Silent Wings Soaring Association

March 2015

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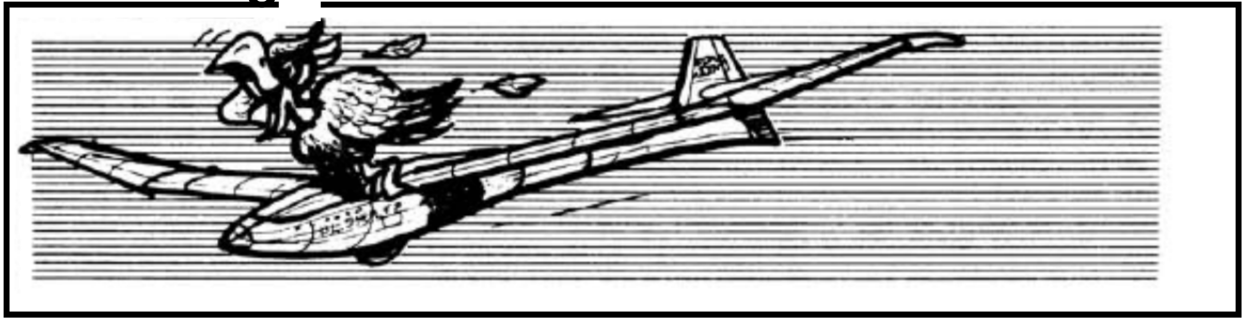
Soaring



Keith **Kindrick** **March** 2015

Over the last couple years new batteries have surfaced making the choices for the right application a little confusing. Many people have been using 5 cells to make the servos faster. Some people like the 4 cell packs just because it is a standard solution with wall chargers available to support them. Manufacturers have been slow to adopt new battery types because they have to be sure anything new works with a high degree of certainty. You see a few of the current radios with new cell types. It's not always easy to convert transmitters from the NiCad/NiMh cells to a LiFe/LiPo due to the space needed. Another drawback might be the charging of them. Transmitters have charge circuits in them to prevent over charging NiCad/NiMh cells. New cells have higher voltage and require you to remove them for charging which is not always convenient.

When I look back at the last decade my batteries were all NiCad's which lasted easily 4 years. Once I started to switch to the new (at the time) NiMh cells I had problems keeping them at full capacity for 3 years.

Since most of us need a certification course to get up to speed let's go to Batteryuniversity.com to get the education we need for battery types and uses.

Nickel-cadmium (NiCd)

The nickel-cadmium battery, invented by Waldmar Jungner in 1899, offered several advantages over lead acid, but the materials were expensive and the early use was restricted. Developments lagged until 1932 when attempts were made to deposit the active materials inside a porous nickel-plated electrode. Further improvements occurred in 1947 by trying to absorb the gases generated during charge. This led to the modern sealed NiCd battery in use today.

For many years, NiCd was the preferred battery choice for two-way radios, emergency medical equipment, professional video cameras and power tools. In the late 1980s, the ultra-high-capacity NiCd rocked the world with capacities that were up to 60 percent higher than the standard NiCd. This was done by packing more active material into the cell, but the gain was met with the side effects of higher internal resistance and shorter cycle.

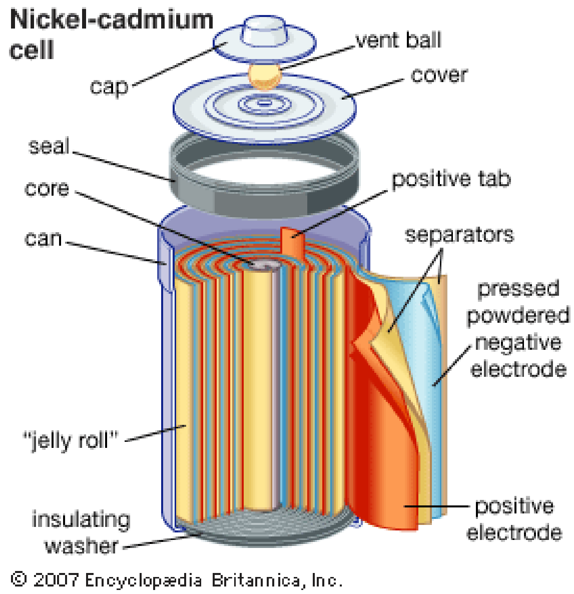
The standard NiCd remains one of the most rugged and forgiving batteries but needs proper care to attain longevity. It is perhaps for this reason that NiCd is the favorite battery of many engineers.

Advantages

- Fast and simple charging even after prolonged storage
- High number of charge/discharge cycles; provides over 1,000 charge/discharge cycles with proper maintenance
- Good load performance; rugged and forgiving if abused
- Long shelf life; can be stored in a discharged state
- Simple storage and transportation; not subject to regulatory control
- Good low-temperature performance
- Economically priced; NiCd is the lowest in terms of cost per cycle
- Available in a wide range of sizes and performance options

Limitations

- Memory effect; needs periodic full discharges
- High self-discharge; needs recharging after storage



Nickel-metal-hydride (NiMH)

Research of nickel-metal-hydride started in 1967; however, instabilities with the metal-hydride led scientists to develop the nickel-hydrogen battery (NiH) instead. Today, NiH is mainly used in satellites.

New hydride alloys discovered in the 1980s offered better stability and the development of NiMH advanced in earnest. Today, NiMH provides 40 percent higher specific energy than a standard NiCd, but the decisive advantage is the absence of toxic metals.

The advancements of NiMH are impressive. Since 1991, the specific energy has doubled and the life span extended.

NiMH also has high self-discharge and loses about 20 percent of its capacity within the first 24 hours, and 10 percent per month thereafter. What is of ongoing concern to the consumer using rechargeable batteries is the high self-discharge, and NiMH behaves like a leaky basketball or bicycle tire. A flashlight or portable entertainment device with a NiMH battery gets "flat" when put away for only a few weeks. Having to recharge the device before each use does not sit well. The Eneloop NiMH by Sanyo has reduced the self-discharge by a factor of six. This means that you can store the charged battery six times longer than a regular NiMH before a recharge becomes necessary. The drawback is a slightly lower specific energy compared to a regular NiMH. Other NiMH manufacturers such as ReCyko by GP claim similar results.

