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In This Issue

Minimum Altitudes for Balloons

The Congressional Conference Report, 105-313, made amendments to HR 2169. This legislation provides the appropriation for the Department of Transportation, including the FAA, for fiscal year 1998. Senator Pete Domenici, from New Mexico, included the following to the report:

"Regulations on the operation of lighter than air vehicles.-- The conferees recognize the increasing popularity of hot air ballooning as a spectator and aviation sport. Currently, hot air balloons, also known as lighter than air (LTA) vehicles, are restricted by 14 CFR 91.119, the federal aviation regulation on minimum safe altitude requirement which normally applies to fixed wing aircraft. Understanding the vast differences between LTA and fixed wing aircraft, the conferees question the feasibility of requiring pilots of hot air balloons to comply with 14 CFR 91.119. The FAA currently exempts helicopters from this provision, and usually waives this regulation for hot air balloon rallies. The conferees encourage the FAA to examine this safety concern for balloonists and report back to the House and Senate Committees on Appropriations on the feasibility of exempting hot air balloons from this provision."

A Basket of a Different Kind

by John Burk with narrative by the editor

RD2-2410, Mt. Holly, NJ 08060

John shares with us his efforts at very light weight basket construction. This assembly was used to make a world record flight in 1983.

Introduction

There's remarkable strength in the fuel tanks commonly carried in balloons. It makes no difference whether the tanks are aluminum or stainless steel. They are very tough structures capable of taking significant abuse without damage.

So why do we take these sturdy tanks and then strap them into less sturdy baskets? Doesn't it instead, make sense to use the strength of tanks to improve the structural integrity of our baskets? In other words, don't put a tank *inside* a basket, but make it *part* of the basket.

While this topic has intrigued me for some time, other commitments have kept me from actively pursuing the idea. Nevertheless, I dropped the idea at the Experimental meet in Vermont last May. John Burk, one of the attendees, offered to share his experiences with us

Figure 1: John Burk's basket is constructed of aluminum and fabric. It weights 44 pounds. The tank is permanently mounted as one corner of the basket structure.

In *Balloon Builders Journal,* Issue #24, pages 8 and 9, are found details of John's most recent basket design. John's construction techniques employ bent up aluminum tubing with clamp fittings and a fabric cover. In Issue 24 we also featured a drawing of a clamp he designed to assemble his most recent basket.

Let's now look at an older Burk basket design. This basket was constructed as part of a 1983 AX-4 world record attempt for distance and duration. He achieved the duration, but didn't quite achieve the distance. His duration record held up until Coy Foster picked up the record in 1986.

John's goal was to create a basket which weighed 10 pounds. His final design resulted in a 14 pound basket with a 14 gallon tank that adds 30 pounds to the overall weight. This basket has proved to be practical and has been used for everyday flying. The major disadvantage is that tank can't be readily changed, as it is part of the basket structure.

He says he isn't flying as much as he used to. But he still enjoys construction. John is still looking for a way to construct a 10 pound basket.

Construction Summary

The photos and drawings show his construction techniques. A top and bottom ring is bent up from 1 inch diameter, .049 wall 6061-T6 aluminum tube. The end of the tubes are closed off with a fitting which bolts to the collars on the aluminum fuel tank. Vertical tubes, with clamp-type end fittings form corners on the basket. Diagonally crossed webbing is used to provide torsional rigidity. Small diameter cables are also installed as a redundant backup system.

Unlike some of the amateur baskets we have seen, John's designs make use of aluminum fittings. These are typically bandsawn from aluminum plate. Appropriate holes are bored or drilled. Some turning is required. The fittings are then finished with a file and abrasive paper.

The use of machining techniques may limit the construction for some of our readers. But some of this work could be farmed out to a small shop. The finish work could be performed by the builder with access to a shop vise.

Construction: Fuel Tanks

The 14 gallon tank is not standard. John built five of these tanks as part of the 1983 record attempt.

If you examine a standard Worthington 10 gallon aluminum tank, you will note that near the bottom of the tank, the tank exterior begins to roll under to form the tank bottom. The bottom of one tank was cut off just below where the roll begins. A second tank was cut in half through the flat cross section in the side of the tank. By setting the rolled edge on top of the flat edge, an overlap joint was created, perfect for welding.

John would not have constructed these tanks except for the fact he knew a very skilled aluminum welder. Aluminum welding is a special art in itself. After welding, the tanks were hydrostatically tested. They were filled with water, pressurized to 500 psi and checked for leaks and distortion.

