Aerotow Release - Better Mousetraps

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~01. Synopsis

#01. Release Mechanisms

Most of popular aerotow release mechanisms are poorly engineered, inefficient, overbuilt, and unreliable.

#02. Actuation

Mechanically inefficient release designs require overbuilt actuation systems, often insecurely mounted in locations at which they will become inaccessible during a lockout, bridle snag prone, and operable only with undue complication and difficulty. A proper two point system actuation device belongs on the basetube, properly mounted, and is smaller than half a grape.

#03. Bridles

Opening bridles are unnecessarily prone to fouling upon actuation.

#04. Drag

Release systems are critical to safety concerns and worthy of being built in but parasitic drag inducing slap-on systems are the norm on gliders which aerotow to the exclusion of all other launch methods. Running cable outside of the length of a faired downtube is insane.

#05. Secondary Releases

A secondary release is not a backup release. Its sole purpose is to release a wrapped bridle - not, as popularly believed and practiced, to compensate for an unreliable or inoperable primary primary release. Depending upon the trim of the system, an out of sequence actuation of a secondary release could prove immediately catastrophic.

#06. Emergency Release

Two hands are required to fly a glider and it is pure insanity to launch with a release configuration whose actuation demands a surrender of control in a critical situation.

#07. Weak Links

`A. Purpose

The sole purpose of a weak link is to serve as a fail safe mechanism to prevent an aircraft from being overloaded and damaged. It is not and cannot be reliably used as a crutch to compensate for every real or imagined threat, defective release system, blown launch, and/or degree of pilot incompetence at the cost of being rated for the ragged edge of sustainable tow. This widespread attitude and approach has lethal potentiality.

`B. Configuration

A weak link at one end of a bridle long enough to wrap does not guarantee protection - weak links at the ends of the tow line or at both ends of the bridle do.

`C. Range

Weak links should be selected as close as possible to 1.4 Gs - the middle of the 0.8 to 2.0 strength range defined by the FAA and the narrower ones specified in sailplane pilots' operating handbooks. As hang gliders are much more difficult to control than their counterparts they are unable to tolerate the bottom of the range and require a minimum of 1.0 Gs. The ubiquitous single loop of Greenspot on a bridle end usually translates to well below half of the strength typically required.

`D. Reliability

A weak link should fail only when the tow tension becomes excessive (and a release should have been actuated long before that happens).

`E. Durability

A weak link should retain its integrity for more than a fraction of a tow.

#08. Inertia

The general state of affairs is stagnant because the hang gliding public has imprinted on erroneous initial concepts which have gone untested and little challenged and changed over the many years since their inceptions. The small portion of individuals applying effective thought to these issues tends to reach similar conclusions and develops convergent design strategies but unnecessary failures continue to occur due to the lack of widespread implementation.

~02. Sailplanes

#01. Releases

Tost sailplane release mechanisms are mission specific, cost multiples of the price of their counterparts assembled from components designed to dump boat sails and stop bicycles, have no backup options, and do not fail.

#02. Weak Links

Although they are much easier to control on tow, because of their size, weight, and performance sailplanes can ill afford to separate in situations with little air below and runway ahead. Therefore their weak link systems cost more than a penny's worth of material and a minute's worth of labor and do not routinely fail fifty feet up for no apparent reason. Their failure rates are something on the order of one per thousand.

~03. Conventional Release Configurations

While the current crop of gliders, tugs, and dollies makes aerotowing an incredibly safe way to leave the ground, the status with respect to popular release configurations is abysmal. There are problems with actuation, failures commonly occur as a result of design, installation, and adjustment problems and totally inadequate weak links, virtually all two point systems exact a substantial drag penalty, and slack line performance can be problematic.

Note: Although the term "two point" is somewhat ambiguous as there is one attachment point per harness shoulder strap, in terms of dynamics of the bridle system the pilot represents a single point and the glider another. The term "three point" is best reserved for the early, obsolete, and lockout conducive scheme of control frame apex and corners.

Note: For standardization purposes in this discussion the secondary bridle and release components of the two point system retain those designations with respect to one point towing.

#01. Tow Tension Distribution

Two basic options exist for routing tension from the tug to the glider.

`A. One Point

`a. Advantages

One point towing of fast, low pitch pressure gliders is attractive in terms of convenience, the minimal equipment involved, and the virtual absence of aerodynamic compromise in free flight.

`b. Disadvantages

i. Trim Speed

As tug tow speeds are above glider trim speeds, negative pitch control pressure must be maintained throughout the tow and the difficulty of staying level with the tug increases.

ii. Control

Because all of the tow tension is routed to the bottom of the pendulum, the pilot is shifted fore with respect to normal control frame relative position and thus is lost the top of the speed range and an easy view of instruments. Likewise when the glider is tracking off line, the pilot is pulled to the foremost side and the control range to counteract the roll is reduced thus making the configuration somewhat more prone to lockout.

`B. Two Point

Two point systems distribute by means of a bridle the tow tension between the pilot and glider and thus better or normally position the pilot over the basetube.

Two mounting options are commonly employed.

`a. Carabiner Mount

The carabiner attachment option is the most easily installed and results in the effective tow point being about a third of the way up between the pilot and the suspension. With the release point at the top end of the bridle a downside of this configuration is the requirement of a considerable length of housed cable to allow play between the downtube and suspension through any extremity of control movement.

`b. Keel Mount

In the optimal progression the primary release is mounted on the keel at the trim point. Forward pressure is taken off the bar. If the trim point is significantly fore, directional stability is enhanced.

`C. Recommendations

The downsides of one point towing are lesser issues than often believed and that mode should be opted for with respect to any glider which can be so towed comfortably.

#02. Release Points

Two options exist with respect to release points for either the one or two point configuration.

`A. Closed Bridle

Both the ends of a two - or, in theory - one point bridle remain attached with the weak link being installed and release being effected, most suitably with a Linknife or remote barrel release, between a ring at the apex of the bridle and the tow line, the advantage being that no fouling of the bridle with a tow ring or, in anything approaching normal circumstances, nose wire is possible. Anchoring the lanyard(s) at the aerotow loops minimizes the effect of pitch attitude changes on lanyard slack. As actuation in two point mode demands release of the basetube it is an unacceptable configuration. In one point mode it offers no advantage.

`B. Opening Bridle

One end of the bridle is released and that half must clear the tow ring.

`a. One Point

As nose wires spread and recede from nose to basetube ends the potential for fouling is fairly negligible. Additionally, the pilot is pulled fore with respect to the glider during tow in this configuration. Thus there is no practical advantage to increasing bridle assembly length and the bridle can and must be short enough to be physically incapable of wrapping. With incorporation of any of the emergency releases described below slack line separation is easily attained with the dedication of one hand at most.

`b. Two Point

The top end of the bridle is released.

i. Weaknesses and Countermeasures

A two point bridle, by definition, positions the tow ring upwind of the nose wires but is capable of wrapping. Its top end can, if the glider has yawed an extreme degree off line, foul with a nose wire after separation from the release mechanism (although this may have never happened in actual practice). Either of these situations is addressed by the freeing of the bottom end. A worst case scenario of fouling with the nose wire and a subsequent bottom end wrap at the tow ring is abated by a release of the front end of the tow line and/or parachute deployment.

ii. Advantages

As the release mechanism, lanyard, and actuation devices may all be firmly mounted on and/or in the airframe, lanyard free play and thus actuation movement and effort may be minimized.

#03. Hardware

`A. One Point

`a. Release Mechanism

The one point system is based on a barrel release (Bailey) constructed using a half inch webbing base, curved pin, and, typically, 5/8-.049 x 1.75 inch OD flared aluminum tubing barrel and attached at the aerotow loop of a harness shoulder strap. There is very little reason not to employ port and starboard units.

`b. Bridle

The one point bridle spans the port and starboard connections.

`B. Two Point

`a. Release Mechanism

The core mechanism of the vast majority of two point systems is the Wichard Quick Release Shackle. The 2673 model, the smallest in the manufacturer's line of small bail spinnaker shackles, is the most appropriate for the task and most commonly employed, although heavier models frequently appear. It appears to be the best off the shelf solution of such mechanisms for the demands, has an excellent latch configuration, and is beautifully engineered for the purpose of holding lines of diameters between about four to fourteen millimeters under a range of tension from slack line (with adaption) up to an eleven hundred kilogram safe working load. (It does not, however, perform well as a release under loads much in excess of those limited by hang glider range weak links.)

`b. Lanyard

A cable is swaged around the spring loaded latch, routed through a cylindrical cable housing stop welded to the bail (the swivel being disabled by welding to accommodate this design), and through about seven feet feet of housing down to the vicinity of the pilot. This configuration allows function in a slack line situation.

`c. Actuation

The cable is terminated at either a velcro mounted bicycle brake lever assembly or a loop through which a hand may be inserted after the end of the housing is anchored to the downtube.

`d. Bridle

The two point bridle spans the spinnaker shackle release and the aforementioned one point bridle.

`C. Weak Link

A weak link is typically a light Dacron line length formed in a loop by joining the ends with a Fisherman's Knot, installed on the primary bridle eye by means of a Double Lark's Head with the Fisherman's Knot at its center, and engaged by the primary release.

#04. Deficiencies

`A. One Point

`a. Structure

i. Accidental Release

The diameter and shape of the flared barrel decrease clearance from and increase propensity to actuate as a result of contact with the basetube as the pilot makes a negative pitch input to correct for a high attitude.

ii. Bridle Wrap

As the aerotow loops are so narrowly separated the unnecessarily long bridles frequently incorporated result in very little tension reduction at the price of introducing a wrap potential. The common practice of mounting a single barrel release with the weak link anchoring the bridle at the opposite aerotow loop magnifies the problem.

`b. Mechanical Advantage

Because of the mechanically inefficient design, actuation under high loading may be difficult as a result of side loading.

`c. Ergonomics

The short flared barrel provides for neither an effective nor comfortable grip.

`d. Actuation

Actuation requires a surrender of the grip of a hand on the basetube and thus of glider control.

`e. Slack Line Performance

A slack line release requires both hands simultaneously if the built in resistance of the release mechanism equals or exceeds the remaining opposition force.

`B. Two Point

`a. Structure

i. Spinnaker Shackle

The spinnaker shackle is designed for holding nearly fourteen times the load that the ubiquitous one millimeter solo weak links can deliver and a line cross sectional area capacity overkill factor of about 196.

Much of its strength is owed to a notched interface between the gate and base. The notch on the former can snag and will degrade the weak link and can delay or prevent release.

The girth of the gate increases from hinge to free end. This characteristic, in a one point configuration, has prevented release with fatal results.

It incorporates a swivel component which is useless for relevant applications.

ii. Primary Bridle

Bridle construction is such that wrapping is somewhat more likely and inadequate splicing techniques result in failure.

iii. Bridles Interface

The bottom eye of the primary is engaged by the secondary bridle. It is possible for this interface to lock in the event the release must be effected with a barrel release and the two elements abrade each other in the course of normal towing.

`b. Mechanical Advantage

Reportedly the hinge area of some portion of spinnaker shackles affords an environment hostile to weak link material. A few minutes worth of careful work with a small file to dress any sharp edges will ensure that this piece of hardware is fiber friendly when closed. However, a modification addressing this issue involves the bulkiest portion of the spinnaker shackle's base (just fore, from our perspective, of the latch pivot area) being drilled through. This allows installation of a mounting cable to substitute for the bail as the component by which attachment to the glider is achieved. The tow force, consequently, is redirected from the hinge about 90 degrees to the gate such that about half of the stress is being transmitted through the latch and there is an increase in required trigger tension.

`c. Lanyard Configuration

The spinnaker shackle is designed to be actuated with light tension delivered by a light leechline lanyard. The adaption of 480 pound strength cable to perform this three and a half pound function is problematic. Changes in direction require substantial turn radii, binding malfunctions result in releases premature and failed, and housing is fairly easily damaged.

`d. Actuation - Brake Lever

i. Mechanical Limitation

A brake lever is designed to deliver in excess of fifty times the tension required to open the unmodified spinnaker shackle. As it commands a very short range of cable movement as a consequence of the mechanical advantage trade-off, adjustment with respect to housing is critical. Assemblies have been known to ship incapable of opening the spinnaker shackle by virtue of the fact that the lever bottoms out on the tube on which it is mounted before enough cable is taken up.

ii. Placement

While any two point configuration is fertile ground for finger on the trigger capability, brake levers are often mounted on downtubes thus potentially lethally amending the release sequence with the same three requirements of the one point. Additionally, as the pilot is a pendulum with respect to the airframe, the relative positions between lever and pilot are subject to considerable change and it can and has happened that a pilot has locked out to port and fallen bellow the point at which a starboard mounted brake lever is inaccessible.

iii. Snag Potential

Brake levers do, however, present a snag potential which is greater if basetube mounted. A bridle wrapped on one can lethally limit control movement.

iv. Mounting

Strapping a brake lever assembly to a tube using velcro fasteners is an inadequate means of securing a critical component of a critical system. On both round and faired downtubes it has happened that an attempt to release has resulted only in the rotation of the lever to the outboard side of the downtube.

`e. Actuation - Loop

A loop is a superior actuation device although the potential exists for interference with hand movement and thus glider control and infliction of injury in a crash (although these risks - in practice - appear to be negligible).

`f. Drag

Mounting a brake lever near the pilot and housed cable outside of the length of a hollow faired downtube reduces glider performance about a point for the remainder of the flight after the one instant mission is fulfilled.

`C. Weak Link

Unreliable and inappropriate weak links and systems improperly configured routinely result in inability to remain on tow to altitude. The potentially catastrophic situations defused by weak links are rare and invariably a consequence of the pilot failing to take timely and appropriate action. The frequent breaks taken as the cost of doing business are, in fact, dangerous. A climb to altitude is always safer than an unplanned landing from a low starting point and the mandatory relaunch and pilot's are occasionally in situations in which tow line tension is the only thing keeping them alive. Additionally - unnecessary breaks result in clogged flight lines, wasted time and fuel, engine wear, and lost soaring and competition opportunities.

`a. Strength Graduation

Strength options are limited by the availability of material and installation configurations. An identical weak link is typically employed for solo gliders with weights varying by as much as two hundred pounds and is appropriate only for the bottom end.

`b. Consistency

Variations in the length, diameter, and coefficient of friction of the material of the bridle on which a weak link is installed greatly affect the tow line tension the weak link can withstand.

`c. Length

Excessively long weak links are prone to snaring the tow ring and otherwise wrapping and preventing release. The length of material extending from the bridle is doubled when a break occurs at the interface with the bridle.

`d. Durability

Strength diminishes with the wear of use, particularly the substantial damage virtually guaranteed as a result of spinnaker shackle actuation, thus mandating frequent inspection and replacement.

`e. Nullification

If a weak link is present only at the release end of a long bridle which wraps, the glider is no longer protected.

~04. Dolly

The use of a dolly is assumed and should be mandatory for all launches for the following reasons.

#01. Hook-In

The hook-in check is built in.

#02. Control

`A. Trim

The dolly insures that the glider begins moving with wings level and an appropriate pitch attitude. Roll remains locked and angle of attack adjusts automatically as airspeed increases to the desired separation point.

`B. Prone

The pilot remains prone from the time he arrives at launch until and unless he rotates up to land. His hands remain properly positioned on the basetube and he is at all times capable of releasing without sacrificing control. He is freed from the tasks of running and changing his grip from the downtubes during the most critical phase of the flight.

#03. Launch Reliability

Blown launches are virtually nonexistent.

~05. Photographs

Photographs illustrating the aerotow release systems options are available at:

http://www.flickr.com/photos/aerotowrelease/

in the AT System Components set and should be viewed prior to and while reading the following (tedious) descriptions.

#01. Orders

Photos are organized in orders:

Primary to Secondary to Weak Link
overview to detail
views - Top, Lateral, Bottom
operation - normal to emergency

#02. Background Color Coding - Perspective

Green - Top (bird's eye)
Blue - Lateral and Bottom

#03. Aft Orientation

Left - Top, Starboard, Bottom
Right - Port

#04. Loading

Secondary Components are mounted on a frame and tensioned to a loading comparable to that to which they are subjected during tow.

#05. Discrepancies

Inconsistencies - usually minor - between photos and discrepancies from text descriptions herein reflect design revisions not yet photographed or justifying reshoots.

~06. Revisions

#01. Cord Lanyard

If the concept of cable actuation and the convenience of quickly slapping an assembly onto a glider going back to the mountains next weekend is tossed in favor of a semipermanent installation with a leechline lanyard a lot of advantages start accruing. The cord routing can undergo sharp changes in direction around pulleys with little or virtually no increase in resistance and installation in the port downtube is as simple a matter as is the VG line in the starboard. Additionally it is very easy to positively secure its bottom end.

#02. Stored Energy

In the recommended configuration tension supplied by a bungee inside the basetube is held by a pin controlled by the pilot's left hand. When the pin is pulled the lanyard routed up through the port downtube takes up any slack in the actuation components and transmits the force to the keel mounted release mechanism.

#03. Block and Tackle

A two to one mechanical advantage pulley system through which the top end of the lanyard is routed provides the following two advantages.

`A. Actuation

An overkill actuation force is delivered to the release mechanism.

`B. Reset

The bungee tension reset is facilitated after the system is fully assembled.

#04. Barrel Release

The spinnaker shackle is replaced by an adaptation of a straight pin barrel release incorporating a pulley aft of the barrel which allows alignment of the actuation tension. It is far smaller, lighter, and more appropriate for the loading and line diameter involved. As the the pin lacks a notch and its length is of uniform girth it is incapable of damaging or retaining a bridle or weak link regardless of size, multiple loops, twisting, or tension. A spring feature of construction imparts an ability to drop as little as a small loop of Greenspot. Its overall length is minimized to maximize the options for effecting an aft trim point.

#05. Tensioner

The release mechanism is connected to the nose by means of a tensioner which locks in the trim position at setup, provides opposition to the force required to overcome the internal resistance of the release, thus allowing functioning in a slack line situation, and keeps exposed elements taut after release, thereby reducing drag.

#06. Actuation

The inboard end of the pin lanyard is routed up between the bases of the last two fingers and terminates in a rubber button. Grasp of the basetube is maintained by the forefinger and thumb while a clockwise/forward twist of the hand effects actuation without interruption of glider control.

#07. Bridle

Construction factors which affect the likelihood of a bridle wrapping include the following and bridles are designed accordingly.

`A. Material

Probability increases with elasticity and flexibility and decreases with low stretch stiff materials.

`B. Ends Construction

Irregularities involved in attachments modifications at bridle ends which affect taper, mass, and stiffness render a bridle more prone.

`C. Length

A secondary bridle can be constructed too short to be capable of wrapping. A primary bridle cannot, but beyond some irrelevantly low threshold, the wrap potential is constant and primarily dependent upon the construction of the top end.

#08. Bridle Thimble

A thimble installed at the bottom end of the primary bridle eliminates abrasion and jamming problems.

#09. Bridle Cinch

A loop of bungee with a cord lock is used to facilitate in flight stowage of the primary bridle.

Note: A single secondary release may be mounted such that it directly engages the primary bridle and its tension is shared by both aerotow loops but there isn't much in the way of a downside to splitting the load with a(nother) barrel release.

#10. Barrel Release

`A. Structure

The barrel release is constructed using a straight parachute pin, leechline base, and 3/8-.058 x 4 inch aluminum tubing length covered by heat shrinkable tubing. Its propensity to catch on the basetube is minimal.

`B. Mechanical Advantage

Required actuation tension is well under a third of that of a curved pin barrel release.

`C. Ergonomics

The length, diameter, and covering of the barrel provide a very effective and comfortable grip.

#11. Bridle

The secondary bridle has a maximum length of seven inches and is incapable of wrapping. Adjusters are installed aft of the port and starboard releases to center the thimble or tow ring on the bridle.

#12. Emergency Releases

Three options exist for replacing a barrel release with an incisors controlled device which allows hands free actuation under tension. All are excellent emergency options and the relative pros and cons are fairly negligible.

`A. Cable Lanyard

`a. Description

Small sailplane type release with a housed cable lanyard.

`b. Actuation

Relaxing bite on a trigger mechanism.

`c. Adjustment

Not an issue.

`d. Primary Release

Suitable.

`e. Slack Line

No hands - normal actuation.

`B. Cord Lanyard

The cord lanyard actuated releases must be adjusted with respect to the geometry of the fore end of the pilot and aerotow loops placement. Positive pitch rotation of the pilot will result in a change of geometry and possible pulling away of the shoulder straps, both of which will reduce lanyard slack.

`a. Remote Barrel

i. Description

Adaptation of primary release design.

ii. Actuation

Pulling lanyard up and away.

iii. Adjustment

Lanyard length.

iv. Primary Release

Suitable.

v. Slack Line

One hand - light push on secondary bridle.

`b. Four-String

i. Description

Multiple string release mechanism in which the traditional grommet and pin is eliminated and the trigger line is safetied by a jam cleat.

ii. Actuation

Pulling lanyard up and away and releasing. May be armed by freeing the trigger line from the cleat and retaining to reduce required action to a relaxed bite.

iii. Adjustment

Positioned with adjuster.

iv. Primary Release

Unsuitable - wears with use.

v. Slack Line

One hand - firm push on secondary bridle.

The Four-String offers excellent load reduction characteristics and some measure of versatility above the other two and discussion below will presume this option. Its trigger line free play is, however, due its origin point, more affected by pilot pitch attitude than is the remote barrel release lanyard.

#13. Weak Links

`A. Function

The sole purpose of weak links is to guarantee that structures are not overloaded. The tug and glider must be protected by them at all times. Although a weak link will limit the progression of a lockout at altitude, as has been demonstrated numerous times a low strength unit is quite capable of surviving a low level lockout to the point at which the pilot can't. Therefore a weak link must not be relied upon to remedy an inadequate release system and/or an inadequately trained or functioning pilot.

`B. Configuration

The traditional loop weak link is replaced by a construction which relies on nylon floss stitching to determine strength. The two forms are herein referred to as break and shear links respectively. The revision does not degrade with use and allows color coded strength graduation in small increments which enables customization for individual gliders. All primary and secondary shear links are constructed such that, in the event of failure, all components save for the strength stitching and, occasionally, a fairing or two are retained and reusable.

Note: The shear link is analogous to the Tost sailplane weak link assembly which is based on graduated metal inserts which are available in hang glider appropriate ratings. In both the critical element is isolated from the components which engage the assemblies. The latter is more amenable to being dragged at the end of a tow line, the tow line installed version of the former has a core mechanism which exacts only about eight percent of the weight penalty.

`C. Rating Selection

The maximum glider loading is approximately the sum of weak link strength and glider weight, i.e., a glider locking out and safetied with a 1 G weak link is limited to about a 2 G loading. In actuality the glider is likely to experience some additional stress due to the acceleration attributable to a turn. A 1.4 G weak link is recommended as this figure is in the middle of the 0.8 to 2.0 range. Loading beyond this range is a probable indication of the glider having diverged to the point at which recovery is no longer an option.

