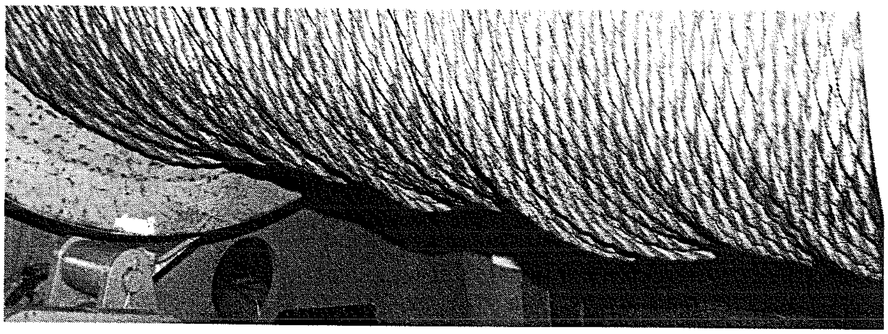
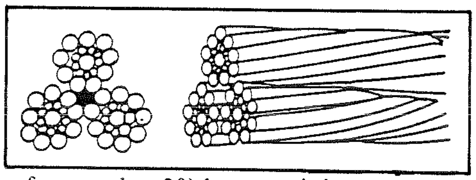
The 'Black Art' of Spooling 3x19 Wire Rope

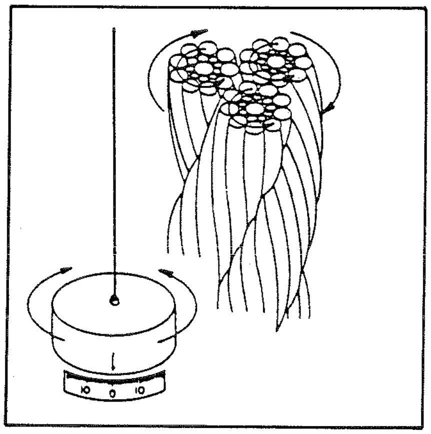
For Optimum Winch Performance, Torque-Balanced, Non-Rotating, Triangular-Shaped Wire Needs Individual Engineered Drum

By Michael J. Markey
President
Markey Machinery Co. Inc.



Drum on R/V *Thompson* (AGOR-23) for 9/16-inch 3x19 before (upper) and after (below) corrective action. Sketches show cross-sections and other views of 3x19 wire rope plus torque indications/directions in rope components.





At a mid-March Marine Technology Society meeting in Ft. Pierce, Florida, the focus was on the near-term developments in electromechanical (EM) cables, aramids, fiber optic cables, and the endless new combinations awaiting cost-effective applications. Markey Machinery Co. Inc. (MMC) (Seattle) presented a paper on what might be called the "indispensible dinosaur" among oceanographic tension members—so what is the problem with 9/16-inch 3/19 wire rope?—Spooling! The long-lay triangular cross section wire does not provide a smooth grove for the next lay of wire.

Nearly every research vessel afloat carries one or more drum loads of 3/19 torque-balanced wire rope, varying in size from 3/16- to 3/4-inch and in length from 5,000 to 45,000 feet. Manufactured primarily by MacWhyte Co. (Kenosha, Wisconsin), these wire ropes are used for science load handling (trawling and coring) that does not require signal and power transmission. Oceanographers have used this "mature" and "nasty" product for 30 years (and probably will for another 30) because it is more or less non-rotating.

Looking for 'Hackle'

The advantage is not in preventing the payload from spinning as it hoists or lowers (most loads use a swivel anyway) but when slack inevitably occurs, the rope has not accumulated torsional energy and therefore does not "hackle"—a term used to describe a twisted snarl sticking out at right angles to the wire's axis. Most operators have seen them.

The next best available product with a non-rotating feature is only 25 percent as effective. That's the reason for using 3x19.

From the winch builder's and deck engineer's viewpoint, this triangular-shaped wire is tolerated at best and quite often hated. The problem centers on spooling it onto either a single-drum pulling winch or onto a traction sheave/storage drum system. Traditional spooling methods are described as "ragged," "hill and valley," and generally untidy.

Most operators feel that they have an operating winch and fairlead system if the wire does not pull down and through lower layers, if the wire does not back-spool over itself, and if they don't have to adjust the fairlead clutch too often.