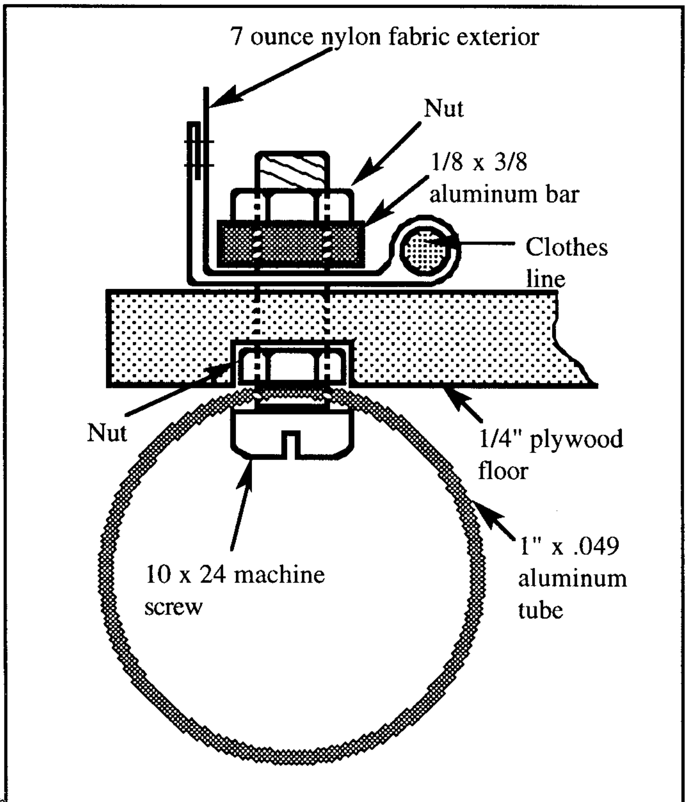


Figure 2: Cross section of the basket floor. An aluminum tube acts as the skid plate and floor support. Screws mount the assembly together with the fabric basket side.

John's professional background permitted him to build these tanks with good expectation of success. But for the record, he is the exception. We at *BBJ* do not recommend builders construct their own tanks. There are a number of legalities as well as serious safety issues involved in such attempts.

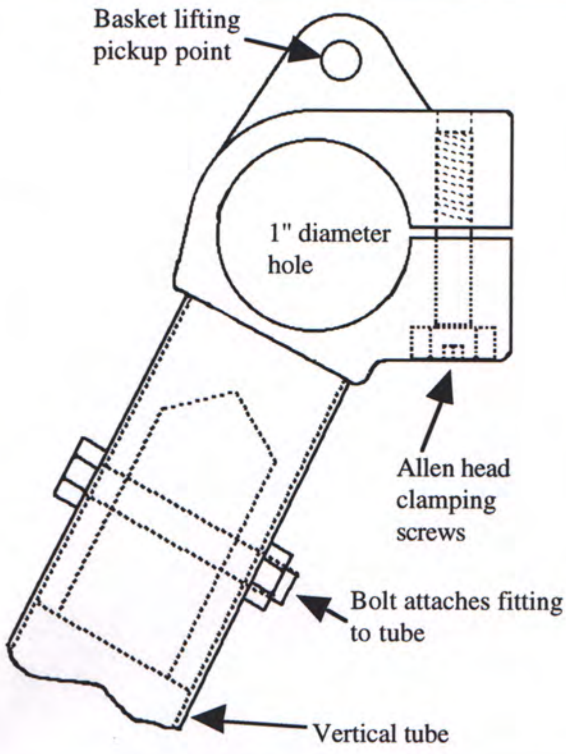
Construction: The Basket

The basket floor is constructed from a quarter inch thick piece of plywood. John was comfortable using this thickness because of the short span; that is, the basket is small and there is an aluminum support member across the middle of the basket bottom. For everyday use thin plywood might be susceptible to puncture on a sharp rock. But for a light basket designed for a world record attempt, this was of minor concern.

The top horizontal rail and the bottom basket rail are of identical size and shape. The bottom horizontal tube is attached to the plywood floor. See *figure 2* for construction details. Every two inches, a number 10 machine screw is run through this tube and through the basket floor. The procedure for mounting these screws is simple. A piece of thread is passed through the screw hole. A slip knot is placed over the threaded end of the screw, and the thread is used to pull the screw through the hole, with the screw head inside the tubing. A nut is tightened over the screw to secure it in place. The plywood bottom was countersunk to accept the nuts while allowing the plywood to rest against the tubing.