There are strong opinions and preferences between battery chemistries, and some experts say that NiMH will serve as an interim solution to the more promising lithium systems. There are many hurdles surrounding Li-ion also and these are cost and safety. Li-ion cells are not offered to the public in AA, AAA and other popular sizes in part because of safety. Even if they were made available, Li-ion has a higher voltage compared to nickel-based batteries.

Advantages

- 30–40 percent higher capacity than a standard NiCd
- Less prone to memory than NiCd
- Simple storage and transportation; not subject to regulatory control
- Environmentally friendly; contains only mild toxins
- Nickel content makes recycling profitable

Limitations

- Limited service life; deep discharge reduces service life
- Requires complex charge formulas
- Does not absorb overcharge well; trickle charge must be kept low
-
- Generates heat during fast-charge and high-load discharge
- High self-discharge; chemical additives reduce self-discharge at the expense of capacity
- Performance degrades if stored at elevated temperatures; should be stored in a cool place at about 40 percent state-of-charge

Figure 1 below gives you the visual image of how the Eneloop NiMh performs at a higher voltage over time at a continuous discharge at 500mah at 77 Deg F (25C).

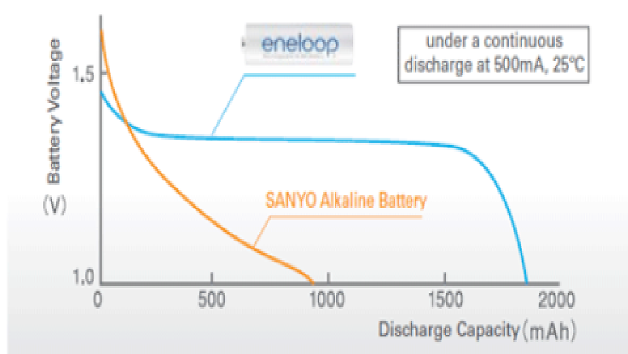


Figure 1

Types of Lithium-ion
Become familiar with the many different types of lithium-ion batteries.

The casual battery user may think there is only one lithium-ion battery. As there are many species of apple trees, so do also lithium-ion batteries vary and the difference lies mainly in the cathode materials. Innovative materials are also appearing in the anode to modify or replace graphite. Scientists prefer to name batteries by their chemical name and the material used, and unless you are a chemist, these terms might get confusing. The table below offers clarity by listing these batteries by their full name, chemical definition, abbreviations and short form. family.

Chemical name	Material	Abbreviation	Short form	Notes
Lithium Cobalt Oxide[1] Also Lithium Cobalate or lithium-ion-cobalt)	$LiCoO_2$ (60% Co)	LCO	Li-cobalt	High capacity; for cell phone laptop, camera
Lithium Manganese Oxide[1] Also Lithium Manganate or lithium-ion-manganese	$LiMn_2O_4$	LMO	Li-manganese, or spinel	Most safe; lower capacity than Li-cobalt but high specific power and long life. Power tools, e-bikes, EV, medical, hobbyist.
Lithium Iron Phosphate[1]	$LiFePO_4$	LFP	Li-phosphate	
Lithium Nickel Manganese Cobalt Oxide[1], also lithium-manganese-cobalt-oxide	$LiNiMnCoO_2$ (10–20% Co)	NMC	NMC	
Lithium Nickel Cobalt Aluminum Oxide[1]	$LiNiCoAlO_2$ 9% Co)	NCA	NCA	Gaining importance in electric powertrain and grid storage
Lithium Titanate[2]	$Li_4Ti_5O_{12}$	LTO	Li-titanate	

Lithium Iron Phosphate ($LiFePO_4$) ***(what most of us know as LiFe)***

In 1996, the University of Texas (and other contributors) discovered phosphate as cathode material for rechargeable lithium batteries. The key benefits are enhanced safety, good thermal stability, tolerant to abuse, high current rating and long cycle life. Storing a fully charged battery has minimal impact on the life span. As trade-off, the lower voltage of 3.3V/cell reduces the specific energy to slightly less than Li-manganese. In addition, cold temperature reduces performance, and elevated storage temperature shortens the service life.

Li-polymer Battery: Substance or Hype?

The *polymer* hype of the early 2000s is still going strong, however, most users cannot distinguish between a regular Li-ion and one with polymer architecture. Lithium-polymer differs from other battery systems in the type of electrolyte used. The original polymer design dating back to the 1970s uses a solid (dry) polymer electrolyte that resembles a plastic-like film.

To make the modern Li-polymer battery conductive at room temperature, gelled electrolyte is added. All Li-ion polymer cells today incorporate a micro porous separator with moisture. The correct term is "Lithium-ion polymer" (Li-ion polymer or Li-polymer for short). Li-polymer can be built on many systems, such as Li-cobalt, NMC, Li-phosphate and Li-manganese. For this reason, Li-polymer is not considered a unique battery chemistry. Most Li-polymer packs for the consumer market are based on Li-cobalt.

With gelled electrolyte added, what then is the difference between a normal Li-ion and Li-ion polymer? As far as the user is concerned, the lithium polymer is essentially the same as the lithium-ion battery. Both use identical cathode and anode material and contain a similar amount of electrolyte. Although the characteristics and performance of the two systems are alike, the Li-polymer is unique in that a micro porous electrolyte replaces the traditional porous separator. The gelled electrolyte becomes the catalyst that enhances the electrical conductivity. Li-polymer offers slightly higher specific energy and can be made thinner than conventional Li-ion, but the manufacturing cost increases by 10–30 percent. Despite the cost disadvantage, the market share of Li-polymer is growing.

Li-polymer cells also come in a flexible foil-type case (polymer laminate or pouch cell) that resembles a food package. While a standard Li-ion needs a rigid case to press the electrodes together, Li-polymer uses laminated sheets that do not need compression. A foil-type enclosure reduces the weight by more than 20 percent over the classic hard shell. Furthermore, thin film technology liberates the format design and the battery can be made into any shape, fitting neatly into stylish cell phones and laptops to make them smaller, thinner and lighter. Li-polymer can be made very slim to resemble a credit card.

Charge and discharge characteristics of Li-polymer are identical to other Li-ion systems and do not require a special charger. Safety issues are also similar in that protection circuits are needed. Gas buildup during charge can cause some Li-polymer in a foil package to swell. Li-polymer in a foil package may be less durable than Li-ion in the cylindrical package. Li-polymer is not limited to a foil package and can also be made into a cylindrical design.

Advantages

- High energy density
- Relatively low self-discharge; less than half that of NiCd and NiMH
- Low maintenance. No periodic discharge is needed; no memory.

