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LTA APPLICATION OF A LONG TRAILING WIRE HIGH SPEED/LOW WEIGHT REELING SYSTEM

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ABSTRACT: This paper is presented to acquaint the LTA community with the sucessful development of a unique yet simple reeling system for handling long trailing tensile members at high speeds. This high speed when combined with the system simplicity, low weight and effective motive power consumption should make this reeling system particularly attractive to LTA planners and designers for numerous LTA missions.

Renewed widespread interest in potential applications of Lighter Than Air (LTA) vehicles has been generated by both military and civilian missions that may involve raising/lowering, towing, transferring, laying, mooring or radiating by use of trailing tensile members. Such trailing tensile members generally would be metal cables, nylon hawsers, coaxial multi-strand electrical wires, fiber-optic communication lines, slender hoses for both liquid and gaseous fluids, and very-low-frequency trailing antenna cables.

This paper addresses the application of a significantly improved method of "winching" a long metal stranded antenna cable from a LTA vehicle; however, this "winching" method could well have numerous military/civilian applications involving the combination of a LTA vehicle and a reeling system for one and/or two-way movement of long trailing flexible and semi-flexible filaments of any nature.

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LTA REELING SYSTEM DESIGN FACTORS

The paramount requirements of most airborne reeling applications involve at least one or all of the following considerations:

1. High speed payout/retrieval of trailing tensile member.
2. System simplicity.
3. Low system weight.
4. Low system motive power.
5. Various mechanical form factor constraints.
   (a) low profile
   (b) low center of gravity
   (c) crash loading integrity

Certain previously classified airborne missions have required trailing an Airborne Very-Low-Frequency (AVLF) antenna cable that places emphasis on all the aforementioned design factors plus one entirely peculiar requirement; handling of a fragile semi-rigid tensile member.

AVLF REELING SYSTEMS

Recent AVLF reeling systems have been applications of a common winch which apply all the trailing antenna cable tensile load onto the rotating drum. Thus the drum had to be "oil-well rig" design rather than tailored to air vehicle design.

Structural support and motive power were adversely constrained by this approach. Unrelieved tensile load and fragile tensile member handling requirements forced including unnecessarily precise cable wrapping procedures. All of these design constraints combined to produce a reeling system that was complex, extremely heavy and slow, handling almost quarter inch diameter copper covered cable at less than 500 feet per minute (FPM) rates. Minor basic design approach changes resulted in a 13,000 pound (lb) mechanical system that handled more than 15,000 feet of cable at no better than 2,000 FPM payout and 500 FPM reel-in respectively.

