050 Monte San Pietro (Bologna) (IT)
- **Righi, Roberto**
41100 Modena (IT)

(74) Representative:
Marchitelli, Mauro et al
Buzzi, Notaro & Antonielli d'Oulx
Corso Fiume 6
10133 Torino (IT)

(54) **Coil with horizontal secondary spool**

(57) An ignition coil intended to be mounted in direct association with a spark plug, comprises a laminated magnetic core (20) of elongated shape, a supporting spool (24) of electrically insulating material, with a cavity (22) that accommodates the magnetic core (20), a high-voltage secondary winding (26s) coaxial with the core (20) and comprising a plurality of turns (40_i) wound onto the supporting spool (24), and a low-voltage primary winding (26p) coaxial with the secondary winding (26s). The surface of the supporting spool (24) in contact with the secondary winding (26s) consists of a continuous outer cylindrical surface (46) and at least one shoulder (44a) with an inclined supporting surface (48a) to support the initial portion of the secondary winding (26s).

FIG. 1



EP 0 887 547 A1

Description

The present invention relates to an ignition coil for internal combustion engines with spark ignition, all as set out in the preamble of Claim 1.

As is well known, an ignition coil comprises a secondary high-tension winding of turns (hereinafter to be referred to also more briefly as the "secondary") capable of sustaining potential differences of the order of several tens of kilovolts applied to its terminals. This winding is realized by winding successive layers of turns onto a supporting spool arranged around a magnetic core, these turns covering either a part or the entire length of the said spool.

The electric lead of which these turns are made is covered with insulating enamel and further insulation between the said turns is obtained by means of an epoxy resin that is poured in such a way as to spread uniformly to occupy all the interstices within the winding, the resin being then solidified by means of polymerization. With a view to avoiding harmful electric punctures of the insulating dielectric, it is essential to avoid arrangements in which turns with a high voltage differential come to lie close to each other.

The solutions currently employed consist of realizing radial separation baffles at regular intervals along the spool on which the secondary winding is realized, thereby dividing the space occupied by the winding into several zones or cells as described, for example, in EP-0 638 971 and US-A-4 514 712.

The winding on of the turns in several layers is always completed in a given cell before the winding process is continued in the next cell. When this is done, each cell will come to comprise only a limited number of consecutive turns and the voltage difference between the first and the last turn will never be greater than the one that the technical characteristics of the interposed insulating material, if correctly deposited, can sustain. Turns with a high potential difference come to be situated very far from each other and will therefore be separated by a considerable thickness of insulating dielectric and the previously mentioned baffles.

This arrangement has the drawback of being rather costly on account of the complex manufacturing process required to produce the spool on to which the secondary is wound. Since its outer surface has to be provided with the radial baffles separating the cells, the spool has to be realized with the help of a mold that is made more complex and therefore also costlier by the presence of these elements.

Nor must one forget that the presence of these radial baffles increases the longitudinal space occupied by the overall structure, whereas it is always desirable to keep this volume as small as possible in view of the fact that these coils have to be mounted at the head of each cylinder, where the available space is always very limited.

Moreover, the molding of the secondary spool tends to be somewhat inaccurate: given the small size (height and thickness) of the baffles, one finds that they are often associated with burrs and other defects.

The purpose of the present invention is that of realizing a spool for the secondary winding of an ignition coil that will permit the longitudinal and radial dimensions of the coil to be reduced and to simplify the molding of the spool, thereby reducing both its cost and the structural defects associated with its manufacture.

According to the invention this scope is attained by means of an ignition coil in accordance with the characterizing part of Claim 1. In a coil according to the invention, the spool supporting the secondary winding has an external cylindrical surface that is devoid of any radial projections in the part on which the secondary is to be wound and is therefore technically easier to realize. A supporting shoulder is formed in the position where the winding is to be commenced and is provided with an inclined surface onto which the first layer of the winding is to be wound. The direction in which the turns of the winding are wound, defined by the inclination of the surface of the supporting shoulder, makes it possible to reduce the radial dimension of the coil and to position turns with a substantial voltage differential well away from each other.