Limitations

- Requires protection circuit to limit voltage and current
- Subject to aging, even if not in use (aging occurs with all batteries and modern Li-ion systems have a similar life span to other chemistries)
- Transportation regulations when shipping in larger quantities

Cycling Performance

(How NiCd, NiMH and Li-ion perform when put to the test)

To compare older and newer battery systems, Cadex tested a large volume of nickel-cadmium, nickel-metal-hydride and lithium ion batteries used in portable for communication devices. Preparations included an initial charge, followed by a regime of full discharge/charge cycles at 1C. The tables show the capacity in percent, DC resistance measurement and self-discharge obtained from time to time by reading the capacity loss incurred during a 48-hour rest period. The tests were carried out on the Cadex 7000 Series battery analyzers.

Nickel-cadmium

In terms of life cycling, nickel-cadmium is the most enduring battery. Figure 2 illustrates the capacity, internal resistance and self-discharge of a 7.2V, 900mA pack with standard NiCd cells. Due to time constraints, the test was terminated after 2,300 cycles. The capacity remained steady; the internal resistance stayed low at 75mWand the self-discharge was stable. This battery receives a grade "A" rating for almost perfect performance.

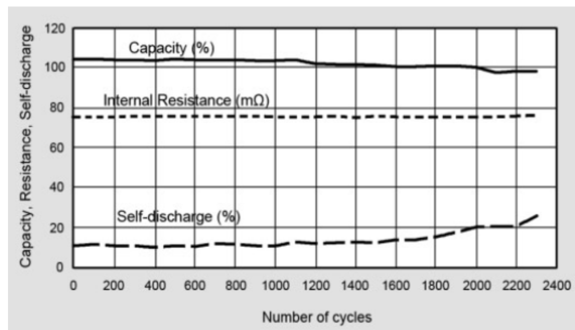


Figure2

Nickel-metal-hydride

Figure 3 examines NiMH, a battery that offers high specific energy but loses capacity after the 300-cycle mark (Blue Triangle). There is also a rapid increase in internal resistance after cycle count 700 (Red Triangle) and rise in self-discharge after 1000 cycles. The test was done on an older generation NiMH. *(this clearly shows the reason why I had problems when I switched over to these cells – KK)*

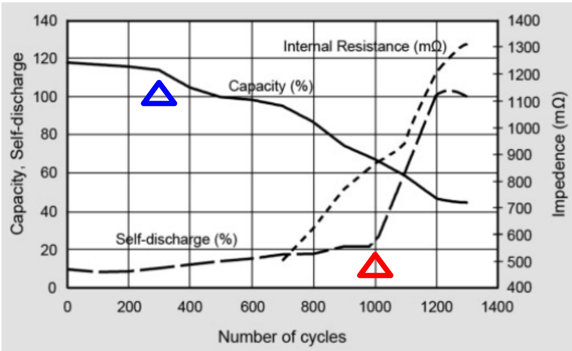


Figure 3

Lithium-ion

Figure 4 examines the capacity fade of a modern Li-ion Power Cell at a 2A, 10A 15A and 20A discharge. Stresses increase with higher load currents, and this also applies to rapid and ultra-fast charging.

Li-ion manufacturers often do not specify the rise of internal resistance and self-discharge as a function of cycling. Advancements have been made with electrolyte additives to keep the resistance low through most of the battery life. The self-discharge of Li-ion is low and is in par with lead acid.

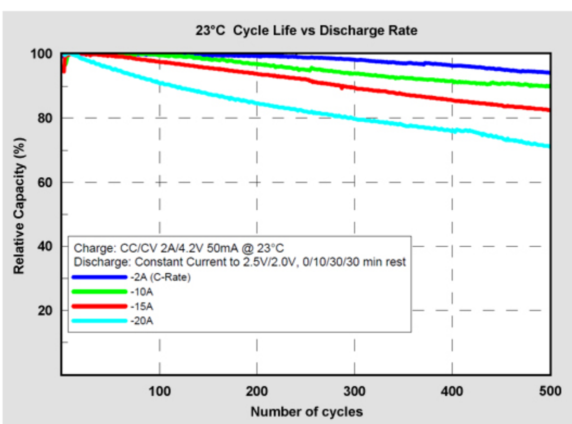


Figure 4

A good reason for changing the way you select a battery type is for voltage and self-discharging. NiMh cells for me do not last nearly as long unless you manage them all the time through a trickle charge. Digital servos have a need for a higher voltage to maintain their performance. Figure 5 shows what happens when you remove the battery from the charger and start using it. A123 cells (LiFe @ 3.3 volts nominal) came on line as a way to solve the need for higher sustained power. In figure 5 you can clearly see these cells stabilize off the charger at a higher voltage than the NiMh cells do. This however, creates another problem with receivers and servos not rated to handle this higher voltage. I found out early on before the 6 volt servos appeared you could easily damage servos without regulating the voltage to a lower level. Figure 6 shows how to wire a Battery Eliminator Circuit (BEC) 10 amp peak voltage regulator from Castle http://www.castlecreations.com/products/ccbec.html I'm very impressed with all of the Castle products and this BEC is no exception because you can have adjustable voltage from 4.8 to 9.0 volts (I typically run at 5.6 volts for the receiver inside my gliders).

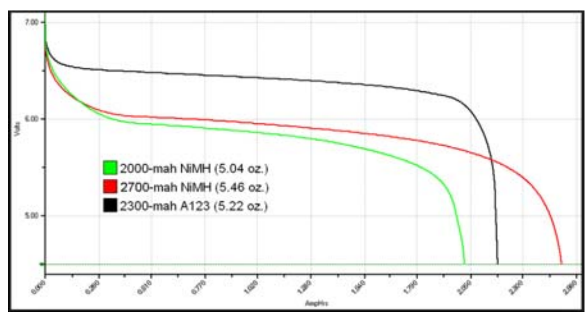


Figure 5

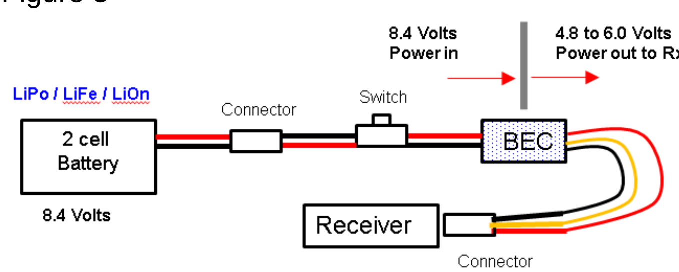


Figure 6

When you use a BEC there is no limit to what type of battery cell you use. It will safely lower the voltage down to the receiver prior to entering it as long as you set the correct voltage.