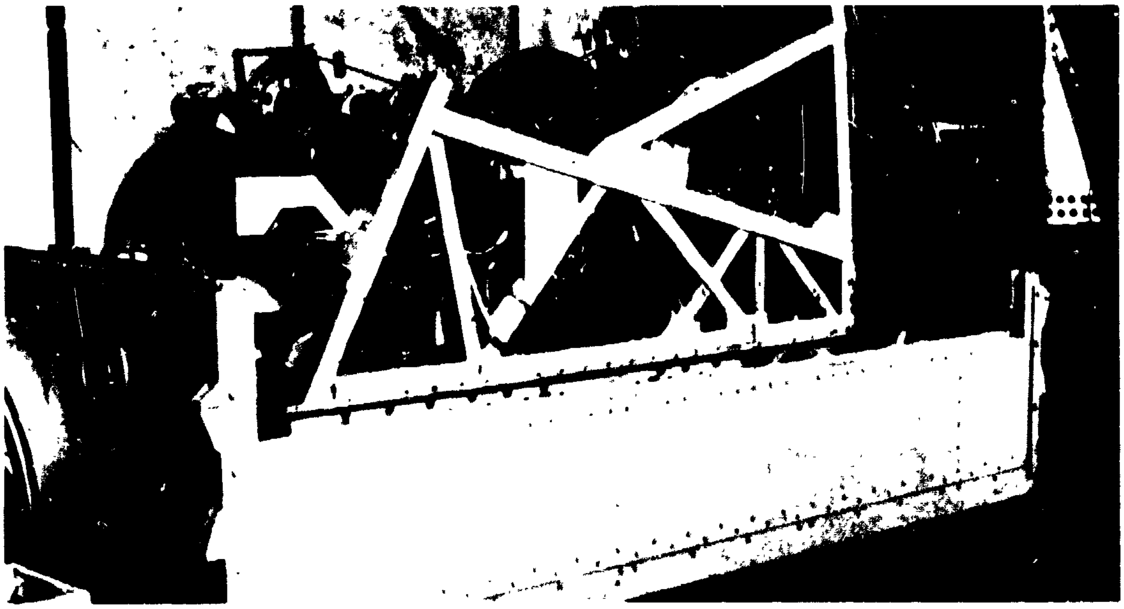

FIGURE 1 - AVLF REELING SYSTEM

Several design iterations have fine tuned these systems to reach 5,000 FPM payout and 1,500 FPM reel-in rates, and 4,000 pound system weight development limit.

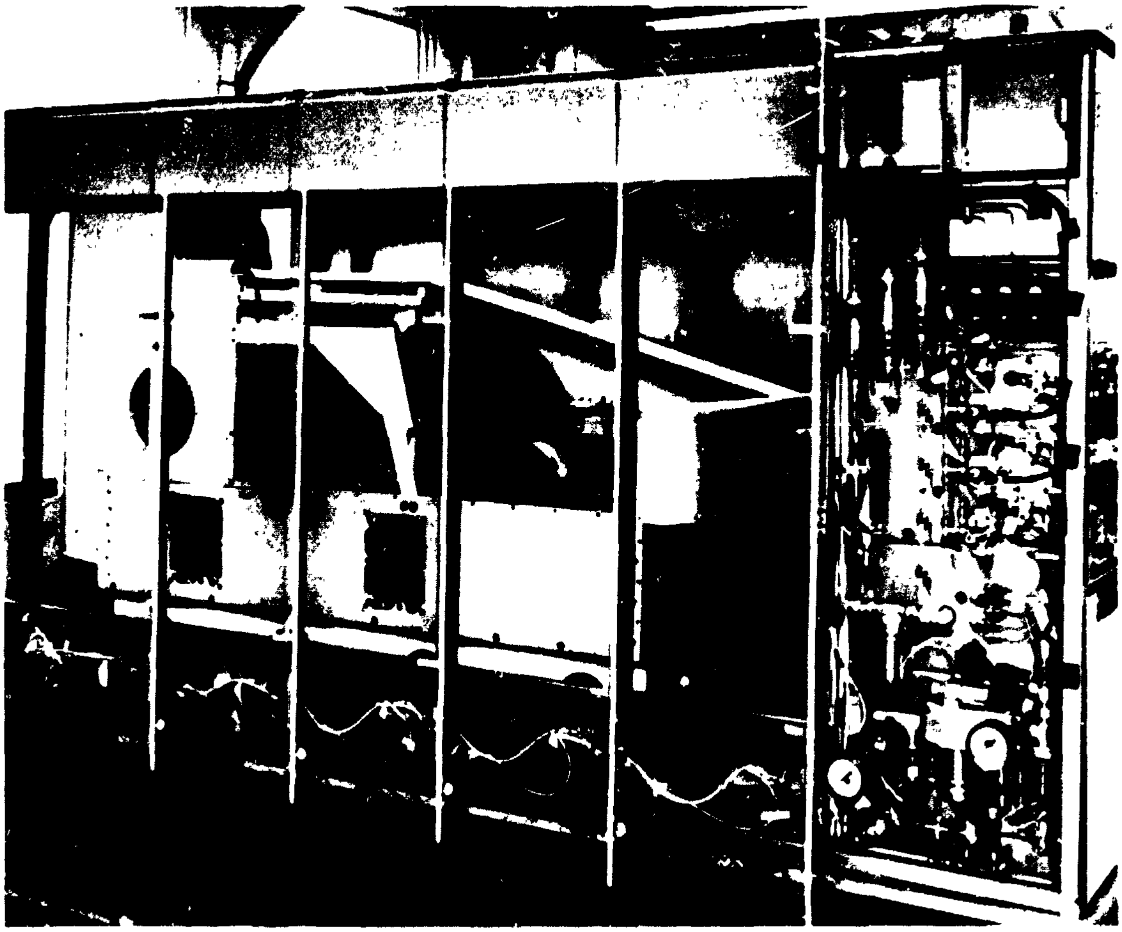

FIGURE 2 - AVLF REELING SYSTEM

However, high rotational speeds, heavy equipment weight, motive power inefficiency, unrelieved tensile loads, precise wrapping/vibration sensitivities, high mass inertia shortcomings and system complexity have not been alleviated.

