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3,240,082

PUSH-PULL CABLE WITH REINFORCED CORE ELEMENT

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FIG. 1

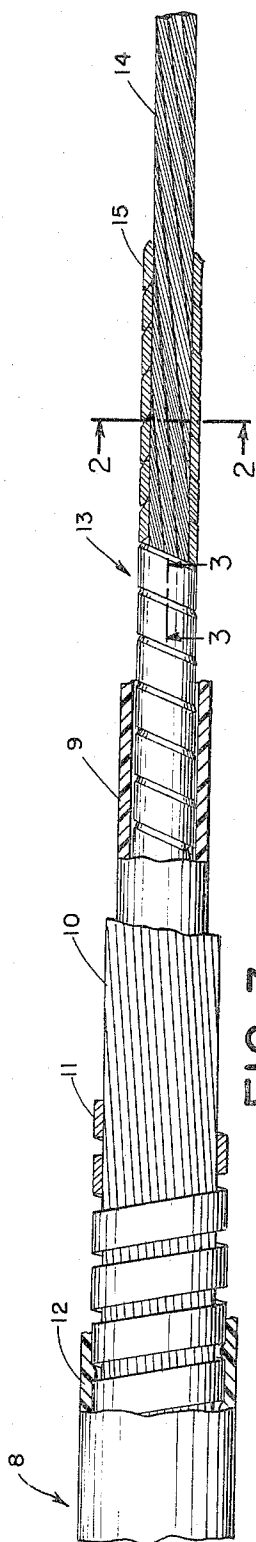


FIG. 3

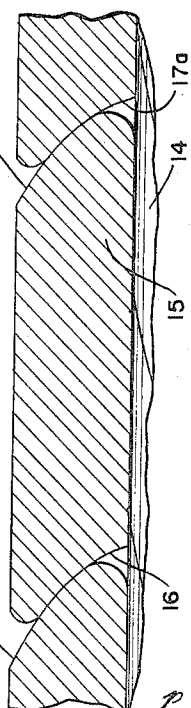


FIG. 4

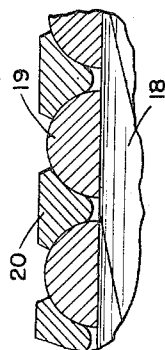


FIG. 2

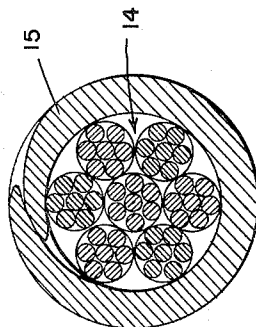
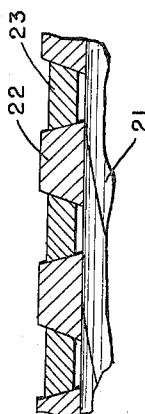


FIG. 5



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PUSH-PULL CABLE WITH REINFORCED CORE ELEMENT

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This invention relates to flexible push-pull cable assemblies comprising a core element slidable within a tubular casing and, more particularly, to an assembly of that type wherein the core element is reinforced with a highly flexible outer wire wrapping of engaged helical turns.

Push-pull cables are often required to transmit high compressive loads of hundreds and even thousands of pounds. In some boat steering devices, for example, the core element of a push-pull cable assembly is urged into its casing by pairs of driving rolls to transmit a strong push to an outboard motor or rudder at the driven end of the assembly. For the ordinary core element, which usually is a stranded wire cable of relatively short lay perhaps eight to twelve times the cable diameter, this compressive loading presents difficulties because of its tendency to buckle between the pairs of driving rolls and to compress axially throughout the casing. Buckling, of course, results in failure of the load transmittal and axial compression seriously reduces the operating efficiency of the push-pull cable assembly.

In studying this problem, consideration has been given to reinforcing the twisted wire core element with a helical wrapping of common flat wire having flat squared-off edges. It was discovered, however, that if the turns of such flat wire reinforcement are in engagement when the core element is straight the wire then functions as a column and greatly reduces the flexibility of the core element in compression. On the other hand, if the flat wire turns are widely spaced to preserve flexibility they then act like a coil spring which contracts under compressive loads. Such contraction may pinch and sever the strands of the inner member, it absorbs considerable energy which reduces operating efficiency, and if the contraction is cyclical it endangers fatigue failure. These disadvantages can be mitigated somewhat if the turns of flat wire are very precisely spaced, in the order of thousandths of an inch, so that they just contact one another on the inside of a bend when the core element is flexed under compression during use. For commercial purposes this dimensional precision is beyond practical control and hence stranded core elements reinforced with conventional flat wire cannot be considered satisfactory.