The characteristics and advantages of the ignition coil according to the invention will be explained more fully in the detailed description of a realization example given hereinbelow, which is provided solely by way of indicative and non limitative example with reference to the attached drawings wherein:

- Figure 1 is a section along the longitudinal axis of the entire ignition coil wherein the high- and low-voltage windings and the seating for the spark plug are shown,
- Figure 2 is a longitudinal section of solely the supporting spool of the secondary or high-voltage winding according to the invention;
- Figure 3 is a side elevation of the spool of Figure 2;
- Figures 4 and 5 are front views of the ends of the spool of Figure 2; and
- Figure 6 is an enlargement of a part of Figure 1 and shows one of the supporting shoulders and the initial part of the secondary winding, for which it also indicates the order in which the turns are wound on.

The following description refers to figure 1 which shows a complete form of realization of the entire ignition coil 10.

The coil 10 is of the socalled "cigar-shaped" type, characterized by the fact of being of elongated and generally cylindrical shape, its longitudinal axis 12 coinciding with the longitudinal axis 14 of the spark plug 16 with which it is assembled. Within the coil, a laminated core 20 of high magnetic permeability, cylindrical in shape and coaxial with the longitudinal axis 12 , is employed as the material means for concentrating the flux lines of the magnetic field generated by the passage of electric current through the appropriate windings and to ensure high inductance values. The realization of the core, which is obtained by means of the superposition of laminae of conducting material appropriately separated by means of layers of insulating paint, is well known to the state of the art as a solution that efficaciously prevents the formation of eddy currents induced by the magnetic flux variations.

The core 20 is inserted in a cylindrical cavity 22 formed within a support spool 24 on which the high-voltage secondary winding 26s is formed (hereinafter this spool will be referred to as "secondary spool") and which is illustrated more clearly in Figure 2, wherein only the secondary spool 24 is shown. This spool, made of non-conducting plastic material, is realized by means of injection molding, using a single mold that makes it possible to mold the entire spool, i.e. both its cylindrical carrying structure and any baffles or shoulders arranged on its surface. The spool 24 is surrounded by a second supporting spool 28 that is coaxial with it and carries the low-voltage primary winding 26p (and which, by analogy, we shall hereinafter call the "primary spool"); this primary spool rests on the annular supporting shoulders 30a and 30b realized at the ends of the secondary spool 24 that ensure the correct axial and longitudinal positioning of the two spools with respect to each other. The side elevation of Figure 3 and the end-on views of Figures 4 and 5 of the spool 24 clearly illustrate both the annular arrangement of the supporting shoulders 30a and 30b and their discontinuity, which creates the communication channels 32' between the space contained between the two coaxial spools and the outside. The purpose and significance of this conformation will become clearer as the description of the coil formation process is completed.

As can be seen from Figure 1, the secondary spool 24 and the primary spool 28 are surrounded by a container 34 made of insulating plastic material, which is likewise of cylindrical shape and closed at one end by an insulating cap 36 fitted around the ferrule 38 intended to accommodate the spark plug 16 . The space between the two spools and between the primary spool 28 and the external container 34 is then filled with insulating epoxy resin (capable of withstanding voltage differences of the order of 20 kilovolt per millimeter of thickness) which is poured in the liquid state to ensure that it will spread in as uniform and complete a manner as possible into all the capillary spaces between the turns 40_i and 41_i of, respectively, the windings 26s and 26p and then solidified by polymerization. The previously mentioned communication channels 32' are needed in order to ensure that this pouring of the resin will prove efficacious and reach the secondary winding 26s between the two spools. The resin contributes to insulating the primary winding 26p and the secondary winding 26s on which voltage differences of the order of as much as 30 kilovolt may be reached even in normal operating conditions.