MOTIONLESS COIL STORAGE/REELING SYSTEM

The Naval Air Development Center, which has an extensive history in airborne towing system development, was tasked to explore new cable handling approaches free of aforementioned shortcomings. Several years of laboratory experimentation and state-of-the-art reviews produced a full scale working model of a Motionless Coil Storage/Reeling System which points the way to alleviation of all the addressed shortcomings.

Motionless Coil Storage (MCS) is a method to store cable in the shape of a coil without constantly continuing to rotate the coil as each successive foot of cable is brought aboard and wrapped. An artist's sketch of the laboratory model is shown in figure 3

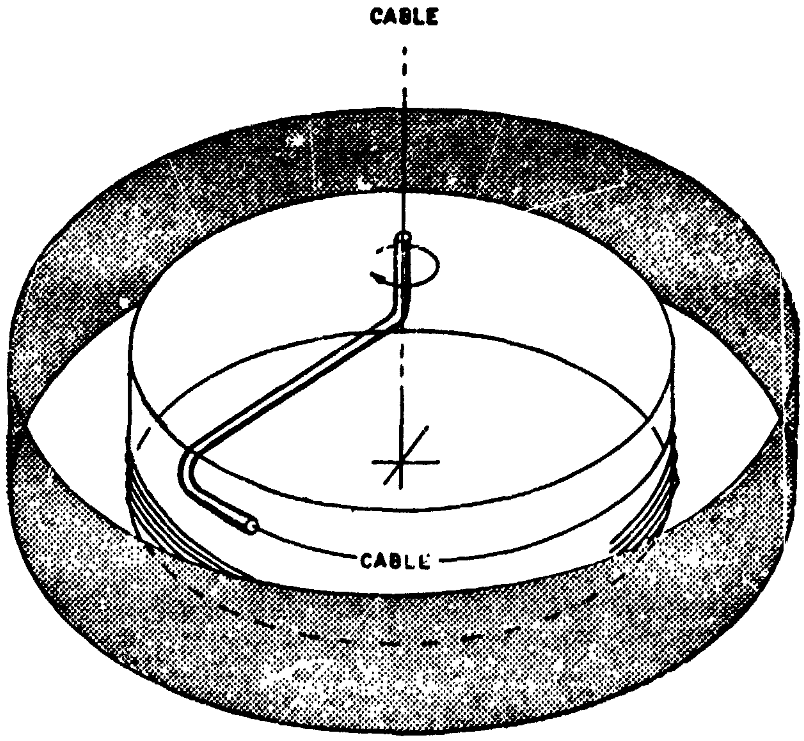

FIGURE 3 - MOTIONLESS COIL STORAGE

The most simple description is to say that it is a significant variation of the sport fisherman's "spinning reel" that has become so popular in recent years. MCS employs one very light low speed rotating member which, in laboratory full scale test setup, reliably demonstrated 6,000/2,500 FPM cable handling rates and successfully performed the reel out of 24,000 feet of a copper covered quarter inch diameter (.65 lbs/ft) tensile member in the total elapsed time of just under 5 minutes (4 min., 42 sec.). Laboratory simulation has indicated that reel-in rates can equal payout rates if sufficient power is available.

Testing began with a concept of pushing and pulling cable into and out of an open cylindrical container. Progressive changing/testing led variously to laying cable inside an annular cavity and finally around to the present concept of freely wrapping the cable about a large-diameter, low-profile vertical stationary drum with a cable distributing spinner. The spinner is extremely light in weight and rotates at a very slow speed while handling cable faster than a mile a minute. The full potential of the inherent high speed capability has not been able to be demonstrated yet; however, design synthesis conservatively indicates a 8,000/5,000 FPM system should total no more than 1,300 pounds.