Ultra-fast Chargers

Ultra-fast chargers have been around for many years. Most NiCd and specialty types of Li-ion batteries, can be charged at a very high rate up to 70 percent state-of-charge (SoC). At a rate of 10C or 10 times the rated current, a 1A battery could theoretically be charged in six minutes, but there are limits. To apply an ultra-fast charge, the following conditions must be observed:

- The battery must be designed to accept an ultra-fast charge. Current handing poses limitation with many pack designs.
- Ultra-fast charging only applies during the first charge phase. The charge current must be lowered when the 70 percent state-of-charge threshold is reached.
- All cells in the pack must be balanced and in good condition. Older batteries with high internal resistance will heat up; they are no longer suitable for ultra-fast charging.
- Ultra-fast charging can only be done under moderate temperatures. Low temperature slows the chemical reaction, and energy that cannot be absorbed causes gassing and heat buildup.
- The charger must include temperature compensations and other safety provisions to halt the charge if the battery gets unduly stressed. Failure to heed to these conditions could cause rapid disintegration of the battery and fire.

An ultra-fast charger can be compared to a high-speed train that is capable to travel 300km per hour (188 mph) on a track built for it. The tracks, and not the machinery, govern the maximum speed. Adding power to a charger is relatively simple; the intelligence lies in assessing the condition of the battery and applying the right amount of maximum charge. A properly designed ultra-fast charger will lower the current when certain conditions occur. In essence, only newer batteries can be ultra-fast charged.

Do not ultra-fast charge batteries if possible and charge at a more moderate rate of 1C or less. Figure below compares the cycle life of a lithium-ion battery when charged and discharged at 1C, 2C and 3C. A 1C charge and discharge cycle causes the capacity drop from 650mAh to 550mAh after 500 cycles, reflecting a decrease to 84 percent. A 2C accelerates capacity fade to 310mAh, representing a decrease to 47 percent, and with 3C the battery fails after only 360 cycles with 26 percent remaining capacity.

As seen figure 5 the harder you drive the cells the worse their performance will be.

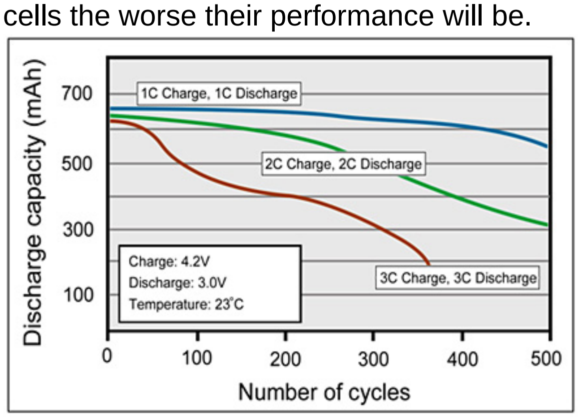


Figure 5

Balancing Cells

Most of the new chargers have a way to balance each cell. Battery balancing and battery redistribution refer to techniques that maximize a battery's capacity to make all of its energy available for use and increase the battery's longevity. A battery balancer or battery regulator is a device in a charger that performs battery balancing. Typically, the individual cells in a battery have somewhat different capacities and may be at different levels of state of charge (SOC). Without redistribution, discharging must stop when the cell with the lowest capacity is empty (even though other cells are still not empty); this limits the energy that can be taken from and returned to the battery.

Without balancing, the cell of smallest capacity is a "weak point", it can be easily overcharged or over-discharged while cells with higher capacity undergo only partial cycle. For the higher capacity cells to undergo full charge/discharge cycle a balancer should “protect” the weaker cells; so that in a balanced battery, the cell with the largest capacity can be filled without overcharging any other (i. e. weaker, smaller) cell, and it can be emptied without over-discharging any other cell. Battery balancing is done by transferring energy from or to individual cells, until the SOC of the cell with the lowest capacity is equal to the battery's SOC.

Battery redistribution is sometimes distinguished from battery balancing by saying the latter stops at matching the cell's state of charge (SOC) only at one point (usually 100% SOC), so that the battery's capacity is only limited by the capacity of its weakest cell. Figure 6 shows how the battery cells are wired internally to accomplish this in LiPo / LiOn / LiFe battery pack.

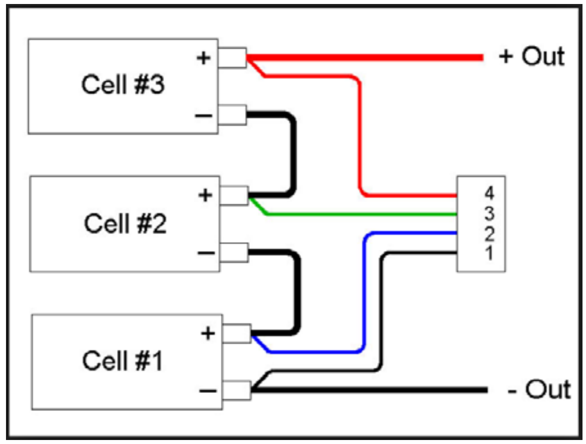


Figure 6

What have we learned?

Nickel-cadmium (NiCd)

- ✓ NiCd remains one of the most rugged and forgiving batteries but needs proper care to attain longevity.
- ✓ It is perhaps for this reason that NiCd is the favorite battery of many manufacturers.

Nickel-metal-hydride (NiMH)

- ✓ 30–40 percent higher capacity than a standard NiCd.
- ✓ Less prone to memory than NiCd. NiMH also has high self-discharge and loses about 20 percent of its capacity within the first 24 hours, and 10 percent per month thereafter.