The rest of the lower construction is intended to capture the fabric wall of the basket. The basket wall is constructed of 7 ounce per square yard coated nylon. A hem is sewn into the edge of the fabric and a piece of rope clothesline is threaded through the hem. The machine screws in the basket bottom are run through the fabric. The fabric is clamped in place using a piece of aluminum bar stock which is held in place by a nut over each bolt.

The basket top rail is also constructed from a bent up aluminum tube, just like the bottom rail. The fabric side is hemmed on the top. The top rail is slipped through the hem, capturing the tube in the fabric cover.



Figures 3 and 4: A drawing and photo of the vertical tube end fitting. The eye on top of the fitting is used as an attachment point for lifting the entire basket assembly. My drawing shows an optional countersunk clamping screw mount. John left his screw heads exposed.

The two basket corners, at the opposite end from the tank, are constructed with aluminum vertical tubes. In each end of these verticals is found a fitting like that one shown in *figures 3 and 4*. This shape was cut out of 1 inch thick aluminum plate using a bandsaw. (Note that aluminum plate can be cut with a sharp saw blade in a standard bandsaw.) The round end which fits into the tube is turned on a lathe. The 1 inch hole as well as other holes are bored. The two allen head screw holes are tapped for the threads. The completed assembly is finished with a file and 'sandpaper.'

This fitting clamps around the horizontal tubes, at the top and the bottom of the basket. Tightening two allen heat bolts engage the clamping action. John chose to use a clamping action rather than a bolt through the fitting and the horizontal tubes.

This was a matter of good construction practice. The end fittings clamp around the bent corners in the horizontal tubes. Bolt holes through these tubes could result in cracks. These cracks could be hidden under the fittings. The clamping action eliminates the bolt holes which could start these cracks.

Outside corners of the basket are formed by the diameter of the vertical tubes. A top and bottom bend is placed in each vertical tube. In addition to adding a bit of style to the basket this also keeps the basket edge on the same plane as the basket floor corners. This eliminates pressure or wear points in the fabric cover and makes the cover last longer under windy landing conditions.

Torsional rigidity is provided by crossed webbing in each side. These are constructed from 1000 pound test $^{1}/_{2}$ inch wide tubular webbing. At the tank end of the basket these attach at the lift fittings. The photo of the clamp fitting shows the webbing termination on the other two corners.

A Velcro™ seam is provided in the fabric cover, at the back of the tank. This allows the fabric to be pulled back. Hot water can then be poured over the tank to increase fuel pressure.

The basket is not intended for quick takedown. Normal disassembly requires separating the fabric exterior from the floor in order to separate out the components. That means removing the nuts which clamp the fabric to basket floor.

Upper Left: Shows details of the basket attachment. Note how the fabric cover folds back to allow pouring hot water over the tank.

Upper Right: The basket bottom shows the skid tube attachment to the bottom tank ring. Note the center support. Cables provide redundant support structure to the basket.

Bottom Photo: Shows the basket interior. Note the machine screws through the floor on two inch centers. Also note the crossed webbing which provides torsional rigidity.

A New Balloon Design Program

By Bob Nungester

19965 Price Ave., Cupertino CA 95014

This article describes a new piece of software which generates gore layout cutting patterns. This is a further refinement on Smalley's work from the 1960's.

Introduction

Readers of the *BBJ* have been using the design spreadsheet presented in issue #1 as the primary tool to generate gore pattern layouts for some time now. I have thought about converting this to a Windows-based program, but I never got motivated enough since there was no real challenge in simply copying the functionality of the spreadsheet.

However, a couple of issues ago it was noted that the Smalley factors produce a balloon with a larger mouth angle than that measured on actual balloons. In addition, I've been interested in the mathematics that lead to the Smalley factors, but I never put much effort into it since Justin Smalley had already solved the problem back in the 1960's.

Since the factors seem to deviate somewhat from a "real" natural balloon shape, I got more interested in the problem and came up with another way to calculate the shape of a balloon.