`D. Aerotow Environment

Whereas surface towed gliders fly at minimum sink to maximize release altitudes, those behind tugs fly at best glide. As that speed is faster on tow than in free flight (as the glider is more heavily loaded), the rate at which tension increases as the glider rolls away and/or pitches up from the desired path is relatively high and thus the penalty for the degree to which a lockout has progressed demanded by a stronger weak link is relatively low.

`E. Installation

`a. Tow Line

i. Fore

The fore weak link must be fail at a tow line tension greater than but no more than 25 percent beyond that allowed by the aft configuration and at below 2 Gs.

ii. Aft

A weak link installed on the aft end of the tow line descends with the tug and thus is subjected to dragging but may be used for multiple gliders. A tow ring integrated in the weak link's aft end provides the means of engaging a bridle.

`b. Bridle

Weak links integrated into the glider's bridle(s) must be produced for each individual but descend with the glider and are not subjected to abuse and provide an advantage in the event of a bridle wrap following release.

i. Length

Weak links are made as short as possible - within the confines of release operation demands - in order that they be incapable of contributing to a wrap.

ii. Durability

The breaking component of the weak link is isolated from the release mechanism and experiences no wear.

iii. Redundancy

Graduated weak links are incorporated at both ends of the primary bridle and thus protection is afforded in the event of the primary bridle wrapping or snagging while trailing. The traditional secondary bridle is replaced by an elongated shear link and renders a two point system one point ready.

~07. Construction Notes

#01. Orientation

`A. Primary

As VG control lines are routed through starboard downtubes the primary release lanyard is routed through the available port. Thus actuation is effected with the left hand and this standardization is maintained with respect to the secondary bridle assembly regardless of its use in a two or one point system. Barrel Releases are assumed to be Port - Starboard units are mirror images.

`B. Secondary

Descriptions below are based on an assumption of aerotow loops attached in a horizontal plane. If the webbing is connected to the harness vertically, outboard is translated to top and other orientations are rotated a quarter turn accordingly.

#02. Synthetic Fiber

`A. Leechline

All references to leechline indicate Dacron.

`B. Shrinkage

Many lines shrink significantly when washed in hot water. Measurements are taken after the material has been immersed in boiling water which reduces the initial length by about five to ten percent. This is particularly important with respect to components which affect critical adjustment such as those involved in primary release mounting and actuation.

`C. Ends

Ends of Dacron and bungee components are heat fused, smoothed, and tapered and listed measurements exclude those areas. As the Vectran core of the Crystalyne is resistant to heat fusing, after the line is cut the cover is retracted, 5 millimeters of the core is trimmed, and the cover is repositioned beyond the core and fused.

#03. Stitching

`A. Sequences

Stitching is effected without overlap such that the strength of a binding is quantifiable and thread can be completely removed without damage to components when disassembly is sequentially the reverse of fabrication and effected with the aid of a marlinespike.

`B. Strength

Stitched bindings are effected to exceed the strength of the material being secured.

`C. Shortening

Structures shorten as they are stitched and materials measurements must allow for this distortion.

#04. Knots

`A. Becket Bends

A Becket Bend is a Sheet Bend in which the bight component of the knot is secured in the form of an eye.

`B. Lark's Heads

For standardization purposes all Lark's Heads, save for some incorporated in break links, are formed with the center of the knot topside. All Lark's Heads used for weak link installation have their centers fore or outboard to allow smooth passage through a tow ring or thimble respectively.

#05. Fasteners

All fasteners - screws, washers, and nylocks - are stainless steel except for the nylon washers used on pulley clevis pins.

`A. Screws

All screws referenced are Phillips machine screws and, except for the Clamcleat screws, pan head. When necessary they are cut to length with the cut end being rounded with a file.

`B. Washers

All washers have all edges - inner and outer - deburred.

#06. Pulleys

All pulleys are Harken 16 millimeter AirBlocks.

`A. Strength

The pulleys whose sole function is to route or magnify actuation tension are overbuilt but the most appropriate for the task available.

`B. Mounting

`a. Clevis Pin

All save for the Basetube Pulley incorporate a clevis pin for mounting.

`b. Washers

Number 06 nylon Washers have their IDs enlarged by filing to snugly fit on the clevis pins and are installed at both ends.

`c. Retainers

A 04/64 x 30 millimeter leechline length is threaded through the clevis pin's hole and secured with stitching.

`d. Harness

The eyes of the harness which engage the clevis pin closely fit over the Washers.

#07. Thimbles

Unless otherwise noted, all thimbles referred to are one of two sizes of stainless steel Ronstan Sailmaker's Thimbles -

RF2180 or RF2182 and are oriented with their wide ends at the folds of the eyes in which they are installed.

#08. Heat Shrinkable Tubing

`A. Application

Nearly all of the procedures which call for application of heat shrinkable tubing can be accomplished via immersion in boiling water.

`B. Distortion

Stretching and distortion are likely to occur if the position of heat shrinkable tubing is adjusted before being allowed to cool.

`C. Discoloration

A soot mark from a candle flame can be removed by cleaning with isopropyl alcohol.

#09. Plastic Tubing

`A. Vinyl

Vinyl tubing (soft, flexible) is utilized where it is desired to prevent its movement with respect to the component which it sleeves.

`B. Polyethylene

Polyethylene tubing (hard, stiff) is utilized to sleeve screws and lanyards where free and easy movement between components is desired. Small diameter tubes can be salvaged from empty spray cans.

`C. Nylon

Nylon tubing is similar in relevant characteristics to polyethylene and is utilized for the primary lanyard conduit.

#10. Threaders

Threaders are appropriate lengths of 03/64 leechline used to draw leechline components through sleeves and control frame tubing.

`A. Doubled

An end end is routed through a sleeve or tube, to the loop of the leechline component, and back out along the same path.

`B. Stitched

By stitching a few passes through the downstream end of the Threader and upstream end of the component to be installed - leaving a few millimeters or more of floss length between the two - a component may be routed in situations in which it is difficult to route a Threader back along the same path - as in a Bungee Assembly installation - or the internal diameter of the tubing precludes use of a doubled Threader - as in the routing of a Primary Lanyard through the Conduit of a replacement downtube.

#11. Glider

The installation described below was adapted for a Wills Wing HPAT 158. Variations for other models will be described in separate sections as the techniques are developed. Only components altered or amended are discussed.

~08. Construction - Actuation System

#01. Mounting Fasteners

`A. Screws

06-32 x 34.5 millimeter Screws aligned parallel to the basetube bolts/pins (fore/aft) are installed aft to fore through the port and starboard ends of the basetube 4 inches inboard and serve as anchors for an internal Pulley Assembly and the joined end of a doubled Bungee respectively.

`B. Nylocks

Nylocks secure the Screws.

#02. Basetube Pulley Assembly

`A. Pulley

A Harken 404 AirBlock serves as the Basetube Pulley.

`B. Axle

A short length 08/64 inch aluminum pin is held in the chuck of an electric hand drill serving as a lathe in order that its diameter along may be slightly reduced with a file. It is ground until three quarters of an inch of its length can be inserted through the rivet around which the sheave rotates and cut to a length of 0.99 inches.

`C. Axle Shims

A pair of 12-08/64 x 0.25 inch vinyl tubing lengths are installed on the Axle - fore and aft of the Pulley - to keep it centered.

`D. Bushing

A 12-08/64 x .33 inch polyethylene tubing length is installed in alignment with the Pulley mounting holes within the housing to preclude the Leader from being damaged by contact with the Screw threads.

`E. Screw Shims

A pair of 12-08/64 x .2875 inch polyethylene tubing lengths are installed on the Screw - fore and aft of the Pulley - to keep it centered.

`F. Pull

A Pull is secured to the Pulley to facilitate removal of the Assembly.

`a. Base

A 05/64 x 240 millimeter leechline length is routed through the strap of the Pulley.

`b. Sleeve

A 12-08/64 x 1 inch vinyl tubing length is installed over the ends of the Base and secured with a Thumb Knot.

#03. Bungee Assembly

`A. Bungee

The Bungee is a 16/64 x 1750 mm length of material.

`B. End Connectors

Pro Flex PFRSB4 Dead Ends are installed on the Bungee ends, aligned as mirror images.

`C. Bushing

The Bungee is folded in half such that the extensions of the End Connectors are joined back to back. A 12-08/64 x .99 inch polyethylene tubing length fills the difference in diameters between the 06-32 Bungee Screw and holes of the End Connectors through which it is installed.

`D. Shims

A pair of 16/64-.170 x 24/64 inch vinyl tubing lengths are installed on the Bushing - fore and aft of the End Connectors - to keep the joined ends of the Bungee Assembly centered in the basetube.

`E. Pull

A Pull straddles the End Connectors pair and fits the over Fore and Aft Stop Sleeves to ensure that the Bungee Assembly can be easily extracted from the basetube.

`a. Base

A 05/64 x 400 millimeter leechline length is formed in a loop by having its ends joined using a Fisherman's Knot. The loop is then drawn linearly such that the Knot is centered on its run. The two runs are stitched together save for 20 millimeter Eyes at the ends.

`b. Loop

A 05/64 x 100 millimeter leechline length is formed in a spiral and stitched to create a small Loop through which the Base is drawn to its midpoint.

`c. Sleeve

The Base is then folded in half such that the Eyes are brought together and the Knot is positioned at the far (starboard) end. Using a Threader through the Eyes the Base is drawn through a 16/64-.170 x 50 millimeter vinyl tubing length which serves to keep the Pull Assembly from shifting inboard.

`d. Installation

The Eyes are placed over the Fore and Aft ends of the Screw and Stop Sleeves and the Pull Sleeve is drawn towards the Eyes to hold the Assembly firmly in place.

`F. Thimble

An RF2180 Thimble is placed between the Bungee runs at the fold.

`G. Collar

A Pro Flex PFTC4 Bungee Loop Connector is installed near the fold just beyond the Thimble such that the Thimble is retained but the Bungee is not stretched.

`H. Leader

A 05/64 x 600 millimeter leechline length serves as a Leader which joins the Bungee Assembly to the Lanyard. It is folded in half and the ends are drawn through the Thimble - top to bottom - and back to fore and aft of the doubled standing part to protrude 35 millimeters from the Bungee. The resulting parallel four runs are stitched together - starboard to port, the stitching continuing about 8 passes beyond the Overlap. 150 millimeters from the fold the two parallel runs are stitched together over a length of 10 millimeters. This Stop Stitching provides a seat for engaging the Cotter Pin. This configuration allows the system to be actuated without drawing the Lanyard into the basetube.

#04. Cotter Pin Lanyard Assembly

`A. Cotter Pin

The Leader is routed up from below the Pulley and exits the basetube under tension slightly inboard of the Port Screw on a radius coplanar with the downtubes. There it is engaged below the Eye by an 06/64 x 1 inch stainless steel Cotter Pin which has been clipped and filed such that its end is even and rounded.

`B. Basetube Washer

The Cotter Pin seats on a Number 06 Washer installed over the hole through which the Leader exits the basetube.

`C. Adhesive

The Basetube Washer is installed using Sears Craftsman Formula 300 hot glue.

`D. Lanyard

The Cotter Pin has attached to it by means of a Double Overhand Noose a Lanyard of 05/64 x 270 millimeter leechline length.

`E. Guide Assembly

`a. Base

The Lanyard runs inboard through a 10-07/64 x 45 millimeter polyethylene tubing length.

`b. Retainer

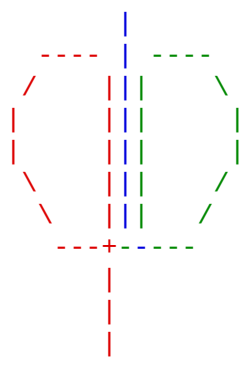
The Guide held in place by a 1.5 inch x 45 millimeter heat shrinkable tubing length.

`F. Button

The inboard end of the Lanyard terminates in a small rubber Button - a 000 faucet washer - which is held between the two outboard fingers of the left hand at their bases (a button won't break a finger as might a loop if something goes awry). The Lanyard is secured to the Button by routing its end:

up through the center from the beveled end;
down around a side;
up through the center a second time;
down around the opposite side; and
up through the center a final time.

The following schematic illustrates this routing in the order of red to green to blue.



`G. Keeper

A loop formed of an 08/64 x 150 millimeter bungee length tied with a Fisherman's Knot encircles the basetube and Guide. After release this Keeper is slid inboard to keep the Button from dangling in the breeze.

#05. Primary Lanyard Installation

`A. Lanyard

A 03/64 x 2005 millimeter leechline length serves as the Primary Lanyard. It engages fold of the of the Leader by means of a Becket Bend.

`B. Lower Routing

The Lanyard enters the downtube inboard through a hole drilled at an upwards angle 8 inches from its bottom and exits through a hole 5 millimeters inboard of the fore extremity of the downtube's cross section 3 inches from the top and drilled at a downward angle. The corner cut defined by the Lanyard at the control frame angle provides clearance for a wheel and minimizes the change in direction and associated friction as the downtube is entered.

`C. Conduit Assemblies

After the Lanyard is threaded through the downtube Conduit Assemblies are installed over the Top and Bottom Lanyard ends and through the downtube walls to protect the Lanyard from abrasion.

`a. Base

An 08-05/64 x 4 inch nylon tubing length serves as the Base.

`b. Stop

A 12-08/64 x 20 millimeter vinyl tubing length is fitted on the outer end of the Base to prevent it from being drawn into the downtube.

`D. Upper Routing

Upon exit the Lanyard is routed through a Pulley bridled to the top of the downtube, through a Pulley connected to the Barrel of the Keel Release, and terminated back to a Lanyard Extension from a becket at the Downtube Pulley using a Becket Bend.

#06. Downtube Pulley Assembly

`A. Pulley

The Downtube Pulley is oriented axis horizontal and becket fore.

`B. Bumper

A 05/64 x 120 millimeter leechline length is coiled four and a half times around the strap of the Downtube Pulley and secured with stitching to form a Bumper which protects the downtube with five Runs.

`C. Harnesses

The Pulley is mounted to the downtube via Out- and Inboard Harnesses, the lengths differing such that the Pulley is aligned with the Keel Release, i.e., offset inboard. The Harnesses are fabricated from 05/64 inch leechline, spirally folded in three Runs and stitched with short Eyes left at the ends. The Runs in millimeters are 38-44-38 and 31-38-31 for Out- and Inboard Harnesses respectively.

`D. Screw

The upper downtube pin is replaced by a Screw of equal diameter long enough to accommodate the downtube, Harnesses, and Nylock.

`E. Nylock

A Nylock secures the downtube and Pulley.

`F. Lanyard Extension

The Lanyard Extension is a loop formed from a 05/64 x 100 millimeter leechline length stitched to the becket of the Downtube Pulley. Ends overlap at aft 15 millimeters, the two Runs are stitched together fore of the becket, and an Eye is left in the fore end.

~09. Construction - Release Assembly Mounting

#01. Aft Anchoring

The Harness is anchored on the cross spar sweep wire restraining bolt (or, better yet, the ball lock pin replacing it) inboard of the wires.

`A. Harness

`a. Extensions

The Port and Starboard Extensions engage the bolt and Harness Base by means of Eyes at their ends. An Extension is constructed from a 05/64 x 500 millimeter leechline length. It is folded in the middle and the halves are stitched together save for the first 10 millimeters from the fold to form the Aft Eye and the 80 millimeters from the ends. A fold to the inside of the structure is made at the midpoint of each free length and the 40 millimeter long Fore Eye is formed by stitching the resulting spiral.

`b. Base

A 10/64 x 400 millimeter leechline length constitutes the Base.

`c. Retainer

A 24-16/64 x 20 millimeter vinyl tubing length constitutes the Retainer which serves to keep the Harness properly configured in the absence of the Primary Release Assembly.

`d. Installation

The (designated) Port end of the Base is secured to the Fore (40 millimeter length) Eye of the (designated) Port Extension by means of a Becket Bend. The Base is then routed through the Retainer, over the keel near the trim point, and back through the Retainer fore to aft and secured to the Fore Eye of the Starboard Extension with a second Becket Bend. At setup the sweep bolt is installed through the port sweep wire thimble, the Aft Eye of the Port Extension, the keel, the Aft Eye of the Starboard Extension, and the starboard sweep wire thimble and secured with the nut and safety ring.

#02. Undersurface Zipper

As the trim point is obstructed by the sail's undersurface a clean enclosure is effected with the installation of two additional zipper sliders in the following configuration:

>===<x>==============

right being forward, "=" being zipper, ">" and "<" being sliders, and "x" being the attachment. The two sliders enclosing the attachment should have their tab keepers sawn off and outside faces filed smooth to preclude interference with the Release.

#03. Tensioner Anchor

`A. Base

The Base is an 08/64 x 400 millimeter leechline length with an Eye formed in one end by folding one end back from the 25 millimeter mark and stitching. It is semipermanently installed around the lower aft nose plate saddle and secured by means of a Becket Bend. It protrudes about five inches aft below the undersurface, i.e., far enough so it need not be dug out from the interior at setup.

`B. Sleeve

A 20-12/64 x 60 millimeter vinyl tubing length serves as a Sleeve which is installed over the aft protrusion and facilitates access.

~10. Construction - Keel Release

The Keel Release is constructed and mounted such that, when engaged, the displacement of the upper Bridle end from the pivot point is minimal. A Keeper component ensures the mechanism remains closed until actuation and is required to negate the effect of the weight of the Barrel and Downtube Pulleys.

#01. Base Pulley

The Base Pulley is oriented axis horizontal and becket fore.

#02. Barrel

The Barrel, a 3/8-.058 x 20 millimeter aluminum tubing length, is drilled through horizontally with a 07/64 inch bit 3 millimeters from its aft end.

#03. Pin

The straight release pin rotates in a vertical plane.

#04. Tensioner Extension

A 04/64 x 250 millimeter leechline length is spirally folded in three Runs, 80 - 90 - 80 millimeters, and stitched, 10 millimeter long Eyes at ends. Eyes are engaged by the Base and bracket the Pin. It is folded in half and oriented Eyes aft and outboard leechline end top starboard.

Note: Minimum material diameter is limited by the ease with which stitching is effected.

#05. Base

`A. Routing

A 05/64 x 325 millimeter leechline length constitutes the Base which connects the Base Pulley to the Pin through the Barrel. In the following descriptions the Eyes referred to are those of the Pin and Tensioner Extension.

The leechline is routed:
 from top starboard through the Eyes
 aft through the Barrel to the top port becket area
 down around the becket and fore through the Barrel
 from the bottom port through the Eyes
 aft through the Barrel to the bottom starboard becket area
 up around the becket and fore through the Barrel
 from top starboard through the Eyes and aft

This is most easily effected by:
 centering the Base through the Eyes and folding
 routing the ends:
  aft through the Barrel
  up through the becket
  fore through the Barrel
 running the port and starboard ends through the Eyes to form the Overlap

`B. Stitching

`a. Orientation

All stitching is in the horizontal plane.

`b. Overlap

The 50 millimeters of the overlapping ends are stitched together.

`c. Stabilization

To stabilize the Overlap configuration in the horizontal plane the four Runs are stitched together aft of the eye of the Pin.

`d. Spring

The bottom port and starboard Runs are stitched together from the eye of the Pin 15 millimeters aft in order to provide a force which springs the mechanism open upon actuation even in the absence of a bridle connection.

#06. Screw

The 04-40 x 18 millimeter Screw length accommodates Barrel, Linkage, Keeper, and Nylock installation.

`A. Smoothing

The center quarter inch of the section of the threaded shank between the head and the installed Nylock is filed smooth to eliminate abrasion of and resistance with the Base. This can be accomplished by using an electric hand drill as a lathe.

`a. Hex Nut Installation

A hex nut is installed on the shank and turned all the way to the head.

`b. Clamping

The hex nut is secured in the chuck such that the length of the shank is exposed.

`c. Filing

The drill is set for reverse rotation, aimed left, and laid flat on a table. With the drill spinning, the threads are filed down using light pressure.

`B. Installation

The Screw is installed from the port through the Linkage Eyes and Barrel and between the top and bottom Run pairs of the Base, care being taken not to trap and damage the leechline.

#07. Nylock

A Nylock secures the Linkage.

#08. Linkage

The Linkage, which connects the Barrel to its Pulley, is a doubled 05/64 x 300 millimeter leechline length whose ends engage the Screw through the Barrel and are secured by having 30 millimeters of their ends folded back aft, ends up, and stitched to form 3 millimeter long Eyes. The port and starboard Runs are stitched together from just aft of the doubled ends aft save for a 30 millimeter long Eye which is routed through the Base Pulley from top to bottom.

#09. Barrel Pulley

The Barrel Pulley is engaged by its Pin with the Aft Eye of the Linkage formed in a Lark's Head.

#10. Harness

A Harness connects the Base Pulley to the D Shackle and is fabricated from a 05/64 x 250 millimeter leechline length spirally folded in three Runs, 80 - 90 - 80 millimeters, and stitched, 10 millimeter long Eyes at ends. Eyes engage Base Pulley Pin. Connected to D Shackle with Lark's Head.

#11. D Shackle

A small D Shackle - Wichard 1401 - is used connect the Release Assembly to the port and starboard Runs of the Harness fore of the Retainer.

#12. Tensioner

The Tensioner is secured to the Extension by means of a Quadruple Becket Bend and serves as a quick tensioning and locking device (similar to a barrel release) with the Pin engaging the Tensioner Anchor.

`A. Base

The Base is constructed of 06/64 x 840 millimeter leechline length.

`B. Pin

A straight release pin is installed on the Base at a fold made 75 millimeters from the fore end. The doubled length is stitched save for a 25 millimeter free area which allows the end of the Pin to fit between the runs.

`C. Lock

A 20-12/64 x 25 millimeter vinyl tubing length constitutes the Lock which secures the Pin.

#13. Keeper

The Keeper is a loop formed by joining with a Fisherman's Knot the ends of a 04/64 x 170 millimeter bungee length. It is installed through the Eyes of the Tensioner Extension and Pin and over the Screw head and Nylock. The Fisherman's Knot is positioned above and fore of the Nylock.

~11. Construction - Ribbon Bridle

Note: As of 2008/05 Crystalyne is no longer available in 06/64 diameter. The Quadruple Ribbon Bridle is recommended as an alternative.

#01. Length

Primary Bridle length determination is a trade-off between the increased loading resulting from the short and stowage issues resulting from the long end of the range. Ten feet is an arbitrary selection which results in an approximate 60 degree angle at the Tow Ring.

#02. Construction

Construction of a Ribbon Bridle is a time consuming and tedious endeavor but the finished product is stiff, virtually uniform over its entire length, and extremely resistant to fouling.

`A. Base

The central and structural component is a 06/64 x 3050 millimeter (ten foot) length of Yale Cordage Crystalyne (as the strength of a single strand of leechline of the same diameter is a bit marginal for the task). Coplanar Primary and Secondary Shear Links, as later described and illustrated with schematics, are stitched to the ends thereby defined as Top/Fore and Bottom/Aft respectively.

`B. Fillers

Port and Starboard Fillers are 06/64 leechline lengths equal to that of the Base minus the sections required for Shear Links installations.

