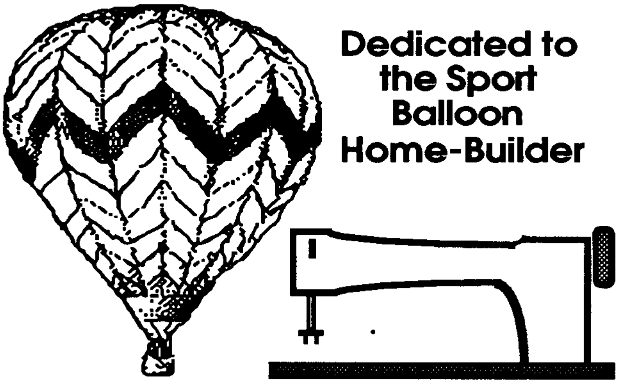
Volume 1, Number 2 $3.00



Dedicated to the Sport Balloon Home-Builder

THE BALLOON BUILDERS' JOURNAL

September-October 1993

IN THIS ISSUE

Aeroquip Fuel Hose Users:

If you are using Aeroquip FC-321 fuel hose in your balloon read about a leak problem on page 10.

In our Next Issue

Paul Brockman, discusses his experiences as a first time builder. We further develop his techniques for determining envelope to basket cable lengths in a separate article. Paul built a multi-panel type balloon, and we will modify The Gore Pattern Spreadsheet to build patterns for this style of envelope.

A Call for Articles

Readers are invited to submit material for publication in *The Balloon Builders' Journal.* For a limited time we will offer free subscriptions for material selected for publication. We are particularly interested in reports from first time builders. Among the questions we think would interest our readers are the following:

Why did you choose to build a balloon?

What were your sources of technical and design information?

What tools and equipment did you have available?

How and where did you purchase materials?

Did you have any reservations about your ability to complete the project?

Did you utilize any new or unusual materials or techniques?

What stumbling blocks did you face?

Are you happy with your product?

Would you do it again?

What would you do differently next time?

What suggestions or warnings would you give prospective builders?

A Plan for the First Time Homebuilder

By Bob LeDoux

There are many ways to build a balloon. In this article, the author presents a personal approach in which the balloon is constructed from vertical half gore patterns; a simple approach for the beginner.

The Basic Idea

It's an unfortunate fact of life that envelopes get tired. Many of us have received six or eight years of service from our balloons and are now faced with significant fabric replacement or the purchase of a new envelope. Manufacturers, keen on encouraging the purchase of new systems, often price new envelopes at levels where a little more buys a whole new balloon. Given the choice of spending $11,000 for an envelope and $16,000 for a whole new system, many pilots opt for the new system. Unfortunately, many pilots also opt out of ballooning all together.

If you are flying a tired envelope or simply wish to consider a new challenge you might want to try another option: build a new envelope for about $3,000. This option is not available to the commercial operator, as amateur built aircraft cannot legally be used for commercial operations. But this is a reasonable alternative for the sport, fun flying pilot, with a bit of technical background. There is one additional benefit. As a builder you are eligible for an FAA repairman's certificate that allows you to perform inspections and repair your aircraft.

As a first time builder there is lots to learn and obstacles to face in the completion of an envelope. I think it would be a mistake to undertake building a new envelope at the beginning of the flying season. This places the builder under pressure to complete the project to fly. A better approach is to anticipate the demise of an envelope so the non-flying season can be used for construction.

When building a new envelope there are several options. One can replicate a current envelope, build from The Gore Pattern Spreadsheet or build from a good set of plans. I don't like the idea of creating patterns from an existing balloon. Tearing apart an envelope, creating patterns from the pieces and building anew has numerous problems. A balloon is being built based on parts which have changed their shape in service. Some panels may have shrunk due to heat, while others are stretched due to in-flight loads. While prototyping with The Gore Pattern Spreadsheet has its appeal, if short on time a much better choice is to find good manufacturer's information, like a repair manual, from which to build a new envelope.