Reviewing Smalley's Work

Smalley's derivation used a set of parametric differential equations to generate the table of factors. This method requires several simplifying assumptions that lead to the differences from a real balloon's shape. The Smalley factors do not account for mouth location, variation of temperature (specific lift) in the envelope, or fabric weight. Actually, Smalley did account for fabric weight in his derivation, but this resulted in the need to solve the differential equations and generate a new table of factors for each fabric weight. The normal table of factors is the one for zero fabric weight.

A New Approach to the Problem

Another way to solve for the shape of a balloon is by using finite element analysis techniques. This method essentially divides the envelope into a huge number of small pieces and solves for the forces on each piece to determine the shape of the balloon. This is the method I've used to write a program in *Visual Basic* that generates the shape and associated gore pattern for any hot air balloon.

You don't need to know any mathematics to use the program, but for anyone who's interested I've included a short discussion at the end of this article that describes the method used in the program.

Putting the Program to Work

Using the program just requires entering a few input numbers and pushing the *Calculate* button (see figure 1). The program works for anything from 10-foot tissue paper balloons to stratospheric balloons of 30 million cubic feet or larger.

The output is a set of summary data as shown in figure 1 as well as a text file containing values of S and 1/2 gore width for the given station spacing, and a second text file containing the detailed values of S, R, Z, area, and volume for the balloon. The values in this second file can be imported into a spreadsheet program in order to plot R versus Z and create a profile graph of the balloon.

If you use input values of zero for mouth diameter and fabric weight the resulting balloon will have the exact same shape as one using the Smalley factors. When using the output file, note that there is no seam allowance included in the gore width numbers. You will need to add this to the listed numbers. Seam allowance may be included in a future version of the program.

As you can see, the program allows you to input the size of the mouth and the fabric weight when performing the calculations. It does not currently allow calculations with variable temperature in the envelope since I haven't found any studies that show the detailed variation of temperature in a balloon.

Still Needed: Envelope Temperature Model

The diagram included in the last issue [#25) of the *BBJ* gives an indication of this variation, but it presents the dynamic situation with a high temperature column in the center while the burner is on. To incorporate variable temperature in the program I'll need to know the steady-state value of average temperature versus height in the envelope. If anyone has other information showing the variation of temperature versus height in a hot air balloon, please let me know and I'll include this in the next version of the program.

You can see from the example in Figure 1 that the effect of fabric weight and mouth location only changes the mouth angle by about three degrees from the 50.2 degree angle obtained using the Smalley factors. The only remaining factor that affects mouth angle at design conditions is the variation of temperature in the envelope. It will be interesting to see what the mouth angle is when temperature variation is included.

Output values for these inputs:

Balloon Volume = 99818. cubic feet

Balloon Surface Area = 10455 square feet

Mouth Angle = 47.84 degrees

Envelope Weight = 196.03 pounds

Maximum 1/2 Gore Width = 71.16 inches

Total Gore Length = 931.58 inches

Obtaining this Software

This program, as well as another program used to set up clearances for 3-rope tethers, is available from the following web site:

http://www.jps.net/chuck1/empty_pockets.htm

Each program is a ZIP file that you put in an empty subdirectory, unzip it using PKUNZIP, and then run the SETUP.EXE program to install it. Feel free to download the program and give it a try. It's shareware, so you're welcome to try it for free, but if you plan to use it please send the $25 registration fee and I'll send you the version with a few more "bells and whistles", such as a Specific Lift calculator which is a pop-up window that calculates specific lift given altitude, ambient/balloon temperatures and type of lifting gas.

Once you register I'll send you free updates of future versions if you have email with file attachment capability (remember to send your email address). If you don't have access to the Internet, I can mail you a disk with both programs when you send in the registration fee. My address is 19965 Price Ave., Cupertino CA 95014.

Program Functioning

The parameters shown in Figure 1 are all that is needed to run the program. The actual calculations performed by the program are