`C. Assembly

`a. Fillers Cutting

i. Securing

After Shear Links installation the free fused end of a spool of leechline is butted against the Port end of the Primary Shear Link and temporarily stitched in place.

ii. Length Determination

The Base is then used as a measuring tape such that the Port filler can be cut and fused to precisely span the distance between the Primary and Secondary Shear Links.

iii. Duplication

The Port Filler is separated and used to cut and fuse a Starboard twin.

`b. Stitching

The three elements are stitched together to form a ribbon, coplanar with the Shear Links. As stitching compresses the outer elements (Fillers), the following technique is employed to prevent distortion.

i. Tension

All stitching tension is light.

ii. Tacking Sequences

Tacking consists of five stitch sequences.

iii. Ends

The Top and Bottom ends of the Port and Starboard Fillers are butted against the Primary and Secondary Shear Link ends

respectively and tacked in place.

iv. Midpoints Tacking

Midpoints of free runs are repeatedly determined and tacked until none remain longer than about three and a half inches.

v. Finishing

All free runs are stitched secure.

`D. Quadruple Option

A Quadruple Ribbon Bridle may be constructed using 06/64 inch leechline for all four elements. The Shear Links and Port and Starboard Fillers are installed between Port and Starboard Base Strands. Further discussion presumes the Triple option unless stated otherwise.

`E. Bridle Thimble

An RF2180 Thimble is installed at the bottom end of a Primary and is engaged by a Secondary Bridle.

`F. Bridle Cinch

The ends of an 08/64 x 260 millimeter bungee length are joined with a Thumb Knot, a cord lock is installed over the resulting loop.

~12. Construction - Secondary Bridle

The Bridle Link is described in the Weak Links section.

Note: The Secondary Bridle must be long enough for the Four-String Release to clear before being contacted by the Primary Bridle Thimble or Tow Ring.

~13. Construction - Barrel Release

#01. Description

`A. Brake

A Brake component sets a minimal internal resistance to ensure that the connection remains secure when not under load.

`B. Triple Overlap

When forming an Eye - temporary or permanent - in the aft end of the leechline Base a region of triple overlap aft of the Barrel travel is required to ensure that the stitching remains intact under load.

`C. Stop Assembly

A Stop Assembly limits the aft travel of the Barrel and thus protects the Triple Overlap.

#02. Pin

All configurations incorporate a straight release pin which is oriented fore and such that its Eye defines a horizontal plane.

#03. Base Assembly

`A. Base

An 08/64 x 530 millimeter leechline length is marked as indicated in the the following table:

000	000	end
185	185	pin
370	185	double
530	160	end

000	000	end
200	200	pin
400	200	double
550	150	end

`a. Pin Installation

A Pin is strung onto the Base at the middle of a fold made in the first 370 millimeters of the leechline. These two Runs - Top and Bottom - are stitched together save for the region from 15 millimeters aft of the Pin Eye to immediately aft of the end of the Pin when rotated back to the closed position.

`b. Loading

A temporary Eye is formed by stitching a loop in the aft end of the Base. With a Barrel temporarily installed the partially completed Barrel Release is loaded in excess of 200 pounds to set the length of the permanently stitched region which increases from about 175 to 180 millimeters.

`c. Eye

A Bridle Link (06/64 inch diameter leechline) is engaged by the partially completed Barrel Release upon which a Barrel is temporarily installed to close the mechanism. The Barrel is drawn aft until it leaves the Pin free to rotate open without interference. With the Pin fore and the fold in the vertical plane with the 185 millimeter (short) Run Top, the free end of the leechline is rotated to port and fore in the horizontal plane and brought in to about 3 millimeters aft of the Barrel. This Final Run is then stitched to the port side of the Middle Run along its length aft to within 30 millimeters of the fold to leave an Eye.

`d. Schematics - Perspectives

Color Coding - Runs:

Red   - Top

Green - Middle
Blue - Final

i. Starboard

Each character represents a distance of 5 millimeters.

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Although the Runs are represented as coplanar there are, in fact, two perpendicular planes defined by the Top/Middle and Middle/Final Runs (as illustrated immediately below).

ii. End

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`B. Brake

The Brake is a 06/64 x 50 millimeter leechline length whose fore end is fused square.

`a. Positioning

With the Pin rotated port and aft and engaging a Bridle Link the Brake is positioned on the port side of the Base such that its fore end is positioned about 1 millimeter aft of the tip of the Pin.

`b. Anchoring - Fore

The fore 15 millimeters of the Brake are secured to the middle of the side of the Base by stitching which alternates between the Top and Middle (bottom) Runs.

`c. Offset

A measure of forward offset to create a hump to account for the desired resistance is estimated.

`d. Anchoring - Aft

The offset is set by stitching the Brake along the aft 15 millimeters with stitching alternating between the Top and Middle Runs.

`e. Schematic

Bird's Eye Perspective

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`C. Stop Assembly

The Stop Assembly limits the aft travel of the Barrel to the point at which the Release opens.

`a. Base

The Base is a 05/64 x 60 millimeter leechline length. It is positioned between the Top and Final Runs of the Barrel Release Base with its fore end even with the fore end of the Final Run and stitched along its fore 15 millimeters with stitching alternating between the Runs.

`b. Sleeve

The Barrel and the Sleeve, a 24-16/64 x 50 millimeter vinyl tubing length, are installed in that order on the Release Base. The Barrel is slid full fore and the Sleeve is slid over the Barrel and Stop Base until its fore end is about 5 millimeters fore of the fore end of the Stop Base.

`c. Adjustment

An Overhand Knot is tied in the aft end of the Stop Base and its position is adjusted to hold the Sleeve such that its fore end is just fore of the fore Stop Base end.

`D. Orientation Indicator

To facilitate the proper orientation of the Barrel Release upon engagement a length of red (or green for a starboard unit) thread (see Bridle Link section) is stitched into the Top Run of the Base from the Pin Fold aft to just aft of the fore end of the Brake. The runs of thread between stitches are 1 millimeter on the starboard (inboard) side and 4 millimeters on the port (outboard, Pin) side.

#04. Base - Knot

An inelegant but perfectly safe and effective basic Barrel Release can very easily be assembled as follows.

`A. Eye

A fold is made 20 millimeters from the an end of an 08/64 x 375 millimeter leechline length and a stitched Eye is formed.

`B. Routing

The other end is routed down through the Eye of a Snap Shackle, fore through a Barrel, up through a Pin Eye, and back aft through the Barrel and joined to the Eye (Bight) by means of a Becket Bend.

`C. Stitching - Optional

The Top and Bottom Runs of the Eye are stitched together from immediately aft of the Ring of the Pin Eye aft to the farthest reach of the Pin tip.

#05. Barrel

Ends are beveled, out- and inside. This is best accomplished using an electric drill as a lathe and a sharp knife and file. Installed from the aft end of the Base and slid fore to the Pin.

Note: The beveling must be closely inspected to ensure absence of irregularities which could damage the Base.

#06. Adhesive

`A. Bolt

A 0.25-20 x 8 inch steel bolt with 7 inches of unthreaded shank is fully inserted through the Barrel.

`B. Barrel Heating

An end of the Barrel is heated by rotation over a candle flame until extremely hot to the touch.

`C. Hot Glue Application

The hot area of the Barrel is rubbed by a stick of Sears Craftsman Formula 300 hot glue and spread with an index finger tip until the coating over the area is complete, thin, and even. Repetitions of the heating and application continue until the entire Barrel is coated.

`D. Cooling

The Barrel is immersed in room temperature water to cool it thus prevent anything from accidentally adhering to it.

#07. Grip

A 0.375 x 103 millimeter heat shrinkable tubing length is installed such that the ends envelope the Barrel.

Note: 3/8 inch adhesive lined (dual wall) 2:1 heat shrinkable tubing in red and green is not available.

`A. Positioning

The heat shrinkable tubing is slid over an uncoated Barrel. Both Barrels are installed on the steel rod, the (designated) aft end of the coated Barrel in contact with the uncoated one. The tubing is pushed onto the coated Barrel. When resistance is encountered the coated Barrel is and rolled between the palms to break the contact. The procedure is repeated until the tubing extends evenly beyond both ends of the Barrel.

`B. Sealing

The Barrel is slowly immersed in near boiling water from end to end.

~14. Adjusters

An Adjuster connects a Secondary or Emergency Release to a Snap Shackle, is constructed from 08/64 leechline, and engages the Snap Shackle by means of a Lark's Head formed in its aft Eye. The Starboard Adjuster positions the Four-String Release such that the Trigger Line is pulled up perpendicular from the line of transmitted tow tension. The Port Adjuster precisely centers the Primary Bridle Thimble or Tow Ring on the Bridle Link. Due to the variables of knot seating and stitching distortion this adjustment is problematic when matching the port to starboard release.

#01. Becket Bend

The Becket Bend Adjuster can be shortened more than its counterpart and is likely the only option with which to mount the (starboard) Four-String Emergency Release.

`A. Construction

An appropriate leechline length is folded in half and the resulting runs are stitched together save for a 30 millimeter long Eye at the Fold.

`B. Interface

It is connected to the Snap Shackle by means of a Lark's Head and engages the Eye of the Release by means of a Becket Bend begun by routing the end up through the Eye and inboard.

`C. Sleeve

Note: When used in conjunction with the Four-String Release the Starboard Adjuster may be set so short as to leave no room for a Sleeve installation. In this case the free end may be secured with a few stitches.

`a. Base

A Sleeve of 24-16/64 x 25 millimeter vinyl tubing immobilizes the free end.

`b. Markers

Sleeves for Port and Starboard Adjusters are enveloped and differentiated by Markers of red and green 0.375 inch heat shrinkable tubing.

#02. Lark's Head

Descriptions assume port installations. A starboard unit is a port flipped top to bottom.

`A. Fixed

The Fixed Lark's Head Adjusters have the advantage of allowing easy separation from the Releases they engage without nullifying the adjustments. One is best employed as one of an identical pair for use in mounting one of a pair of Barrel Releases.

`a. Aft Eye

The aft 80 millimeters of an excess 08/64 leechline length is folded to starboard and pinned to the standing part. This region will accommodate a 30 millimeter long Aft Eye and 50 millimeters of stitched Overlap to ensure the required strength.

`b. Fore Eye

By rotating the fore excess to starboard a second fold is made fore in the standing part at a point estimated to position the Release the desired distance from its mounting. The temporary Fore Eye thus established is used to engage the Eye of the Release via a Lark's Head. This Fore Eye is adjusted to yield the desired length when the junction is hand tightened.

`c. Stitching

The resulting double and triple overlaps are stitched together from 10 millimeters aft of the fore fold to 30 millimeters fore of the aft fold. The resulting assembly (Release and Adjuster) is tensioned in excess of 200 pounds and checked for the accuracy of the result.

`d. Finishing

Upon attainment of the desired length the Starboard Run is trimmed at the fore end of the Aft Eye and fused.

`B. Variable

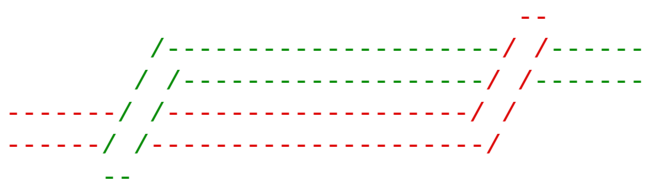
`a. Description

The Variable Lark's Head Adjuster is the best option for centering the Bridle Link when using a Barrel and Four-String Release. It is about an inch longer than a Fixed Adjuster but otherwise identical. It is installed on the Barrel Release using an untightened Lark's Head which incorporates the excess length such that the Bridle Link is centered. The two pairs of leechline runs - Barrel and Adjuster - between the ends of the Eyes are stitched vertically - Port Release to Port Adjuster and Starboard Release to Starboard Adjuster - at a density of about one stitch per millimeter.

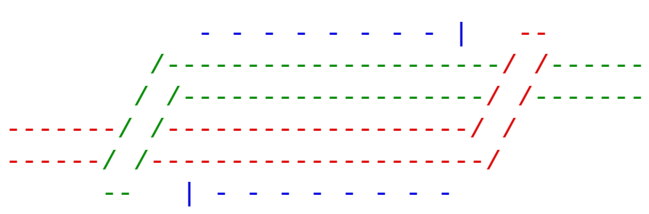
`b. Schematics

Perspective is port, Barrel Release is Red, Adjuster is Green, stitching is Blue.

i. Unstitched



ii. Stitched



~15. Construction - Snap Shackles

The Secondary Bridle Snap Shackles connect the Secondary Bridle Assembly to the aerotow loops. The Gates open outboard (or up, depending upon the orientation of the aerotow loops).

Note: Quick links may be substituted for snap shackles, especially when convenient removal and replacement is not an issue. It is, however, advisable to ensure that the gates remain firmly secured.

~16. Construction - Remote Barrel Release

The Remote Barrel Release is constructed as is the Keel Release with the following modifications.

#01. Inversion

The assembly is inverted to allow actuation from above.

#02. Elongation

The Base is elongated to match or exceed the length of the barrel release (which can be extended) thereby allowing incorporation of a short Secondary Bridle (and better aligned release actuation tension). The Overlap section is positioned aft top port.

#03. Linkage

The Linkage is fabricated from a 03/64 x 460 millimeter leechline length. The aft 100 millimeters of the port and starboard Runs are stitched together save for a 5 millimeter long Eye at the end.

#04. Lanyard

The Lanyard consists of a 05/64 x 375 millimeter leechline length (approximate) in which the fore 15 millimeter is folded and stitched back leaving a 3 millimeter long Eye by which means it is secured to the Eye of the Linkage with a Lark's Head.

#05. Mounting

The port Snap Shackle replaces the D Shackle.

~17. Construction - Four-String

#01. Description

The Body of the Four-String Release is an elongated spiral of 2765 millimeters of 05/64 inch leechline starting with an inner single Run, whose free end faces fore and serves as the Trigger Line, surrounded by three loops of increasing lengths which wind clockwise to the aft facing outer end. It is mounted via an Eye at the aft end and safetied with a jam cleat. A Guard prevents the Trigger Line from relocking.

`A. Runs

The seven Runs of this structure are numbered from the inside.

`B. Loops

The loops likewise are numbered from the inside.

`C. Eye

A 25 millimeter long Eye is left at the aft end, the innermost elements of which are Runs 1 and 2. The aft ends are aligned vertically from inner down to evenly distribute the load.

`D. Base

The Base is formed by stitching together the seven Runs from the Eye 75 millimeters fore.

`E. Cleat

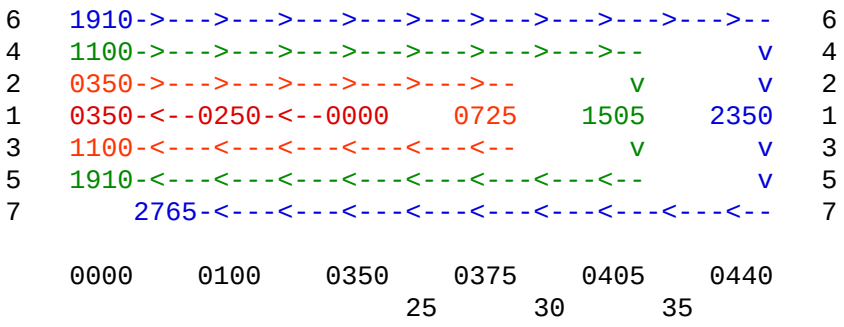
A Clamcleat CL263 Micro (jam) Cleat is secured to the top face of the Base with Screws, Washers, and Nylocks.

`F. Guard

The Guard is a doubled loop of light bungee lightly stretched over the Cleat.

#02. Body Measurements

The table below indicates:
 the spiral of the seven Runs and alignment measurements;
 measurements from aft to fore; and
 clearances between the four elements.



#03. Construction

`A. Body

`a. Marking

The leechline is marked at the following increments in millimeters for the related definitions.

0250 - Trigger Line
0325 - Eye
0350
1100
1910 - aft turn points

`b. Tacking

To facilitate construction, eliminate twisting, and laterally compress the Base area, as the Base is formed each Run is tacked to the existing formation with stitching widely spaced at about 8 millimeters and, to ensure alignment of the aft turn points, effected from the Eye to fore. The five tacking steps are illustrated as follows:

1+2
12+3
123+4
1234+5
12345+6

`c. Eye Formation

As the Loops are thus formed a quarter inch diameter rod is inserted vertically through the resulting and forming Eye to properly structure it and align the marks.

`d. Loops Completion

Upon completion of the formation of the second loop the final loop is formed by bringing the outer end back to the starboard fore end of the Eye (25 millimeters shy of the end).

`e. Base Stitching

The Base is completed with tight and closely spaced stitching.

`f. Eye Completion

The bottom loop of the Eye is pulled up through the middle and top loops and the top loop is pushed over the Eye to the bottom position. The three elements of the resulting twisted formation are lightly stitched together.

`g. Trigger Length Variations

The marking points and total length for constructions deviating from the suggested 250 millimeter standard are determined by the following formulae in which T is the the Trigger Line length:

T
T+75
T+100

T+100+(T+100+25)*2
T+100+(T+100+25)*2+(T+100+25+30)*2
T+100+(T+100+25)*2+(T+100+25+30)*2+(T+100+25+30+35)*2-25

or, simplified:

T
T+75
T+100
T*3+350
T*5+660
T*7+1015

`B. Cleat

`a. Screws

The ends of two half inch 06-32 x 10 millimeter oval head Screws are rounded with a file.

`b. Installation Tools

A 11-08/64 x 32 millimeter polyethylene tubing length is divided in half with a diagonal cut through the middle to produce two pointed ends.

`c. Base Openings

A marlinespike is used to force openings between Runs 1 and 2 25 and 49 millimeters aft of the fore of the Base.

`d. Tools Insertion

The tubing sections are inserted through the openings, points first from the top.

`e. Threading

The screws are installed through the Cleat mounting holes and started into the squared tubing ends.

`f. Screws Installation

The tubing sections are pulled down all the way and the Screws are screwed fully through the Base, care being taken to avoid damage to the leechline.

`g. Tools Removal

The tubing sections are removed from the Screws.

`h. Washers Installation

Washers are installed on the Screw ends.

`i. Nylocks Installation

Nylocks are installed on the Screws.

`C. Guard

A 04/64 x 150 millimeter bungee length is wound in two coils and the ends are joined with a Fisherman's Knot. The resulting Guard is stretched over the Cleat such that the Fisherman's Knot is positioned between the Nylocks, the opposite end of the doubled loop is positioned fore of the Fore Nylock, and the coils cross over the top.

#04. Installation

`A. Connection

The Four-String Release engages the Secondary Bridle by inserting the third loop through the Starboard Eye from the inboard side to establish an orientation to optimize the disengagement of the loop and Trigger Line ends.

Note: The Four-String Release must not engage a Break Link of material of less than 05/64 inch diameter.

`B. Sequencing

The end of the second loop is then fed through the end of the third, the end of the first through the end of the second, and the end of the Trigger Line through the end of the first.

`C. Safetying

The Trigger Line is fed from fore to aft through the Cleat and down into the locking grooves.

Loop 1 is pulled fore with several pounds of force to establish the lock.

`D. Fail-Safing

The Trigger Line is routed back fore under the Guard and out the top of the Cleat.

#05. Performance

`A. Minimum Tension

A direct force of about 30 pounds is required to effect a release.

`B. Load Reduction

Due to the stepping down and other reductions through the mechanical advantage, friction, and resistance of the mechanism, when subjected to a 240 pound tow tension in One Point configuration the load transmitted to the Trigger Line remains well under two pounds.

`C. String Length Progression

Attempting to reduce the overall length of the mechanism by minimizing the progression of loop sizing will reduce performance and reliability due to the stiffness of the material.

`D. Cleat

`a. Pull Angle

Although the Clamcleat CL263 Micro Cleat performs best with a pull on the line it is retaining of 45 degrees up from aft, interference with the helmet's chin guard precludes this ideal. The best compromise is an Adjuster setting which will yield a perpendicular pull.

`b. Arming Tension

The Guard requires a forward routing of the Trigger Line as it exits the grooves but as the bungee stretches this deficiency is minimized and the Four-String is armed with no more than about five to seven and a half pounds of tension.

`E. Minimum Length

The minimum length of the mechanism is determined by a Trigger Line length which will allow freedom of head movement during tow.

#06. Adjustment Testing

Determining Adjuster length and the suitability of Release of a particular Trigger Line length is somewhat problematic due to the flexing and distortion undergone by the harness under the force of tow - the degree of displacement fore can be surprising. The initial flight is initiated with the end of the Trigger Line held between the lips such that it will pull free without arming the Release if it is too far out of adjustment. Otherwise, at any time after the dolly has rolled for a couple of seconds, the Trigger Line may be held between the incisors and a check for enough play to allow sufficient freedom of head movement is made.

#07. Use

The Four-String Release is likely to perform its function in One Point mode slightly more often than the parachute of a regular aerotow non-aerobatic pilot and never in Two Point. It is designed to be used in an emergency situation only and experiences significant wear when actuated under a heavy load.

~18. Construction - Shear Links

#01. Objective

A properly constructed Shear Link will maintain its integrity to its breaking point, failing instantly and cleanly. The construction objective is to obtain as high a strength per stitch value as possible in order to maximize predictability.

#02. Structure

Shear Links are based on side-to-side, in-and-out Runs of waxed nylon dental Floss stitching which bind either the four Strands of two elements or the two Strands of a folded element to a straight one.

`A. Materials

The elements stitched together are of materials identical in type and diameter. Otherwise the strength of the binding is degraded due to differences in stretch.

`B. Run Ends

Floss ends are unsecured, protruding 20 millimeters at beginnings and ends of Runs to facilitate complete removal after a failure and allow a visual inspection to verify that a Run maintains the originally intended number of stitches.

`C. Stitching

`a. Rate

i. Average

Stitching density averages one per two millimeters.

ii. Maximum

Density at the beginnings and ends of Runs is biased on the high side for no more than four to six stitches with a minimum separation of one millimeter such that premature separation of the leechline ends is guarded against. Density elsewhere is slightly reduced to compensate and maintain the average.

`b. Tension

i. Low

Upon loading low tension stitching allows the end of an outer element to begin to pull free of and thus prematurely weaken the assembly.

ii. High

Excessive tension pre-stresses the Floss and reduces its ability to shift and distribute the load.

iii. Target

Moderately taut stitching holds the assembly firm and intact and allows a degree of shifting such that stress tends towards equalization throughout the Runs, thus maximizing strength potential and predictability. The dense stitching at the beginnings and ends of Runs is biased with increased tension as a small portion of the protrusion will be drawn in as loading is maximized.

`c. Fiber Alignment

Upon completion of each stitch the protruding Floss with the needle is freely suspended from the assembly to reduce any twisting which may have occurred. Stitches are checked for twisting before seating.

`d. Load Distribution

It may be advantageous to gently flex the Overlap of a higher strength Tow Line Shear Link in its plane to even the tension of the Strength Stitching after completion.

#03. Strength Graduation

`A. Bottom End

Testing of the range of stitching from one to four passes results in holding to 185 and 383 grams and 11 and 24 pounds with the Floss pulling clear upon failure. Beyond that range the Floss breaks at failure. Test values for the next two increments are 47 and 72 pounds.

`B. Working Range

A Run of seven stitches is used as the lower limit of the working range as at this point the ratio of number of stitches to strength becomes reasonably linear.

