Office de la Propriété Intellectuelle du Canada
Un organisme d'Industrie Canada

Canadian Intellectual Property Office
An agency of Industry Canada

CA 2311207 C 2007/04/10

(11)(21) 2 311 207

(12) BREVET CANADIEN
CANADIAN PATENT

(13) C

(22) Date de dépôt/Filing Date: 2000/06/09
(41) Mise à la disp. pub./Open to Public Insp.: 2000/12/11
(45) Date de délivrance/Issue Date: 2007/04/10
(30) Priorité/Priority: 1999/06/11 (CH99 810512.6)

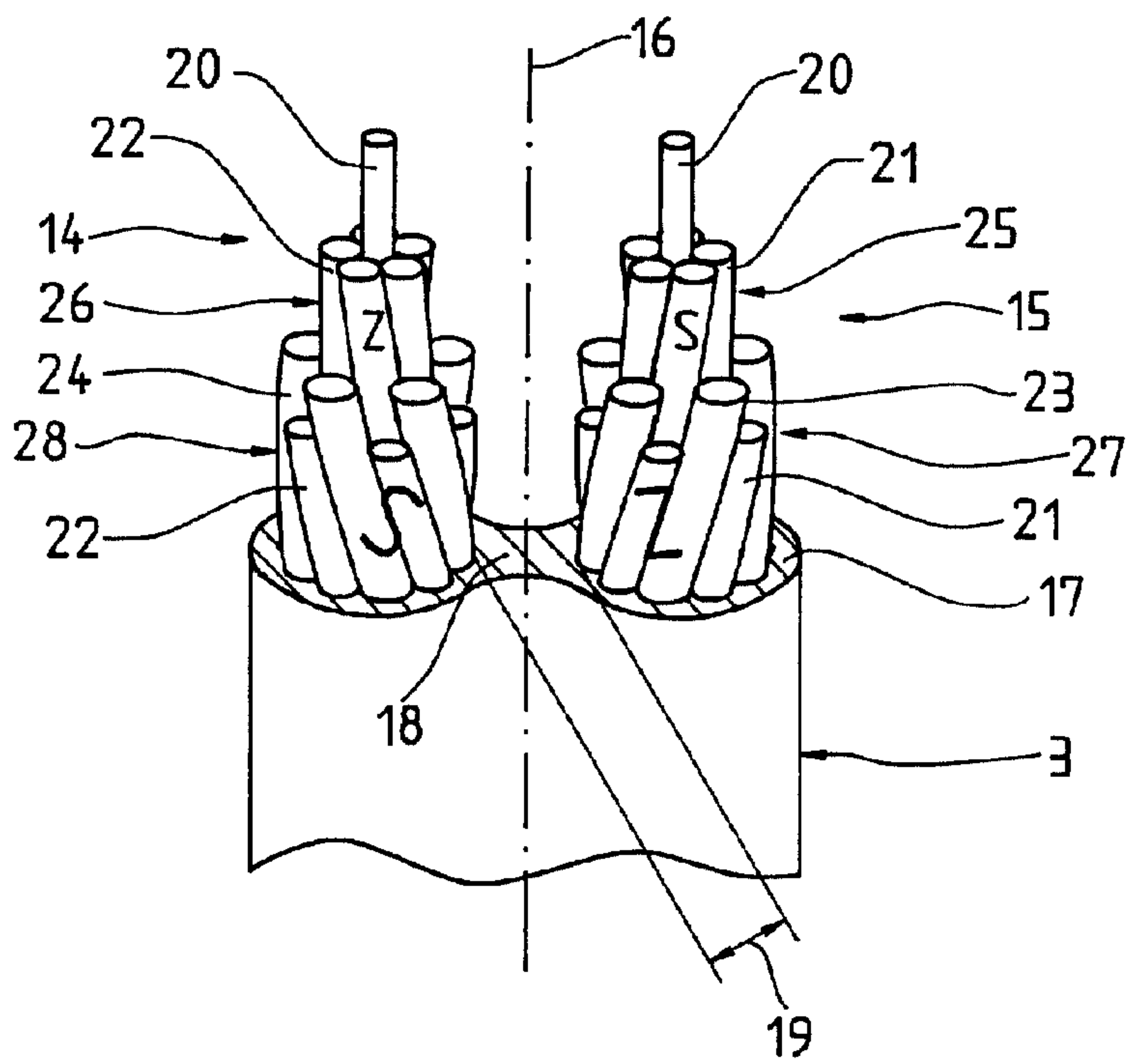
(51) Cl.Int./Int.Cl. *D07B 1/02* (2006.01), *D07B 1/16* (2006.01), *D07B 1/22* (2006.01)

