May 29, 1962 H. MÜLLER ET AL 3,036,490

MOUNTAINEERING ROPES

Filed Sept. 16, 1958

FIG. 1

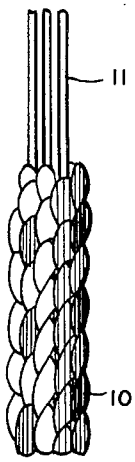


FIG. 2

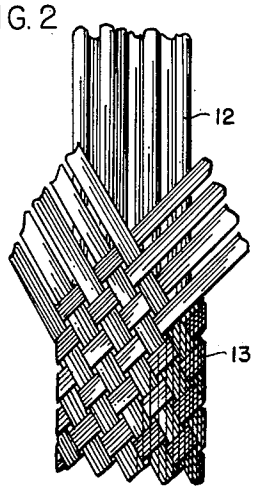


FIG. 3

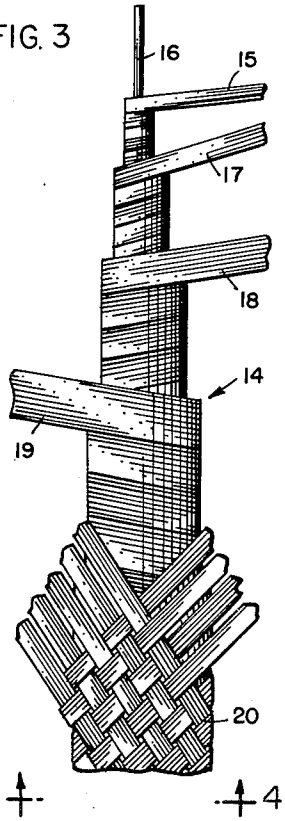
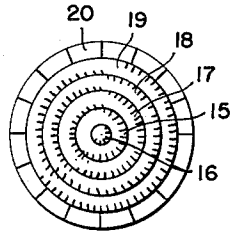


FIG. 4



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MOUNTAINEERING ROPES

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This invention, in general, relates to the production of ropes and has particular application to the production of ropes which may be subjected to severe shock and bending, as in the case of ropes used in mountain climbing.

The production of ropes of fiber yarns or endless threads can be accomplished in various manners. In the processing of continuous, synthetically produced filaments into ropes, twisted or braided ropes and also core-and-mantle construction ropes are produced. The twisted rope is built up by constantly increasing twist units. The spirally formed (plaited or braided) rope is produced by the well known Barmen plaiting.

The mantles produced by Barmen plaiting are composed of cross-braided strands which are spirally braided about the core. Each strand follows a spiral, undulating path. The braided mantle has an appearance similar to the structure of a woven fabric. The cross-braided mantles are illustrated in FIGS. 2 and 3 of the drawings.

These ropes, because of their constructive development, have a moderate to poor utilization of material. By material utilization is meant the quotient of the specific rope strength to the total of the specific thread or filament strength. This value varies between 0.33 and 0.55, or 33% to 55%, in ropes of the construction above mentioned. This means that only 33% to 55% of the total maximum usable strength of the filaments is utilized in the rope.

According to the results of thorough investigation of the various rope structures, it is possible to expect in twisted ropes a material utilization of 50% to 55% and with spirally braided ropes a material utilization of only 33% to 40% in ropes having a diameter of 10 mm. to 12 mm., a diameter common with mountaineering ropes. A clear improvement in the material utilization is provided by the core-and-mantle construction, in which the core, in a known manner, is composed of a multiplicity of parallel yarns, which are held together by a mantle of Barmen plaiting. The filaments of the mantle may be of the same or of a different material than the core.

In a straight pulling test, the ropes of core and mantle construction have, primarily through parallelism of the yarns in the core and through certain arrangements which bring about a simultaneous breakage of core and mantle at the attainment of breaking strength, a material utilization of 70% and above. Ropes, especially mountaineering ropes, however, are hardly ever subjected to demands involving only simple tensile strength in a serious situation. Generally, shock loads occur, in which the rope is strained additionally by bending in a narrow bending radius over edges of rocks and the like.

These bending strains can be absorbed only very incompletely by straight, parallel yarns, such as are contained in the above-mentioned prior rope constructions. In ropes utilizing cables of parallel yarns, tension and pressure zones always occur at the bending point, which result, at the moment of crash load, in a very unfavorable distribution of stress. The entire load shock is there taken up by only a part of the parallel threads, and this one-sided load absorption leads to tearing of the overstrained core yarns. In such a case, therefore, there is a clear impairment of the crash strength of such a rope.

It was found in accordance with our invention that

ropes distribute the tensions in the bending cross-section more uniformly, if they are composed of synthetic polymer threads with a mantle-core structure illustrated in the accompanying drawing in which at least 60% of the thread quantity is contained in the core **1**, and the core consists of strands twisted in cable fashion, while the mantle **2** is built up of braided thread layers. In ropes constructed in this manner there are always only short pieces of thread in the pressure or tension area and a good balancing of the various types of tension is thereby provided.