Key to attaining these high handling speeds with such a low weight, low profile mechanical system is the inherent simplicity of the overall system design. The spinner requires a simple hydro or electromechanical drive to maintain low cable tension (5 to 25 pounds) when reeling-in. Design simplicity for reeling-out is assured by taking advantage of a unique physical phenomenon discovered in laboratory testing described as a "reverse loop". The MCS when reeling-out forms a "reverse loop" at a threshold speed which acts as a stabilizer against the MCS outer wall, thereby permitting these high speeds without complex control devices.

ILLUSTRATION OF MOTIONLESS COIL "REVERSE LOOP"

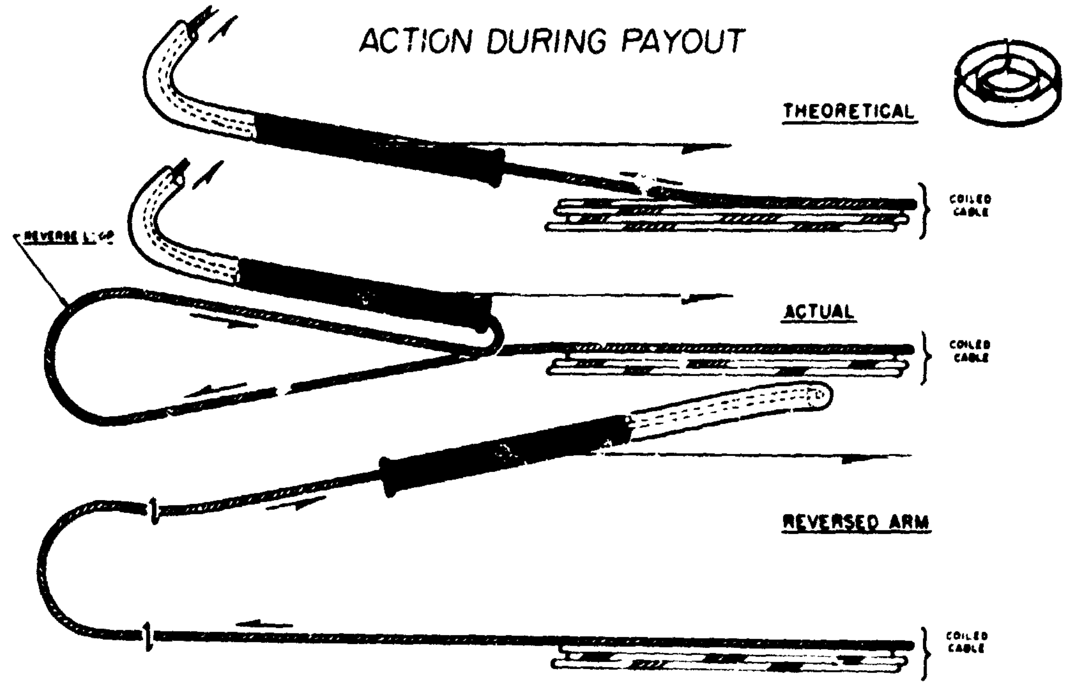

FIGURE 4

The spinner is not dynamic balance sensitive and does not require weighty support structure as does a rotating drum and cable combination. Low mass movement of inertia is inherently more safe and more easily meets "g" loading structural requirements for crash conditions.

Reliability and maintainability are assured since the system is a model of simplicity which requires correspondingly simple control and drive mechanisms.

The MCS has a cable torsion sensitivity threshold which is easily established by laboratory simulation to finalize engineering preliminary design parameters.

Although this paper has addressed the MCS in a VLF trailing antenna application, the MCS can be combined with cable driving/pulling devices such as multiple capstans, pinch rollers, linear transport devices or "free fall" methods and integrated with LTA vehicles or even stationary groundborne applications to fulfill limitless missions.

Expanding the laboratory facilities would permit demonstration of higher speeds with longer length cables but the NAVAIRDEVCEN has completed sufficient ground testing of the MSC concept to conclude that the next most economical step is the design and installation of an airborne prototype.

This paper is presented to acquaint the LTA community with the successful development of this technology for whatever applications community members can devise for their particular needs.