(72) Inventeur/Inventor:
DE ANGELIS, CLAUDIO, CH

(73) Propriétaire/Owner:
INVENTIO AG, CH

(74) Agent: RICHES, MCKENZIE & HERBERT LLP

(54) Titre : CABLE EN FIBRES SYNTHETIQUES ENTRAINE PAR REA
(54) Title: SYNTHETIC FIBER ROPE TO BE DRIVEN BY A ROPE SHEAVE



(57) Abrégé/Abstract:
A synthetic fiber rope to be driven by a rope sheave is constructed as a twin rope (30) consisting of two ropes (14), (15) with opposite directions of twist (S), (Z) which are laid together and fixed in their positions parallel to, and at a distance from, each other, and so as not to rotate, by means of a common rope sheath (17). The rope sheath (17), which according to the invention is constructed over both ropes (14), (15), acts as a torque neutralizer which, when the twin rope (3) is loaded longitudinally, mutually offsets the oppositely oriented torques of the ropes (14), (15) which arise due to the structure of the rope, thereby causing over the entire cross-section of the twin rope (3) equalization of the torques from the sum of all the parts having right-hand strands and all the parts having left-hand strands. When the twin rope (3) runs over a rope sheave its behavior is free of rotation.

Abstract:

A synthetic fiber rope to be driven by a rope sheave is constructed as a twin rope (30) consisting of two ropes (14), (15) with opposite directions of twist (S), (Z) which are laid together and fixed in their positions parallel to, and at a distance from, each other, and so as not to rotate, by means of a common rope sheath (17). The rope sheath (17), which according to the invention is constructed over both ropes (14), (15), acts as a torque neutralizer which, when the twin rope (3) is loaded longitudinally, mutually offsets the oppositely oriented torques of the ropes (14), (15) which arise due to the structure of the rope, thereby causing over the entire cross-section of the twin rope (3) equalization of the torques from the sum of all the parts having right-hand strands and all the parts having left-hand strands. When the twin rope (3) runs over a rope sheave its behavior is free of rotation.

(Figure 2)

Synthetic Fiber Rope to be Driven by a Rope Sheave

The invention relates to a synthetic fiber rope, preferably or aromatic polyamide, to be driven by a rope sheave and consisting of a first load-bearing rope of synthetic fiber strands able to withstand tension which are twisted in a first direction of twist and a rope sheath surrounding the first rope.

In materials handling technology, especially on elevators, in crane construction, and in open-pit mining, moving ropes are an important element of machinery and subject to heavy use. An especially complex aspect is the loading of driven ropes, for example as they are used in elevator construction.

In conventional elevator installations the car sling of a car, which is moved in an elevator hoistway, and a counterweight are connected together by several steel stranded ropes. To raise and lower the car and the counterweight, the ropes run over a traction sheave which is driven by a drive motor. The drive torque is transferred by friction to the section of rope which at any moment is lying in the angle of wrap. At this point the ropes are subjected to tensile, bending, pressure, and torsion stresses. The relative movements caused by bending over the rope sheave cause friction within the rope structure which affects rope wear negatively depending on the concentration of lubricant. Depending on the rope construction, radius of bending, groove profile, and rope safety factor the primary and secondary stresses arising have a negative effect on the condition of the rope.

On elevator installations, as well as the strength requirements, considerations of energy lead to the demand for smallest possible masses. High-tensile synthetic fiber ropes, for example of aromatic polyamides or aramides with highly oriented molecule chains, fulfil these requirements better than steel ropes.

By comparison with conventional steel ropes of the same cross sectional area and same lifting capacity, ropes constructed of aramide fibers have only between one quarter and one fifth of the specific rope weight. In contrast to steel, due to the uniform alignment of the molecular chains, aramide fibers have a substantially lower transverse strength in relation to their longitudinal load-bearing capacity.

For this reason, to minimize the lateral stresses to which the aramide fibers are subjected as they pass over the traction sheave, EP 0 672 781 A1 for example proposes an aramide fiber stranded rope with suitable parallel lay for use as a driving rope. The aramide rope which has thereby become known affords very satisfactory values in relation to service life, high wear resistance, and fatigue strength under reverse bending stresses; however, under unfavorable conditions with parallel laid aramide ropes, there is the possibility that partial unwinding of the rope occurs, which is permanently detrimental to the original balance of the rope structure. Such unwinding results firstly from the internal torques around the longitudinal axis of the rope which, depending on the load on the rope, generate unwinding of the rope, and secondly from the rope deflections caused externally, for example by the rope running out of alignment over rope pulleys. In this case, dragging of the rope on the flanks of the grooves causes a further change in the structure of the rope. The unwinding causes excessive lengths in the covering layer of strands which are permanently displaced in one direction or the other depending on the direction of rolling. Such occurrences are undesirable because the functionality of the aramide rope can be permanently impaired.

The invention has the objective of avoiding the disadvantages of the known synthetic fiber rope, and proposing a synthetic fiber rope with a construction which is neutral to twisting.