Paperwork and Other Decisions

The first thing to do if contemplating a balloon building project is to contact the local FAA Flight Standards District Office (FSDO). A maintenance engineer will give advise on expectations for paperwork. Ask to receive their builder's packet of material. Keep a written log of all design and construction tasks, and keep all receipts for materials and equipment purchases.

Next, apply for an "N" number. The local FAA inspector will not issue an airworthiness certificate until a proper registration number has been obtained. This can take a month or more. So apply for a number early in your process. Your application will require a notarized statement and may require copies of materials receipts.

I would then choose an envelope. A vertical, half gore pattern is quick and easy to build making it a good beginner's choice. For most balloons the replacement envelopes of choice would be a replica of a 77,500 or 90,000 cubic foot envelope in a 24 gore configuration. If a smaller AX-6 size envelope is needed a 54,000 cubic foot envelope in 16 gore configuration like the S-49A would be a good choice. I consider a copy of an Aerostar Rally envelope a choice for the builder with sewing experience. Construction of this envelope is a bit more difficult because of more complex fabric fitting, and sewing of multiple layers of load tape. (My own double needle sewing machine, a World War II vintage Singer 112W140 will not handle the heavier load tape construction in a Rally type envelope.)

Fabric and Other Materials

Building a 77,500 cubic foot envelope, with limited color changes will require about 900 lineal yards of 60 inch wide fabric and 1,000 yards of type 5038-IV load tape one inch wide.

I prefer Star Ultra Dee® bonded polyester thread for construction. Expect to use 3 pounds of size 24 (E) thread and 1/4 pound of size 16 (F) thread. Numerous other incidentals like Velcro®–type fastener, ropes and lines for the vent/deflation system, and pyrometer line are also required.

One of the major purchases in a balloon is fabric. I think elasticity of nylon makes it the better choice for the beginning builder. It is more forgiving of variations in construction often found in a beginner's balloon. As a builder, I would never purchase approved balloon fabric from a balloon manufacturer. Simply put, there is no economic justification to building with $8 a yard fabric. An envelope would cost as much as a factory built product. Certain repair stations, like Paul Stumpf, will sell custom yardage at below the factory cost.

Another option is to look for a dealer who is willing to broker a lot of mill-ends (sometimes called "shorts.") Mill-ends are overages generated in the production of a fabric order. When a company orders 10,000 yards of fabric, the mill may produce 12,000 because some fabric will have weave failures, uneven coating, or uneven color. Once the order is filled, the extra fabric or mill-ends, can be classified as firsts or seconds. Seconds are fabric with defects which are removed during grading of the product. Firsts are fabric that meet the grade but were produced to ensure having enough yardage to fill the order.

Often, a group of firsts is sold as a lot. Colors may vary and a 1,100 yard lot may consist of as many as 30 rolls in as few as 1 or as many as 7 or 8 colors. Costs may be less than a quarter of the balloon factory fabric prices.

I have no trouble using such fabric for balloon construction. If I am uncertain about fabric quality I will unroll every yard and inspect it for uneven weave or coating failures. If I have any questions regarding strength I may perform tensile tear pull tests for my own edification. Some seconds may "inadvertently" be included in a lot of firsts. So buy more yardage than needed.

Many builders can afford to replace an envelope after a shorter service life. Don't expect mill-end fabric to go 400 or more hours without replacement. Balloon manufacturers often inspect the lots of fabric they receive and have the option of refusing delivery for problems such as degraded tensile strength or poor UV resistance. Those factors are important in a balloon with a 400 hour warranty. But they are less important for balloon with an expected life of 250 hours.

The Sewing Machine and Other Tools

A home swing machine is generally not adequate for balloon building. I am aware of a few balloons built with a single needle machine home machine like the Pfaff 130. But sewing each seam twice to complete a felled seam will try most builder's patience. The modern computer operated, light duty home machines will be quickly "trashed" by the demands of balloon construction. These machines are not intended for extensive sewing using size 24 or 16 thread with size 18 to 20 needles.