The structure of the coil 10 is completed at the end opposite to the seating for the spark plug 16 by the low-voltage electric terminals that are jointly and generically indicated by 42 and serve to apply the voltage of the supply battery to the primary winding 26p.

With reference to Figures 2 and 5 and the enlarged view of region II shown in Figure 6, we shall now pass on to taking a closer look at the secondary spool 24 , the actual object of the invention.

As can clearly be seen from the figures just listed, the portion of the secondary spool 24 intended to accommodate the high-voltage winding 26s is comprised between two inner annular shoulders 44a and 44b and has an outer cylindrical surface 46 that is completely smooth, i.e. without any radial projections.

The inner annular shoulders 44a and 44b have truncated cone surfaces 48a and 48b that face the smooth surface tract 46 and serve as supports for the terminal portions of the secondary winding 26s . These inner shoulders, just like the previously described outer shoulders 30a and 30b, are discontinuous and thus ensure the presence of the channels 32" that permit the passage of the insulating resin when it is poured during the production process.

In this condition the choice of a longitudinal direction of deposition of the turns 40_i known in the prior art, would lead to a situation in which there would be a high voltage difference between adjacent turns of successive layers, with the highest voltage differences occurring in particular at the two ends of the coil. Possible inaccuracies in producing the winding could cause turns of non-adjacent layers to become situated close to each other, in which case the voltage differentials to be withstood would become even greater. The small thickness of the insulating dielectric separating the turns might not be capable of withstanding such high voltage differences with the attendant risk of disruptive breakdown and the consequent deterioration of the performance of the device.

The present invention draws its origin from observation of the fact that the radial extension of the winding 26s is smaller than its longitudinal counterpart, so that it becomes convenient to deposit the turns 40_i in such a manner as to form layers 50_i extending in a direction inclined with respect to the longitudinal axis of the spool 24, and placed side by side along the longitudinal direction of the spool. In this way, as will be explained in greater detail further on, the voltage difference that becomes established between each turn 40_i and the adjacent turns can be easily sustained by the insulating material, thus avoiding phenomena of electric puncture.

The inner shoulder 44a at the starting point of the winding 26s makes it possible to arrange the turns along the direction defined by the angle of inclination of the truncated cone surface 48a of that shoulder with respect to the longitudinal axis 12. The said surface 48a serves as support for the first layer 50_1 of turns; appropriate control of the winding speed and the elastic tension applied to the lead during the process, together with the definition of a suitable angle of inclination, preferably less than 45°, makes it possible to avoid slippings and to wind all layers following the first in such a manner that each layer will be supported by the preceding one.

The deposition sequence is clarified with reference to Figure 6, wherein the first three layers 50_1, 50_2, 50_3 of turns and their deposition directions 60_1, 60_2, 60_3 are summarily shown.

The first turn, indicated by the generic numeral 40 and the suffix that distinguishes the order in which they are wound, starting at the spool surface 46 along the inclined surface 48a, in the direction indicated by 60_1, gradually increasing their diameter. After having wound the last turn 40_n of this layer, the next turn 40_{n+1} is wound immediately adjacent to it and resting on the previously wound turns, thus commencing the winding of the second layer 50_2 , which is wound in the opposite direction. The winding therefore proceeds in the direction indicated by 60_2, and the layer 50_2 is supported on the previous layer and therefore maintains the same inclination. The same procedure is followed for the formation of the whole winding: having wound the last turn 40_{n+p} of the layer 50_2 , which once again rests on the surface 46 of the spool, the layer 50_3 of turns commences with the winding of turn 40_{n+p+1} and proceeds in the outward direction 60_3 with increasing turn diameters, and so on. On completion and as seen in a longitudinal section, successive turns will follow a zig-zag sequence and the layers will form a herringbone pattern. In this way the voltage difference between turns 40_1 and 40_{n+p} can still be easily tolerated by the dielectric, while the winding structure is self-supporting and there is no need for realizing a subdivision into separate cells.