According to the invention, in one aspect, this objective is achieve by a synthetic fiber rope to be driven by a rope sheave including of a first load-bearing rope of synthetic fiber strands able to withstand tension which are twisted in a first direction of twist, wherein, a second rope twisted in the opposite direction of twist to the first direction of twist is positioned substantially parallel to the first twisted rope and at a distance from it, and that the two twisted ropes are surround and fixed in their parallel relationship to each other against rotation by means of a common rope sheath.

In the twin rope according to the invention, the rope sheath formed over both aramide ropes acts as a torque neutralizer. The aramide ropes preferably have an identical rope construction, but the directions of their lays are mirror images of each other, i.e. one rope is right-handed, the other rope is left-handed. This ensures that the opposing torques around the longitudinal rope axis which arise under tension, and when passing over rope sheaves, are mutually compensated by means of the torque neutralizer so that the sum of the torques resulting from the right-hand and left-hand aramide ropes when under load is zero. The external torque acting on the rope as it passes over the traction sheave is neutralized by the external contour of the sheathed twin rope. The former round shape of the rope is now approximately oval, the aramide rope being preferably twice as wide as high.

The rope construction of each of the twin ropes may then differ from each other if the function of the twin rope in its entirety, meaning the neutralization of the sum of the torques, is given.

The service life of parallel laid strands can be increased if, for example, in the case of two layers laid with parallel lay, the direction of twist of the fibers of the strands of one layer of strands is opposite to the direction of twist of the fibers of strands of the other layer of strands.

The invention is described in detail below by reference to exemplary embodiments shown the drawings. The drawings show:

Figure 1 A schematic view of an elevator installation with a car connected to a counterweight by synthetic fiber stranded ropes according to the invention;

Figure 2 A perspective view of a first exemplary embodiment of the twin rope according to the invention;

Figure 3 A cross-sectional view of a second exemplary embodiment of the invention.

According to Figure 1, a car 2 which moves in a hoistway 1 hangs from several, here three, load-bearing twin ropes 3 of aramide fibers according to the invention which pass over a traction sheave 5 connected to a drive motor 4. On the car 2 are rope end connections 6 to which the twin ropes 3 are fastened with one end. The other end of each of the twin ropes 3 is fastened in the same manner to a counterweight 7, which also moves in the hoistway 1. Compensating ropes 9 are attached in a similar manner with one end to the underside of the car 2, from where the compensating ropes 9 are guided over a diverter pulley 11 located on the hoistway floor 10 aligned directly below the point of attachment to the car floor, and over an adjacent diverter pulley 12 also mounted on the hoistway floor 10 aligned to the counterweight 7, to the underside of the counterweight 7 to which they are linked. Over their entire length between the car 2 and the counterweight 7, the compensating ropes 9 are maintained under tension by means of weights or, as shown here, by means of the pulley 12. Here an extension spring 13, which is anchored to the hoistway wall, pulls the diverter pulley 12 in the direction of the hoistway wall thereby maintaining tension in the compensating ropes 9. Instead of the extension spring, the diverter pulley can be equipped with a suitable linkage arrangement to apply tension to the compensating ropes.

In contrast to the elevator installation shown in Figure 1, due to the use of the twin rope of aramid fibre having reduced specific rope weight, the number of compensating ropes can be reduced or compensation ropes even are not necessary any more. This enables higher maximum travel hight and/ or larger maximum permissable load for the aramid ropes having identical dimensions compared to conventional steel ropes.

The traction sheave 5 has three double grooves 8 lying close to each other, each of which is for a twin rope 3, 3' according to the invention as described further below. Until the present time, traction sheaves in elevator construction have usually had two to twelve grooves; correspondingly, when twin ropes 3 according to the invention are used, traction sheaves can be provided with one to six double grooves 8.

Instead of the layout of a traction drive elevator shown in Figure 1, the drive 4, 5 can be located either on the hoistway floor 10, or on the hoistway wall in the lower part of the elevator hoistway 1 below the car 2 and counterweight 7. The diverter pulleys 11, 12 - or only one diverter pulley - would then be anchored at the upper end of the hoistway. The compensating ropes 9 then essentially take over the load-bearing function, and the twin ropes 3 according to the invention the raising and lowering of the car 2 and counterweight 7.

Figure 2 shows a twin rope 3 in its details. The twin rope 3 is built up of two synthetic fiber ropes 14, 15 arranged parallel to, and at a distance from, each other which are fixed in their position relative to each other, and in particular prevented from twisting, by the rope sheath 17 which surrounds them both and combines them together to the twin rope 3 according to the invention. The ropes 14, 15 are twisted ropes manufactured by two-stage laying of rope strands, there being in the second stage two layers 25, 26, 27, 28 of rope strands 20, 21, 22, 23, 24 laid together. According to the invention, the two synthetic fiber ropes 14, 15 differ with respect to their direction of twist S, Z, where S indicates a left-handed and Z a right-handed direction of twist.