Lithium Iron Phosphate($LiFePO_4$)

- ✓ High energy density.
- ✓ Relatively low self-discharge; less than half that of NiCd and NiMH.
- ✓ Low maintenance.
- ✓ No periodic discharge is needed; no memory.
- ✓ Requires protection circuit to limit voltage and current.
- ✓ Subject to aging, even if not in use

Cycling Performance

- ✓ In terms of life cycling, nickel-cadmium is the most enduring battery.
- ✓ NiMH as battery that offers high specific energy but loses capacity after the 300-cycles. There is also a rapid increase in internal resistance after 700 cycles. A rise in self-discharge after 1000 cycles.
- ✓ Li-ion Power Cells at a 2A, 10A 15A and 20A discharge rates have increased stress with higher load currents, and this also applies to rapid and ultra-fast charging. (Li-ion manufacturers often do not specify the rise of internal resistance and self-discharge as a function of cycling. Advancements have been made with electrolyte additives to keep the resistance low through most of the battery life)
- ✓ The self-discharge of Li-ion is low and is in par with lead acid.

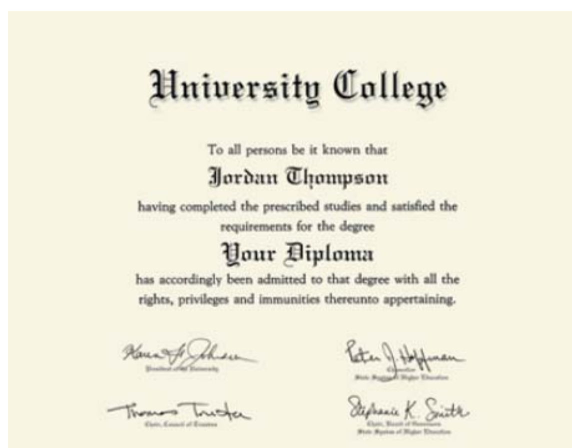
Ultra-Fast Chargers

- ✓ Do not ultra-fast charge batteries if possible and charge at a more moderate rate of 1C or less.
- ✓ A 1C charge and discharge cycle causes the capacity drop from 650mAh to 550mAh after 500 cycles, reflecting a decrease to 84 percent.
- ✓ A 2C accelerates capacity fade to 310mAh, representing a decrease to 47 percent.
- ✓ At 3C the battery fails after only 360 cycles with 26 percent remaining capacity.

Balancing Cells

- ✓ Without balancing, the cell of smallest capacity is a "weak point", it can be easily overcharged or over-discharged while cells with higher capacity undergo only partial cycle.

That concludes our certification course for Battery University! Congratulations!


University College

To all persons be it known that

Jordan Thompson

having completed the prescribed studies and satisfied the requirements for the degree

Your Diploma

has accordingly been admitted to that degree with all the rights, privileges and immunities thereunto appertaining.

Let's ALL Fly!

That is it for this month.

Thermals to all ~ Keith

Take a look back in time during the golden years of sailplane design with Part 2 of a 4 Part series by the master of sailplanes Dave Thornburg.

This is CLASSIC information located at the end of this newsletter.

2015 Contest Schedule

DATE	EVENT	CD
Sunday **March 8, 2015**	**SWSA CLUB**	John Barr
Sunday **April 12, 2015**	**SWSA CLUB**	Frank Corsaro
Friday **May 1, 2015**	**CVRC ALES**	CVRC
Saturday & Sunday **May 2-3/2015**	**CVRC Bent Wing**	CVRC
Saturday **May 9, 2015**	**SWSA CLUB**	Henry Rodriguez
Sunday **June 14, 2015**	**SWSA CLUB**	Harvey Jenkins
Saturday & Sunday **June 20-21**	Sacramento	SVSS
Sunday **July 12, 2015**	**SWSA CLUB**	TBD
Sunday **August 9, 2015**	**SWSA CLUB**	Bruce Averson
Sunday **Sept 13 , 2015**	**SWSA CLUB**	James **Smith**
Sunday **Sept TBD, 2015**	**Wilson Cup**	CVRC
Saturday & Sunday **Oct 3-4, 2015**	**VISALIA FSF**	CVRC
Sunday **Oct 11, 2015**	**SWSA CLUB**	Keith **Kindrick**
Sunday **Nov 8, 2015**	**SWSA CLUB**	TBD
TBD **December 2015**	**SWSA Year End Party**	

Silent Wings Soaring Association

March 2015

2015 SC2 Contest Schedule

Sunday March 22	SULA	Field of Dreams
Sunday April 26	SWSA	SWSA
Sunday May 17	VVRC	VVRC
Sunday June 28	Harbor Soaring	Harbor Soaring
Sunday July 19	Inland Soaring	Inland Soaring
Sunday August 23	TOSS	TOSS
Sunday	Club	Location
September 20	SULA	Field of Dreams
Sunday October 18	TPG	TPG
Sunday November 15	Rain Date	

More Information @
www.sc2soaring.com

If you have any events let me know

2015 Holidays and Observances

Apr 5	**Easter Sunday**
Apr 13	**Thomas Jefferson's Birthday**
May 10	**Mothers' Day**
May 25	**Memorial Day**
Jun 21	**Fathers' Day**
Jul 3	**'Independence Day' observed**
Jul 4	**Independence Day**
Sep 7	**Labor Day**
Oct 12	**Columbus Day (Most regions)**
Oct 31	**Halloween**
Nov 11	**Veterans Day**
Nov 26	**Thanksgiving Day**
Dec 24	**Christmas Eve**
Dec 25	**Christmas Day**
Dec 31	**New Year's Eve**

Herb Semmelmeyer's beautiful "Elliptical" multi-task FAI design, featured as a 3-view on page 50. The model shown here was built by Harry Menke, of Santa Rosa, and was flown in the 1976 LSF Tournament held there. Model has a 117-inch span, 1046 sq. in. area.

DESIGNING YOUR OWN SAILPLANE

By DAVE THORNBURG . . . Part Two of a series, Dave discusses the pros and cons of "penetrators" and "floaters", and sets down some design parameters for a hypothetical minimum-sink sailplane.