The inclination of the layers 50_i not only renders possible implementation of the particular winding method that has just been described, but also brings with it the possibility of reducing the size of the coil 10 in the radial direction. It can readily be seen from Figure 6 that, as seen in section, the turns 40_i are not "piled" on top of each other, but are rather formed according to a diagonal pattern, so that the radial dimension of the volume occupied by all the turns is reduced by a factor equal to the sine of the angle of inclination of the supporting surface 48a; this space saving can be exploited, for example, for increasing the thickness of the resin layer that separates the low-voltage primary winding 26p from its high-voltage counterpart 26s, thereby improving the insulation between the two windings.

Claims

1. An ignition coil intended to be being mounted in direct association with a spark plug, comprising:

   - a laminated magnetic core (20) with an elongated shape along a longitudinal axis (12) defining a principal axis of the coil,
   - a supporting spool (24) made of electrically insulating material and having an interior cavity (22) to accommodate the said magnetic core (20),
   - a high-voltage secondary winding (26s) coaxial with the core (20) and comprising a plurality of turns (40_i) wound onto the said supporting spool (24), and
   - a low-voltage primary winding (26p) coaxial with the said secondary winding (26s), characterized in that the surface of the said supporting spool (24) in contact with the secondary winding (26s) consists of a continuous outer cylindrical surface (46) and at least one shoulder (44a) with an inclined supporting surface (48a) to support the initial portion of the secondary winding (26s).

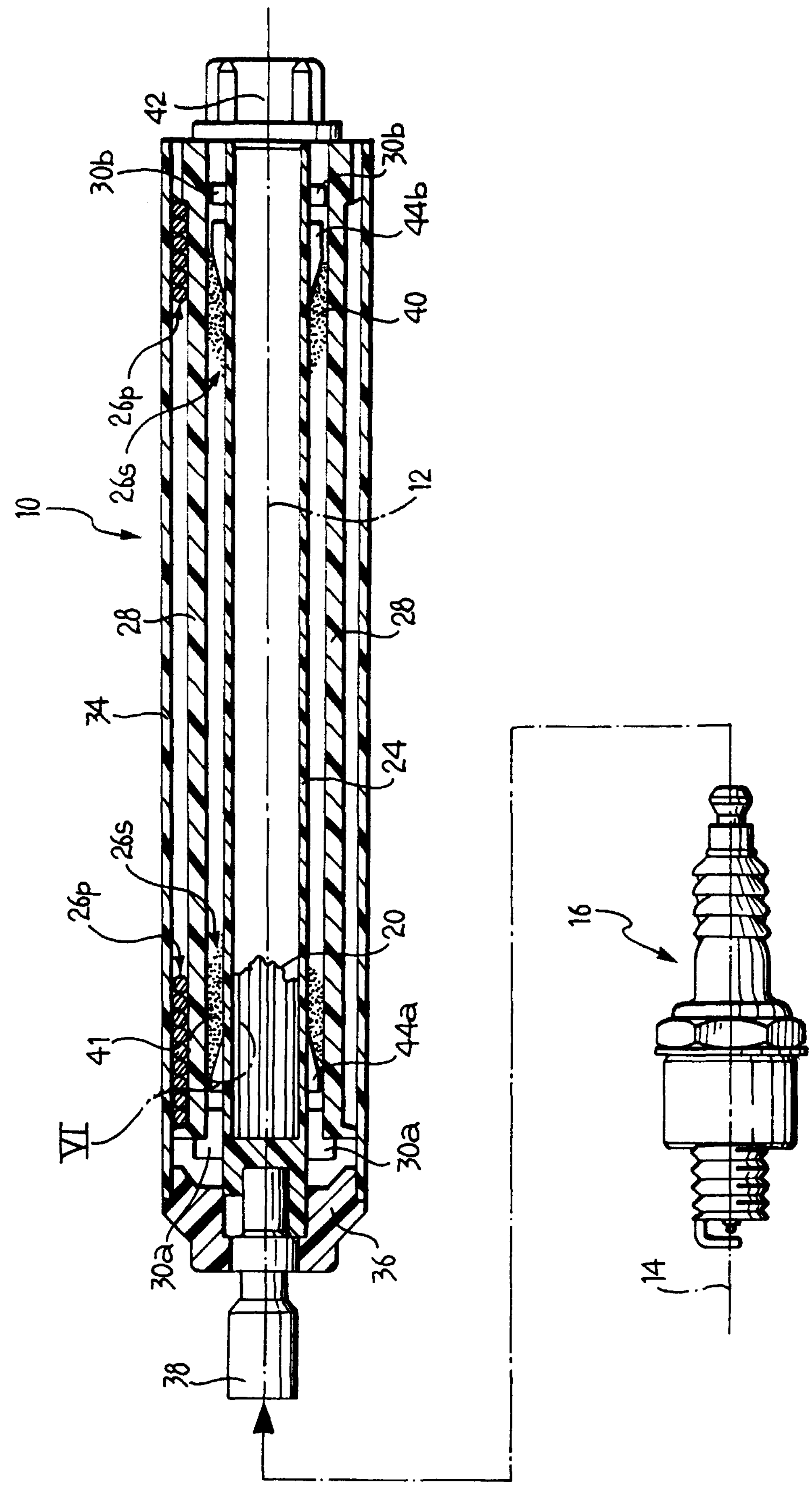
2. An ignition coil in accordance with Claim 1, characterized in that the said supporting surface (48a) has the shape of a truncated cone converging onto the said longitudinal axis (12).