`C. Top End

Although weak links rated up to a thousand pounds may be appropriate for heavy tandem gliders the tail structure of a Dragonfly tug is under-engineered and the Light Range Tow Line Shear Links discussed below encompass the G loading capability of what is typically used. Predictability is good up to about 36 stitches.

`D. Quality Control

`a. Floss Integrity

i. Batch

It is possible for Floss from a new spool to come frayed to the extent that strength is substantially affected. A magnifying glass should be used to check the Run for loose filaments prior to stitching.

ii. Wear

Only the excess area of Floss at the needle end is touched during stitching so that no fraying of the relevant length occurs.

`b. Count

i. Counter

A recording device (such as a pocket calculator) is punched with each stitch.

ii. Check

By noting whether the needle protrudes from the opposite or same side as the 20 millimeter Floss protrusion a check can be made on the count to the extent of an odd or even number.

`E. G Ratings Tables

The G ratings tables in the following sections provide single stitch average increments and cover gliders from light solo to heavy tandem. Weights are represented in pounds. The "1.4" column lists the ideal glider weight for the particular Shear Link and the "min" column lists the minimum allowable glider weight for which one can be certain that the tolerance of the particular Shear link will ensure that the tension remains at or below 2.0 Gs.

#04. Maximum Strength

Maximum strength of a Shear Link is attained when the load is distributed perfectly evenly between all stitches. This is most evenly and likely achieved at the low end of the working range at which the stitches in the run are most free to adjust themselves when loaded. Extensive testing has yielded a top average pounds per stitch rating of 23.7 and Shear Links must be selected with respect to that figure - which is rounded up to 24 for the purposes of this discussion. In no case will a Shear Link which represents the closest increment to 1.4 Gs based on a tested average subject a glider to tension at or above 2.0 Gs.

#05. Glider Loading

Weak link rating recommendations are made under the assumption that the manufacturer's specified maximum hook-in weight is not exceeded.

#06. Fairings

Fairings of heat shrinkable tubing are used wherever their incorporation will not interfere with release to ensure the integrity of the Shear Link by protecting it from UV, abrasion, catching, and soiling.

#07. Identification

`A. Overlap

The Overlap length allocated for Strength Stitching can be used for a rough approximation for ensuring that the Shear Link strength is within an acceptable range.

`B. Color Coding

A standardized dual color coding, repeating when necessary, of areas of stitching with colored thread and the Fairings provide the means of identifying the exact number of Strength Stitches once the range has been determined. Abbreviations used are consistent with those utilized by the heat shrinkable tubing supplier.

`a. Fore/Bottom/Starboard

Fore/Bottom/Starboard color is based on black through gray to white, the first being no energy/off/zero.

bk - black
gy - gray
wt - white

`b. Aft/Top/Port

Aft/Top/Port color is based on the spectrum, red being low frequency/energy/number. Available spectrum color abbreviations are as follows.

rd - red
or - orange
yl - yellow
gn - green
bl - blue
pl - purple

`c. Identification Table

The following table relates the number of stitches in the Light and Heavy Ranges.

lt	hv		
07	25	bk	rd
08	26	gy	rd
09	27	wt	rd
10	28	bk	or
11	29	gy	or
12	30	wt	or
13	31	bk	yl
14	32	gy	yl
15	33	wt	yl
16	34	bk	gn
17	35	gy	gn
18	36	wt	gn
19	37	bk	bl
20	38	gy	bl
21	39	wt	bl
22	40	bk	pl
23	41	gy	pl
24	42	wt	pl

Shear Links coded Black/Black are experimental and/or demonstration units of no designated rating.

`d. Thread

Stitching areas of Shear Links using colored thread provides a means of ensuring and verifying a particular rating as the thread - unlike a pair of Fairings - is not readily removable and replaceable. This is particularly important with respect to a Bridle Link used in a Two Point configuration as the Fairings must be removed for operation in that environment.

i. Colors

The regular floss is used to code for white. The remaining eight colors are indicated by Coats and Clark Dual Duty XP polyester thread.

0900 - black
0620 - slate
2250 - red
7640 - orange
7330 - yellow
6450 - bright green
4320 - blue
3690 - purple

ii. Applications

The Constrictions of Tow Line Shear and Bridle Links and the top and bottom 10 millimeters of Ribbon Bridles are stitched.

`e. Heat Shrinkable Tubing

The Fairings of colored heat shrinkable tubing provide a quick and easy means of identification.

#08. Failure

`A. Onset

Immediately prior to failure the outer leechline ends begin to pull away.

`B. Pattern

Upon reaching the rated load the Strength Stitching usually fails along one side of the assembly. Occasionally in longer runs failure occurs in multiple sequences on opposite sides.

#09. Configuration

Shear Links installed on the ends of the Tow Line are subjected to nearly twice the loading of those incorporated in a Bridle and require more labor intensive construction. The Link installed on the aft end of the Tow Line is subjected to dragging while the tug is landing and taxiing and thus should not be used in conjunction with Bridle Shear Links.

#10. Schematics

`A. Perspectives

Perspectives are starboard and fore.

`B. Constrictions

Constrictions lengths are reduced for the purpose of illustration.

`C. Color Coding

`a. Base Components

i. Tow Line Shear Link

Red - Fore
Green - Aft

ii. Ribbon Bridles

Red - Bases
Green - Bridles

iii. Bridle Link

Red - Port
Green - Starboard

`b. Constriction/Identification Stitching

Identification stitching is appropriately colored.

`c. Strength Stitching

Blue - Strength Stitching

~19. Construction - Tow Line Shear Links

#01. Base

A Tow Line Shear Link has a two part Fore and Aft Base of lengths of leechline, 06 and 08/64 inch for the Light and Heavy Range Increments respectively, each of which is folded in half.

`A. Overlap

A length from the end opposite the Fold is allotted for Strength Stitching.

`B. Gap

A Gap is left between the Strength Stitching and the Constriction which accommodates the fused leechline ends. Length in millimeters is:

05 - Light
10 - Heavy

`C. Constriction

The two parallel Strands are stitched together using color coded thread from the Gap towards the Fold. Length of this section in millimeters is:

20 - Light
30 - Heavy

`D. Eyes

The Eye is defined as the region from the Constriction to the Fold. Its length is independent of strength range and accommodates installation of a Thimble. Under loading the leechline elongates and the nylon stitching forming the Eye stretches and shifts to distribute the stress of the spreading of the strands of its Base Half.

`a. Lengths

i. Fore

A 50 millimeter Eye length is allotted for installation of an RF2180 Thimble.

ii. Aft

In order that any Shear Link be adaptable as either Fore or Aft, an additional 20 millimeters is amended to accommodate the larger RF2182 Thimble, regardless of which Thimble is actually installed.

`b. Stitching

Stitching is continued from the Constriction towards the fold at a rate of one per millimeter as far as possible within the groove of the thimble. After completion thimbles may be removed with aid of a marlinespike and reinstalled with little or no adjustment of the stitching to allow installation and removal of the Fairings.

`E. Refurbishment

In the event of Strength Stitching failure along one side only, much of the previously distributed load is momentarily transferred to the other/inner Strand of the Base Half of the failure edge. The inner Strand may be damaged if this load approximates the rating of the leechline and it may be necessary to replace the Base Half. This problem manifests itself in Heavy Range Shear Links of Ratings in excess of 600 pounds.

#02. Strength Stitching

`A. Overlap

The Base Halves are arranged with the Eyes of both in opposition and the leechline ends overlapped and interspersed and pinned together.

`B. Floss Lengths

Floss is consumed approximately at the following rates expressed in millimeters per stitch.

10.0 - Light

12.5 - Heavy

The length of Floss required for a Run is determined by multiplying the appropriate value from above by the number of stitches and adding to the result 120 millimeters to allow for the protrusions and enough material to complete and tighten the final stitch.

`C. Initiation

Stitching Runs are started, to increase strength, from the side opposite a leechline end and, for standardization purposes, at the aft end of the Fore Base Half.

`D. Distortion

Outer Base Strands are longitudinally compressed by the Strength Stitching more than inner ones. Thus the inner leechline end of the Aft Base Half will extend farther fore than the outer one and similarly the Eye of the Fore Base Half will not be centered on that length of leechline.

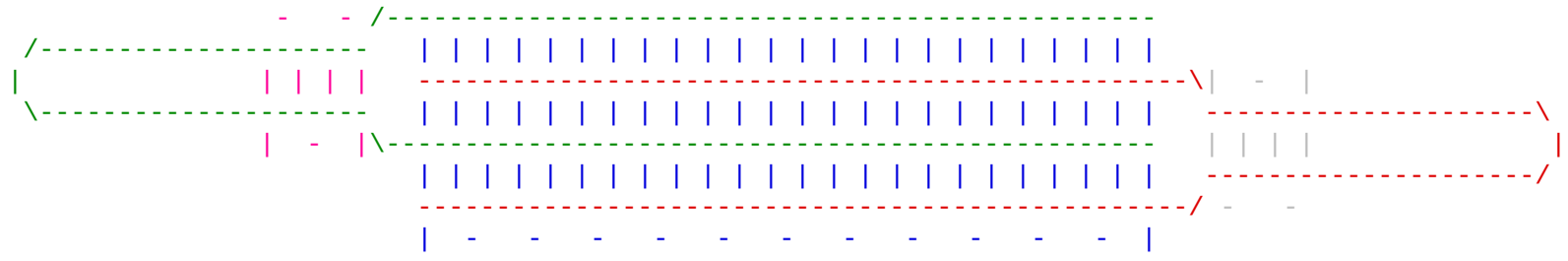
`a. New

New Shear Links are constructed by first completing the Strength Stitching and then effecting the Aft and Fore Constrictions.

`b. Refurbishment

Strength Stitching is replaced after a Shear Link failure or in the event inspection reveals the Stitching to be compromised. All fragments of broken Stitching are removed before restitching. Although it is possible to compensate for distortion when aligning the Base Halves and save the Constriction and Eye stitching it is practically faster, easier, and less tedious to remove all stitching from both Halves and proceed as with a new construction.

#03. Schematic



#04. Fairings

`A. Span

A Fairing covers the Constriction and Gap and extends to shy of the far leechline ends.

`B. Lengths

Fore and Aft Fairings are of equal lengths. Several extra millimeters are amended to compensate for longitudinal shrinkage.

`C. Sequence

The Aft Fairing is applied first such that the resulting configuration will not act as a scoop for contaminants.

`D. Application

`a. Sequence

A Fairing is immersed from the Eye end of the Constriction to the Overlap to ensure the Constriction area is fully covered.

`b. Heating

After application of the Aft Fairing the Fore is positioned and immersed.

Note: The fit between the seated Aft and unheated Fore Fairings is particularly close in the Light Range Shear Links. Difficulty in positioning the Fore Fairing may be remedied with a drop of dishwashing detergent applied to the Aft Fairing.

`c. Check

The Fairings are repositioned towards the respective ends of the Shear Link to ensure that they have not adhered to each other.

`d. Finishing

With each Fairing pulled about ten millimeters clear of its seated position, the bulges resulting from the outboard leechline ends of the opposite Base Half are heated using a candle flame to even tapers.

#05. Thimbles Installations

Thimbles protect the ends of the Shear Links from abrasion which would otherwise be incurred as a result of the components engaging them and dragging across the surface.

`A. RF2180

The smallest sized RF2180 Thimbles are installed in both Eyes of the Fore and the Fore Eye of the Aft Shear Links.

`B. RF2182

The larger RF2182 Thimble is installed in the Aft Eye of the Aft Shear Link and serves as the Tow Ring.

Note: The Tow Ring must allow passage of the Bridle Thimble. If lateral axes are aligned this occurs with a negligible degree of resistance but a deviation over the diameter of the material specified for the Secondary Shear Link may be

problematic.

#06. Coupler

A Coupler is an extension engaging the Fore Eye of the Aft Shear Shear Link which allows and facilitates connection to a carabiner and aligns the planes of the latter two components such that they will more likely be horizontal when dragged, thus reducing the exposure of the Shear Link's leechline to abrasion.

`A. Base

The Base is an 08/64 x 160 millimeter leechline length.

`a. Marking

Marks are made 60 millimeters from the ends.

`b. Insertion

The Base is fed through the Eye of the Shear Link.

`c. Stitching

The Base is formed in a right hand coil with the marked ends regions overlapping and stitched such that a loop 100 millimeters in circumference results.

`B. Thimble

An RF2182 Thimble is installed in the loop with the Overlap oriented aft.

#07. Tow Line

The Fore Shear Link is connected to the fore end of a Spectra hollow braid Tow Line via an Eye Splice through its Aft Eye.

#08. Strengths

Test results yield an average strength of about eighteen and a quarter pounds per stitch. The following table relates the numbers of stitches in Light through Medium Range Tow Line Shear Links to approximate minimum, probable, and maximum strengths.

stch	x15	x18	x24			
07	105	126	168	bk	rd	lt
08	120	144	192	gy	rd	
09	135	162	216	wt	rd	
10	150	180	240	bk	or	
11	165	198	264	gy	or	
12	180	216	288	wt	or	
13	195	234	312	bk	yl	
14	210	252	336	gy	yl	
15	225	270	360	wt	yl	
16	240	288	384	bk	gn	
17	255	306	408	gy	gn	
18	270	324	432	wt	gn	
19	285	342	456	bk	bl	
20	300	360	480	gy	bl	
21	315	378	504	wt	bl	
22	330	396	528	bk	pl	
23	345	414	552	gy	pl	
24	360	432	576	wt	pl	
25	375	450	600	bk	rd	hv
26	390	468	624	gy	rd	
27	405	486	648	wt	rd	
28	420	504	672	bk	or	
29	435	522	696	gy	or	
30	450	540	720	wt	or	
31	465	558	744	bk	yl	
32	480	576	768	gy	yl	
33	495	594	792	wt	yl	
34	510	612	816	bk	gn	
35	525	630	840	gy	gn	
36	540	648	864	wt	gn	

#09. G Ratings

stch			TL	1.4	min	150	200	250	300	350	400	450	500	550
07	bk	rd	126	090	084	~~0.84~~	~~0.63~~	~~0.50~~	~~0.42~~	~~0.36~~	~~0.32~~	~~0.28~~	~~0.25~~	~~0.23~~
08	gy	rd	144	103	096	~~0.96~~	~~0.72~~	~~0.58~~	~~0.48~~	~~0.41~~	~~0.36~~	~~0.32~~	~~0.29~~	~~0.26~~
09	wt	rd	162	116	108	1.08	~~0.81~~	~~0.65~~	~~0.54~~	~~0.46~~	~~0.41~~	~~0.36~~	~~0.32~~	~~0.29~~
10	bk	or	180	129	120	1.20	~~0.90~~	~~0.72~~	~~0.60~~	~~0.51~~	~~0.45~~	~~0.40~~	~~0.36~~	~~0.33~~
11	gy	or	198	141	132	1.32	~~0.99~~	~~0.79~~	~~0.66~~	~~0.57~~	~~0.50~~	~~0.44~~	~~0.40~~	~~0.36~~
12	wt	or	216	154	144	1.44	1.08	~~0.86~~	~~0.72~~	~~0.62~~	~~0.54~~	~~0.48~~	~~0.43~~	~~0.39~~
13	bk	yl	234	167	156	1.56	1.17	~~0.94~~	~~0.78~~	~~0.67~~	~~0.59~~	~~0.52~~	~~0.47~~	~~0.43~~
14	gy	yl	252	180	168	1.68	1.26	1.01	~~0.84~~	~~0.72~~	~~0.63~~	~~0.56~~	~~0.50~~	~~0.46~~
15	wt	yl	270	193	180	1.80	1.35	1.08	~~0.90~~	~~0.77~~	~~0.68~~	~~0.60~~	~~0.54~~	~~0.49~~
16	bk	gn	288	206	192	1.92	1.44	1.15	~~0.96~~	~~0.82~~	~~0.72~~	~~0.64~~	~~0.58~~	~~0.52~~
17	gy	gn	306	219	204	~~2.04~~	1.53	1.22	1.02	~~0.87~~	~~0.77~~	~~0.68~~	~~0.61~~	~~0.56~~
18	wt	gn	324	231	216	~~2.16~~	1.62	1.30	1.08	~~0.93~~	~~0.81~~	~~0.72~~	~~0.65~~	~~0.59~~
19	bk	bl	342	244	228	~~2.28~~	1.71	1.37	1.14	~~0.98~~	~~0.86~~	~~0.76~~	~~0.68~~	~~0.62~~
20	gy	bl	360	257	240	~~2.40~~	1.80	1.44	1.20	1.03	~~0.90~~	~~0.80~~	~~0.72~~	~~0.65~~
21	wt	bl	378	270	252	~~2.52~~	1.89	1.51	1.26	1.08	~~0.95~~	~~0.84~~	~~0.76~~	~~0.69~~
22	bk	pl	396	283	264	~~2.64~~	1.98	1.58	1.32	1.13	~~0.99~~	~~0.88~~	~~0.79~~	~~0.72~~
23	gy	pl	414	296	276	~~2.76~~	~~2.07~~	1.66	1.38	1.18	1.03	~~0.92~~	~~0.83~~	~~0.75~~
24	wt	pl	432	309	288	~~2.88~~	~~2.16~~	1.73	1.44	1.23	1.08	~~0.96~~	~~0.86~~	~~0.79~~
25	bk	rd	450	321	300	~~3.00~~	~~2.25~~	1.80	1.50	1.29	1.13	1.00	~~0.90~~	~~0.82~~
26	gy	rd	468	334	312	~~3.12~~	~~2.34~~	1.87	1.56	1.34	1.17	1.04	~~0.94~~	~~0.85~~
27	wt	rd	486	347	324	~~3.24~~	~~2.43~~	1.94	1.62	1.39	1.22	1.08	~~0.97~~	~~0.88~~
28	bk	or	504	360	336	~~3.36~~	~~2.52~~	~~2.02~~	1.68	1.44	1.26	1.12	1.01	~~0.92~~
29	gy	or	522	373	348	~~3.48~~	~~2.61~~	~~2.09~~	1.74	1.49	1.31	1.16	1.04	~~0.95~~
30	wt	or	540	386	360	~~3.60~~	~~2.70~~	~~2.16~~	1.80	1.54	1.35	1.20	1.08	~~0.98~~
31	bk	yl	558	399	372	~~3.72~~	~~2.79~~	~~2.23~~	1.86	1.59	1.40	1.24	1.12	1.01
32	gy	yl	576	411	384	~~3.84~~	~~2.88~~	~~2.30~~	1.92	1.65	1.44	1.28	1.15	1.05
33	wt	yl	594	424	396	~~3.96~~	~~2.97~~	~~2.38~~	1.98	1.70	1.49	1.32	1.19	1.08
34	bk	gn	612	437	408	~~4.08~~	~~3.06~~	~~2.45~~	~~2.04~~	1.75	1.53	1.36	1.22	1.11
35	gy	gn	630	450	420	~~4.20~~	~~3.15~~	~~2.52~~	~~2.10~~	1.80	1.58	1.40	1.26	1.15
36	wt	gn	648	463	432	~~4.32~~	~~3.24~~	~~2.59~~	~~2.16~~	1.85	1.62	1.44	1.30	1.18
--	--	--	666	476	444	~~4.44~~	~~3.33~~	~~2.66~~	~~2.22~~	1.90	1.67	1.48	1.33	1.21
--	--	--	684	489	456	~~4.56~~	~~3.42~~	~~2.74~~	~~2.28~~	1.95	1.71	1.52	1.37	1.24
--	--	--	702	501	468	~~4.68~~	~~3.51~~	~~2.81~~	~~2.34~~	~~2.01~~	1.76	1.56	1.40	1.28
--	--	--	720	514	480	~~4.80~~	~~3.60~~	~~2.88~~	~~2.40~~	~~2.06~~	1.80	1.60	1.44	1.31
--	--	--	738	527	492	~~4.92~~	~~3.69~~	~~2.95~~	~~2.46~~	~~2.11~~	1.85	1.64	1.48	1.34
--	--	--	756	540	504	~~5.04~~	~~3.78~~	~~3.02~~	~~2.52~~	~~2.16~~	1.89	1.68	1.51	1.37
--	--	--	774	553	516	~~5.16~~	~~3.87~~	~~3.10~~	~~2.58~~	~~2.21~~	1.94	1.72	1.55	1.41
--	--	--	792	566	528	~~5.28~~	~~3.96~~	~~3.17~~	~~2.64~~	~~2.26~~	1.98	1.76	1.58	1.44
--	--	--	810	579	540	~~5.40~~	~~4.05~~	~~3.24~~	~~2.70~~	~~2.31~~	~~2.03~~	1.80	1.62	1.47
--	--	--	828	591	552	~~5.52~~	~~4.14~~	~~3.31~~	~~2.76~~	~~2.37~~	~~2.07~~	1.84	1.66	1.51
--	--	--	846	604	564	~~5.64~~	~~4.23~~	~~3.38~~	~~2.82~~	~~2.42~~	~~2.12~~	1.88	1.69	1.54
--	--	--	864	617	576	~~5.76~~	~~4.32~~	~~3.46~~	~~2.88~~	~~2.47~~	~~2.16~~	1.92	1.73	1.57
--	--	--	882	630	588	~~5.88~~	~~4.41~~	~~3.53~~	~~2.94~~	~~2.52~~	~~2.21~~	1.96	1.76	1.60
--	--	--	900	643	600	~~6.00~~	~~4.50~~	~~3.60~~	~~3.00~~	~~2.57~~	~~2.25~~	2.00	1.80	1.64
--	--	--	918	656	612	~~6.12~~	~~4.59~~	~~3.67~~	~~3.06~~	~~2.62~~	~~2.30~~	~~2.04~~	1.84	1.67
--	--	--	936	669	624	~~6.24~~	~~4.68~~	~~3.74~~	~~3.12~~	~~2.67~~	~~2.34~~	~~2.08~~	1.87	1.70
--	--	--	954	681	636	~~6.36~~	~~4.77~~	~~3.82~~	~~3.18~~	~~2.73~~	~~2.38~~	~~2.12~~	1.91	1.73
--	--	--	972	694	648	~~6.48~~	~~4.86~~	~~3.89~~	~~3.24~~	~~2.78~~	~~2.43~~	~~2.16~~	1.94	1.77
--	--	--	990	707	660	~~6.60~~	~~4.95~~	~~3.96~~	~~3.30~~	~~2.83~~	~~2.48~~	~~2.20~~	1.98	1.80
--	--	--	01K	720	672	~~6.72~~	~~5.04~~	~~4.03~~	~~3.36~~	~~2.88~~	~~2.52~~	~~2.24~~	~~2.02~~	1.83

#10. G Ratings - Tost Weak Links

daN	TL	1.4	150	200	250	300	350	400	450	500	550	#	code
080	180	128	1.20	~~0.90~~	~~0.72~~	~~0.60~~	~~0.51~~	~~0.45~~	~~0.40~~	~~0.36~~	~~0.33~~	11	orange
120	270	193	1.80	1.35	1.08	~~0.90~~	~~0.77~~	~~0.67~~	~~0.60~~	~~0.54~~	~~0.49~~	14	turquoise
150	337	241	~~2.25~~	1.69	1.35	1.12	~~0.96~~	~~0.84~~	~~0.75~~	~~0.67~~	~~0.61~~	09	gray
200	450	321	~~3.00~~	~~2.25~~	1.80	1.50	1.28	1.12	1.00	~~0.90~~	~~0.82~~	08	mauve
300	674	482	~~4.50~~	~~3.37~~	~~2.70~~	~~2.25~~	1.93	1.69	1.50	1.35	1.23	07	green
400	899	642	~~5.99~~	~~4.50~~	~~3.60~~	~~3.00~~	~~2.57~~	~~2.25~~	2.00	1.80	1.63	06	yellow

~20. Construction - Ribbon Bridle Shear Links

#01. Strengths

`A. Primary

The Primary Weak Link should be rated for 1.4 Gs.