In rope 14 rope yarns of aramide fibers with twist S are laid together to strands 22, 24 with twist Z. In a first layer of strands 26, five such strands 22 with twist Z are laid with twist S around a core strand 20. Parallel to these five strands 22, five strands 24 of greater diameter with twist Z are laid to form a second layer of strands 28. Together they form a twisted, two-layer stranded rope, namely the rope 14 with twist S.

The construction of rope 15 is the same as that of rope 14 except for contrary directions of twist S, Z. Thus, in rope 15, synthetic fiber rope yarns with twist Z are twisted into strands 21, 23 with twist S. These strands 21, 23 with twist S are laid in two layers 25, 27 into the rope 15 with twist Z.

In the second layer of strands 27 the strands 23 of greater diameter lie in the hollows of the first layer of strands 25 that carries them, whereas the five strands 21 lie on the highest points of the first layer of strands 25 that carries them, thereby filling the gaps between adjacent strands 23 of greater diameter. In this manner, the two-layer parallel laid ropes 14, 15 obtain an almost cylindrical external profile.

Whereas the strands 21, 23, 22, 24 are laid together with a balanced relationship between the length of lay of fibers and strands, the aramide fiber yarns can be laid with the same or, as in the embodiment shown in Figure 1, with opposite directions of twist to the strands 21, 23, 22, 24 of the layer 25, 27, 26, 28 to which they belong. The same direction of twist achieves a better cohesion of the lay of the twin rope 3, 3' in the unloaded state. An increase in the service life can be achieved if the direction of twist of the rope yarns of the first layer of strands 25, 26 is chosen to be opposite to the direction of twist of the threads of strands 21, 23 of the second layer of strands 27, 28 or vice versa.

The directions of twist S and Z, i.e. the helical direction of pitch of the aramide fibers of the rope yarns of a strand 21, 22, 23, 24 and of the strands 21, 22, 23, 24 in the ropes 14, 15, 14', 15', are defined in that with twist S the rope yarns and/or the strands 22, 24 are all laid together in one direction such that lying helically they follow the middle segment of the letter S; hence the designation "twist S". For a lay with twist Z the situation is converse, in that the elements 21, 23 to be laid together also all lie helically uniformly against each other in the direction of the middle segment of the letter Z and the lay is therefore designated as "twist Z".

As already mentioned above, the strands 20, 21, 22, 23, 24, 25, 36, 37, used for the twin rope 3, 3' are twisted from aramide fiber yarns. To protect the fibers, each individual aramide fiber yarn, and also the strands 20, 21, 22, 23, 24, 35, 36, 37 themselves, is treated with an impregnating substance, e.g. polyurethane, polyolefin, or polyvinylchloride. Depending on the desired reverse-bending performance, the proportion of impregnation can lie between 10 and 60%.

The entire external circumference of the ropes 14 and 15 is surrounded by a rope sheath 17 of plastic material such as, for example, rubber, polyurethane, polyolefin, polyvinylchloride, or polyamide. The elastically formable material of whatever sort is sprayed or extruded onto the ropes 14 and 15' and then compressed onto them. The rope sheath material thus penetrates from the exterior into all the interstices between the strands 22, 24 on the external circumference and fills them. The bonding of the rope sheath 17 to the ropes 14 and 15 thereby formed is so strong that only slight relative movements occur between strands 22, 24 of the ropes 14, 15 and the rope sheath 17; furthermore, the single-piece rope sheath 17 formed over both ropes 14, 15 according to the invention serves as a connecting web 18 bridging the gap between the two regular-lay ropes 14, 15 which acts as a torque bridge and mutually eliminates the oppositely-oriented torques in the ropes 14, 15 caused by the rope construction which arise when the twin rope 3 is loaded longitudinally, and thereby results in neutralization of the torques between the sum of all right-handed and all left-handed strands over the entire cross-section of the twin rope 3 according to the invention.

The external profile of the rope sheath 17 of the twin rope 3 has the shape of a dumbbell with which to bring about better transmission of force and a constant coefficient of friction with a value greater than 0.18 and a supporting effect by the flanks of the grooves to increase the service life further. The twin ropes can also be used on a cylindrical, oval, concave, rectangular, or wedge-shaped groove. The external profile of the twin ropes 30 is adapted to correspond to this purpose. For example, a rib formed along the length of the rope acts together with a complementary shape of groove for exactly true running of the twin rope on the rope traction sheave.

In a second exemplary embodiment shown in Figure 3, the twin rope 30 consists of two ropes 31, 32 twisted with opposite directions of twist S, Z, which are fixed parallel to, and at a distance from, each other, and so as not to rotate, by means of a common rope sheath 33. Except for the different directions of twist S, Z of the ropes 31, 32 the twin rope 30 is constructed symmetrical to the longitudinal axis of the rope 33.