Frequently a nearby drum will be handling "round section" 0.322- or 0.680-inch-diameter EM cable which spools evenly, smoothly, tightly, and with satisfactory precision on most machines. The visual contrast between the "beautiful" EM drum and the "rough" 3x19 drum can raise serious questions in the owner's mind about why the idiot winch builder can't get the 3x19 wire onto its drum properly.

R/V *Thompson* & Normal Procedures

The new R/V *Thomas G. Thompson* (AGOR-23) provided the entire range of experience involving an MMC two-drum, 150-horsepower electric research winch. In the process the combined perseverance of the owner and the winch builder achieved positive results, reaffirmed several physical limitations, and fine-tuned several rules of thumb.

The MMC winch layout (type DESH-9-11WF) included a high drum for 10,000 meters of MacWhyte 9/16-inch 3x19 torque-balanced non-rotating wire rope and a low drum for 10,000 meters of Rochester 0.680-inch standard UNOLS EM cable. A single diamond screw type level-wind fairleader serves both drums, with the two chain drives feeding through a manual selector clutch.

Each drum barrel was fitted with a Lebus International Engineers (Longview, Texas) double-offset grooved shell. (Lebus has provided most of the removable grooved drum shells for winches for the oil field and oceanographic ships for many years).

In the usual Markey/Lebus practice, the precision machined pitch of the shell groves was arrived at only after Lebus had tension measured samples of the *actual* wire and cable at the Lebus factory. These samples are pulled in 500-pound increments with several diameter readings at each tension level with special micrometers—90° anvil micrometers since the wire cross section is triangular.

Diameters are tabulated at both increasing and decreasing loads since the post-test diameter of the unloaded wire is generally a few thousandths smaller than pre-test. With the tabulated wire data faxed to the winch builder, an "experienced based" shell grove pitch is selected over the telephone. Knowing the inside width of the winch drum (MMC drum faces being machined inside) the number of Lebus shell groves must be either an integer number or an integer-and-half. For example, a 55.000-inch-width drum would have 99.69 points if the wires just touched each other and the flanges.

The 'No Touch' Policy

But the wires must not touch; there must be an air gap. Therefore the choices would be 99.50, 99.00, and 98.50 groves, etc. Once a design grove pitch is selected, the fairlead drive must traverse the head at *exactly* that same distance per turn of the winch drum. But first there is a bit of Lebus procedure to be remembered.

Would you believe magic?

The number of drum turns per layer is *less* by exactly 1/2—if there are 98.50 groves, there are 98.00 turns. The mechanical ratio between the winch drum and the fairlead diamond screw must be *exact*. Diamond screw proportions differ between winch makers, but for those using hard drive fairlead systems, if the calculated ratio between the drum and the screw is 9.87654/1, then sprockets and gears must be found that give an actual ratio of 9.87654/1—not as daunting as it sounds.

Since the wire-builder ships wire with inevitable tolerances (both in nominal diameter and in diameter constancy along a typical 10,000-meter length) the critical matching of the drum shell and fairlead to a *particular* wire is probably the only Achilles' heel in the Lebus shell system. A wire acquired later on that is a few thousandths smaller will probably work, but one 0.005 inches larger probably will not work.

MMC initially spooled the two AGOR-23 drums at its Seattle factory in November 1990, directly from wooden shipping reels. The reels had been so loosely loaded that only around 800 pounds of tension could be developed without pulling the wire down through the reel layers. The 0.680-inch wire loaded perfectly in 33 layers. Amazingly, so did the 9/16-inch 3x19 on its 34 layers, so the winch was shipped, all with good feelings; how naive!

On the Waterfront, Out to Sea

In the Trinity shipyard at Halter Marine Inc. (Moss Point, Mississippi), two of us were aboard the day the winch and its 9/16-inch wire first tried to lift the 15,000-pound test load. The load came up 4 inches and we were summoned to the winch room to observe the wire exiting the stack approximately at 90°—having pulled almost all the way down into the barrel! Thus ended the good cheer —the learning process began.

In the Caribbean Sea enroute to Seattle, the *Thompson* payed out all the 3x19 into a deep ocean trench. The pull of the weight of the wire coming back on board was much higher than from the initial shop spool in Seattle. The Lebus shell and fairlead provided an excellent layup through about 20 layers—above which more attention with the fairlead clutch was required. In vivid contrast to the 0.680-inch cable that just went up and down with little attention and a lay that was always smooth, taught, and level, the 3x19 became increasingly less-perfect looking above 20 to 22 layers.