I find very few tools are need to build a balloon. A good sharp pair of scissors, preferably light in weight is essential. A commercial double needle lock stitch sewing machine with a 1/4 to 3/8 inch needle spacing will be your primary tool. This machine should also be able to do all the single needle work. A reverse lever on the sewing machine is nice but definitely not essential; my machine doesn't have one. A vertical, half gore balloon can be assembled without seam folders, or pullers. There will be occasions when a helper at the sewing machine is essential. A tape feeder is nice, but some balloons have been built without them. If necessary, one can construct a simple wheel under the sewing table which feeds the tape around and over the front of the table. Commercial sewing machines can be rented for about $150 a month in larger cities. Plan on needing it for more than one month.

The Workshop

Assuming the envelope is based on vertical half gores, a gym floor is a good choice for cutting out fabric. Expect to spend a weekend cutting and to end up with a sore back. Remember that you are cutting out half a mile of fabric. Save your knees and buy a good set of knee pads. Cutting fabric on a gym floor is a two person job. A small bedroom can be converted to a sewing room if most of the furniture is removed. Large amounts of floor space are not required for a sewing area.

Assume about 200 hours of work time to construct a basic envelope. This does not include initial design. As the envelope pattern becomes more complex the time increases dramatically. Our AX-7 with a southwest Indian pattern required about 500 hours to design and build.

Buying a Used Basket

If you don't currently own a balloon, then you also need to purchase a basket. I would look around for a mid-80's vintage assembly for which the envelope is no longer airworthy. If you can't find a system locally, check the classified ads in the BFA *Skylines*. Another timely source of used equipment is *The Balloon Clearing House* (PO Box 203, Sheridan, WY 82801, $15 per year).

While there are many brands of baskets available, let's touch on a few systems and options generally available to builders.

I have seen Balloon Works systems with un-airworthy envelopes for under $2,500. A good choice would also be a Raven or Aerostar Rally basket. To really go modern buy an Aurora basket and burner but the costs would be higher.

Sometimes dealers will accept a competing brand of balloon, in trade, just to get it off the market. A dealer might sell you the basket knowing it would not be used under a competing brand of envelope. Another option might be to make a deal with a local dealer. He might be willing to buy a complete balloon, sell you the basket at a savings while providing another buyer with a new envelope.

The Balloon Works baskets and burners have undergone limited changes over the years which indicates good up front engineering. I consider the Balloon Works burners as one of the best on the market. Certainly, from a weight standpoint, no other manufacturer can touch their efficiency.

The Raven (Aerostar) Rally baskets are inexpensive, in part because they are no longer in production. But Aerostar is very sensitive to providing continued customer support. Parts are generally available.

With Aerostar products I strongly suggest buying a basket with the Square Shooter II or newer burner. These burners were first produced in 1979. The early Square Shooter I can be identified by the plumbing which sits outside the bottom of the burner base. Parts for these burners, in particular, pressure gauges, are getting difficult to find. Parts are also expensive. I still use one of these burners on my small balloon. These burners are not the most efficient, and mine produces a diffuse flame which requires care to avoid envelope burn damage around the mouth. But the biggest disadvantage is that condensation forms around the plumbing and drips onto clothing. Each spot ruins an otherwise nice shirt. Avoid this burner if you can.

Each different basket has its strengths and weaknesses. A friendly repairman can show you of what to be wary. For example, the Raven Rally basket runs wicker through the floor. If the basket has not received proper care this wicker could be rotten. If significant portions of the vertical wicker need replacement this could be a major undertaking involving the replacement of oak skid plates.

The Little Parts Get Expensive

When buying a basket consider how to attach the envelope. The Rally, for example, employs a burner load ring which is attached to the envelope. That ring could get expensive if a used one cannot be purchased. Consider buying a non-airworthy envelope with a basket if it is offered as part of the deal. Load rings, cable fittings, pyrometer or thermister wire, skirt hoops and other non-fabric entities can get expensive when bought piecemeal.