The ropes 31 and 32 each consist of three groups of strands 35, 36, 37 with different diameters. The number of yarns in all the strands 35, 36, 37 of the twin rope 30 is the same, and depends on the desired diameter of the ropes 31, 32 to be made. In rope 31 of this exemplary embodiment three strands 35 with twist Z are laid into a rope core with twist S. Around this rope core three further strands 36 are laid in parallel lay and lie close against the outer profile of the rope core. Lastly, the interstices between the strands 35, 36 which are laid together on the outside circumference of rope 31 are filled with strands 37 of the third group. These strands 37 are also laid parallel and helically to the rope 31. The structure of rope 32 differs from that of rope 31 solely in the opposite directions of twist S, Z of the aramide yarns and strands.

In this exemplary embodiment, the rope sheath 33 is formed to be flat and surround the ropes 14', 15' on all sides, the width of the twin rope 30 being substantially greater than its thickness. To produce a desired coefficient of friction, the rope sheath 33 is completely, or as here partially in the region of the connecting web 38, coated with suitable materials. As an alternative, or additionally, to produce a desired coefficient of friction, the material of the traction sheave groove liners can be appropriately selected.

List of Reference Numbers

1	Hoistway
2	Car
3	Twin rope
4	Drive motor
5	Traction sheave
6	Rope end connection
7	Counterweight
8	Double grooves
9	Compensating rope
10	Hoistway floor
11	Diverter pulley
12	Diverter pulley
13	Extension spring
14	Rope with twist S
15	Rope with twist Z
16	Longitudinal axis of rope
17	Rope sheath
18	Connecting web
19	Distance between ropes
20	Core strand
21	Strand, twist S
22	Strand, twist Z
23	Strand, twist S
24	Strand, twist Z
25	First layer of strands, twist Z
26	First layer of strands, twist S
27	Second layer of strands, twist Z
28	Second layer of strands, twist S
29	
30	Twin rope
31	Rope
32	Rope
33	Rope sheath
34	Longitudinal axis of rope
35	Strand

36	Strand, thick
37	Strand, thin

Claims:

1. Synthetic fiber rope to be driven by a rope sheave including a first load-bearing rope of synthetic fiber strands able to withstand tension which are twisted in a first direction of twist, wherein,

a second rope twisted in the opposite direction of twist to the first direction of twist is positioned substantially parallel to the first twisted rope and at a distance from it, and that the two twisted ropes are surround and fixed in their parallel relationship to each other against rotation by means of a common rope sheath.

2. Synthetic fiber rope according to Claim 1, characterized in that the synthetic fiber rope, except for the different directions of twist of the twisted ropes is constructed symmetrically about the longitudinal axis of the rope.

3. Synthetic fiber rope according to Claim 1, characterized in that the strands consist of aramide fibers lying parallel to each other.

4. Synthetic fiber rope according to Claim 1, characterized in that synthetic fibers with twist S are laid into strands with twist S, and synthetic fibers with twist Z are laid into strands with twist Z.

5. Synthetic fiber rope according to Claim 1, characterized in that synthetic fibers with twist S are laid into strands with twist Z, and synthetic fibers with twist Z are laid into strands with twist S.

6. Synthetic fiber rope according to Claim 4 or Claim 5, characterized in that strands with twist S are laid into a rope with twist 2, and strands with twist Z are laid into a rope with twist S.

7. Synthetic fiber rope according to any one of Claims 1 to 6 characterized in that

the cross section of the rope sheath has a shape selected from a flat shape and a dumbbell shape.

8. Synthetic fiber rope according to any one of Claims 1 to 6 characterized in that

the rope sheath has a cross-sectional shape selected from the group consisting of a cylindrical shape, an oval shape, a concave shape, a rectangular shape, and a wedge-shape.

9. Synthetic fiber rope according to any one of Claims 1 to 8 characterized in that

the rope sheath is constructed in one piece.