An extremely serious drawback which occurs in the mountaineering ropes hitherto used, namely a looping or twisting tendency after shock loadings can likewise be largely eliminated by the rope construction according to the invention. What is important here is the structure of the core. The core, in accordance with the invention, must consist of one or more cable-twisted strands, which are built up from two or more yarn layers in such a way that the sum of the yarn twist and strand twist torques under loading is equal to zero. Especially favorable properties are achieved in ropes in which the twist length in the outermost core layer is between 70 mm. and 90 mm., preferably about 80 mm. Such a rope, whose construction is made clear in detail from Example 3, shows an almost complete rope-stabilization after a shock loading.

The advantage of the rope structure according to our invention can best be explained by comparative examples in which are described ropes made from continuous nylon filaments as: (1) a spirally braided nylon rope with core; (2) a nylon rope composed of almost parallel weakly twisted threads as core and a cross-braided mantle; and (3) a nylon rope according to our invention with a cable-twisted core and a cross-braided mantle.

The following examples describe the aforementioned types of rope in conjunction with the drawing wherein:

FIG. 1 shows the spirally braided rope with a parallel strand core of previously known construction;

FIG. 2 illustrates a rope of known construction having a substantially parallel, mildly twisted strand core with a cross-braided mantle;

FIG. 3 illustrates an embodiment of a rope constructed in accordance with our invention; and

FIG. 4 illustrates a cross-section of the rope of FIG. 3 taken at right angles to the rope axis.

Example 1

A rope (FIG. 1) of altogether 30 yarns of poly-ε-caprolactam each of 14,400 denier, has a spirally braided mantle **10** which makes up 97.4% of the total weight mass of the yarns. The core **11** consists of only 3 yarns of 10,800 denier each, which lie nearly parallel and about which the mantle is braided. The basic yarn has a strength of about 6.5 g./denier at a stretch of 15%. The rope strength amounts to 1.25 g./denier at 92% stretch, has a relative edge strength of 52% and a relative loop strength of 60%. Spirally braided ropes are described, for example, in Melliand-Textilberichte, pp. 406–408 (1935).

Example 2

A rope (FIG. 2) of ε-caprolactam polyamide threads, consisting of core **12** and mantle **13**, with a weight distribution of 60% of the threads by weight in the core and 40% by weight in the mantle is built up in the following manner. The rope is composed of 40 parallel yarns with a denier of 5,750 denier each. Each thread has a S-twist of 80 turns/meter. The threads of the core are stretched in a ratio of 1:4.2. The basic yarn strength amounts to 4.0 g./denier at a breaking elongation of 32%.

Around this core **12**, a cross-braided mantle **13** is built up, and it is braided from 4 braids, each with 6 braided

yarns. Each of these yarns consists of 5 hot-stretched, 850 denier threads of the same caprolactam polyamide with a Z-twist of 30 turns/meter. Strength of the basic mantle yarn was 5–6 g./denier at a breaking extension of 18%. The breaking strength of the entire rope amounted, at 9.6 mm. diameter, to approximately 2.9 g./denier, with a breakage extension of approximately 33%. The relative edge strength of the rope was 55%, and the relative loop strength was 60%.

Example 3

Referring to FIGS. 3 and 4, a core is built up from 8,000 denier poly-ε-caprolactam strands by S-twisting (winding in a S-direction) 6 strands **15** about a central, single strand **16** at a twist length of 19 mm. to a diameter of 3.2 mm. About this segment is further S-twisted, at a twist length of 44 mm., 12 additional strands **17** to a diameter of 5.3 mm. The core is further built up by S-twisting about the latter segment eighteen additional strands **18** at a twist length of 66 mm. to a diameter of 7.5 mm. Finally, the core is completed by Z-twisting about the 7.5 mm. segment **24** additional strands **19** at a twist length of 71 mm. to a 9.3 mm. diameter. This core is surrounded by a braided mantle **20**, which is constructed of 3,000 denier strands in Barmen plaiting to give a mass distribution of 65% by weight in the core and 35% by weight in the mantle. The strength of the basic yarn amounts to 6.5 g./denier at 22% stretch. The strength of the entire rope is 3.7 g./denier at 28% stretch. The rope had a relative edge strength of 60%, and a relative loop strength of 69%.

The invention is hereby claimed as follows:

1. A mountaineering rope consisting of a core and mantle composed only of strands of synthetic filament yarns wherein the core contains at least 60% by weight of the rope yarn mass and consists essentially of a plurality of superposed, S-wound and Z-wound layers of strands of synthetic filament yarns, and the mantle consists of strands of synthetic filament yarns braided about the core.

2. A mountaineering rope consisting of a core and mantle composed only of strands of synthetic filament yarns wherein the core contains at least 60% by weight of the rope yarn mass and consists essentially of a plurality of superposed, S-wound and Z-wound layers of strands made of twisted yarns of synthetic fibers, wherein the amount of twist and the direction of twist of the respective yarns and strands in the core makes the sum of the torques of the yarns and the strands in the core equal to zero under loading, and the mantle consists of strands of synthetic filament yarns braided about the core.

3. The rope of claim 2 wherein the innermost layer of the layers of wound strands of the core is wound about a central strand.

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