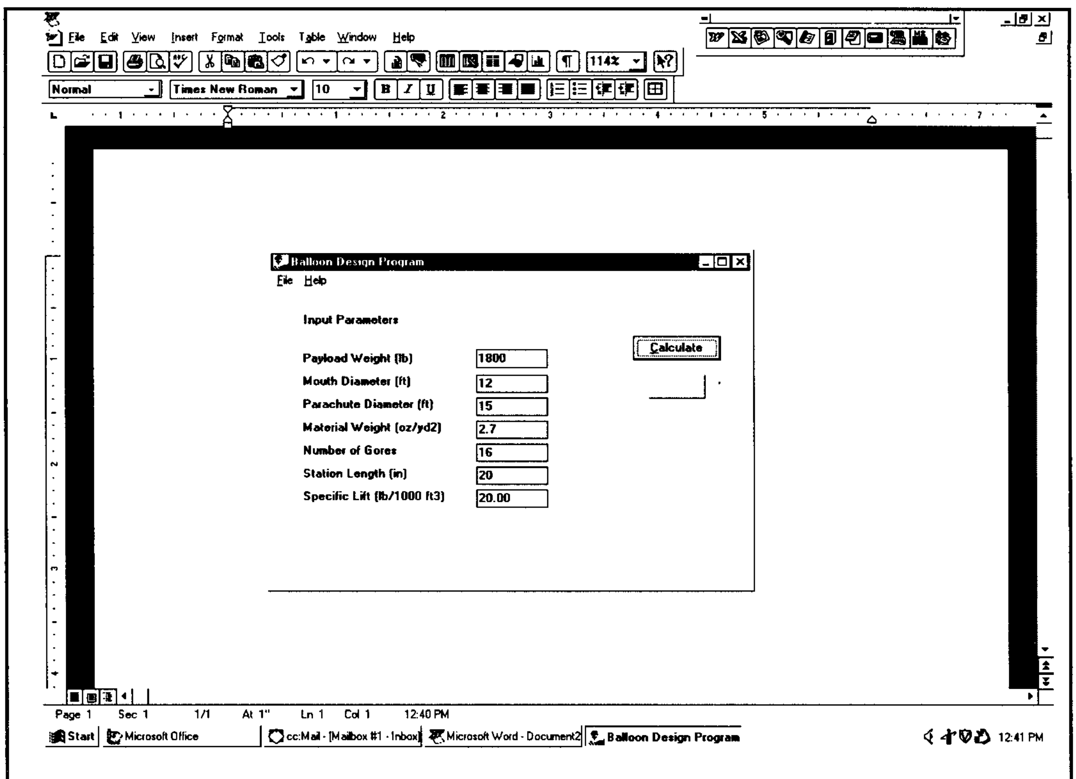


Figure 1: Input screen for the envelope design program

quite complicated.

The program assumes a value for the mouth angle and then begins calculating the forces in the envelope and the shape of the balloon. For each small step moving from the mouth toward the crown it is necessary to calculate several forces and directions. The known values are the stress force and direction on the bottom of the step (from the top of the step below the current one), the fabric weight, and the force due to internal pressure.

Each of these varies with height and/or distance from centerline in the envelope. The unknown variables that must be calculated are the size and direction of the stress at the top of the step, and the small angle between the current step and the previous step. These values are solved using several force balance equations, and then the force at the bottom of the next step is set to the value of the force at the top of the current step.

The calculations proceed in this way until the chain of steps finally intersects the centerline of the balloon. At this point the program checks to see if the last step hits the centerline "flat" (top of balloon must be flat).

If not, this indicates the mouth angle assumed at the start was not correct so it is adjusted and all the calculations are repeated. The mouth angle is adjusted several times (actually a binary search) until the top of the balloon is flat. This typically takes about 10-15 iterations of the calculations. This represents a massive amount of computing that would have required a mainframe computer back when Smalley developed his calculations.

With today's PCs these calculations only take about 3 or 4 seconds on a 33 MHz 486. On a 200 MHz Pentium the results appear almost instantly after starting the calculations.

Letters to the Editor and Other Bits of Information

About Fabric and Soggy Ground

11/16/97

Hi Bob.

I just canceled a high altitude run (it is 6 am) and I am pretty depressed about it. Almost perfect sky, but we have had rain now for several days, and the fields are under water.

Anyway, just wanted to drop a line and say hi. I have had several conversations lately with Mike, [Emich] Ron Cassidy, Paul Stumpf, and one of Mike's friends (I can't remember his name) about fabric. I also have received some very nice samples from Westmark, and the lady there (Debbie) is very nice and seems to have no trouble selling me fabric.

I'm holding my breath to see if she gets more 1.3. She has silicone coated 1.9!! Ever heard of that before? looks like regular Cameron fabric, but feels like SoarC___ youknowwhat :-).

Also, I have asked both Mike and Ron about our idea about having a "grab a couple of beers, get in a circle and talk about building" session at Brian [Boland's Experimental Balloon Meet] next year. They are very much in favor for something organized. Lets talk some more about that.