Last month, amid a flurry of name-dropping and plugs for just about everybody's book but my own (it hasn't found a publisher yet), we discussed airfoils and made a few infuriating generalizations, to wit:

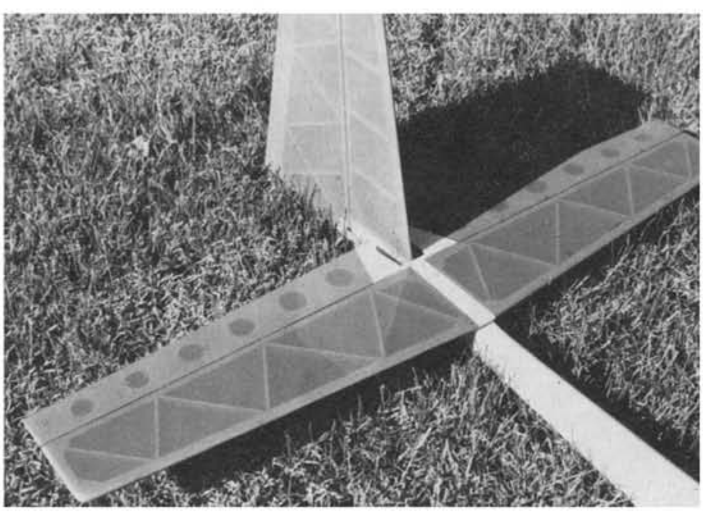
1) Fatter airfoils (10-12% and up) are easier to build and easier to fly than skinny (9% and under) airfoils.
2) Skinny airfoils are generally faster and more efficient than fat ones.
3) Airfoil IS design. The shape of the airfoil (in conjunction with the wing loading) determines the performance range of the sailplane. Everything else is largely cosmetics.

Before we start our actual doodling on paper, let's look at some of the implications of these three points. They can help us make some basic decisions about what we want from our Dream Soarer. After all, we're here to *design* a new sailplane, not merely to draw one. You design for performance, you draw for looks. Right? (Let's hear a little more enthusiasm out there. And turn down that TV, will you?)

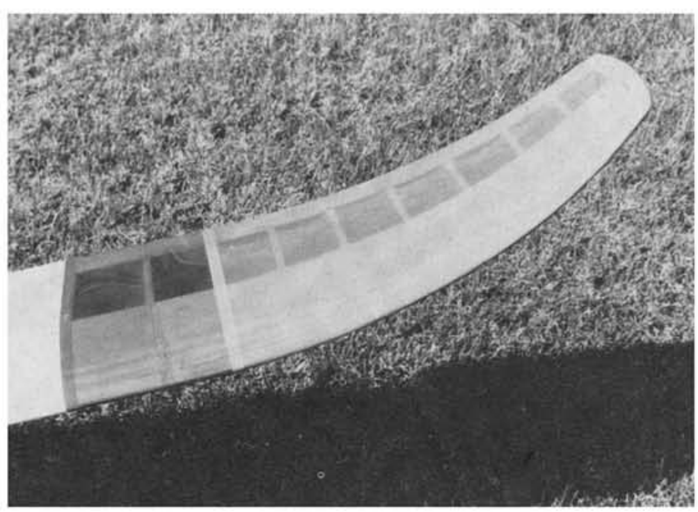
So ask yourself this, for starters: do you want to design a floater or a penetrator? Do you like the slow, gentle, forgiving performance of the Olympic II, or do you prefer the fast, smooth, powerful feel of the Astro Flight ASW-17? This is the basic choice you jave to make, the choice between minimum sink and maximum go. You can't optimize both in a single airplane, because they're at opposite ends of a broad performance spectrum. Only my hero Muhammed Ali can float like a butterfly AND sting like a bee . . . a sailplane has got to settle for doing one or the other.

So which will it be, minimum sink or maximum go?

Minimum sink means the ability to ride very light lift, to stay aloft a little longer in poor conditions, to make a slow and gentle landing after a slow and gentle flight. Minimum sink designs are relaxing and forgiving to fly, and as a consequence they're very popular with beginners and "Sunday fliers" and (surprise!) contest winners as well. (An airplane that's slow and easy to land is a natural for spot-landing accuracy, and since 90% of all American contests are won or lost *on the ground. . .*) It's probably safe to say that "minimum sink" designs represent 70-80% of all kit sales in the U.S. at the present . . . take a poll of at least three flying sites before you disagree . . . so if you opt for minimum sink, you certainly won't be



Simple, functional tail feathers on the Elliptical belie its carefully thought-out design, balanced proportions.



The 18-inch elliptical dihedral wing tips were built on a special jig. Herb soaks the balsa with ammonia to mold it.

alone.

But "maximum go" sailplanes have an appeal all their own. Just ten years ago this winter I got hold of my first one, a Fliteglas Phoebus, and it taught me more about soaring in six months than my four previous years of flying minimum-sink ships had done. Since then, I've owned three Hobie (now Midwest) Hawks, one overweight (34 oz.) Windfree, and two Graupner Cumuluses (Cumuli? Cumulese? Cumulae? Oh, hell . . I owned a Graupner Cumulus, and then another one just like it!). Also a Soarcraft Libelle. All these ships had one thing in common: the liked to move around the sky pretty quickly. Put the nose down and they were *gone*, no questions asked. Slow them up too much in a tight thermal, close to the ground, and you were through flying for the day.

They were like rack-and-pinion racing cars, after years of driving sluggish family sedans. They gave me a sense of power, precision, command, with a little shot of danger thrown in. These ships weren't at the mercy of every gust and bubble . . . they didn't hop and bounce all over the sky like windblown Kleenex, registering every nuance of turbulence, every roll and toss of the restless air. Instead, they went planing about in smooth and graceful arcs, riding invisible rails. They had, as the wine connoisseurs put it, *authority*.

So you see, a case can be made for the ships at either end of the spectrum, and the choice is still yours. I've designed and flown both types in the past, and will probably continue to design and fly both types in the future. Floaters and penetrators each have their own virtues.

Now I hear what you're grumbling about, out there: *why can't we compromise*, you're saying. Why can't we have both minimum sink *and* maximum go in the same airplane? Why does this Thornburg fellow keep talking about floaters and penetrators as if they were in two separate worlds?

Because that's the easiest way to think about them, when you're designing. Obviously, what you finally come up with *will* be a compromise of some sort: either a floater with (hopefully) some ability to penetrate, or a maximum-go machine that will slow down to at least Mach I when you gotta ride light lift. Your Dream Soarer will fall somewhere on the broad spectrum between the "floater" and "penetrator" extremes.

All I'm suggesting is that you be aware of the extremes, and *make a conscious choice to design toward maximizing one of them.* If you try to develop the perfect compromise, the halfway machine, the true floater-penetrator, what you're likely to wind up with is a plane that does everything *adequately* and does nothing *well.* There are plenty of those in kit form at your local hobby shop; why design your own?