In the high pull deep water recovery, the pull on the recovery line enabled operations from the rough outer layers of the 9/16-inch wire without pulling down through. The first improvement had thus been made, but the owner's goal remained fixed on essentially unattended visual perfection to match the round 0.680's performance. *Action* was requested!

Only one spooling contractor with a big truck, a reel stand, a properly sized traction retarding machine, and the willingness to drive from Houston to Seattle was found after an extensive search. Haynes Wire Rope Co. met the requirements and met the ship at her University of Washington facility on the Lake Washington ship canal. All 10,000 meters of cable were taken ashore.

Once the outer 3,000 meters were taken off, the remaining 7,000 meters on the drum looked decent. During the removal, close attention was paid to the way in which the triangular wires reacted to their next-door neighbors and how the air gap between wraps *varied*.

The plan was to respool the same wire onto the same Lebus shell—but at a uniform 4,000-pound tension. Once the traction retarder had established the tension, the well-used 9/16-inch wire was measured, with a range of diameters between 0.579 inches and 0.570—all against a nominal of 0.563 inches! Wire does differ!

The controlled dockside reloading indicated that:

- The triangular wire was being

forcibly positioned by the Lebus groves on the first layer

- The first layer's outer surface groves were very irregularly shaped (compared to the uniform channel formed by round cable).
- Each wrap is heavily impacted by how hard it is "leaning" against its adjacent warp
- Sometimes the adjacent triangles nested closely, and then they made a wrap contacting only on the high spots, which forces the oncoming wire ahead of where the underlying grove would like it to be.

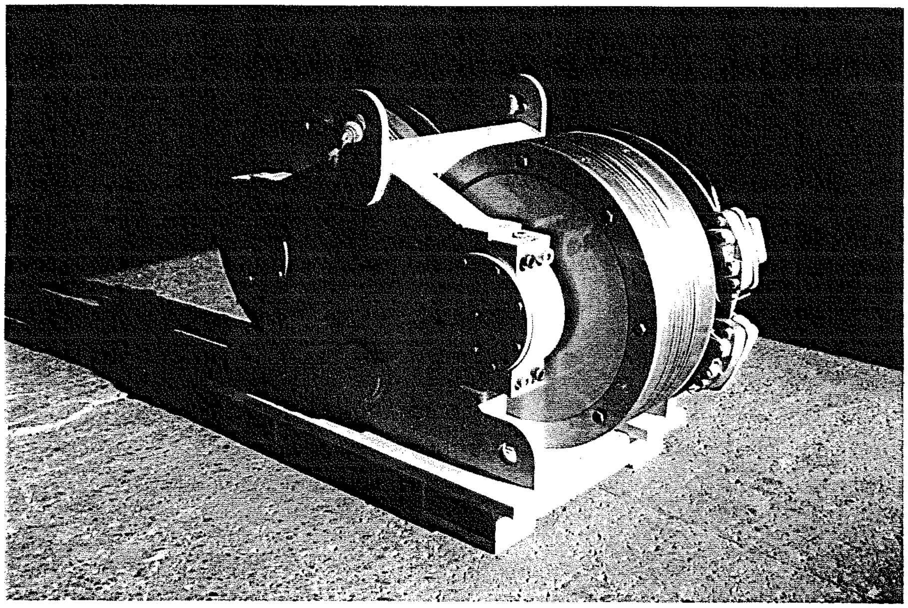
The wire was actually seen to roll away from its neighbor, opening what MMC has termed a "nesting gap"—a gap wider than the design value that moved the wire a tiny amount ahead of where the fairlead head was positioning it to be.

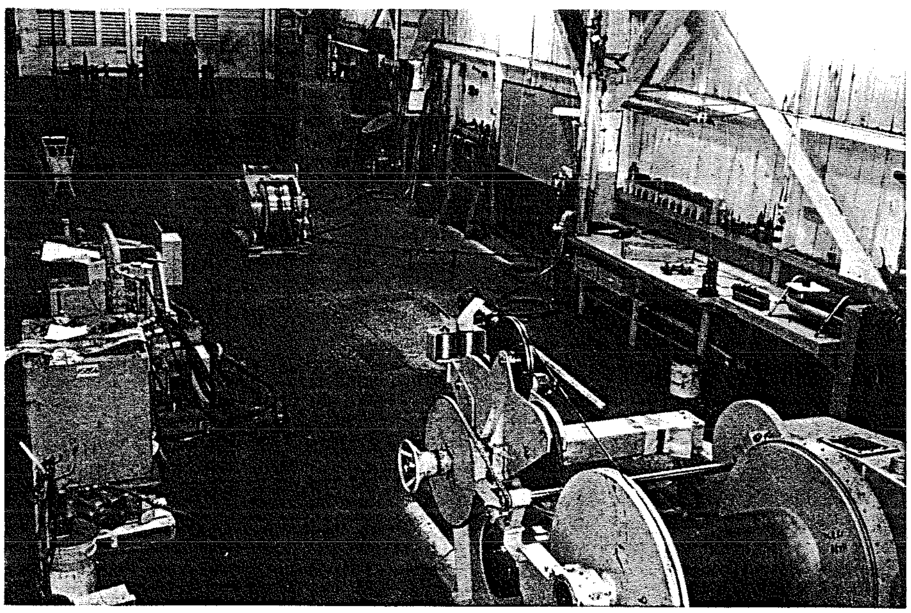
The tiny gaps accumulated.