`B. Secondary

The Secondary Weak Link is only strong enough to reliably survive the Primary. An increase of 20 percent used in conjunction with a 1.4 G Primary translates to 0.966 Gs when directly loaded. The Secondary is better defined and thought of as an auto-release mechanism which comes into play in the following circumstances.

`a. Wrap Following:

i. Primary Release Actuation

In the event of a Bridle wrap under only normal tow tension the Secondary Weak Link will very likely fail as a consequence of the jolt delivered the moment the bridle catches above and beyond the near double loading which results as a consequence of the glider going into One Point tow mode.

ii. Primary Weak Link Failure

In the event of a Bridle wrap following a Primary Weak Link failure the Secondary Weak Link will fail instantly.

`b. Trailing Bridle

The Secondary Weak Link mitigates the danger of a snag of a Bridle trailing from a ground skimming glider.

#02. Structure

`A. Base

`a. Material

A length of 06/64 line of the same material as the bridle for which it is designated is folded in half and constitutes the Base.

`b. Configuration

i. Eye

The region of the fold constitutes the Eye.

ii. Overlap

The region between the Filler and Bridle end constitutes the Overlap.

iii. Secondary Extension

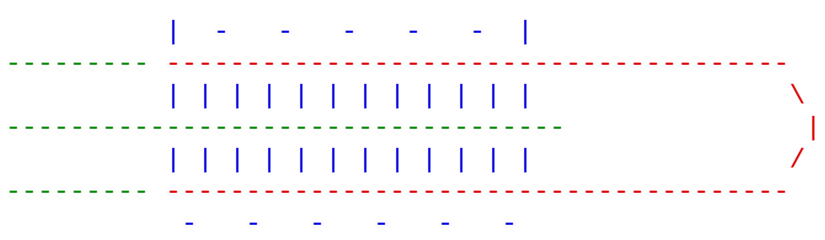
In the case of the Secondary Shear Link, 5 millimeters of the doubled Base immediately proximal to the Eye are allotted as the Extension. This region is aligned with the terminal 5 millimeters of the Bridle immediately proximal to its fused end(s). It serves as a buffer to ensure that, under loading, the Strength Stitching remains fully covered and protected by the Fairing.

`B. Strength Stitching

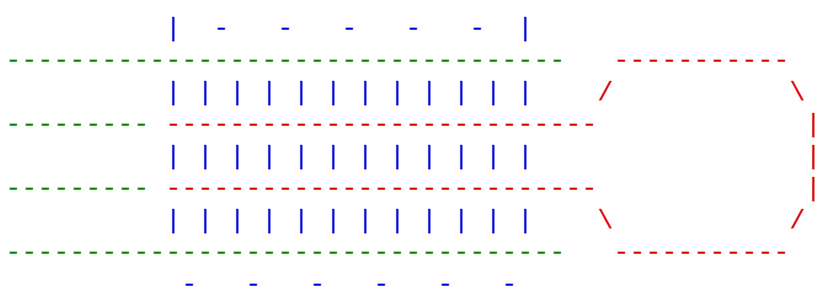
Strength Stitching Runs are started 5 millimeters from the Bridle end. Bridle material is thus compressed and shifted proximally as stitching continues which helps equalize the tension of the Base and Bridle components.

`C. Schematics

`a. Triple



`b. Quadruple



`D. Fairings

Primary and Secondary Shear Link Fairings are 20 and 110 millimeters in length respectively. They are applied over the body of the Ribbon Bridle such that no constrictions result from shrinking over the irregularities at the Shear Links. The Primary must be kept short to allow the top end of the Bridle to clear the Tow Ring with minimal resistance.

`E. Strengths

The following table relates the Triple Ribbon Bridle Strength Stitching to test results, a 16 pound average, and the maximum possible strength in the second, third, and fourth columns respectively.

stch	tst	x16	x24		
07	093	112	168	bk	rd
08	116	128	192	gy	rd
09	133	144	216	wt	rd
10	153	160	240	bk	or
11	171	176	264	gy	or
12	198	192	288	wt	or
13	217	208	312	bk	yl
14	225	224	336	gy	yl
15	243	240	360	wt	yl
16	260	256	384	bk	gn
17	264	272	408	gy	gn
18	299	288	432	wt	gn

`F. G Ratings

The following table relates Ribbon Bridle Shear Link strengths to equivalent Tow Line tensions. A 60 degree Primary Bridle apex angle is presumed. The first column lists Primary-Secondary stitch combinations.

stch			RB	TL	1.4	min	150	200	250	300	350	400	450	500	550
-----	--	--	080	139	099	093	~~0.93~~	~~0.70~~	~~0.56~~	~~0.46~~	~~0.40~~	~~0.35~~	~~0.31~~	~~0.28~~	~~0.25~~
-----	--	--	096	167	119	111	1.11	~~0.83~~	~~0.67~~	~~0.56~~	~~0.48~~	~~0.42~~	~~0.37~~	~~0.33~~	~~0.30~~
07-08	bk	rd	112	195	139	130	1.30	~~0.97~~	~~0.78~~	~~0.65~~	~~0.56~~	~~0.49~~	~~0.43~~	~~0.39~~	~~0.35~~
08-10	gy	rd	128	223	159	148	1.48	1.11	~~0.89~~	~~0.74~~	~~0.64~~	~~0.56~~	~~0.49~~	~~0.45~~	~~0.40~~
09-11	wt	rd	144	250	179	167	1.67	1.25	1.00	~~0.83~~	~~0.72~~	~~0.63~~	~~0.56~~	~~0.50~~	~~0.46~~
10-12	bk	or	160	278	199	186	1.86	1.39	1.11	~~0.93~~	~~0.80~~	~~0.70~~	~~0.62~~	~~0.56~~	~~0.51~~
11-13	gy	or	176	306	219	204	~~2.04~~	1.53	1.22	1.02	~~0.87~~	~~0.77~~	~~0.68~~	~~0.61~~	~~0.56~~
12-14	wt	or	192	334	239	223	~~2.23~~	1.67	1.34	1.11	~~0.95~~	~~0.83~~	~~0.74~~	~~0.67~~	~~0.61~~
13-16	bk	yl	208	362	258	241	~~2.41~~	1.81	1.45	1.21	1.03	~~0.90~~	~~0.80~~	~~0.72~~	~~0.66~~
14-17	gy	yl	224	390	278	260	~~2.60~~	1.95	1.56	1.30	1.11	~~0.97~~	~~0.87~~	~~0.78~~	~~0.71~~
15-18	wt	yl	240	417	298	278	~~2.78~~	~~2.09~~	1.67	1.39	1.19	1.04	~~0.93~~	~~0.83~~	~~0.76~~
16-19	bk	gn	256	445	318	297	~~2.97~~	~~2.23~~	1.78	1.48	1.27	1.11	~~0.99~~	~~0.89~~	~~0.81~~
17-20	gy	gn	272	473	338	315	~~3.15~~	~~2.37~~	1.89	1.58	1.35	1.18	1.05	~~0.95~~	~~0.86~~
18-22	wt	gn	288	501	358	334	~~3.34~~	~~2.50~~	~~2.00~~	1.67	1.43	1.25	1.11	1.00	~~0.91~~
19-23	bk	bl	304	529	378	352	~~3.52~~	~~2.64~~	~~2.11~~	1.76	1.51	1.32	1.17	1.06	0.96
20-24	gy	bl	320	557	398	371	~~3.71~~	~~2.78~~	~~2.23~~	1.86	1.59	1.39	1.24	1.11	1.01
21-25	wt	bl	336	584	417	390	~~3.90~~	~~2.92~~	~~2.34~~	1.95	1.67	1.46	1.30	1.17	1.06
22-26	bk	pl	352	612	437	408	~~4.08~~	~~3.06~~	~~2.45~~	~~2.04~~	1.75	1.53	1.36	1.22	1.11
23-28	gy	pl	368	640	457	427	~~4.27~~	~~3.20~~	~~2.56~~	~~2.13~~	1.83	1.60	1.42	1.28	1.16
24-29	wt	pl	384	668	477	445	~~4.45~~	~~3.34~~	~~2.67~~	~~2.23~~	1.91	1.67	1.48	1.34	1.21
25-30	bk	rd	400	696	497	464	~~4.64~~	~~3.48~~	~~2.78~~	~~2.32~~	1.99	1.74	1.55	1.39	1.26
26-31	gy	rd	416	723	517	482	~~4.82~~	~~3.62~~	~~2.89~~	~~2.41~~	~~2.07~~	1.81	1.61	1.45	1.32
27-32	wt	rd	432	751	537	501	~~5.01~~	~~3.76~~	~~3.01~~	~~2.50~~	~~2.15~~	1.88	1.67	1.50	1.37
28-34	bk	or	448	779	557	519	~~5.19~~	~~3.90~~	~~3.12~~	~~2.60~~	~~2.23~~	1.95	1.73	1.56	1.42
29-35	gy	or	464	807	576	538	~~5.38~~	~~4.03~~	~~3.23~~	~~2.69~~	~~2.31~~	~~2.02~~	1.79	1.61	1.47
30-36	wt	or	480	835	596	557	~~5.57~~	~~4.17~~	~~3.34~~	~~2.78~~	~~2.39~~	~~2.09~~	1.86	1.67	1.52
31-37	bk	yl	496	863	616	575	~~5.75~~	~~4.31~~	~~3.45~~	~~2.88~~	~~2.46~~	~~2.16~~	1.92	1.73	1.57
32-38	gy	yl	512	890	636	594	~~5.94~~	~~4.45~~	~~3.56~~	~~2.97~~	~~2.54~~	~~2.23~~	1.98	1.78	1.62
33-40	wt	yl	528	918	656	612	~~6.12~~	~~4.59~~	~~3.67~~	~~3.06~~	~~2.62~~	~~2.30~~	~~2.04~~	1.84	1.67
34-41	bk	gn	544	946	676	631	~~6.31~~	~~4.73~~	~~3.78~~	~~3.15~~	~~2.70~~	~~2.37~~	~~2.10~~	1.89	1.72
35-42	gy	gn	560	974	696	649	~~6.49~~	~~4.87~~	~~3.90~~	~~3.25~~	~~2.78~~	~~2.43~~	~~2.16~~	1.95	1.77
36-43	wt	gn	576	K02	716	668	~~6.68~~	~~5.01~~	~~4.01~~	~~3.34~~	~~2.86~~	~~2.50~~	~~2.23~~	2.00	1.82

`G. Applications

`a. Primary

The Primary Shear Link forms an Eye 25 millimeters in length.

length:
(25+(n*2))*2=4n+50

`b. Secondary

i. Structure

The Secondary Shear Link is attached to the bottom end of the Bridle with 120 percent of the number of Stitches of the Primary, rounded to the nearest integer. It forms an Eye 80 or 65 millimeters in length for Triple (Crystalyne) or Quadruple (Dacron) Ribbon Bridles respectively and engages the Thimble by means of a Lark's Head.

length:

Triple
(80+5+(n*2))*2=4n+170

Quadruple
(65+5+(n*2))*2=4n+140

ii. Safety Stitching

To prevent it locking onto the Secondary Bridle it is critical that the Secondary Shear Link remain seated on the Thimble. The Lark's Head is safetied with five light stitches to form a small Eye at the middle, one through the Eye and the two Runs passing through it, and three through the two Runs between the Thimble and Bridle.

~21. Construction - Bridle Link

The Bridle Link replaces the Secondary Bridle and is similar in construction to the Tow Line Shear Link with the specifications and modifications described below. In the absence of a bottom end weak link on a Primary Bridle a 1.0 G Bridle Link can serve as a Secondary Weak Link when used with a 1.4 G Primary.

#01. Base

`A. Material

A 06/64 x 730 millimeter leechline length - exclusive of an existing fused end - is cut from the spool. Its cut end is fused and the resulting length is cut in half. After fusing these these cuts two 06/64 x 360 millimeter leechline lengths result to constitute the Base Halves.

`B. Lengths - Millimeters

025 - Eye
025 - Constriction
005 - Gap
125 - Overlap

#02. Strength Stitching

Strength Stitching is as evenly as possible divided between the two areas of leechline ends in order that it not be compromised through wear as a result of contact with the Thimble or Tow Ring. In the case of odd numbered ratings the

higher number of stitches are effected at the starboard end of the Overlap for purposes of standardization and rating check.

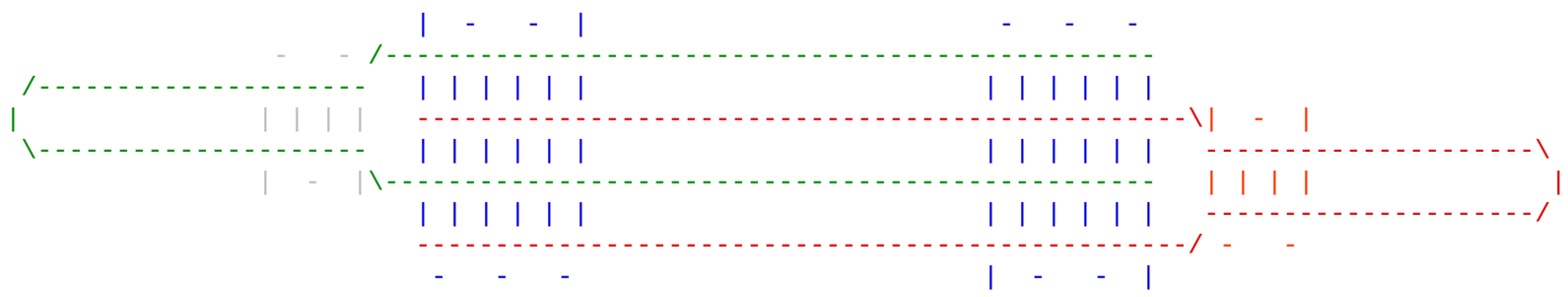
#03. Fairings

Fairings are 0.25 heat shrinkable tubing lengths which completely cover the Constriction and extend to 5 millimeters fore of the Strength Stitching. They must be removed when the Bridle Link is employed as the Secondary Bridle in a Two Point system as they impede the clearance from the Bridle Thimble in a low tension situation. Likewise they must not be used in One Point configuration in conjunction with an excessively small Tow Ring.

#04. Low End Modifications

A Run of Strength Stitching does not fall below five (the point at which the Floss fails rather than pulls through). Therefore, for ratings from seven to nine, the Strength Stitching is effected entirely on the port end of the Overlap and the starboard end is secured with three stitches which do not significantly increase the breaking strength. However, since the load tends to be distributed very evenly amongst the stitches, these Bridle Links tend to fail at points above average and it is advisable to bias selection on the low side.

#05. Schematic



#06. Strengths

As the Secondary Bridle apex angle is negligible Bridle Link strengths can be translated directly into maximum Tow Line tension. Testing indicates 36 pounds per stitch as a reliable guide. The following table provides Port and Starboard Strength Stitching divisions and strength predictions in pounds.

ttl	pt	sd	x36	x48		
07	7	0	252	336	bk	rd
08	8	0	288	384	gy	rd
09	9	0	324	432	wt	rd
10	5	5	360	480	bk	or
11	5	6	396	528	gy	or
12	6	6	432	576	wt	or
13	6	7	468	624	bk	yl
14	7	7	504	672	gy	yl
15	7	8	540	720	wt	yl
16	8	8	576	768	bk	gn
17	8	9	612	816	gy	gn
18	9	9	648	864	wt	gn

#07. G Ratings

stch			TL	1.4	min	150	200	250	300	350	400	450	500	550
07	bk	rd	252	180	168	1.68	1.26	1.01	~~0.84~~	~~0.72~~	~~0.63~~	~~0.56~~	~~0.50~~	~~0.46~~
08	gy	rd	288	206	192	1.92	1.44	1.15	~~0.96~~	~~0.82~~	~~0.72~~	~~0.64~~	~~0.58~~	~~0.52~~
09	wt	rd	324	231	216	~~2.16~~	1.62	1.30	1.08	~~0.93~~	~~0.81~~	~~0.72~~	~~0.65~~	~~0.59~~
10	bk	or	360	257	240	~~2.40~~	1.80	1.44	1.20	1.03	~~0.90~~	~~0.80~~	~~0.72~~	~~0.65~~
11	gy	or	396	283	264	~~2.64~~	1.98	1.58	1.32	1.13	~~0.99~~	~~0.88~~	~~0.79~~	~~0.72~~
12	wt	or	432	309	288	~~2.88~~	~~2.16~~	1.73	1.44	1.23	1.08	~~0.96~~	~~0.86~~	~~0.79~~
13	bk	yl	468	334	312	~~3.12~~	~~2.34~~	1.87	1.56	1.34	1.17	1.04	~~0.94~~	~~0.85~~
14	gy	yl	504	360	336	~~3.36~~	~~2.52~~	~~2.02~~	1.68	1.44	1.26	1.12	1.01	~~0.92~~
15	wt	yl	540	386	360	~~3.60~~	~~2.70~~	~~2.16~~	1.80	1.54	1.35	1.20	1.08	~~0.98~~
16	bk	gn	576	411	384	~~3.84~~	~~2.88~~	~~2.30~~	1.92	1.65	1.44	1.28	1.15	1.05
17	gy	gn	612	437	408	~~4.08~~	~~3.06~~	~~2.45~~	~~2.04~~	1.75	1.53	1.36	1.22	1.11
18	wt	gn	648	463	432	~~4.32~~	~~3.24~~	~~2.59~~	~~2.16~~	1.85	1.62	1.44	1.30	1.18
19	bk	bl	684	489	456	~~4.56~~	~~3.42~~	~~2.74~~	~~2.28~~	1.95	1.71	1.52	1.37	1.24
20	gy	bl	720	514	480	~~4.80~~	~~3.60~~	~~2.88~~	~~2.40~~	~~2.06~~	1.80	1.60	1.44	1.31
21	wt	bl	756	540	504	~~5.04~~	~~3.78~~	~~3.02~~	~~2.52~~	~~2.16~~	1.89	1.68	1.51	1.37
22	bk	pl	792	566	528	~~5.28~~	~~3.96~~	~~3.17~~	~~2.64~~	~~2.26~~	1.98	1.76	1.58	1.44
23	gy	pl	828	591	552	~~5.52~~	~~4.14~~	~~3.31~~	~~2.76~~	~~2.37~~	~~2.07~~	1.84	1.66	1.51
24	wt	pl	864	617	576	~~5.76~~	~~4.32~~	~~3.46~~	~~2.88~~	~~2.47~~	~~2.16~~	1.92	1.73	1.57

~22. Shear Link Equivalents

The following table relates the three forms of Shear Links - Tow Line, Ribbon Bridle, and Bridle Links - to the average Tow Line tension at which they will fail and ranks each with its nearest equivalent(s) in the two other placements.

TL			line	RB			line	BL			line
11	gy	or	198	07	bk	rd	195				
12	wt	or	216	08	gy	rd	223				
13	bk	yl	234	08	gy	rd	223				
14	gy	yl	252	09	wt	rd	250	07	bk	rd	252
15	wt	yl	270	10	bk	or	278	07	bk	rd	252
15	wt	yl	270	10	bk	or	278	08	gy	rd	288
16	bk	gn	288	10	bk	or	278	08	gy	rd	288
17	gy	gn	306	11	gy	or	306	08	gy	rd	288
17	gy	gn	306	11	gy	or	306	09	wt	rd	324
18	wt	gn	324	12	wt	or	334	09	wt	rd	324
19	bk	bl	342	12	wt	or	334	09	wt	rd	324
19	bk	bl	342	12	wt	or	334	10	bk	or	360
20	gy	bl	360	13	bk	yl	362	10	bk	or	360
21	wt	bl	378	14	gy	yl	390	10	bk	or	360
21	wt	bl	378	14	gy	yl	390	11	gy	or	396
22	bk	pl	396	14	gy	yl	390	11	gy	or	396
23	gy	pl	414	15	wt	yl	417	11	gy	or	396
23	gy	pl	414	15	wt	yl	417	12	wt	or	432
24	wt	pl	432	16	bk	gn	445	12	wt	or	432
25	bk	rd	450	16	bk	gn	445	12	wt	or	432
25	bk	rd	450	16	bk	gn	445	13	bk	yl	468
26	gy	rd	468	17	gy	gn	473	13	bk	yl	468
27	wt	rd	486	17	gy	gn	473	13	bk	yl	468
27	wt	rd	486	17	gy	gn	473	14	gy	yl	504
28	bk	or	504	18	wt	gn	501	14	gy	yl	504
29	gy	or	522	19	bk	bl	529	14	gy	yl	504
29	gy	or	522	19	bk	bl	529	15	wt	yl	540
30	wt	or	540	19	bk	bl	529	15	wt	yl	540
31	bk	yl	558	20	gy	bl	557	15	wt	yl	540
31	bk	yl	558	20	gy	bl	557	16	bk	gn	576
32	gy	yl	576	21	wt	bl	584	16	bk	gn	576
33	wt	yl	594	21	wt	bl	584	16	bk	gn	576
33	wt	yl	594	21	wt	bl	584	17	gy	gn	612
34	bk	gn	612	22	bk	pl	612	17	gy	gn	612
35	gy	gn	630	23	gy	pl	640	17	gy	gn	612
35	gy	gn	630	23	gy	pl	640	18	wt	gn	648
36	wt	gn	648	23	gy	pl	640	18	wt	gn	648
				24	wt	pl	668	19	bk	bl	684

~23. Construction - Break Links

#01. Minimal Size

Break Links are constructed as small as will allow safe functioning of a release mechanism or installation of a Thimble.

#02. Seating

Seating of a Break Link installation is required to determine the necessary protrusion, which is defined as the length in millimeters of doubled stretched loop available for connection.

#03. Protrusion Requirements

17 - Barrel Release
61 - Thimble
20 - Spinnaker Shackle

#04. Loop Length

The length of a seated and uninstalled Break Link loop can be used to determine the length of the material from which it was constructed.

#05. 05/64 Leechline

`A. Strength

A loop fails at a factor of approximately 1.5 times that of a loop of 130 pound Cortland Greenspot.

`B. Length

Length in millimeters for installation on bridle.

235 - 12/64 braided Dacron
220 - Spectra hollow braid - 2000 pound
210 - Spectra hollow braid - 1000 pound

`C. Seating

200 pounds

`D. Loop Length

092 millimeters from 235 millimeters

#06. Braided Dacron Trolling Line

`A. Specifications

Cortland Greenspot 1 millimeter (130 pound test).