GETTING DOWN TO FIGURES

Let's suppose you opt for a floater, and you already have a wingspan in mind . . . say 90 inches. Why 90 inches? Well, why not? I'm a little tired of 72 inches, 100

Dave Thornburg launching the Schweizer 1-29 mentioned in the article, out on the New Mexico flatlands, about 1970. No need for frequency flags when you fly alone!

inches, 120 inches, and other sizes that are dictated either by rules or by rulers. Ninety inches is a nice number. Besides, I had a lovely little Schweizer 1-29 with a 90-inch span, once. Flew great until I wore out the wing, and replaced it with one that had a laminar-flow airfoil, like the full-scale 1-29 has. What a bag of worms! Had to double the wing loading to get a decent glide, and then it flew fine again . . . at about 30 mph! (That's a scale speed of almost 200 mph!)

Standard class floaters usually run about 4 or 5 ounces per linear foot of wingspan, so our 90-inch ship will probably weigh between 30 and 37 ounces. See . . . just by multiplying seven-and-a-half feet by 4, and again by 5, we've got some *nice solid figures* on paper already! Ain't Science wonderful?

Of course, what we're really interested in is *wing loading* . . . the number of ounces that each square foot of wing has to carry. Wing loading is the traditional "yardstick" for comparing different airplanes within a similar size range. You have to be careful how you apply the wing-loading yardstick across *different* size ranges, however, because something very magic takes place as a sailplane grows larger. A certain 600-square-inch plane might be considered a penetrator at 8 ounces per square foot, but when the same airfoil is scaled up to, say, 1400 square inches, it becomes a real floater at that wing loading. To get it back into the penetrator class it may need a wing loading of closer to 11 or 12 ounces per square foot. Engineers dismiss this phenomenon as "scale effect" or "Reynolds number effect", but what it is, basically, is magic. Big airplanes simply fly better than small ones. It doesn't please me to admit this, because I *prefer* smaller airplanes. But it's true.

So what kind of wing loading should our 90-inch floater have? Let's take a quick look at the wing loading chart for some of the popular kits on the market today. The Oly II comes in at 5.9 ounces a foot, the Windrifter at 6.8 . . . and that about brackets it. A figure of six to six-and-a-half also happens to agree pretty closely with my personal prejudices. I feel that the advantages of being much under 6 oz/ft are usually outweighed by the disadvantages, at least for sport flying: superlight structures often prove too fragile to take the knocks, and superlight ships can be at the mercy of unexpected turbulence, especially on landing pattern.

Awright. Now we have a weight range (30-37 ounces) and a wing loading (around 6 to 6.5 ounces per foot) to shoot for. This tells us we're thinking about a 5 or 6 square foot airplane, right? If we decide on 5 square feet, however, we'll need to build it light to hit our 6.5 ounce maximum wing loading . . . 6.5 times 5 is only 32.5 ounces flying weight. Can we expect to build a plane with the wing area of a Cumulus and the weight of a Windfree? Hmmm. . . On the other hand, if we try 6 square feet in our formula, then we have 6.5 times 6, or 39 ounces, to play with. Now *that* sounds

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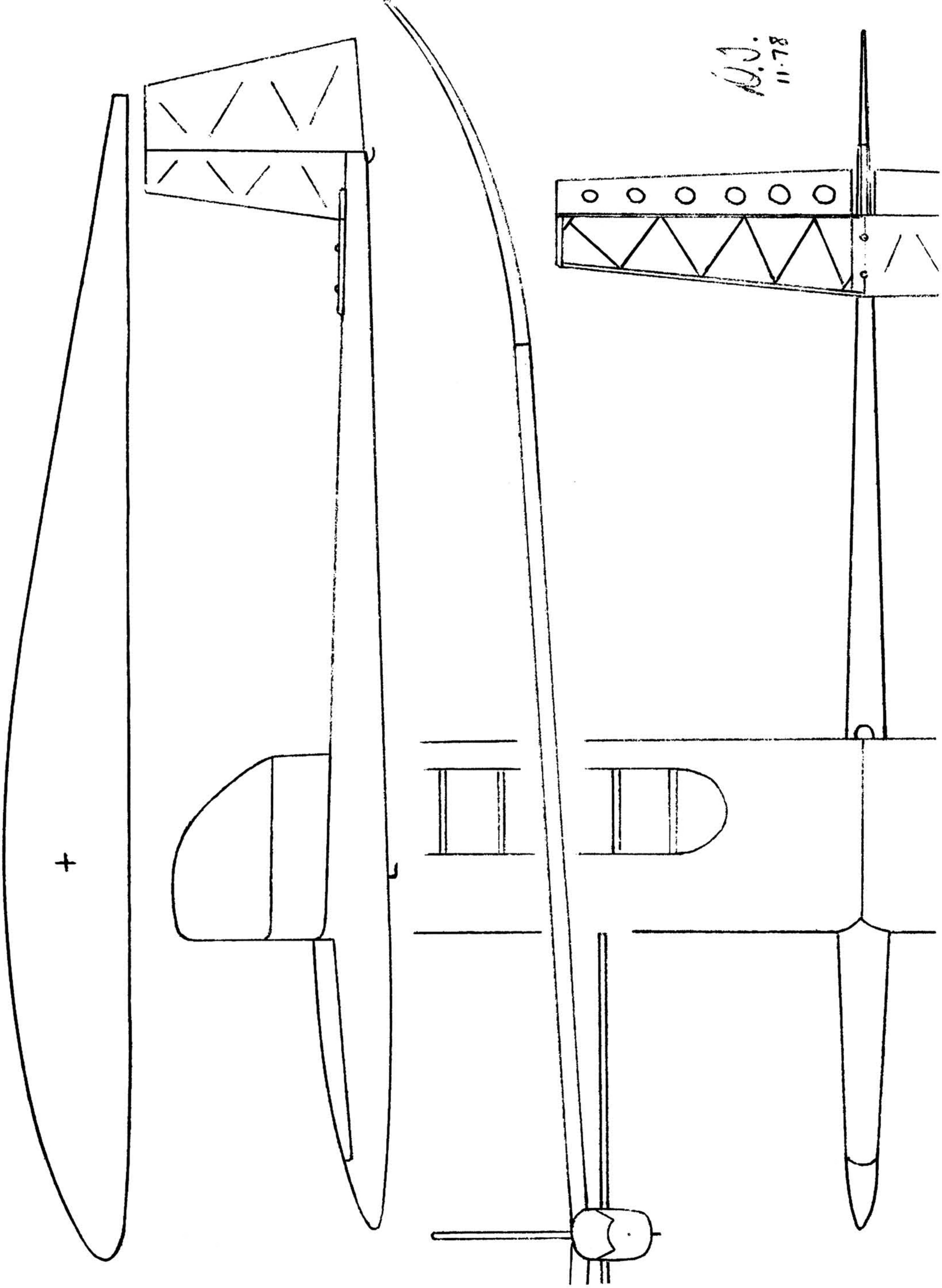
PLANE	SPAN	AREA	WT.	OZ/FT²	AR
Aquila	99	810	40-44	7.5	12.1
ASW-17	132	950	58-62	9.0	18.3
Bird of Time	118	1070	42-44	5.8	13.0
Californian	115	915	40-44	6.6	14.5
Centurion II	99	618	28-32	7.0	15.9
Cumulus 2800	110	753	54-58	10.7	16.0
Grand Esprit	134	1100	64-66	8.5	16.3
Javelin II	134	1005	51-53	7.5	17.9
Legionaire 140	140	1325	65-74	7.5	14.8
Midwest Hawk	99	590	38-40	9.5	16.6
Maestro Mk III	132	990	54-56	8.0	17.6
Olympic II	99	928	37-39	5.9	10.6
Paragon	118	1080	44-46	6.0	12.9
Sailaire	150	1643	120	10.5	13.7
Viking	118	1200	53-55	6.5	11.6
Wanderer 72	72	563	22-24	5.9	9.2
Windfree	99	555	30-32	8.0	17.7
Windrifter/SD-100	99	902	40-45	6.8	10.9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Sailplane Des. . *Continued from page 49*