3. An ignition coil in accordance with Claim 1, characterized in that the turns (40_i) of the secondary winding (26s) are wound onto inclined surfaces substantially parallel to the said supporting surface (48a).

4. An ignition coil in accordance with Claim 3, characterized in that the secondary winding (26s) comprises a multitude of layers (50_i), each made up of plurality of turns (40_i) wound onto a conical surface, the said layers (50_i) being arranged in a general herringbone pattern when seen in a section that passes through the longitudinal axis (12) of the core.

5. An ignition coil in accordance with Claim 4, characterized in that adjacent layers (50_i, 50_{i+1}) of the secondary winding 26s) are formed with deposition directions (60_i) of the turns of the second layer are wound on opposite to each other.

FIG. 1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30b
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26p
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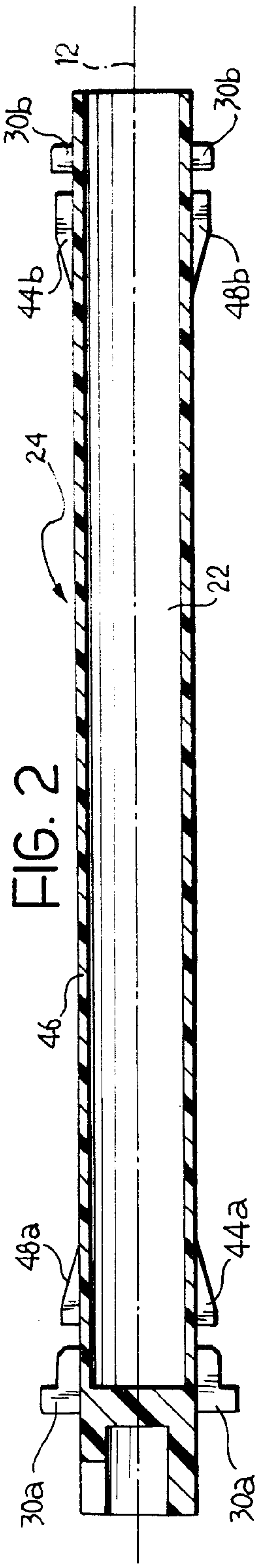