`B. Test Length

150 millimeters

`C. Seating

120 pounds

`D. Loop Length

061 millimeters

The material length of a seated Break Link loop is determined by the formula:

      150 plus or minus twice the difference between the loop length and 61.

`E. Failure

The Break Link fails at the point at which a Run exits the bridle eye.

`F. Test Results

diameter of braided Dacron bridle in sixty-fourths of an inch
protrusion in millimeters
failure in pounds

5	6	8	10	12	16	-	diameter
49	43	39	35	28	16	-	protrusion
115	135	145	155	175	215	-	failure

A Break Link material length is determined by the formula:

      150 minus twice the difference between the test and desired protrusions.

`G. Spectra Bridles

Failure for both one and two thousand pound Spectra hollow braid line is about 140 pounds and protrusion values are 46 and 42 millimeters respectively.

~24. Assembly

#01. Basetube Components

`A. Pulley Assembly

`a. Assembly Pin

The 08/64 inch diameter steel or aluminum Assembly Pin, whose length is just under the internal measurement of the basetube, is installed through the Pulley's mount with the Bushing and Shims.

`b. Installation Tool

A 6 inch length of three quarter inch PVC pipe is notched at opposite points on the circumference its starboard end. Masking tape is applied on the lengths of the opposite sides defined by the notches. Longitudinal lines are drawn on the tape segments in alignment with the notches and perpendicular marks are made on the circumference of the pipe at at distance 4 inches from the starboard end and serve as a depth indicator. If the basetube in which the installation will be effected is faired it will likely be necessary to employ a Pipe or piece of Tubing of smaller diameter.

`c. Engagement

An end of an 08/64 x 18 inch Bungee length is fed through a Cord Lock, a Fender Washer, the Pipe from port to starboard, the Pulley sheave, and back through the aforementioned. With the Assembly Pin and Shims seated in the notches, the Bungee is tensioned and secured with the Cord Lock.

`d. Insertion

The Pulley Assembly is inserted in the port end of the basetube and, if the basetube is of a round cross section, pitched to avoid interference between the Axle and Assembly Pin at the bolt and screw holes.

`e. Installation Pin

Upon reaching the proper depth, alignment is made and an Installation Pin of a length equal to or greater than the external measurement of the basetube is used to push the Assembly Pin slightly through the basetube wall. At this point Bungee tension is relieved and the Installation Pin is fully inserted to replace the Assembly Pin.

`f. Pulley Screw

The Screw then replaces the Installation Pin and is secured, one end of the Installation Tool Bungee is freed, and the Installation Tool Assembly is withdrawn.

`B. Bungee Assembly

`a. Threader

A Threader is routed into the Leader Exit Hole, down and to starboard around the Pulley sheave, and out the starboard end of the basetube where its end is stitched to the Leader.

`b. Assembly Pin

After insertion of the Bungee Screw Bushing through the End Connectors and Fore and Aft Shims, the Assembly Pin is inserted in the Bushing in order to aid installation and alignment.

`c. Engagement

The Bushing is engaged by the of the Installation Tool Bungee, fore or aft of the End Connectors pair, as described above.

`d. Insertion

The Threader is pulled to draw the Bungee Assembly into the downtube and the Assembly Pin ends are aligned with the Bungee Screw Holes by means of the Installation Tool.

`e. Bungee Screw

The Bungee Screw is pushed through the basetube, replacing the Assembly Pin, and secured.

`f. Leader

i. Routing

The Threader is pulled to draw the Leader out of the basetube about 20 millimeters and secured by clamping with a hemostat.

ii. Leader Extractor

The Leader Extractor is a 500 millimeter 130 pound Cortland Greenspot Braided Dacron Trolling Line length. It is fed to its midpoint through the fold of the Leader and used to tension and slacken the Bungee.

Note: If the unsecured Leader end is lost inside the basetube the entire Bungee Assembly installation procedure must be repeated.

iii. Stowage Link

The Stowage Link is constructed from a 05/64 x 280 millimeter leechline length spirally folded and stitched in three Runs, 90 - 100 - 90 mm, leaving 10 mm long Eyes at the ends. The ends of the Leader Extractor and bottom end of the Primary Lanyard are secured by means of Becket Bends to the Eyes whenever the Bungee is slackened.

In glider configurations in which the basetube must be separated from the control frame for breakdown a second Stowage Link will be required to ensure that the Primary Lanyard is not lost into its Conduit.

#02. Barrel Release Connection

`A. Bridle Engagement

The diameter of a Weak Link component or Bridle engaged by the Barrel Release should not exceed 06/64 inches so performance is not significantly affected.

`B. Pin Rotation

A plane is defined by the eye of the the Barrel Release Pin. The connection is made by inserting the end of the Pin through the inboard side of the port Bridle Link Eye and rotating the Pin aft within the defined plane. This assembly ensures that the Pin will rotate unobstructed upon actuation.

`C. Closing

The Barrel is slid fore over about two thirds of the length of the Pin Shaft.

~25. Performance Considerations

#01. Bungee

Bungee length is weighted towards the maximum which delivers sufficient tension. 12 pounds at the Cotter Pin demands less than 4 pounds of actuation tension.

#02. Leader

`A. Bungee To Stop Stitching

The Bungee to Stop Stitching length of the Leader should allow the Leader to be drawn out of the basetube beyond the Stop stitching at least 30 millimeters to facilitate insertion of the Cotter Pin between the two runs.

`B. Stop Stitching To End

There must be enough Leader length beyond the Stop Stitching to take up Lanyard slack and actuate the Primary Release with a comfortable margin of tension without drawing the Lanyard into the Basetube.

#03. Cotter Pin

`A. Length

A short Cotter Pin is more susceptible to a minor hang up resulting from the end being pulled down as it passes over the opening as a longer one has more leverage to counteract the Bungee tension.

`B. Lanyard

The Cotter Pin Lanyard length is a compromise up from so hair trigger short that one finds oneself off tow after a minor adjustment of grip.

#04. Primary Lanyard

Lanyard length is adjusted such that the Leader end protrudes no less than about 10 millimeters out of the basetube after actuation to ensure that no interference is encountered at actuation and the Lanyard is not damaged. There must be enough freeplay to preclude the possibility of an undesired actuation with the tug high and to the right. After the Lanyard is trimmed to length the freeplay may be adjusted by adjusting the Release Assembly Harness and Tensioner Anchor - simultaneously shortening one and lengthening the other - thus altering the trim point to a small degree.

#05. Release Assembly Harness

At the expense of a little positive bar pressure, biasing the trim point aft reduces the length of Primary Lanyard exposed to the airflow and the severity of negative pitching in the event the Primary Bridle is released from the bottom and wraps at the Tow Ring.

#06. Tensioner

The Tensioner is adjusted by adjusting the Becket Bend of the Tensioner Anchor to shorten the loop to the point that any further reduction results in undo difficulty in making the connection. This ensures that the Release Assembly is held as flush as possible against the undersurface of the sail after actuation.

~26. Setup

#01. Wheels Installation

Wheels are installed and fixed with respect to lateral movement outboard as far as possible while allowing clearance from the downtubes.

#02. Instrument Mounting

Possible complications associated with basetube mounting of instruments include:

interference with the bridle assembly;

entanglement with the dolly bridle prohibiting separation from that vehicle when glider becomes airborne;

fouling with Primary Bridle upon release interfering with pitch control;

penetration of the pilot's chest or abdomen upon crash.

Installation of an extended Secondary Bridle will mitigate interference problems with an instrument mounted on the center of the basetube.

#03. Release Assembly Installation

After the glider is tensioned and the preflight check of the sail's interior is completed the Release Assembly is installed.

`A. Bungee Tensioning

`a. Primary Lanyard Separation

The Primary Lanyard is untied from the top Eye of the Stowage Link. Care must be taken to avoid interfering with the top end of the Lanyard and drawing the bottom end into the Conduit at this juncture.

`b. Leader Extractor

From fore of the basetube a couple of coils of the Leader Extractor are wrapped around the right index finger and the Extractor is drawn straight away (up) from the basetube until the Stop Stitching clears the basetube by an inch or so. This procedure subjects the Bungee Assembly to loads greater than those to which they will subjected in flight and thus serves as a preflight check.

`B. Cotter Pin

`a. Installation

The Cotter Pin is inserted between the two Runs of the Leader below the Stop Stitching and tension is relaxed to seat the Pin.

`b. Free Play Set

The Pin position is adjusted such that its end is flush with the port extremity of the Basetube Washer.

`C. Undersurface Preparation

The aft two zipper sliders are slid all the way aft and, to facilitate closing after the Tensioner is engaged, the fore is slid aft about a third of the distance to the trim point.

`D. Shackle Connection

The Release Assembly is shackled to the Mounting Harness.

`E. Lanyard Connection

The Primary Lanyard is untied from the Lanyard Extension, routed from the top around the Barrel Pulley, and retied to the Lanyard Extension.

`F. Tensioning

The Tensioner is engaged and the Primary Lanyard tension is checked and, if necessary, adjusted by altering the trim point.

`G. Keeper Check

The Keeper is checked for proper tension and the security of the Fisherman's Knot.

`H. Undersurface Closure

The fore two zipper sliders are positioned to snugly enclose the Release Assembly attachment.

`I. Retensioning

To reengage the Cotter Pin after the Release Assembly has been fully installed the Leader is most easily drawn out by pulling down on the section of Lanyard between the Barrel Pulley and becket.

`J. Four-String Release Check

`a. Trigger Line

The Trigger Line must be securely locked in the Cleat.

`b. Guard

The Guard must be installed on the Cleat with moderate tension with the Fisherman's Knot secure.

~27. Staging

#01. Glider Preparation

`A. Harness Connection

Clipping the harness into the glider prior to pilot entry ("Aussie method"), although of virtually no value in ensuring the pilot is clipped in for a dolly launch, does facilitate clipping into glider suspension, inspection of suspension system, preparation of harness and peripherals (e.g., radio, pod lanyards, tow bridle), and reduces potential for overheating.

Note: Whether or not using a carabiner mounted Primary Release, due to consideration of the parachute bridle action the proper orientation of the carabiner is gate opening up and fore.

`B. Bridle Connection

The Two Point Bridle is routed, twist free, through the Tow Ring of the Shear Link where relevant, and connected to the release mechanism.

`C. Lines Stowage

The VG and pod zipper lines are secured to prevent fouling with the dolly.

#02. Dolly

`A. Adjustment

Dolly configuration for the glider in question should have been previously noted to facilitate operations by making adjustments prior to loading.

`a. Keel Bracket Longitudinal Adjustment

Keel bracket longitudinal adjustment is effected such that aft flying wires and their attachment point is clear.

`b. Attitude Set

Keel bracket height is adjusted such that wing tips attitude is horizontal. Too low a pitch may prevent the glider from lifting off from the dolly. Too high an attitude will render the glider unnecessarily vulnerable to effects of crosswinds.

`c. Basetube Brackets

Basetube brackets are symmetrically positioned inboard of basetube mounted wheels and outboard as far as possible while leaving enough clearance to avoid interference with the wheels at liftoff. Note the distance between the dolly frame and the bracket at the aft bracket support tube (with, as a suggestion, a comparison with a fist width or hand length).

`B. Loading

`a. Sequence

Depending upon dolly availability the glider may be loaded prior to connecting the harness. If access time is limited the pilot enters the harness prior to loading the glider on the dolly.

`b. Wind

Dolly and glider are turned into a significant wind.

`c. Keel Bracket

Assistance in guiding the keel into the bracket is desirable.

`d. Cotter Pin Lanyard Guide

The Cotter Pin Lanyard Guide is checked to ensure that it is aligned with the end of the basetube and leader exit.

Note: The Cotter Pin must be installed through the Leader prior to dolly loading to prevent mangling when caught between the basetube and bracket.

#03. Deck

When separated from a single tug by only two gliders the following final actions, preparations, and checks should be completed.

`A. Instruments

The flight deck, GPS receiver, and radio should be on, stabilized, and checked.

`B. Harness

Legs are through loops and buckles are secure.

`C. Helmet

Particular note should be made with respect to the helmet buckling as a loose strap could interfere with the Four-String Release.

`D. Bridle

Bridle routing above the basetube and clear of radio wires must be ensured.

`E. Gloves

Gloves are on and safetied and the loop of the Bridle Cinch is installed over the thumb of the left (assuming right dominance) hand and the cord lock is adjusted for a snug hold.

~28. Tow

#01. Launch

`A. Kicking In

Place one foot in the boot of the harness before suspension.

`B. Suspension

If the aft end of the harness is in range of the rear wheel of the dolly, legs are spread to rest on opposite sides of the frame or with both legs in the boot knees are bent to prevent abrasion.

Note: Accepting the risk of bellying in in the event of a low separation, one may choose to launch with the pod closed. Bending at the knees will serve, if necessary, to keep the boot clear of the rear dolly wheel.

`C. Release Actuators Engagement

`a. Emergency

The end of the Trigger Line is placed in the incisors.

`b. Primary

To prevent an inadvertent firing of the release, after the Button is inserted between the fingers the port side of the dolly bridle is fed into the grasp of the left hand by the right hand.

Note: Should one neglect to engage the Button at launch a swat at the exposed Leader between the base- and downtubes makes for a good Plan B.

`D. Tow Line Connection

The Tow Line carabiner is clipped onto the Bridle or Coupler. If towing one point the carabiner is oriented gate up to prevent it from engaging the basetube.

#02. Climb

`A. Four-String

While it is advisable to retain the Trigger Line throughout the tow to maintain the slack line advantage of the device the performances of the Keel, where applicable, and Barrel Releases render this option somewhat superfluous.

`B. Slack Line

Following a situation in which slack develops in the Tow Line, the tow and Weak Link may be preserved by increasing speed before the Tow Line tautens.

#03. Free Flight

`A. Release

`a. Normal

Whenever circumstances permit it is advisable to climb a little above tug level then dive before releasing. This action slackens the Tow Line and thus reduces the likelihood of a Primary Bridle wrap and eliminates the (near) stall experienced with an abrupt loss of tension.

`b. Tow Line Shear Link Failure

In the event of a wrap of a Tow Line Shear Link failure the remainder of the weak link assembly must be secured before releasing and stowing the Bridle.

`c. Bridle Wrap

i. Top End

In the event of a wrap of the top end of the Primary Bridle, at which time all Aerotow Release Bridle System components from the wrap aft will experience near double loading in addition to the shock which occurs due to the temporary acceleration of the tug and deceleration of the glider, Secondary Weak Link failure may occur. Otherwise the Barrel Release is employed.

Note: In the event of a wrap, as the Tow Line will drop and the pilot will be pulled fore with respect to the control frame, it is possible that a Barrel Release will be dragged across the basetube and auto-actuate.

ii. Bottom End

If the Primary Release is mounted to accommodate trim far enough forward on the keel and:

the bottom end of the Primary Bridle is separated from its attachment;
the Primary Bridle wraps at the Tow Ring; and
the weak link remains intact

then the glider will experience a severe pitch down and catastrophic structural failure under negative loading.

The only excuse for the bottom end of the Primary Bridle being released out of sequence is an accidental triggering of a Barrel Release through contact with the basetube and the pilot should be primed to actuate the Primary to guard against the consequences of a wrap when this situation becomes imminent.

Note that the Primary Weak Link may remain intact as it is routed to the lighter glider rather than the heavier pilot and the shock loading is dampened due to the ease with which the glider will pitch negative in response.

`d. Slack Line

In a slack line situation it is unlikely that opposition tension will fall below what is required to actuate the Barrel Release with one hand. In that event the tension may be created with the other or an Emergency Release may be actuated.

`B. Stowage

`a. Bridle

i. Control Safety

If low immediately or if high as a top priority task, the bridle is pulled clear of the basetube and allowed to trail along the underside of the harness so as to minimize potential for interference with pitch control at landing.

ii. Securing

As soon as convenient stow the bridle assembly. With the right hand, figure 8 loop short lengths of the Primary Bridle over the thumb extended from the left still gripping the basetube. Loosen the cord lock of the Bridle Cinch to enlarge the loop, pull the loop over the end of the the thumb and, consequently, the runs of the coil, and tighten around the middle of the coil. (This operation may be completed in stages as control demands allow.) Stuff into harness in area of chest or zippered pocket, if available. Rotating body vertically to relieve pressure in that area will facilitate the former operation.

If circumstances and/or time do not allow for proper stowage then at least upon landing and before moving off, if practical, stow the bridle to reduce abrasion and soiling.

`b. Cotter Pin Lanyard

Slide the Keeper inboard to near the Button to minimize its drag effect.

~29. Emergency Operation

#01. Four-String

At the first sign of a dangerous situation developing the Four-String is armed for a benefit of the possible saving of a critical second - regardless of whether the glider is in One or Two Point mode - at a cost of having to hold Trigger Line tension for the remainder of the tow. The Four-String is not, however, actuated prior to the Primary Release.

#02. Low Altitude

`A. Situations

`a. Pitch

The glider climbs so far above position that it threatens to nose in the tug.

`b. Roll

i. Limit

The glider rolls past 45 degrees.

ii. Control

The glider fails respond to a roll correction within a second.

iii. Oscillation

An oscillation worsens.

`c. Yaw

The glider heading has diverged more than twenty degrees from the tow.

`B. Procedures

`a. Pitch

Release.

`b. Roll

i. Lockout

If a glider is locking out but still climbing it may be advisable to remain on tow to enhance the opportunity neutralize the bank.

ii. Oscillation

To guard against the likelihood of a dangerous stall, a release is effected early in the progression but only as the glider is starting to recover from a cycle.

#03. Bridle Wrap - Load:

`A. Low

In the highly unlikely event that a wrap occurs in the absence of enough tension to cause failure of the Secondary Weak Link the Barrel or, if required, Emergency Release is actuated.

`B. Moderate

Under normal tow tension failure of the Secondary Weak Link following a wrap is likely. Otherwise, proceed as above.

`C. High

The likelihood of a wrap will tend to increase under the high loading resulting from a severe lockout. However, at any time the tow tension exceeds about 0.75 Gs during a wrap, Secondary Weak Link failure is a certainly.

#03. Nose Wire Fouling

Fouling of the Primary Bridle with a nose wire is possible if a yawing has progressed enough to cause the Bridle to contact the wire prior to release or Ribbon Bridle Shear Link failure. The Trigger Line of the armed Four-String is released immediately to prevent destruction of the glider.

#04. Slack Line

A slack tow line situation is an emergency if:

it occurs low enough for a snag; or
the potential exists for fouling the glider (especially if still connected to the tug.

`A Two Point

Actuate the Primary Release.

`B. One Point

`a. Four-String

If the Trigger Line is still engaged push the Secondary Bridle forward while actuating the Four-String.

`b. Barrel

Actuate the Barrel Release with the left hand while pushing the Secondary Bridle forward with the right.

~30. Breakdown

At breakdown the setup sequence is reversed. The Keel Release is stowed with the Pin secured in the Barrel so as to ensure retention of the Keeper.

~31. Downtube Replacement

#01. Conduit Prefitting

A spare port downtube is prefitted with a Conduit.

#02. Tensioning

The Lanyard is withdrawn from the damaged downtube and Bungee tension is held with the Cotter Pin.

#03. Lanyard

`A. Rethreading

The Lanyard ends immediately take on a set when the Becket Bends are loaded and it will likely require use of a Threader to reroute the Lanyard through the Conduit.

`B. Securing

The top and bottom ends of the Lanyard are secured to the Lanyard Extension and a Stowage Link, respectively.

#04. Installation

The new downtube is swapped in and the Pulley Assembly is transferred as part of the installation process.

~32. Partial Installations

Benefits can be realized from elements of the system independent of the full installation.

#01. Basetube

Folding, faired, and/or carbon variations may be problematic with respect to the stored energy components of this system. The internal basetube assembly may be eliminated and a cord lanyard can be routed through a pulley and pulled by hand.

#02. Tensioner

Any Two Point release will benefit from a tensioner. A spinnaker shackle, stock or modified but with an offset modification bypassed and mounted via the bail, or Schweizer style release will function in the absence of tow tension when keel mounted and and tensioned, thus eliminating the requirement of cable actuation.

#03. One Point

The Secondary Bridle/Release Assembly described herein will easily accommodate the near double loading that the One Point configuration transmits. On a suitable glider, given this One Point system's advantages of cost, simplicity, weight, aerodynamic cleanliness, absence of bridle wrap potential, and virtually effortless emergency release, a very good argument can be made for sacrificing the control advantage afforded by the full installation.

~33. Care

#01. Bridle Assembly

`A. Ultraviolet Exposure

Between flights the bridle assembly should be kept out of the sun, preferably in with the bagged harness.

`B. Stowage

The Primary Bridle is neatly made up using short figure 8 coils and the entire assembly can be stowed by tossing it through the shoulder straps into the body of the harness or a zippered pocket or separately.

#02. Pulleys

Regular operation in a dusty environment may have a detrimental effect on the pulleys. Regular rinsing in water is

recommended.

#03. Barrel Release

The following two issues apply only in the event the loading exceeds what is every likely to be encountered in flight. This device has been extensively and very successfully bench tested and high tension tests should be avoided.

`A. Base

Upon actuation the Base assembly recoils aft with respect to the Barrel and the leechline may be frayed in the vicinity of the Pin.

`B. Barrel

The Pin continues to rotate after release and will slam into either the Barrel or one's hand, depending upon how far fore the Barrel is gripped. The force is enough to damage the Grip or bruise the hand. Gloves, which are a good idea in any case, should be worn.

#04. Clamcleat

Although the nylon Clamcleat CL263 Micro Cleat is overbuilt for the function it performs as a component of the Four-String Release and is subjected to virtually no wear in that environment, it has a relatively short life expectancy when subjected to regular use with substantial loads and thus a copy used in the Emergency Release system should be so dedicated.

#05. Cleaning

Saturation of fabric components with liquid laundry detergent followed by immersion in boiling water is an effective method of cleaning. The Clamcleat is not harmed by boiling but bungee components should be separated.

~34. Tandem

#01. Capacity

All components described herein are quite sufficient for tandem operation.

#02. Actuation

The top pilot in an over/under configuration can easily access the Primary Lanyard at the point at which it exits the downtube and actuate the Release.

#03. Shear Links Configuration

As tandem gliders do not tow in One Point configuration for longer than it takes to contend with a wrapped Primary Bridle, a Bridle Link, if employed, need only reliably exceed the strength of the Primary (Bridle) Shear Link.

~35. Wills Wing U2

The following configuration was installed on a U2 160. The Sport 2, Talon, and T2 incorporate identical Litestream control frame hardware and are thus compatible with this variation. WHOOSH wheels were utilized on this glider. Installation of the Wills Wing Slipstream/Litestream Basetube Wheels (70M-1240) eliminates the incentive to reposition the VG cleat.

#01. VG Cleat

`A. Positioning

The Holt Allen HA 4446 VG cleat is moved 0.75 inches inboard to 2-40/64 inches from the starboard basetube end to allow the wheel to be installed outboard of it.

`B. Fasteners

The VG cleat is secured by a pair of 06-32 x 7.5 millimeter screws and nylocks, the latter inside the basetube.