more reasonable . . . after all an Oly II weighs about that, and has 6.4 feet of wing area.

At this point, some clown is going to ask the inevitable: what's to stop us from making the wing *seven* square feet? Or eight? We may have decided on a 90-inch span, but can't we make the chord as wide as we want to? Who says sailplane wings have got to be long and skinny, anyhow?

Well, the answer to that question is (and the engineers are gonna hate me for this one): *nobody* says they've got to be long and skinny, because *nobody really knows how important aspect ratio is on model sailplanes!*

Aspect ratio, you'll remember, was defined last month as the ratio of length to width (span to chord) of a wing. Thus a 99-inch wing with an average chord of 8 inches has an aspect ratio of 99 ÷ 8 = 12.38, right? You can arrive at this same number by squaring the wingspan and dividing by the wing area, and that's how I prefer doing it . . . "average" wing chords can be a little tricky to figure, sometimes.

The fact is, our current "knowledge" or aspect ratio importance is derived from full-scale theories, and many full-scale theories *simply don't work* when applied to model sizes, weights and speeds . . . in precisely the same way that scientific "laws" of cause and effect break down on the subatomic scale (don't ask a nuclear physicist to predict where an electron is going to be at any time, because he'll have to admit that he can't.).

About all that can be said for sure about aspect ratios is that they seem to be coming down: the current crop of U.S. competition craft are growing stubbier wings. The Graupner "Cirrus", king of the heap eight or ten years back, had an aspect ratio of 17.3; the Paragon of today is down to 12.9, and the Olympic II figures out to 10.6! In the two-meter class, Mark's Wanderer is under 10, and way down in the saltgrass country of South Texas, John Rimmer flies his highly successful little Nemisis at a record *seven-point-four*!

So a lot of wing area *can* be packed into a short span, at the designer's option. The practical limits are probably more aesthetic than aerodynamic, for the performance range we need. For our hypothetical Dream Soarer, then, why don't we settle on an aspect ratio of ten to one, about halfway between that of the Olympic and that of the Wanderer. An AR of 10 would give us an average chord of 9 inches on our 90-inch span, so our wing area would figure out to 9 x 90 = 810 square inches, or 5.6 square feet. Now our weight range becomes 33-36 ounces, if we want to say in the 6.0 to 6.5 ounce-per-foot class, and keep our "floater" status.

That about settles our major parameters, then: we're designing a floater of around 800 square inches, 9 x 90 inch wing, 6 to 6.5 ounce loading. All we need is a floater airfoil (we can swipe it from our favorite floater kit, or pull it out of one of the sources given last month) and we're ready to put pencil to paper and begin scratching out . . . excuse me, *lofting* . . . our Dream Soarer! Next month we'll talk about *moments* . . . how long de tail ought to be, how big de stab. We'll look at the moments of half a dozen popular designs, and decide whose to steal. We'll call the lecture "Great Moments in Sailplane History". . .

MODEL OF THE MONTH

This month's three-view comes from Northern California. Called simply "The Elliptical", it's a multi-task (that is, FAI speed-distance-duration) design by Herb Semmelmeyer of Santa Rosa. If the general outlines remind you a little of Rick Walters' "White Trash" (**MB** plan No. 1723), that's because Herb and Rick were collaborators for years, back in the early seventies. The airfoil (shown full size) is Herb's own, a 10% section that features a straight line from the trailing edge upward to the 50% point.

Vital statistics on the Elliptical are as follows: 117-inch span, 1046 square inch area, aspect ratio 13, wing loading 7 ounces minimum to 15 ounces maximum (52 to 109 ounce flying weight), stab area 13.5%, vertical fin area 6.9%.

Herb emphasizes that the plane shown is merely a simplified prototype of his original dream, which was to have had full-span elliptical dihedral, a la the Midwest Hawk. The 18-inch elliptical tip panels were jig-built from spruce and balsa; Herb feels that the construction is probably "more work than the average builder would care to tackle." I'd have to add that the work was worth it, however, because the prototype I flew had smooth and instantaneous rudder response, in spite of what I consider "heavy" wingtips.

Three Ellipticals have been built so far, including one begun almost three years ago, and just now being completed by its new owner, Pete Bechtel of Couer d'Alene, Idaho. The ship shown in the photos is by Harry Menke of Santa Rosa. It flew in the 1976 LSF Tournament, held in Harry's hometown.

Before you engineers out there whip out your micrometers, let me point out that the signature on the three-view is that of the *artist*, not the draftsman! The drawing is a 1/6-scale copy of Menke's ship, so it's at least four stages removed from Plato's *ideal*, as the philosophers say. (The argument goes like this: the three-view shown is the printer's imperfect reproduction of Thornburg's imperfect drawing of Menke's imperfect model of Semmelmeyer's imperfect manifestation of his own *ideal* of a multi-task sailplane. And so much for human perfectability.) •