For 20 to 25 layers, the Lebus shell maintained control while the fairlead head positioned the wire one to two diameters "behind" the on-lead point, in order to drag it back into it's "corner." Above these layers, accumulated irregularities began to occur—to the point where the wire skipped one entire diameter ahead. This caused roughness—generally at only one drum flange. The operators had the choice of whether to leave the adjustment clutch alone and let the spooling go irregular (adjusting only if the wire climbed backward over itself. . .), or to fight it to achieve cosmetic "perfection."

In the layers from the low 20s to the low 30s this is almost a constant battle.

This dockside 4,000-pound tension reload ended in a greatly improved, but not perfect spooling, and the *Thompson* made a number of working casts before the spooling deteriorated—at one point 2,000 meters were cut off as unretrievable—to some extent the result of the attempt to manually force the wire into its ideal location with the clutch, which completely de-timed the operation.





Markey Machinery Company line tensioner, and factory spooling with tensioner and spooling rig.

Corrective Action

MMC determined that a replacement Lebus shell with a wider air gap should reduce the "side-nesting-gap" effect and allow the under layer grove to deepen slightly and exert more control. A new shell with approximately twice the air gap was placed on order. In the interim, MMC built itself a six-grove 30-inch disc-braked traction retarding machine with interchangeable groving, including a set specifically for the 9/16-inch wire.

In July of 1992, the 9/16-inch wire was again off-loaded in Seattle, and the new Lebus shell was bolted to the drum barrel; the new final drive sprocket was bolted on; and the fairlead head was checked for having turn-around points spaced exactly the same at each drum flange.

The new shell provided approximately twice the wire-to-wire air gap—the equivalent to running the drum with one less wrap across the face.

The reloading over the MMC traction wheels (from a rented reel stand) proceeded with tensions in the order of 4,500 pounds. It was clearly evident that the wider air gap was a major improvement. Visual perfection prevailed up to the 17th layer (which, incidently, is the range Lebus suggests as their comfort zone), and from there to the 26th layer, slight open gaps would appear, *but they were self-correcting,* rather than *cumulative.* The 30th layer saw the full

8,000 meters aboard, and only one fairlead head adjustment had been made early on to ensure the correct head location "lag."

The wider air gap replacement grooved shell was considered to be a qualified success. Fortunately MMC was able to put its service technician aboard during an eight-day transit between Hawaii and Seattle with the opportunity to do a full scope deployment and recovery—observing the real-world differences from the "laboratory" spooling alongside a dock in calm water.

The 8,000 meters was deployed at approximately 12 knots with a 1,000 pound sea anchor attached. Approximately 60 manual fairlead clutch adjustments were required during the payout—the reason being that during the preceding weeks and months, the procedure had been to station a person in the winch room, frequently adjusting the head to attempt a smooth and uniform recovery. Aside from utilizing a crew person in an inefficient (and unacceptable) manner, this assured that the relationship between the head's position relative to the Lebus shell was lost.

It was during this 8,000 meter recovery that another important characteristic of the triangular 3x19 wire was observed. It literally "threads" its way through the eight sheaves that guide the wire from the waterline to the winch fairlead (which has three additional sheaves itself). In the winch room one could place a hand on the wire and feel a full 90° twist in the 20 feet before the winch.

This threading effect is inherent, and the accumulated torsion appears to be one of the reasons why the 3x19 will "roll forward," opening gaps that later cause "holes" and imperfect turn-arounds.