FIG. 2

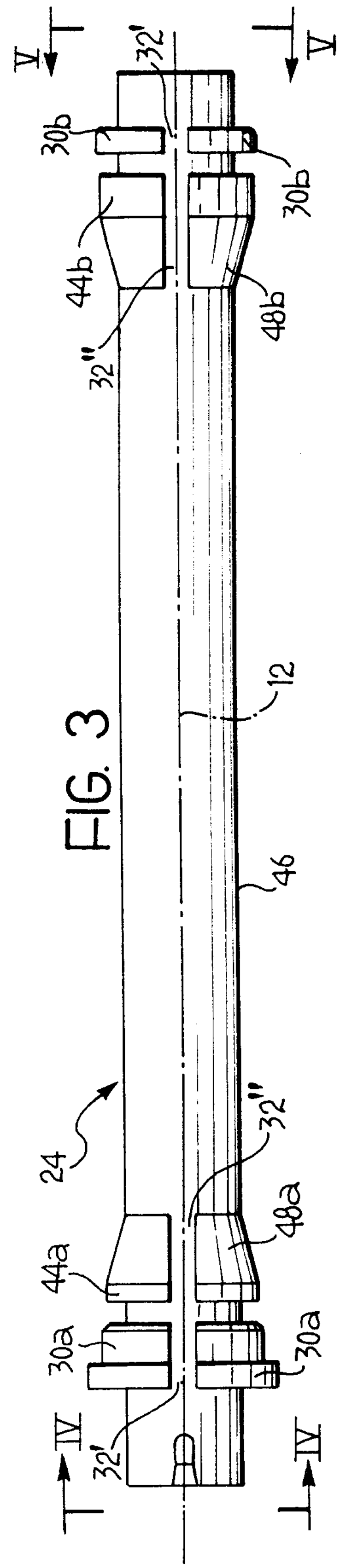


FIG. 3

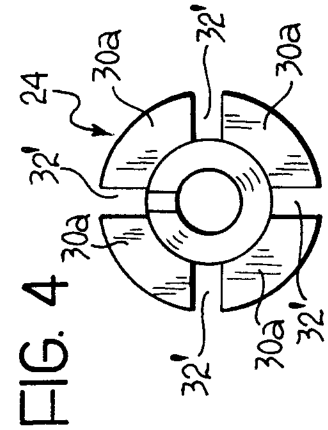


FIG. 4

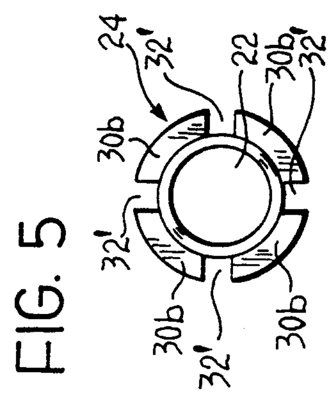
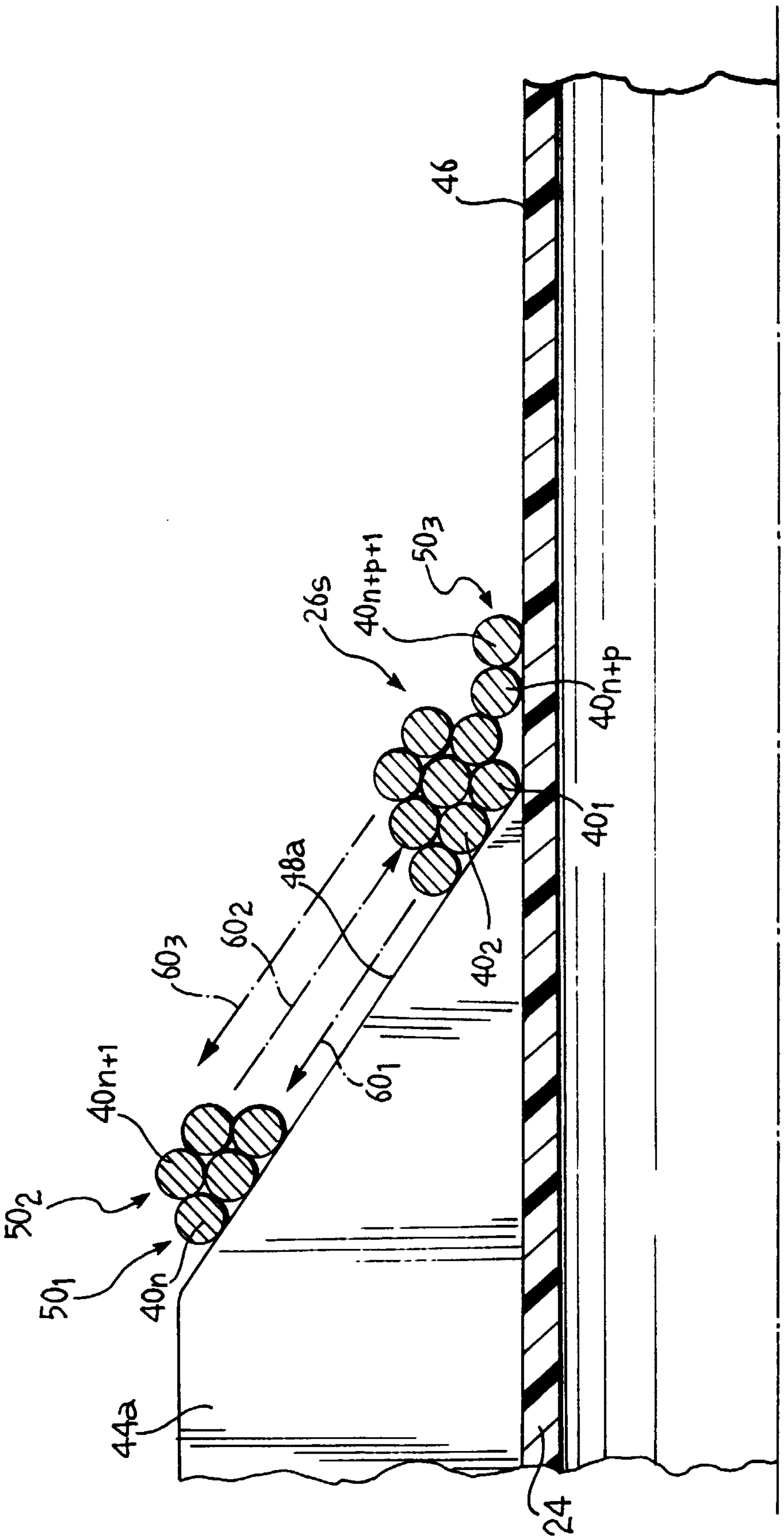


FIG. 5

FIG. 6


46
50_3
26s
40_{n+p+1}
40_{n+p}
40_1
40_2
48a
60_2
60_3
60_1
40_{n+1}
50_2
50_1
40_n
44a
24

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EUROPEAN SEARCH REPORT

Application Number
EP 97 83 0306

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.6)
Y	CH 196 451 A (JAKOB BOHLI) * the whole document * ---	1-3	F02P13/00 H01F38/12 H01T13/44
Y	EP 0 431 322 A (NIPPON DENSO CO) * column 2, line 21 - line 37 * * column 10, line 29 - column 11, line 40; figures 9,10,14,16 * ---	1-3	
A	EP 0 142 175 A (NIPPON DENSO CO) * the whole document * ---	1,2	
A	US 5 128 646 A (SUZUKI TOSHIRO ET AL) * abstract * * column 6, line 20 - line 52; figure 10 * -----	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

F02P
H01F
H01T

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	14 November 1997	Fuchs, P

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