Fig. 1

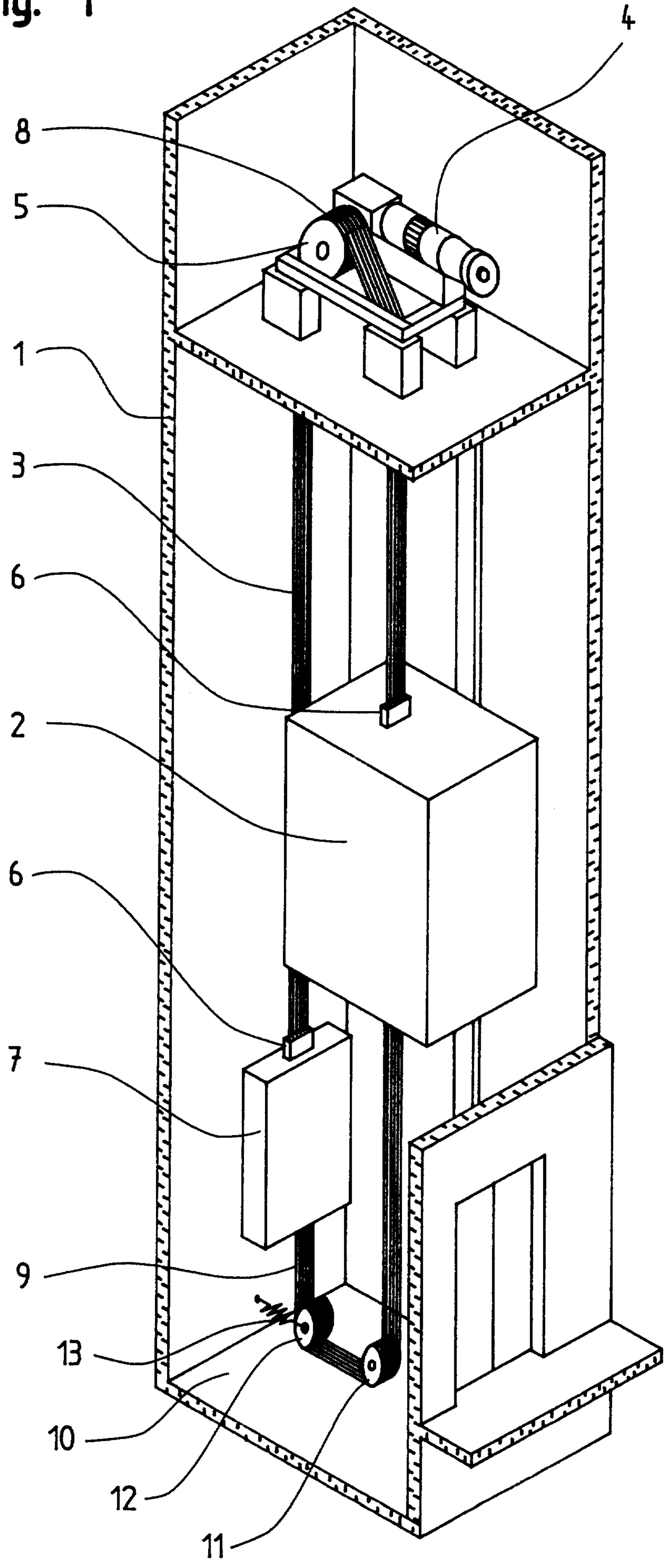


Fig. 2

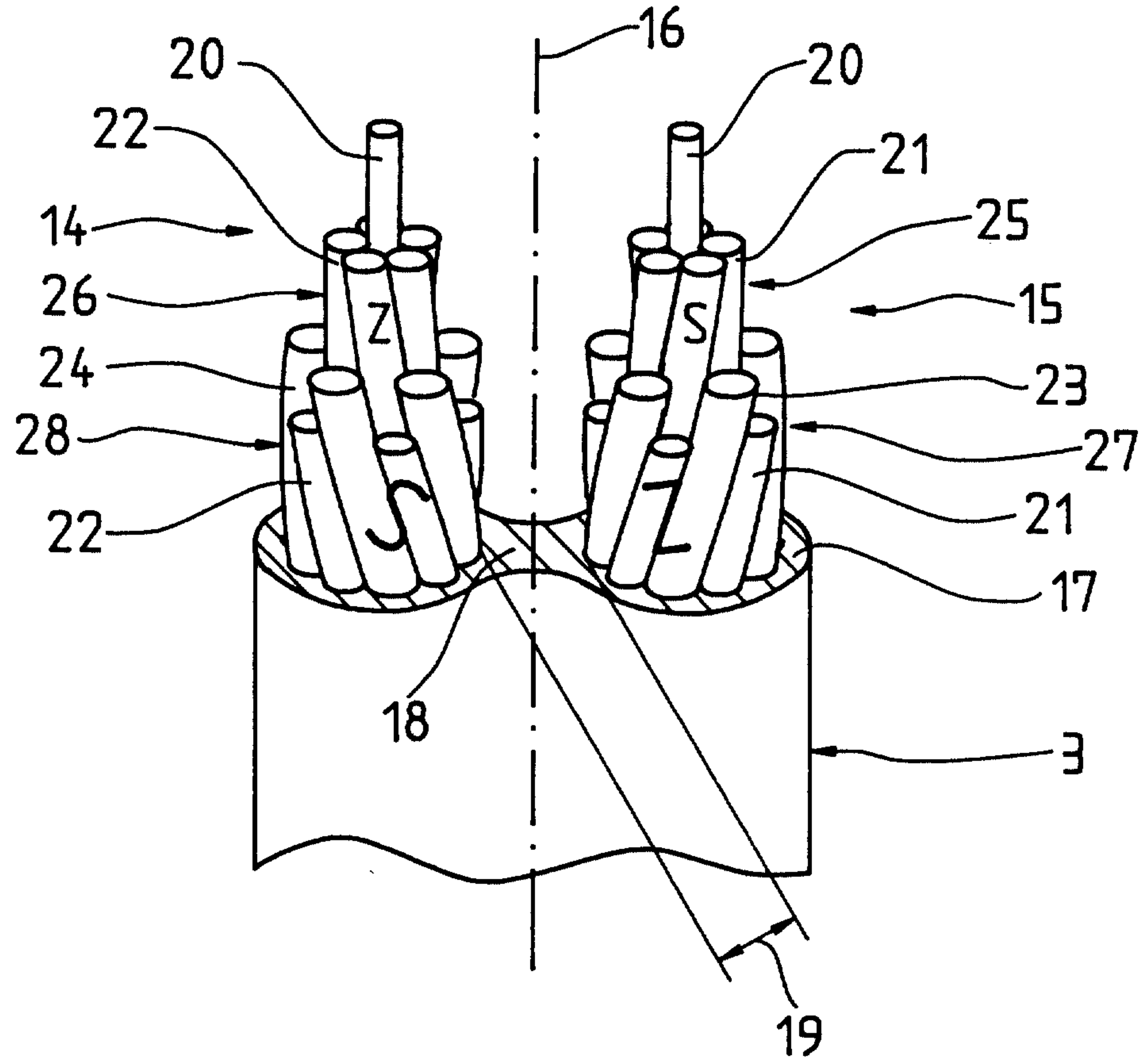