I was trying to think of some way that we could all look at building pictures, each picture showing something unique to talk about, like a slide show. Folks could send me pictures in the mail; I could scan them in as jpgs, but from there, I don't know what to do.

Also, I am busy out in the garage building up a new 20 gallon bottom end for my upcoming 23,000. I'd like to share some ideas with you.

Give me a buzz or drop an email

Enough for now, I am still depressed about canceling :-(

see ya

Phil MacNutt

11/16

Phil,

Sorry to hear about your weather. Here in the wet side of Oregon we just got our first sprinkles in a couple of weeks. *El Nino* has really messed things up. California is getting soaked and we are dry. This is about as late in the year as I can remember being able to fly in this area. But I know it will soon come to an end.

The new heavy weight silicone coated is interesting. I'd buy it up if I were interested. In this business its hard to know how long fabric stock will remain available. My technique is to monitor what is available and buy when I find something I think I will need in the next couple of years.

Currently, I have 1800 yards of the heavy stuff that I purchased in 1993 and I'm getting ready to build an envelope this winter for general, all around flying. I still prefer to use the 1.9 ounce fabric for general purpose flying. We go to a number of rally's and have local families who have crewed for us for years. They feel more useful if the envelope bag is big and the balloon takes some work!?

I think we could add a seminar setting to the Vermont Experimental Balloon Meet. Saturday evening, last spring, a group of us got together around the sewing machines and talked builders' topics for a couple of hours.

We could set aside an evening with a slide projector. Invite all comers to bring slides of their projects, even those who can't bring their projects to the seminar. Every builder would have time in the evening to show and explain their slides. This would allow builders to show the processes and tools they use as well as the results.

Joe Seawright shows off his *Baby Grand.*

There is even some discussion going on about having a builder's seminar at a more central location. How about meeting somewhere in the Midwest?

The Sailplane Homebuilders Association holds an Eastern US and Western US conference every year. I don't know whether we have enough interest to pull something like that together.

Good Luck,
Bob

Joe Seawright's Baby Grand

11/13

Hi Bob,

Don't know if I ever sent you a digital photo of the 'now certified and veteran of one flying season' *Baby Grand,* or even if Compuserve will accept JPEG files, but here she is. Flies like a dream. What a feeling to take to the sky in an aircraft made with your own two hands, as you well know!

Thanks for the inspiration and encouragement.

the Duke of Url
Joe Seawright
N 369RD
"Baby Grand"

Joe went through a lot of effort to obtain his airworthiness certificate. We are glad to see his efforts were successful. This is a very pretty balloon, Joe-Editor

Technical Assistance for Builders

Bob,

I am willing to help any homebuilder who asks for assistance–techniques, materials–or any other questions, by telephone, during the day.

Guy Gauthier
Telephone: 903-297-0003
Guygauthier@worldnet.att.com
4015 W. Marshall Ave
Congview, TX 75604

Guy is one of the most experienced balloon builders and manufacturers around.

Bob,

I finally finished my envelope. I'll be sending an article soon. Here's a picture of the envelope, less the scoop skirt.

Larry Lankenau
8633 River Canyon Drive
Fort Wayne, IN 46835

Larry Lankenau's new envelope in yellow, green and black.

An Editorial Comment

I thought I would take this opportunity to comment on a few issues around homebuilding. -Editor

Fabric Availability

In the past, we have published the names of fabric brokers, in addition to resellers. We may want to be more selective in continuing this practice in the future.

I'm using the term 'reseller,' to describe companies like *Westmark*, which sell mill ends and seconds in quantities from a few yards up to hundreds of yards. A 'broker' represents a fabric manufacturer and generally sells in lots of hundreds or thousands of yards. Brokers typically supply to other wholesale outlets, like *Westmark*, and to a lesser extent sell to individuals.

In the past, we have had several brokers who were willing to sell to balloon builders. Unfortunately, we have also lost access to some of these suppliers. There have been several reasons for this loss of access.

Some builders do not understand the broker arrangement. Typically, one buys large quantities of fabric, at very reasonable prices, from a broker. The goods are generally sight unseen, with no exchange or return policy.

A few builders have jeopardized these arrangements by placing unreasonable demands on brokers or by being unwilling to accept this risk. For builders with these concerns a better arrangement is to pay the somewhat higher prices for fabric from companies like *Westmark*. These companies, unlike the brokers, will typically provide some guarantee of their products.