The present invention achieves full reinforcement against buckling and compression of the core element without reducing flexibility, pinching the inner strands, endangering fatigue failure, impairing efficiency, or requiring extraordinary dimensional control during fabrication. In broad terms, the invention is directed to either the new core element alone or in combination with an exterior tubular casing within which it is slidable in a flexible push-pull cable. This core element comprises an elongated inner member, and at least one wire helically wrapped about the inner member with adjacent turns of the wire in partially overlapped engagement permitting limited axial sliding displacement of the engaged turns with respect to one another when the core element is bent. In its more specific forms, at least one reinforcing wire may be provided about the inner member which is of substantially parallelogram cross section with corresponding concave and convex opposed edge portions, or of other cross sections and other edge portions, which overlap in mating engagement from one

turn to the next. The elongated inner member may comprise a plurality of twisted wire strands.

When the core element of a push-pull cable is reinforced with a helical wrapping of engaged overlapping turns of wire in accordance with this invention, there is a great increase in its resistance to column stress which would tend to buckle the core element between pairs of driving rolls where it is not surrounded by the exterior tubular casing. Because each pair of adjacent turns of the new wire core reinforcement are in full line or surface contact with one another in the straight or bent position of the assembly, the reinforcing wire does not contract like a spring when it transmits compression and hence there is no appreciable absorption of energy and reduction in efficiency of operation. For the same reason, no inter-turn gaps are present in the reinforcement which could close under compression to pinch the outer wire strands of the inner member and cause failure. Furthermore, the full engagement between the turns of the new reinforcement precludes fatigue failure due to repeated expansion and contraction. Notwithstanding the high column strength contributed by the new outer reinforcement due to full inter-turn engagement, the composite core element preserves optimum flexibility even under compression because the overlapped engagement between the turns permits limited axial sliding displacement of one turn with respect to the next when the core element is bent. Thus, on the inside of a bend a given turn slides in one direction over the next a very slight amount while on the outside of the bend the diametrically opposed portion of that same turn slides in the opposite direction over the next a comparable slight amount. The net result is that the turns remain in full engagement even when bent and their neutral bending axis remains coincident with their geometric axis. This novel construction has the further advantage of not requiring unusual dimensional control during assembly to achieve the desired results, and hence it is eminently practical for commercial purposes.

A preferred embodiment of the invention is described hereinbelow with reference to the accompanying drawing, wherein

FIG. 1 is a fragmentary elevation partly broken away of a length of push-pull cable equipped with the improved inner core element;

FIG. 2 is an enlarged section taken along the line 2—2 of FIG. 1;

FIG. 3 is an enlarged fragmentary section taken along the line 3—3 of FIG. 1;

FIG. 4 is an enlarged fragmentary section of another embodiment of the new reinforced core element; and

FIG. 5 is an enlarged fragmentary section of a further embodiment of the new reinforced core element.

Referring first to FIG. 1, the push-pull cable assembly includes an outer tubular casing shown generally by the reference numeral 8. One of the most advantageous forms of the casing 8 which avoids stretching when the core element of the assembly is subjected to compressive forces is that which includes an interior liner 9 of plastic material such as polytetrafluoroethylene. Disposed about the liner 9 is a plurality of side-by-side helically arranged wires 10 of relatively long lay, and these wires in turn are held together by a flat wire 11 tightly applied helically in a relatively short lay with spaces between its successive convolutions. An outer sheath 12 of plastic is extruded about the flat wire 11 to define a protective exterior on the casing. This tubular casing is disclosed here for purposes of example because it is representative of one of the better modern designs, but it is to be understood that the core element provided by the invention does not necessarily have to be combined with a casing of that type. Indeed, in some instances the new core element described hereinbelow may operate

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successfully to transmit compression or tension without any tubular casing at all, for example between closely spaced pairs of guiding or driving rolls.

The new core element shown generally by the reference numeral 13 has a maximum outside diameter slightly less than the bore diameter of the casing liner 9 so that it may slide therewithin longitudinally with ease but with as little free transverse movement as possible. In general, the core element 13 comprises an elongated inner member 14 wrapped about with a wire 15. In order to achieve maximum load transmission and flexibility along with greater fatigue life when the core element is passed over sheaves of minimum diameter, the inner member 14 of the core element is advantageously formed of 7 x 7 cable construction as shown in FIG. 2. Thus seven strands each formed of seven twisted wires are laid together helically in a manner well known in the art. Such a 7 x 7 construction is particularly suitable when the assembly is used as a control cable for boat steering devices. Where the assembly is not to be bent to its critical minimum radius, a core element inner member of 1 x 19 construction may be employed instead.