#02. Wheel Stops

Wheel movement to outboard is limited by the basetube screws at both ends and inboard by the VG cleat and Basetube Pulley Assembly Screw at the port and starboard ends respectively. Wheel Stops are installed immediately inboard of the wheels, protect the hub from the hardware, and fill the inboard gaps.

`A. Starboard

A 10/64 leechline length is coiled twice around the periphery of the basetube cross section and the doubled width is stitched secure.

`B. Port

A length of.5 inch nylon webbing is wrapped twice around the basetube and stitched secure.

#03. Actuation System

`A. Leader/Lanyard Routing

As the Slipstream (faired) basetube is pitched well below perpendicular to the downtube, routing the Leader and Lanyard between the two control frame components is somewhat problematic. Three measures are taken to compensate for this geometry.

`a. Basetube Pulley Positioning

The Basetube Pulley is positioned as far aft as possible.

`b. Drilling

i. Basetube

The Leader exits the Basetube 2-43/64 inches from the port end and well aft of the point perpendicular to the Sheave

center.

ii. Downtube

The Lanyard enters to the downtube well fore - immediately aft of the inboard trip ridge and 4.5 inches above the bottom end and exits it 15 mm fore of inboard trip ridge 3.0 inches from top end.

`B. Basetube Pulley Assembly

`a. Screw

A 06-32 x 53.5 millimeter screw aligned on the longitudinal axis of the basetube installed through the basetube 2.5 inches inboard of the port end secures the Basetube Pulley Assembly.

`b. Axle

The Axle is cut to a length of 36.5 millimeters.

`c. Shims

Fore and Aft Axle and Screw Shims bias the Pulley as far aft as possible in the basetube.

i. Axle

12-08/64 vinyl tubing.

ii. Screw

12-08/64 polyethylene tubing.

`C. Bungee Assembly

`a. VG Cleat Collar

Prior to installation of the Thimble and Thimble Collar, the Bungee Assembly is amended with an additional Pro Flex PFTC4 Bungee Loop Connector installed near the starboard end of the doubled Bungee so as to leave a 0.75 inch gap between it and the pair of End Connectors. This component is necessary to allow the End Connectors to pass by the VG cleat fasteners during assembly.

`b. Extension

The Extension serves to anchor the Bungee to the screw which secures the basetube to the starboard bracket and prevent the Bungee from being interfered with and damaged by the VG cleat fasteners.

i. Base

An 08/64 x 400 millimeter leechline length is secured in a loop by stitching the ends together in a 50 millimeter Overlap. The loop is pulled linearly with the Overlap centered on a half. Using a Threader, the folded end of the opposite half is pulled through the eyes of the End connectors to the middle of the loop.

ii. Sleeve

The ends of the loop are pulled through a 28-20/64 x 055 millimeter vinyl tubing length which protects the leechline from the VG cleat fasteners.

`c. Bushing

A 20/64-.233 x 1-26/64 inch polyethylene tubing length is inserted through the ends of the loop and the Extension Sleeve is pulled to starboard to hold the Bracket Screw Bushing in place.

`d. Stops

16/64-.170 x 24/64 inch vinyl tubing lengths serve as the Fore and Aft Stops to keep the Extension centered on the Bushing.

`D. Cotter Pin Lanyard

A 05/64 x 300 millimeter leechline length constitutes the Cotter Pin Lanyard.

#04. Downtube Pulley Mounting

`A. Pin

The Downtube Pulley Assembly is mounted on an RWO 6731 12/64 x 3/16 inch Clevis Pin which replaces the factory upper downtube pin.

`B. Washer

A Number 08 nylon Washer is filed to snugly fit over the Pin and retains the Inboard Harness.

#05. Primary Release Assembly Mounting

`A. Aft

`a. Tang

A Wills Wing 20E-2206 upper side wire Tang serves as the anchor for the Primary Release Assembly.

`b. Thimble

A small Loos Standard Thimble (stainless steel) - LSAN100C3 - is installed in the larger (.3125 inch) hole of the Tang.

`c. Harness

A 05/64 x 275 mm leechline length is configured in a spiral coil around the Thimble with a triple overlap fore and double overlap aft. The entire periphery is stitched laterally and the triple overlap is stitched vertically from the

end of the Thimble fore leaving a small Eye to accommodate the pin of the D Shackle.

`d. Bolt

The AN4-21 (.25 x 2-1/8 inch) hex bolt which secures the kingpost is replaced by the next longer increment AN4-22 (.25 x 2-2/8 inch) which is used to secure the Mounting Assembly to the underside of the keel.

`B. Tensioner Anchor Base

A 06/64 x 500 millimeter leechline length is routed around both fore and aft noseplate spacers to preclude interference with the snap button.

#06. Assembly - Basetube

After a Threader is routed in the Leader Exit Hole, through the Basetube Pulley, out the starboard end of the basetube, the Bungee Screw Sleeve Bushing is positioned inside the starboard basetube bracket and held in place by inserting a Bracket Installation Pin - a 10-08/64 x 44 millimeter polyethylene tubing length (or any cylindrical pin of 12/64 inch or slightly smaller diameter and that length) - is inserted through the holes and Sleeve to hold the components in alignment. The Threader is then pulled to draw the Bungee Assembly through the basetube and the Leader out, the bracket is seated, and the Pin is pushed out by installing the Screw.

#07. Partial Installation

A much simpler and very satisfactory installation may be effected by eliminating the stored energy components of the actuation system. By substituting a starboard side 20P-1270 VG Bearing for the port 10T-5103 Nylon Spacer, the Primary Lanyard may be routed into the port downtube as is the VG line. Installation of a jam cleat on the basetube would allow the pilot to lock tension on the release assembly following actuation.

~36. Hook Knife

If a hook knife is used as an aerotow emergency measure in dealing with a failed separation, the action is a likely result of the shoddiness of the release system involved. Although it should be on hand to deal with post flight emergencies it has little place in this discussion.

~37. Surface Towing

Some of the components described above may be utilized with advantage in surface towing operation.

#01. Platform Launch

`A. Conventional Configurations

`a. Bridle Assembly

The traditional platform launch bridle is connected to the aft tow loops of the harness with the release mechanism fixed at its center.

`b. Release Mechanism

The release is typically a three- or two-string mechanism.

`c. Actuation

A lanyard is secured to a shoulder strap or wrist.

`d. Weak Link

The weak link is installed between the tow line and ring.

`B. Deficiencies

`a. Bridle Assembly

The bridle halves are subjected to uneven loading.

`b. Release Mechanism

The multi-string releases wear with use, do not reliably separate from a slack line, and should not engage a conventional weak link.

`c. Actuation

Both lanyard configurations suffer from the characteristic of slack being affected by attitude and the latter by hand movement as well.

`d. Weak Link

The weak link descends and, in the case of a solid surface, often gets dragged across the ground with the tow line.

`e. Drag

The entire assembly remains in the airflow for the duration of the flight and presents a least desirable profile.

`C. Revisions

The conventional configuration is replaced by a slightly modified two barrel secondary release and Ribbon Bridle assembly.

`a. Bridle

The Tow Ring moves freely on the bridle, thus maintaining even loading throughout the assembly and attachment points.

`b. Release Mechanisms

Barrel releases suffer virtually no wear from use and perform better in a slack line situation.

`c. Actuation

Barrel releases are within immediate reach and unaffected by attitude.

`d. Shear Links

An elongated Bridle Link stays with the glider and suffers virtually no wear as a consequence of a flight.

`e. Drag

After actuation the components stream with the airflow. The Bridle may be disengaged from the remaining closed (Starboard) Barrel Release and stowed.

`D. Construction

`a. Bridle Link

As distance between attachment points is increased, the length of the Bridle Link is extended to compensate. 500 millimeter Base Halves are incorporated. All specifications are the same as those of the standard aerotow Bridle Link except for the Gaps to which the extra material is allotted.

`b. Release Mechanisms

Standard Port and Starboard Barrel Releases are employed.

`c. Actuation

Port and Starboard Adjusters are set to evenly extend the Barrel Releases to the point at which a chest mounted parachute will not impede actuation but not so much that the Barrels are beyond easy grasp with the Assembly tensioned full aft.

#02. Two Stage

`A. Conventional

Although the conventional two stage (Keller/Koch) release is an effective mechanism for emergency release it may be problematic when actuated with extreme tow line angles and contributes a lot of drag to a flight.

`B. Revision

By installing a Secondary Release Assembly incorporating a Barrel Release and any of the Emergency Releases on the aerotow loops and the platform launch release assembly described above on the aft tow loops, the emergency release capability is approximated and the negative aspects are eliminated or mitigated.

~38. Theory

The goal of a release system is to transmit a tension of up to hundreds of pounds to the glider and disengage instantly, reliably, and with minimal effort and complication. All systems, save for those based on the Linknife (which is a composite inclined plane), use mechanical advantage to step down the tow line tension and are based on the simple machines of the pulley and/or second class lever (in which the load (tow) force is applied between the fulcrum and effort (retaining) force).

#01. Bridles

Bridles, as a result of being less than infinitely long, impart a mechanical disadvantage. The resultant increase in loading of the components securing them is calculated by comparing half the tow force to that figure multiplied by the secant of half the apex angle.

`A. Primary

With a 200 pound tow and a 60 degree angle of the Primary Bridle at the Tow Ring the Bridle weak Links would be subjected to a strain of about 115 pounds.

`B. Secondary

Due to the minimal separation of the aerotow loops the angle formed in the Secondary Bridle and loading increase both tend to be relatively small.

#02. Pulleys

Ignoring the angle determined by the length of the Primary Bridle, friction, and stiffness of materials a Two Point aerotow release system which employs a Secondary Bridle steps the tow tension down by a factor of two and four at the point at which it engages the primary and secondary release mechanisms respectively. The force reaching the Four-String Release Trigger Line has been stepped down by a factor of 64.

#03. Levers

`A. Spinnaker Shackle

`a. Hinge

The Wichard spinnaker shackle is designed to situate the weak link at the hinge (fulcrum) of its lever (gate). Modification to alter the attachment point relocates the load force about half the distance to the end of the gate.

`b. Latch

The latch is a second class lever in which the effort force must overcome some spring tension. The force exerted by the gate on the latch is negligible. When modified about a quarter of the tow force is transmitted to the latch which becomes a primarily third class lever in which the friction at the area of contact with the latch must be overcome with a mechanical disadvantage of about one to two.

`B. Barrel Releases

`a. Straight Pin

A straight pin barrel release with a leechline base locates the load force as close as possible to the fulcrum and the

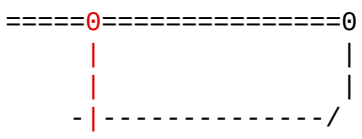
retaining force at the extreme end of the pin, thus providing the maximum possible mechanical advantage. The configuration remains intact until the instant of release when the forces are abruptly unloaded.

`b. Curved Pin

A curved pin barrel release locates and the half inch webbing base forces the load force farther from the fulcrum. It locates the retaining force a little beyond the halfway point along the length of the pin. Because of the larger barrel diameter necessitated the lever is, in effect, already open about 30 degrees when the mechanism is fully locked. As the barrel is withdrawn the retaining force moves toward the end of the pin and the load force moves away from the fulcrum. Just prior to the instant of release the pin is open at an effective angle of about 50 degrees.

`C. Schweizer Release

The Schweizer sailplane release and variations of the design, like the spinnaker shackle, operates by means of a hinged gate retained by a pivoting latch as illustrated in the simplified schematic below.



It is designed to engage a heavy steel ring and is inappropriate for use with 3/32 inch leechline as the load force is applied at an unnecessarily distant point from the fulcrum.

~39. Lever Based Release Performance

The performance of a release is expressed in terms of a load to actuation ratio - L/A. The required actuation force associated with the release is a function of the mechanical advantage and internal friction of the device.

The Linknife is something of an anomaly - its effectiveness in inversely proportional to the tow tension and is good even in a slack line situation.

The Four-String Emergency Release steps the load down so much that the fraction delivered to the Trigger Line is negligible.

#01. Test Loads

Release mechanisms were directly loaded at the lowest or more of the following tensions - expressed in pounds.

062.5 - normal tow tension
140.0 - weak link, single loop
200.0 - weak link, double loop
227.5 - shear link, 455 pound (mine)
250.0 - arbitrary
300.0 - arbitrary

#02. Releases

The releases tested were:

Bailey - curved pin barrel
Wide   - as above with a straight pin substituted
Remote - Remote Barrel
Barrel - Straight Pin - quarter inch ID barrel
shackle - Wichard 2673 spinnaker shackle - unmodified (Wallaby, Lookout)
Quest   - Wichard 2673 spinnaker shackle - drilled
Hinkel - mission specific cable actuated release

#03. Results

The columns of the following table represent, in order:

L/A ratio
maximum permissible tow tension to remain within the 25 pound actuation requirement
maximum load tested (also tested at all lower graduations)

---

barrels:

06.2 - 0310 - 227.5 - Bailey
10.5 - 0522 - 227.5 - wide
16.8 - 0820 - 300.0 - remote
20.4 - 1020 - 300.0 - barrel

spinnaker shackles:

16.1 - 0806 - 300.0 - shackle
06.3 - 0312 - 062.5 - Quest

mission specific:

30.6 - 1530 - 300.0 - Hinkel

~40. Tow Tension Gauges

#01. Testing

Prior to conducting a test, dolly or tandem glider tires should be properly inflated and glider weight, density altitude, and wind conditions should be recorded.

#02. Shear

The Shear Tow Tension Gauge is a configuration of a series of graduated Shear Links. By noting the lowest Strength Stitching Rating still intact after the tug lands the maximum load experienced by the Tow Line can be determined to within about sixteen pounds. Prior to testing it must be ensured that dolly or landing gear tires are properly

inflated.

`A. Base

The Base is the outer element and consists of 12/64 inch polyester double braid.

`a. Loop

The Base is formed into a loop by overlapping the ends 120 millimeters and binding them with sixty stitches.

`b. Eyes

The loop is drawn longitudinally such that the overlap and fold constitute the Fore and Aft Eyes respectively.

`c. Reference Marks

Reference Marks are made opposite each other on the Port and Starboard Stands at 25 millimeter intervals.

`B. Breaker

The Breaker is the inner element and consists of a 10/64 inch leechline length anchored immediately aft of the Fore Eye with a number of stitches no less than three above those of the highest Strength Stitching Run.

`C. Strength Stitching

The Strength Stitching consists of incremental Runs binding the Breaker to the Port and Starboard Strands of the Base. Slack is introduced in the Base Strands between Runs which are arranged high fore to low aft and the Reference Marks are used to keep the assembly symmetrical.

`D. Sleeves

`a. Fore

The Fore Sleeve is a 32-24/64 x 3 inch vinyl tubing length installed over the aft region of overlap and fore Breaker anchor region and defines the Fore Eye.

`b. Aft

The Aft Sleeve is a 24-16/64 x 1 inch vinyl tubing length installed over the Base only (and not the Breaker) aft of the aft Run of Strength Stitching and defines the Aft Eye.

`E. Thimble

An RF2182 Thimble is installed in the Aft Eye and the Sleeve is positioned to hold it in place.

`F. Installation

`a. Fore

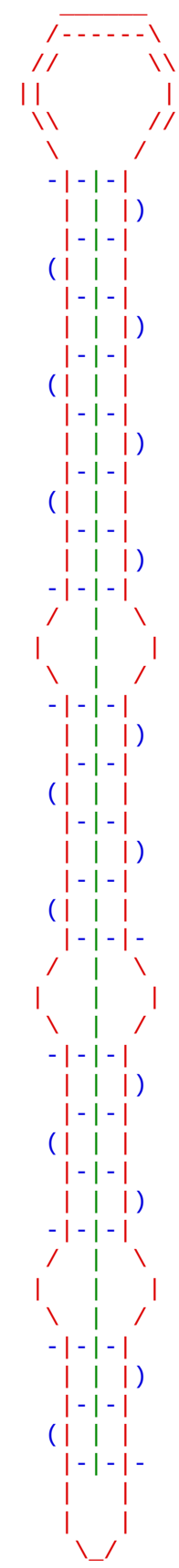
The Fore Eye of the Gauge is connected to the aft end of the Tow Line by means of a carabiner.

`b. Aft

A Bridle with weak link protection may be inserted through the Thimble or a Tow Line Shear Link may be tied to it by means of a short leechline length using a Double Sheet Bend.

`G. Schematic

The schematic illustrates a scaled down Tow Tension Gauge (minus Sleeves and Thimbles) - Fore top, Base in red, Breaker in Green, and Strength Stitching in Blue. It is anchored with eight stitches and has Runs of five, four, and three Strength Stitches.



#03. Hydraulic

`A. Cautions

The Hydraulic Tow Tension Gauge yields constant (as opposed to maximum) and more accurate tension readings but its use is magnitudes more problematic than is that of the Shear version. It is bulky, heavy, presents a threat to the glider pilot in the event of a premature release and/or crash, stays with the glider after release, and must be stowed immediately after release. Its use is best limited to dedicated flights in smooth, predictable flying conditions. It is very easy to get far out of position by focusing too long on the gauge which is best totally ignored until a safe altitude is attained.

`B. Tow Line Connection

An Aft Tow Line Shear Link which protects the cylinder from overloading is installed on the aft end of the Tow Line. Its Aft Thimble is removed to allow direct engagement by a Barrel Release.

`C. Stowage

After release the assembly is (rather uncomfortably) stuffed into the front of the harness along with the bridle components.

`D. Components

`a. Cylinder

A Bimba H-091-DUZ Hydraulic Cylinder is oriented, in flight test configuration, rear fore/rod aft and upside down.

`b. Hydraulics

i. Thread Sealer

Teflon tape is applied to the male threads of the three peripheral components involved with the Cylinder's hydraulic function.

ii. Adapter

A 1/8 inch male to 1/4 inch female NPT thread Adapter is required to install the Gauge.

iii. Fluid

With the Rod retracted to about eighty percent of its stroke the Rod side of the Cylinder is filled with soybean oil up

to the top of the Adapter and a moderate amount is added to the rear side of the piston for lubrication.

iv. Gauge

A Flowfit 0-500 PSI Pressure Gauge is installed to face aft.

Note: DO NOT snip the cap as instructed on the decal lest a constant glycerine leak ensue. Remove the decal.

v. Breather

A Shraeder valve is installed on the rear side of the piston and allows pressure compensation for any piston movement and is periodically purged.

vi. Cap

A Cap is loosely installed on the valve and tightened whenever a possibility exists for dust or other contaminants to be drawn into the Cylinder.

`c. Pin

The Pin and E-Clips from a Bimba D-8322-A Pivot Bracket are installed in the Cylinder.

`d. Washers

.25 inch ID Washers are installed at each end of the Pin to protect and help retain the Bridle. IDs are enlarged, if necessary, by filing to snugly fit over the Pin.

i. Inner

A pair of deburred Steel Washers separates the Bridle from the threads of the rear end of the Cylinder.

ii. Outer

A pair of Nylon Washers separate the Bridle from the E-Clips.

`e. Bridle

A Bridle is fabricated from a 06/64 x 290 millimeter leechline length, spirally folded in three Runs of 090, 110, and 090 millimeters and stitched to form 010 millimeter long Eyes at the ends by which it is secured to the Pin.

`f. Rod

i. Rod Clevis

A Bimba D-8309-A Rod Clevis is installed on the Rod and set by means of a Hex Nut and Nylon Washer.

ii. Boot

A Harken H369 Stand-Up Boot, Small protects the Rod.

`g. Loop

A stitched Loop of 08/64 leechline connects the Tow Ring to the Rod Clevis Pin.

i. Base

A 08/64 x 210 millimeter leechline length is formed in a coil with a 60 millimeter Overlap which is bound with stitching at a density of one per millimeter. This loop is drawn to form folds centered at the middle of the Overlap and the opposite end. The two sides of the non overlapping region are stitched to retain an RF2182 Thimble.

ii. Overlap Sleeve

A Sleeve of 24-16/64 x 35 millimeter vinyl tubing is installed over the Overlap and pulled fore to the extent of the Thimble retention stitching such that an Aft Eye is cleared for installation on the Rod Clevis.

`h. Tow Ring

An RF2182 Thimble is installed in the Loop as it is in a Shear Link eye and engages the glider's Tow Bridle.

`i. Rod Clevis Sleeve

A Sleeve of 48-40/64 x 80 millimeter vinyl tubing covers the Rod Clevis and extends over the Loop to the Tow Ring to protect the glider's Tow Bridle in the event of an emergency release.

`E. Two Point

`a. Remote Barrel Release

A Remote Barrel Release is connected to the Cylinder via its Bridle.

`b. Guide

A 12-08/64 x 165 millimeter polyethylene tubing length guards against fouling with the Cylinder's peripheral elements.

`c. Retainers

Rubber bands installed fore of the Breather and aft of the Adapter hold the Guide flush along the lower port side of the Cylinder.

`c. Lanyard

The Remote Barrel's normal 05/64 leechline Lanyard is removed and replaced, using a Becket Bend, by leechline of sufficient length (about eight feet) to reach the bail of the Port Snap Shackle of the Secondary Release Assembly where it is anchored with a Double Overhand Noose.

`d. Operation

Upon release the Cylinder Assembly is recovered from below the basetube. If a normal release is actuated or the Primary Weak Link fails the Remote Barrel Release will auto-actuate and the Cylinder Assembly will be suspended by its Lanyard from the Port Snap Shackle.

`F. One Point

`a. Secondary Release Assembly

A Secondary Release Assembly consisting of Port and Starboard Barrel Releases and Bridle Link is employed. The Assembly must be short enough to keep the Barrel Release referred to below within safe reaching distance. The amount of displacement which occurs upon loading is very significant and must not be underestimated.

`b. Barrel Release

A Barrel Release is connected to the Cylinder via its Bridle.

`c. Operation

After release the Cylinder Assembly is grasped in the right hand and the Port Barrel release is actuated. Use of a normal glider release will send the Cylinder Assembly down with the tug on the end of the Tow Line and may necessitate jettisoning.

#04. Testing Results

Conclusions drawn from the limited testing run to date are as follows with all tensions and weights given in units of pounds.

`A. Environment

`a. Tug

i. Model

Bailey-Moyes Dragonfly

ii. Engine

Rotax 914 Turbo - 115 HP

iii. Propeller

Kiev - 5 blade

`b. Runway

63' MSL, grass, firm

`c. Air

i. Temperature

75 degrees Fahrenheit

ii. Relative Humidity

31 percent

iii. Wind

5 mph, aligned with runway

`d. Glider

i. Model

Wills Wing HPAT 158, (full) VG on

ii. Harness

pod, closed

iii. Weight

310

`B. Tension

`a. Maximum

Maximum tension is experienced immediately upon acceleration from launch, appears to be related to the mass of the glider, and within the above parameters was recorded at about 160 to 175. (The tension required to accelerate a fairly heavily loaded tandem glider peaked in the range of 224 to 240.)