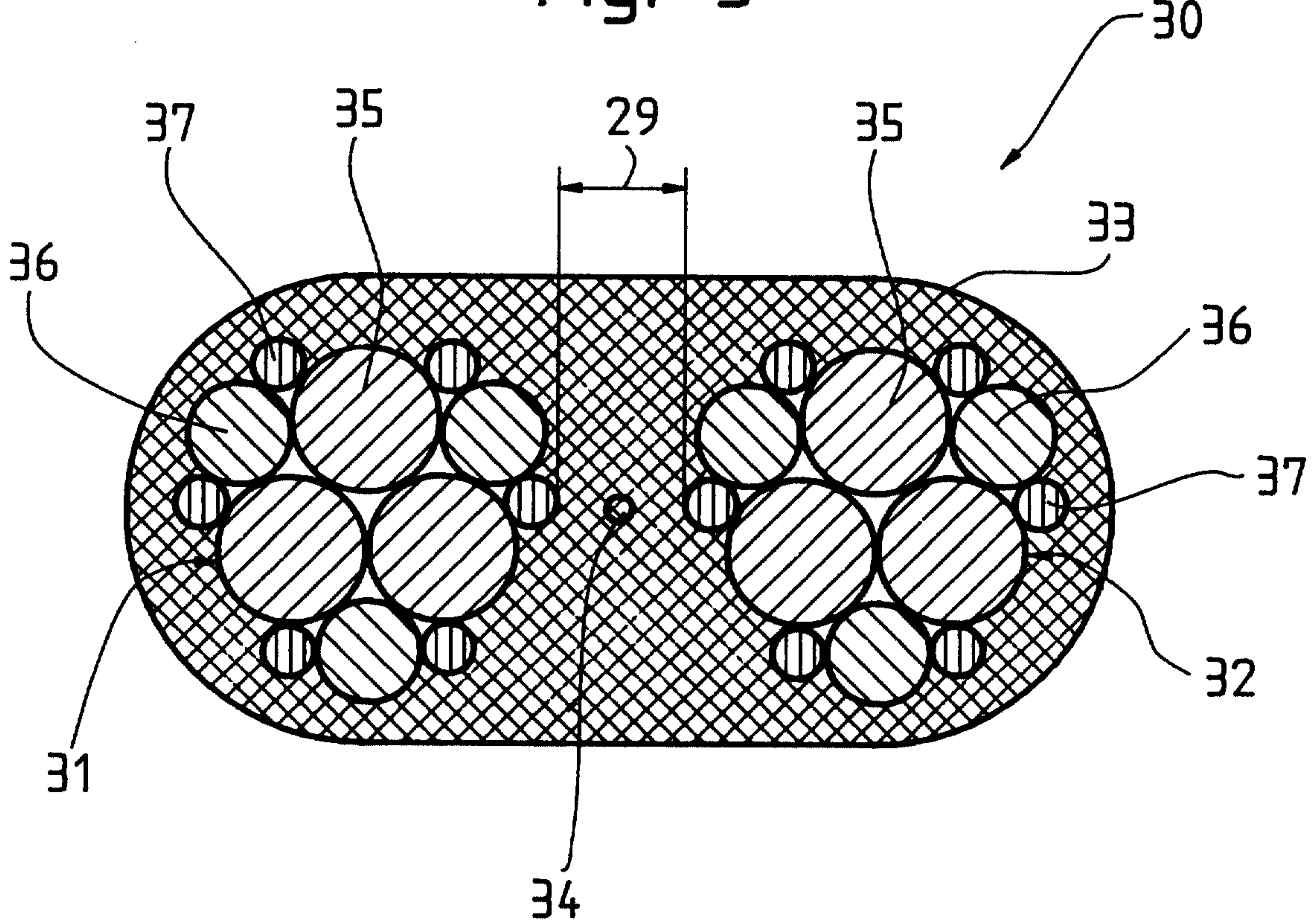
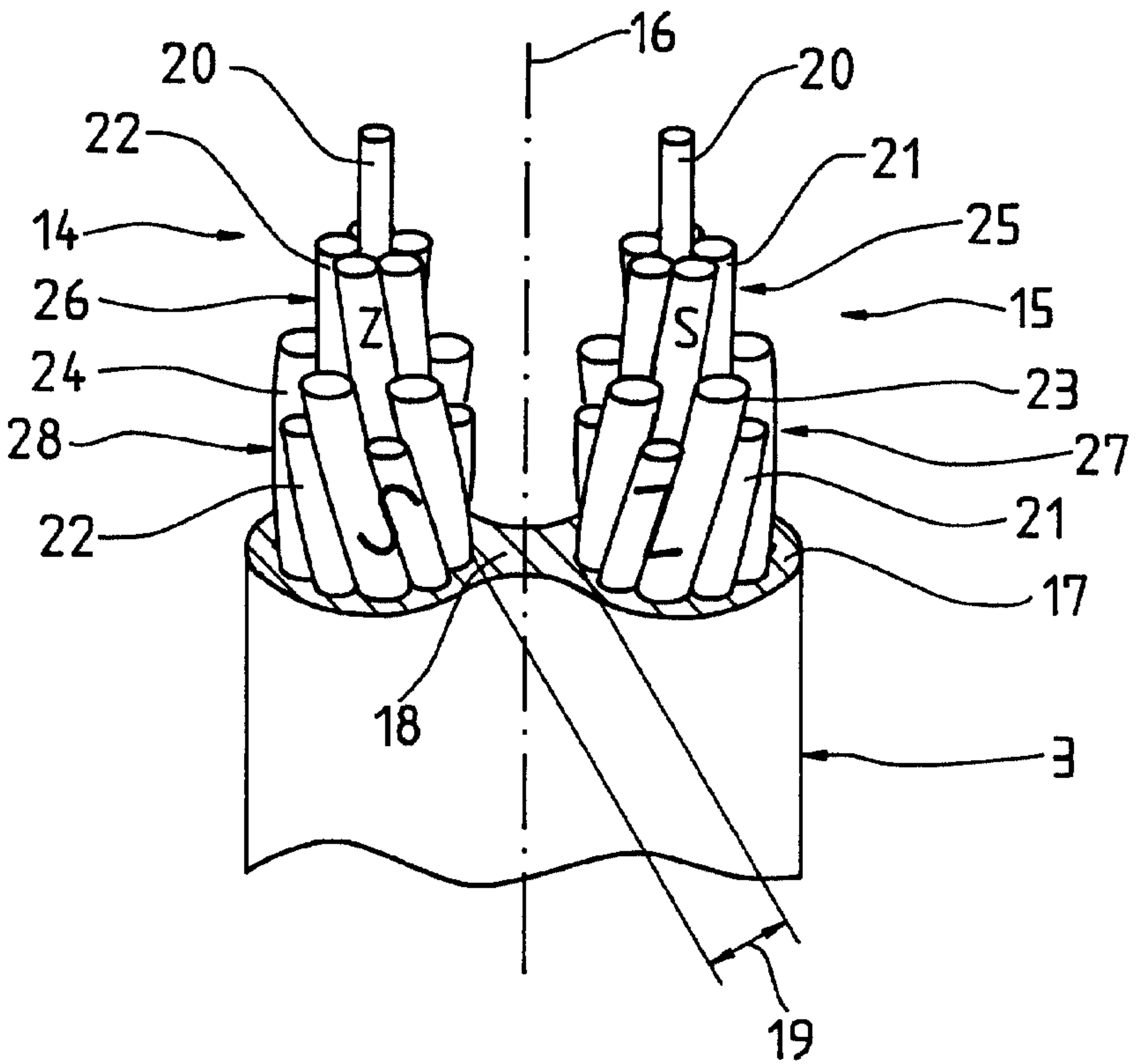

20
16
20
22
21
14
25
26
15
Z
S
24
23
28
27
22
21
17
18
3
19

Fig. 3


30
37
35
29
35
33
36
36
37
31
32
34


16
20
20
22
21
14
25
26
15
Z
S
24
23
28
27
22
21
17
18
3
19