In accordance with the invention, the stranded inner member 14 is helically wrapped about by the wire 15 which advantageously is of flat parallelogram cross section with corresponding concave and convex opposed edge portions 16 and 17 as shown in FIG. 3. The wire 15 should be tightly applied and swaged if necessary. The opposed edge portions 16 and 17 on adjacent turns of the wire 15 are in overlapped mating engagement which permits limited axial sliding displacement of the engaged turns with respect to one another when the core element is bent.

Thus, if the turn of the wire 15 shown in FIG. 3 is on the inside of a bend, the concave edge 16 will slide slightly up over the convex edge 16A of one adjacent turn and the convex edge 17 will slide slightly down under the concave edge 17A of the other adjacent turn. If the turn of the wire 15 shown in FIG. 2 is on the outside of the bend, this movement will be precisely the opposite and the concave edge 16 will slide down under adjacent edge 16A while the convex edge 17 will slide up over the adjoining edge 17A. As a result, the neutral and geometric axis of the helically wrapped wire 15 will remain coincident and the core element will flex easily without interruption in the complete turn to turn contact. The mating concave and convex services contribute to the smoothness of this bending operation while remaining in surface-to-surface engagement much in the manner of a ball and socket joint, though for some purposes other overlapping edge configurations may be provided on the wire 15.

Tests have been conducted to compare one embodiment of the new assembly wherein the core element has a 7 x 7 inner stranded member with a prior art embodiment which is similar in all respects except that its core element is a 1 x 19 stranded member without any armor. The tests showed that the embodiment of the invention possesses far greater column strength and thus minimizes distortion and its resultant inefficiency under high loads. In one such test, the embodiment of the invention withstood a 3,000 lb. compressive load without buckling while the prior art embodiment buckled at 1,200 lbs. compressive load. In another such test, the prior art embodiment was reinforced with conventional flat wire having squared-off edges, as compared to the overlapping reinforcing wire on the embodiment of the invention; the reinforced prior art sample failed under fatigue stress after 100,000 cycles at a 180° bend on a 2 ft. radius with an output of 150 lbs. whereas the embodiment of the invention withstood 400,000 cycles of such fatigue stress without failure. As to efficiency, this reinforced prior art sample produced a push at the output end of 640 lbs. with a 1,500 lb. load applied to the

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input end (i.e. 42% efficiency) whereas the embodiment of the invention produced a push at the output end of 1,020 lbs. under the same input force (i.e. 60% efficiency).

Various modifications may be made in the embodiment described hereinbefore without departing from the scope of the invention and in FIGS. 4 and 5 two such variations are shown. Here, two reinforcing wires having cross sections different from that shown in FIG. 3 are helically wrapped about the strand much in the manner of a double-lead thread.

Referring to FIG. 4, a stranded inner member 18 is first helically wrapped with a wire 19 of semi-circular cross section with spaces left between its successive turns. These turns of the wire 19 receive a second helically wrapped wire 20 having a cross section conforming generally to the cross sectional shape of one such inter-turn space. Thus, the rounded shoulders of semi-circular wire 19 seat into corresponding concave shoulders on the wire 20. Some clearance is left between the inside circumference of the turns of wire 20 and the inner member 18 in the straight position of the assembly. It remains true that the adjacent turns of the wires 19 and 20 are in partially overlapped engagement permitting limited axial displacement of the engaged turns with respect to one another when the core element is bent. All of the advantages of the previously described embodiment are therefore present in the form of the invention shown in FIG. 4.

In FIG. 5, a stranded inner member 21 is wrapped helically with two wires 22 and 23 in a manner similar to the FIG. 4 embodiment. Each of the wires 22 and 23 is of corresponding trapezoidal cross section respectively inverted relative to one another when applied about the inner member 21, and they are dimensioned such that the wire 23 nests in spaces between the wire 22. Clearance is provided between the inner circumference of the turns of wire 23 and the inner member 21 in the straight position of the assembly. Again, the turns partially overlap and remain in constant axial sliding engagement even when the core element is flexed.

I claim:

1. In a flexible push-pull cable including in combination an exterior tubular casing and an interior core element axially slideable within said casing, said core element comprising:

- (a) an elongated inner member, and
- (b) at least one wire helically wrapped and compressed about said inner member radially with respect to the cable axis with adjacent turns of the wire having surfaces in partially overlapped slideable engagement permitting limited axial sliding displacement of the engaged turns with respect to one another when the core element is bent.

2. A push-pull cable core element comprising:

- (a) an elongated inner member, and
- (b) at least one wire helically wrapped and compressed about said inner member radially with respect to the cable axis with adjacent turns of the wire having surfaces in partially overlapped slideable engagement permitting limited axial sliding displacement of the engaged turns with respect to one another when the core element is bent.

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