`b. Steady

i. Normal

125

ii. Turbo Boost

155

~41. Components

#01. Actuation System

`A. Mounting Fasteners

`a. Basetube Pulley

Screw
      Phillips pan head, stainless steel
      06-32 x 34.5 mm (1.50)
+
Nylock
      stainless steel
      06-32
+

`b. Bungee

Screw
      Phillips pan head, stainless steel
      06-32 x 34.5 mm (1.50)
+
Nylock
      stainless steel
      06-32
+

`B. Basetube Pulley Assembly

Pulley
      Harken 404 16 mm Fixed Single AirBlock
+
Axle
      pin - aluminum
      < 1/8 x .99 inch
+
Axle Shim - Fore
      tubing, vinyl
      12-08/64 x .25 inch
+
Axle Shim - Aft
      tubing, vinyl
      12-08/64 x .25 inch
+
Screw
      Phillips pan head, stainless steel
      06-32 x 34.5 mm (1.50)
+
Nylock
      stainless steel
      06-32
+
Bushing
      tubing, polyethylene
      12-08/64 x .33 inch
+
Screw Shim - Fore
      tubing, polyethylene
      12-08/64 x .2875 inch
+
Screw Shim - Aft
      tubing, polyethylene
      12-08/64 x .2875 inch
+
Pull
      leechline
      05/64 x 240 mm
      Thumb Knot
+
Pull Sleeve
      tubing, vinyl
      12-08/64 x 1 inch
+

`C. Bungee Assembly

Bungee
      bungee
      Novatec Braids
      Nova Shock
      MRSC14
      16/64 x 1750 mm
+
End Connector - Fore
      Pro Flex PFRSB4 Dead End
+
End Connector - Fore
      Pro Flex PFRSB4 Dead End
+
Bushing
      tubing, polyethylene
      12-08/64 x .99 inch
+
Shim - Fore
      tubing, vinyl
      20-12/64 x 6 mm
+

Shim - Aft
	tubing, vinyl
	20-12/64 x 6 mm
+
Pull Base
	leechline
	05/64 x 400 mm
	Fisherman's Knot
+
Pull Loop
	leechline
	05/64 x 100 mm
+
Pull Sleeve
	tubing, vinyl
	16/64-.170 x 50 mm
+
Thimble
	RF2180 Ronstan Sailmaker's Thimble
+
Collar
	Pro Flex PFTC4 Loop Connector - .25 inch
+
Leader
	leechline
	05/64 x 600 mm
+

`D. Cotter Pin Lanyard Assembly

Cotter Pin
	cotter pin, stainless steel
	06/64 x 1.0 inch
	end evened and rounded
+
Basetube Washer
	washer, stainless steel
	06 - 20-09/64
+
Basetube Washer Adhesive
	Sears Craftsman Formula 300 hot glue
+
Lanyard
	leechline
	05/64 x 270 mm
	Double Overhand Noose
+
Guide Base
	tubing, polyethylene
	10-07/64 x 45 mm
+
Guide Retainer
	heat shrinkable tubing
	1.5000 inch - red x 45 mm
+
Button
	beveled faucet washer
	000 - 15-06/32 - 35089
+
Keeper
	bungee
	08/64 x 150 mm
	Fisherman's Knot
+

`E. Primary Lanyard Installation

Primary Lanyard
	leechline
	03/64 x 2005 mm
	Becket Bends
+
Conduit - Bottom
	tubing, nylon - 58027
	08-05/64 x 4 inches
+
Conduit - Top
	tubing, nylon - 58027
	08-05/64 x 4 inches
+
Stop - Bottom
	tubing, vinyl
	12-08/64 x 20 mm
+
Stop - Top
	tubing, vinyl
	12-08/64 x 20 mm
+

`F. Downtube Pulley Assembly

Downtube Pulley
	Harken 405 16 mm Fixed Single AirBlock with Becket
+
Downtube Pulley Pin
	RWO Clevis Pin 6616

      10 x 40/64
+
Downtube Pulley Pin Washer - Port
      washer, nylon
      06 - 20-09-02/64
+
Downtube Pulley Pin Washer - Starboard
      washer, nylon
      06 - 20-09-02/64
+
Downtube Pulley Pin Retainer
      leechline
      04/64 x 30 mm
+
Downtube Pulley Bumper
      leechline
      05/64 x 120 mm
+
Lanyard Extension
      leechline
      05/64 x 100 mm
+
Downtube Pulley Harness - Inboard
      leechline
      05/64 x 100 mm
            31-38-31
+
Downtube Pulley Harness - Outboard
      leechline
      05/64 x 120 mm
            38-44-38
+
Downtube Pulley Bridle Screw
      Phillips pan head, stainless steel
      10-32 x 37 mm (1.5)
+
Downtube Pulley Bridle Screw Bushing - Outboard
      tubing, vinyl
      20-12/64 x 05/64 inch
+
Downtube Pulley Bridle Screw Bushing - Inboard
      tubing, vinyl
      20-12/64 x 05/64 inch
+
Downtube Pulley Bridle Nylock
      stainless steel
      10-32
+

      #02. Primary Release Mounting

            `A. Mounting Harness

Base
      leechline
      10/64 x 440 mm
      Becket Bend x 2
+
Interface - Port
      leechline
      05/64 x 500 mm
            doubled
            75 mm - eye overlap
+
Interface - Starboard
      leechline
      05/64 x 500 mm
            doubled
            75 mm - eye overlap
+
Retainer
      tubing, vinyl
      24-16/64 x 20 mm
+

            `B. Tensioner Anchor

Base
      leechline
      08/64 x 430 mm
      Becket Bend
+
Sleeve
      tubing, vinyl
      20-12/64 x 60 mm
+

      #03. Keel Release

Base Pulley
      Harken 405 16 mm Fixed Single AirBlock with Becket
+
Base Pulley Pin
      RWO Clevis Pin 6616
      10 x 40/64
+

Base Pulley Pin Washer - Port
	washer, nylon
	06 - 20-09-02/64
+
Base Pulley Pin Washer - Starboard
	washer, nylon
	06 - 20-09-02/64
+
Base Pulley Pin Retainer
	leechline
	04/64 x 30 mm
+
Barrel
	tubing, aluminum
	6061 T6
	A1118
	24/64-.058 (.259 ID) x 20 mm
	drilling
		03 mm from aft
		07/64 through horizontally
+
Pin
	Aerolite Stainless Steel Straight Release Pin
+
Tensioner Extension
	leechline
	04/64 x 250 mm
		80-90-80
+
Base
	leechline
	05/64 x 325 mm
		50 mm - overlap
+
Screw
	Phillips pan head, stainless steel
	04-40 x 18 mm (0.75)
+
Nylock
	stainless steel
	04-40
+
Linkage
	leechline
	05/64 x 300 mm
		030 - ends doubling
		eyes length
			003 - fore
			030 - aft
+
Barrel Pulley
	Harken 404 16 mm Fixed Single AirBlock
+
Barrel Pulley Pin
	RWO Clevis Pin 6616
	10 x 40/64
+
Barrel Pulley Pin Washer - Port
	washer, nylon
	06 - 20-09-02/64
+
Barrel Pulley Pin Washer - Starboard
	washer, nylon
	06 - 20-09-02/64
+
Barrel Pulley Pin Retainer
	leechline
	04/64 x 30 mm
+
Harness
	leechline
	05/64 x 250 mm
		80-90-80
	Lark's Head
+
D Shackle
	Wichard 1401 "D" Shackle - Captive Pin
+
Tensioner Base
	leechline
	06/64 x 850 mm
	100 mm doubled
		050 mm eye
	Triple Becket Bend
+
Tensioner Pin
	Aerolite Stainless Steel Straight Release Pin
+
Tensioner Pin Lock
	tubing, vinyl
	20-12/64 x 25 mm
+
Keeper
	bungee
	04/64 x 170 mm
	Fisherman's Knot

+

#04. Primary Bridle Assembly

`A. Ribbon

Triple Base
Crystalyne
06/64 x 3050 mm
+
Quadruple Base
leechline
06/64 x 3050 mm x 2
+
Fillers
leechline
06/64 x 2
+

`B. Cinch

Base
bungee
08/64 inch x 200 mm
+
Cord Lock
cord lock - small
+

#05. Barrel Release

Barrel Release Base
leechline
08/64 x 530 mm
+
Barrel Release Base - Knot
leechline
08/64 x 375 mm
+
Stop Base
leechline
05/64 x 60 mm
Overhand Knot
+
Stop Sleeve
tubing, vinyl
24-16/64 x 25 mm
+
Brake
leechline
08/64 x 40 mm
+
Barrel Release Pin
Aerolite Stainless Steel Straight Release Pin
+
Barrel
tubing, aluminum
6061 T6
A1118
24/64-.058 (.259 ID) x 4 inch
+
Adhesive
Sears Craftsman Formula 300 hot glue
+
Grip
heat shrinkable tubing
0.3750 inch - red x 103 mm
+

#06. Adjusters

Barrel Release Adjuster - Becket Bend
leechline
08/64 x 640 mm
+
Barrel Release Adjuster - Becket Bend - Sleeve
tubing, vinyl
24-16/64 x 25 mm
+
Barrel Release Adjuster - Becket Bend - Sleeve Marker
heat shrinkable tubing
0.3750 inch - red x 29 mm
+
Four-String Release Adjuster - Becket Bend
leechline
08/64 x 200 mm
+
Four-String Release Adjuster Sleeve
tubing, vinyl
24-16/64 x 25 mm
+
Four-String Release Adjuster Sleeve Marker
heat shrinkable tubing
0.3750 inch - green x 29 mm
+
Adjuster - Lark's Head

leechline
08/64 x 420 mm
+
Secondary Bridle Snap Shackle - Port
Wichard Stainless Steel Fixed Bail Snap Shackle - 2470
+
Secondary Bridle Snap Shackle - Starboard
Wichard Stainless Steel Fixed Bail Snap Shackle - 2470
+

#07. Emergency Releases

`A. Remote Barrel - Modifications

Base
leechline
05/64 x 900 mm
+
Linkage
leechline
03/64 x 460 mm
030 - ends doubling
003 - aft eye length
+
Lanyard
leechline
05/64 x 375 mm
15 mm - end doubled
+

`B. Four-String

Base
leechline
05/64 x 2765 mm
+
Cleat
Clamcleat CL263 Micro Cleat
+
Cleat Screw - Fore
oval head Phillips, stainless steel
06-32 x 10 mm (0.50)
+
Cleat Washer - Fore
washer, stainless steel
06
+
Cleat Nylock - Fore
stainless steel
06-32
+
Cleat Screw - Aft
oval head Phillips, stainless steel
06-32 x 10 mm (0.50)
+
Cleat Washer - Aft
washer, stainless steel
06
+
Cleat Nylock - Aft
stainless steel
06-32
+
Cleat Guard
bungee
04/64 x 150 mm
Fisherman's Knot
+

#08. Shear Links

`A. Tow Line

`a. Body

Base - Light
leechline
06/64
+
Base - Heavy
leechline
08/64
+
Fairing - Light
heat shrinkable tubing
0.2500 inch
+
Fairing - Heavy
heat shrinkable tubing
0.3750 inch
+

`b. Hardware

i. Fore

Tug Bridle Thimble
      RF2180 Ronstan Sailmaker's Thimble
+
Tow Line Thimble
      RF2180 Ronstan Sailmaker's Thimble
+

                        ii. Aft

Tow Line Thimble
      RF2180 Ronstan Sailmaker's Thimble
+
Tow Ring
      RF2182 Ronstan Sailmaker's Thimble
+

                  `c. Coupler

Base
      leechline
      08/64 x 100 mm
+
Thimble
      RF2182 Ronstan Sailmaker's Thimble
+

            `B. Ribbon Bridle

Base, Triple Option Ribbon
      leechline
      06/64
+
Base, Quadruple Option Ribbon/Line
      leechline
      06/64
+
Primary/Secondary Shear Link Fairing
      heat shrinkable tubing
      0.2500 inch
+
Thimble
      RF2180 Ronstan Sailmaker's Thimble
+

            `C. Bridle Link

Base
      leechline
      06/64
+
Fairing
      heat shrinkable tubing
      0.2500 inch x 50 mm
+
Thread, Identification
      Coats and Clark
      Dual Duty XP
+

      #09. Break Links

Primary
      Braided Dacron Trolling Line
      130 lb.
+
Secondary
      leechline
      05/64
+

      #10. Basetube Assembly Installation Kit

Pipe, PVC
      .838-.599 (3/4) x 6 inch
      longitudinal guidelines through opposite points
      notches at insertion end at guidelines ends
      depth indicator line around circumference at 4 inches
      end caps - 50157 - 2
+
Tubing, Aluminum
      6061 T6
      A1118
      24/64-.058 (.259 ID) x 5.25 inch
      lined and notched as above
+
Bungee
      bungee
      08/64 x 18 inch
+
Washer, Fender
      08 - 48-11/64
      00325
+
Cord Lock
+
Assembly Pin

      steel
      rounded ends
      08/64 x 0.99 inch
+
Installation Pin
      steel
      rounded ends
      1/8 x 1.25 inch
+

      #11. Four-String Release Cleat Installation Tools

Four-String Release Cleat Installation Tool - Fore
      tubing, polyethylene
      11-08/64 x 16 mm
+
Four-String Release Cleat Installation Tool - Aft
      tubing, polyethylene
      11-08/64 x 16 mm
+

      #13. Tow Tension Gauges

            `A. Shear

Base
      Sta-Set
      12/64 inch
+
Breaker
      leechline
      10/64 inch
+
Sleeve - Fore
      tubing, vinyl
      32-24/64 x 3 inch
+
Sleeve - Aft
      tubing, vinyl
      24-16/64 x 1 inch
+
Thimble - Fore
      RF2182 Ronstan Sailmaker's Thimble
+
Thimble - Aft
      RF2182 Ronstan Sailmaker's Thimble
+
            `B. Hydraulic

Cylinder
      Hydraulic Cylinder
      Bimba H-091-DUZ
+
Thread Sealer
      Teflon tape
      8 inches
+
Adapter
      NPT thread adapter
      1/8 inch male to 1/4 inch female
+
Fluid
      soybean oil
+
Gauge
      Flowfit 0-500 PSI Pressure Gauge
+
Breather
      Shraeder valve and cap
      NPT threads
      1/8 inch male
+
Pin
      Bimba D-8322-A Pivot Bracket
      pin
      E-clips
+
Washers, Inner
      washers, steel
      16/64 x 2
+
Washers, Outer
      washers, nylon
      16/64 x 2
+
Bridle
      leechline
      06/64 x 290 mm
+
Rod Clevis
      Bimba D-8309-A Rod Clevis
+
Boot
      Harken H369 Stand-Up Boot, Small
+
Loop Base

leechline
08/64 x 210 mm
+
Loop Sleeve
tubing, vinyl
24-16/64 x 35 mm
+
Tow Ring
RF2182 Ronstan Sailmaker's Thimble
+
Rod Clevis Sleeve
tubing, vinyl
48-40/64 x 80 mm
+
Guide
tubing, polyethylene
12-08/64 x 165 mm
+
Retainers
rubber bands
2
+
Lanyard
leechline
05/64 x 2800 mm
+

~42. Components - Wills Wing U2

#01. Actuation

`A. Basetube Assembly

`a. VG Cleat

Screws - Fore and Aft
Phillips pan head, stainless steel
06-32 x 7.5 mm (0.375)
+
Nylocks - Fore and Aft
stainless steel
06-32
+

`b. Wheel Stops

Starboard
leechline
10/64
+
Port
webbing, nylon
.5 inch
+

`c. Basetube Pulley Assembly

Screw
Phillips pan head, stainless steel
06-32 x 53.5 mm (2.25)
+
Axle
pin - aluminum
< 1/8 x 36.5 mm
+
Shims - Axle
tubing, vinyl
12-08/64
+
Shims - Screw
tubing, polyethylene
12-08/64
+

`d. Bungee Assembly

VG Cleat Collar
Pro Flex PFTC4 Loop Connector - .25 inch
+
Extension - Base
leechline
08/64 x 400 mm
+
Extension - Sleeve
tubing, vinyl
28-20/64 x 055 mm
+
Bushing
tubing, polyethylene
20/64-.233 x 1-26/64 inch
+
Stop - Fore
tubing, vinyl
16/64-.170 x 24/64 inch
+
Stop - Aft
tubing, vinyl

16/64-.170 x 24/64 inch
+

`e. Cotter Pin Lanyard Assembly

Cotter Pin Lanyard
leechline
05/64 x 300 mm
+

#02. Downtube Pulley Mounting

Pin
RWO Clevis Pin 6731
12/64 x 1-3/16
+
Washer
washer, nylon
08 - 24-12/64
+

#03. Primary Release Assembly Mounting

Tang
Wills Wing 20E-2206 Tang
+
Thimble
Loos Standard Thimble
stainless steel
LSAN100C3
03-06/64
+
Harness
leechline
05/64 x 300 mm
+
Bolt
AN4-22

~43. Drilling

(inches) - diameter - from end

#01. Basetube

Bungee Anchor/Basetube Pulley - Fore/Aft
09/64 - 4

Leader
09/64 - 4 10/64

#02. Downtube

Lanyard Conduit - Lower/Upper
08/64 - 8 - 3

Downtube Pulley
12/64 - 24/64
(existing)

~44. Materials

#01. Company

Aerolite

M111S Aerolite Stainless Steel Straight Release Pin

shaft cross section with respect to plane of eye - inches
.100 - coplanar
.125 - perpendicular

ParaGear
www.para-gear.com
+
Annapolis Performance Sailing

Loos & Company SM6682 End Eye

Pro Flex
.25 inch
PFRSB4 - Dead End
PFTC4   - Loop Connector

Wichard Stainless Steel Fixed Bail Snap Shackle - 2470

Yale Cordage Crystalyne - 06/64 inch

www.apsltd.com
+
Bainbridge International
(Howe & Bainbridge)

Aquabatten Dacron Leechline

/64

breaking strengths (pounds)

E330 - 03 - 040
E331 - 04 - 050
E332 - 05 - 205
E334 - 08 - 505
E335 - 10 - 767

www.bainbridgeint.com
www.fisheriessupply.com
+
CSR, Inc.
Sellersville PA

Ultra High Molecular Weight
Polyethylene Braids
Spectra
Stretched
Synthetic Finish

CSR Style 9516-
      1000
            2000'
      2000
            0550'

www.csrbraids.com
+
CableOrganizer.com
866-222-0030

heat shrinkable tubing
polyolefin
2:1
HS2-
0188FT-
      RD - Red
0250FT-
0375FT-
      BK - Black
      GY - Gray
      CL - Clear
      WT - White
      RD - Red
      OR - Orange
      YL - Yellow
      GN - Green
      BL - Blue
      PL - Purple
1500FT-
      RD - Red

http://cableorganizer.com/
+
Clamcleat

Holt
Holt Allen

Clamcleat CL263 Micro Cleat
      fasteners - 3 mm / 1/8 / No. 4
      line diameter - 1-4 mm

www.clamcleat.com
www.fisheriessupply.com
+
Coats and Clark

Dual Duty XP
Corespun Polyester
General Purpose
125 yards

0900 - black
0620 - slate
0100 - white
2250 - red
7640 - orange
7330 - yellow
6450 - bright green
4320 - blue
3690 - purple

www.coatsandclark.com
Jo-Ann Fabrics and Crafts
www.joann.com
+
Cortland Line Company, Inc.
Cortland NY 13045

Greenspot
IGFA Class
International Game Fish Association
Braided Dacron Trolling Line
1 mm
130 lb. test

60 KG
STK 163294
43372

www.cortlandline.com
+
Harken Yacht Equipment

16 mm Fixed Single AirBlock
	load - pounds
		0250 - SWL - sheave
		0700 - SWL - housing - minimum
		1200 - break
	404
		axle to mounting centers = 14 mm / 9/16 inch
	405 - with Becket
		07 x 16/64 becket
		12.0 grams

www.harken.com
+
K&B True Value
Hardware House

tubing

polyethylene
	24-16/64
	36.1144 grams/meter

vinyl
	12-08/64

http://ww2.truevalue.com/hardwarehouse/
+
Leading Edge Air Foils

tubing, aluminum
	6061 T6
	24/64-.058 (.259 ID)
	99.5902 grams/meter

http://leadingedgeairfoils.com/
+
Loos & Company

SM6682   - End Eye

LSAN100C3 - Standard Thimble

www.loosco.com
+
Marlow Ropes

Excel Vectran

04/64
Tensile Strength:
206 pounds

www.marlowropes.com
+
New England Ropes

Braided Luffline

08/64
0.5 lbs/100'
530 pound BL

www.neropes.com
www.westmarine.com
+
Novatec Braids

Nova Shock

www.novabraid.com
+
Pro Flex Manufacturing, Incorporated
600 Guy Paine Road
Macon GA 31206

478-781-4335
+
Rhode Island Textile Company
Pawtucket RI 02862

Stretch-Rite
Round Cord Elastic
5 yards
White
42% polyester
58% rubber
3960
0 70049 23960 0

www.ritextile.com
Jo-Ann Fabrics and Crafts
www.joann.com
+
Ronstan

Sailmaker's Thimbles
Stainless Steel
Grade 316

RF218-
/32
gm

line
IW
IL
groove width
weight

0	04	11	20	06	03.7
1	05	14	25	07	05.9
2	06	21	34	08	10.1

www.ronstan.com
+
R&W - Rope Warehouse

Dacron leechline
/64
breaking strengths (pounds)
$

03	0150
04	0200
06	0350
08	0530
10	0730
12	1000

www.rwrope.com

www.elwoodbraiding.com
+
RWO Marine Equipment Limited

RWO Clevis Pins

www.rwo-marine.com
+
Sears

Craftsman E-Z Fix Sticks, Multipak
Oval Glue Stick Variety Pack
80485
Formula 300
	very sticky and flexible
	remains tacky for a while allowing for some repositioning

www.sears.com
+
United States Plastic Corporation
1390 Neubrecht Road
Lima OH 45801-3196

Type H Nylon Tubing
08-05/64
58027

www.usplastic.com
+
Wichard

1401 "D" Shackle - Captive Pin
	4 mm diameter
	load - KG
		0400 - functional
		1000 - break

Stainless Steel Fixed Bail Snap Shackle - 2470
	load - KG
		0200 - functional
		0400 - break

www.wichard.com
+
Yale Cordage

Crystalyne

06/64 inch
breaking strength - pounds:
1000

www.yalecordage.com
www.apsltd.com
*
YKK Zippers

Yoshida Kogyo Kabushikikaisha
Yoshida Company Limited

Outdoor Wilderness Fabrics
www.owfinc.com

Sailrite
http://sailrite.com/
+

#02. Generic

floss, nylon
load - pounds
8.3 - break
+

~45. Credit

Bite controlled multiple string releases have been developed for surface towing by Rob McKenzie in southern California and for aerotowing in eastern Europe circa 1990. The basis for concept described herein was reinvented at the beginning of the 2005 season by Steve Kinsley of Washington, DC.

~46. Links

skysailingtowing
http://groups.yahoo.com/group/skysailingtowing/
+
Skyting Criteria
http://www.birrendesign.com/rhgpa_criteria.html
+
T-Dolly
http://home.golden.net/~jpop/
+
Tost

www.tost.de
www.wingsandwheels.com
+

Tad Eareckson
TadErcksn
at
aoldotcom

2009/06/20