A Final Lesson Taught

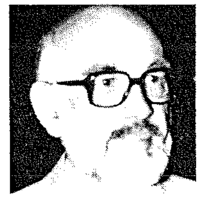
The final lesson taught by this winch and wire system was to note that at tensions in the order of 16,000 pounds, the fairlead clutch should lead directly to the entry-tangent point. As the tensions dropped toward 4,000 pounds, the fairlead head was adjusted for increasing "holdback."

The 3x19 wire rope requires a wider shell pitch and matching fairlead travel rate than does round section EM cable. The fairlead head's holdback should be increased as wire tension is reduced. Also no fairlead system will spool slack wire!

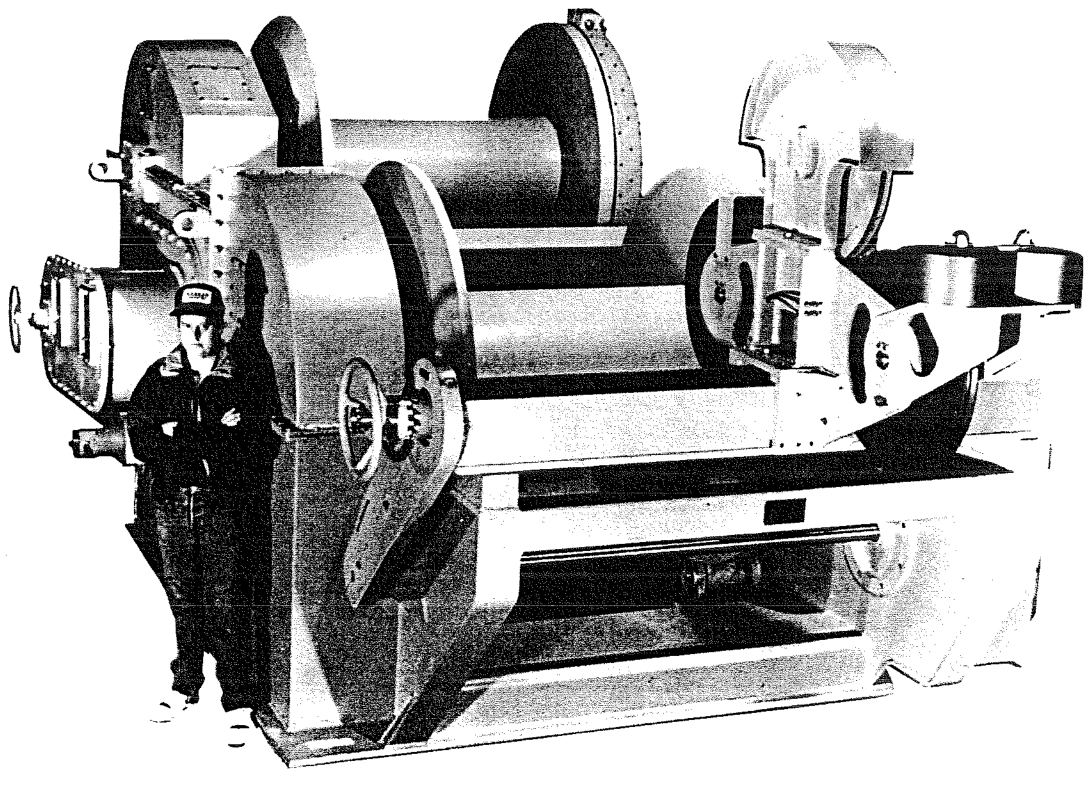
At sea, ship motions can apparently result in very low tension values periodically. It may be of assistance to occasionally pay out all the wire while cruising to give it a chance to unwind and "start fresh."

The best lesson of all would seem to be to limit future drums of this type wire to between 20 and 25 layers by changes to barrel diameter and face width.

Some visual roughness in the outer layers may be inevitable, but if the wire deploys and comes home safely with minimum crew attention, the machine will be doing its job. /st/



Michael J. Markey formerly was chief engineer, engineer, draftsman, and a 1958 hire-in. Not without other industrial experience, he had been a sales engineer with General Electric Co. in the medium steam turbine and gear department after some test training. He contributed to Alan Driscoll's yellow-green Handbook of Winch, Wire & Cable Technology. *Markey obtained a B.S. degree in mechanical engineering from Stanford University in 1954.*



MMCo.DESH - 9 - 11WF 10,000 meters of 0.680" EM cable; 10,000 meters of $^{9}/_{16}$" wire rope. 150 hp AC-SCR/DC drive; 0-30,000 lb. line pull; 0-500 ft/min line speed. Enclosed clutch with plexiglass viewports; manual/air operated brakes.