I would like to purpose that we be more cautious about naming our brokers. Let's protect these sources by providing these names to other builders on a request basis. if you have a reliable broker, be a cautious about who you refer to them for business.

We also have a few balloon manufacturers which are attempting to limit our access to fabric. Most of the balloon manufacturers in the U.S. receive *BBJ*, either by direct subscription or through an employee or agent of the company who is a subscriber. I consider their interest as a compliment. It means they recognize amateur builders as innovative and potentially the source for the coming innovations in factory products. But it also means they are knowledgeable about our sources of materials, and may chose to impact that access.

Balloon Manufacturers and Homebuilding

The market for type certified balloons is tight, and each of the major balloon manufacturers is trying to maintain market share. Within this environment, the growing popularity of homebuilding is viewed by a few within the manufacturing arena with concern. There is a fear that building may reduce sales in an already tight market.

I know of at least two American manufacturers which have taken steps to keep fabric out of the hands balloon builders. One balloon manufacturer has advised its fabric mills and finishers against selling their products to builders. The stated purpose for this position is to protect their suppliers from product liability. This balloon company has made a significant investment into a fabric line specifically tailored to balloon products. I can understand their concern about protecting their supplier from perceived risk.

But I think protecting market share is also part of this position. As builders, we create an aircraft for $2500 which performs the same functions as a factory produced aircraft at ten times the cost. But since balloon factories can't produce their aircraft for $2500, they have developed marketing strategies consistent with their manufacturing costs.

Part of that strategy is based on competing for recreational dollars. Today's family has numerous choices on which to spend their discretionary dollars. A family can buy a new power boat, a new camping trailer, outfit for winter skiing, or purchase a new balloon.

Each of these activities requires the same significant financial commitment. Balloon manufacturers are at a disadvantage. Much more work is required to become a balloonist. There must be the commitment to get a license, to obtain extra help in the form of crew, to get up before sunrise. All of these mitigate against winning the recreational dollar challenge.

Balloon Builders and Commercial Operations

A few balloon builders are also encouraging an anti-building attitude from balloon factories. U.S. regulations create a clear definition for the use of amateur built aircraft. These aircraft are not intended for nor approved for compensation or hire. Yet we occasionally hear of an operator whose stated purpose is to circumvent the letter, if not the intent of the regulations.

We are aware of the commercial operator who is flying passengers over a homebuilt envelope, or the operator who has "remanufactured" an old and tattered envelope Occasionally we hear of the operator who sells one day shares to riders, so that the riders become "owners" of an experimental aircraft, at the cost of a ride.

These attitudes can come back to haunt us. Look what's happened to the kit airplane market. This past spring, the FAA sent a memorandum to all of its field offices which targets the *Lancair* kit airplanes. FAA offices have been advised to be very careful about issuing airworthiness certificates for these projects. It seems that a contingent of professional builders are offering to construct these kits, thus placing them outside the amateur built regulations.

Some of us have faced the spin-off of this FAA policy. During my last inspection for a new airworthiness certificate, the FAA inspector wanted to see clear evidence that I had built my balloon. I hate to think what the FAA could do if they had reason to believe experimental balloons were being used for commercial activities.

Let's Appreciate What the Manufacturers Have Done For Us

At the Experimental Balloon Meet in Vermont, last spring, I saw a small group of builders level light hearted sarcasm at those 'heavy factory built balloons.' (I admit the comments were partly in jest.) But to a pilot each of them was flying a homebuilt balloon with a type certified burner, using a fuel system, for which the technology was borrowed from a type certified balloon, and used a venting and deflation system which was first marketed in a type certified balloon.

Stop and think where our technology would be today, were it not for the type certified sport balloon and the market that has supported it over the past 35 years.

We Need Each Other

Let's be cautious about our image, we cannot afford these divisions among balloonists. We are part of a common community. Its to our betterment that both the manufacturing and the homebuilding interests prosper. Our purpose is not to encourage homebuilding to the detriment of the Aerostar's and Balloon Work's.

Builders, lets remember to support those pilots and would-be pilots who have no interest in building. *The reality is that very few people are ready or willing to trust their lives to an aircraft they have built.* For the great majority of pilots, the type certified balloon will remain the appropriate choice.

As balloon enthusiasts, regardless of whether we are in it for the sport or commercial endeavors, we are part of a very small group. As we look around us we see external pressures which will make our flying activities more difficult in the future. We need to work together as that common community to promote and protect our common interests.