This article discussed building an envelope around the vertical half gore style as typified by the Aerostar "S" series of balloon. As a contrast, in our next issue Paul Brockman will discuss building a multi-panel envelope in the style of the Cameron "A" envelope. This will give the new builder a chance to compare between two different building styles.

A Homebuilder's Tip: I would never use black or white load tapes on a homebuilt balloon. Colored load tapes set a balloon apart from factory built aircraft. In our balloons we used red tapes in one envelope and gold tape in the other. Specialty weavers like Bally Ribbon Mills in Bally, PA, can provide a color chart. They sent me a chart with 42 different colors including fluorescent shades. When ordering less than 1,000 yards there may be special dye charges unless the color is in stock. Check a sample of tape for colorfastness by soaking it in water and wrapping it in balloon fabric .

The Novice Builder: Part 2, Sizing the Envelope Mouth and Top

By Bob LeDoux

This is a second article, following up on The Gore Pattern Spreadsheet presented in our last issue. In this article we look at sizing the envelope mouth and deflation/venting systems. We also discuss placement of horizontal, "rip-stopping" load tapes.

Introduction

In our first issue we developed complete instructions for making The Gore Pattern Spreadsheet, which is a computer spreadsheet intended for the balloon builder. By entering three values; desired envelope volume, number of gores in the envelope, and seam allowance, the user creates a pattern from which to cut out gore fabric panels for a range of envelope sizes and configurations.

Because of the length of that first article, a number of other important measurements were not discussed. This article discusses some of those measurements. Among these are sizing the envelope mouth; number and placement of circumferential, rip stopping, load tapes; and various parameters for the deflation and venting system. Envelope to basket cable lengths will be discussed in our next issue.

Because the parachute top is recognized as a simple, reliable and effective venting and deflation system, it is a good choice for a first balloon project. We will limit our discussion to this style of "top."

Table 1, on page 6, summarizes various dimensions for a variety of balloon sizes. These dimensions were developed from a review of commercial balloon products as well as calculations from The Gore Pattern Spreadsheet. Each column represents a particular balloon volume with a specified number of gores in the design. The columns are ordered in increasing volume so the reader can see how dimensions change as balloon size increases. Each row represents a specific data element for the range of envelope volumes.

Lets begin with a simple summary: There is considerable latitude when it comes to sizing envelope components. A review of Table 1 shows that dimensions don't necessarily change consistently as envelope size increases. The factors discussed in the following text tend to be conservative and have been proven in a variety of factory produced envelopes.

Mouth Diameter

Mouth diameter defines the opening into which the balloon burner operates. When using The Gore Pattern Spreadsheet, a decision on mouth size determines the point, up the pattern from the bottom, at which a cutoff is made. (Refer to figure 2a in our last issue to see how this occurs.)

For the envelope shape generated by The Gore Pattern Spreadsheet, 12 feet in diameter is a good starting point for a mouth diameter. In very small balloons, smaller than an AX-6, this dimension might be reduced. Too small a diameter tends to make the mouth subject to burner damage during inflation and during in-air turbulence. Too large a diameter tends to adversely reduce the overall volume of the envelope. It also tends to place the burner too far below the mouth and is generally less aesthetically appealing.

From row 7 of Table 1 we can see selected mouth diameters across various envelope volumes. A small envelope of 31,200 cubic feet shows a diameter of 10.09 feet. This is as small as I would go unless special fire protection fabrics were incorporated in the burner area, such as a Nomex® mouth and/or skirt. As the volume of the envelope increases, the mouth diameter reaches the 12 foot diameter, and this is appropriate for most sport size balloons. In large balloons, over 90,000 cubic feet, a slightly larger dimension, approximately 13 feet, is found in some commercial balloons.

The mouth diameter is also a function of the envelope shape. The numbers shown in Table 1 are appropriate for an envelope based on the Smalley factors contained in The Gore Pattern Spreadsheet. If a different shape was employed, like the shape found in Balloon Works products, then a different mouth size and configuration may be appropriate.

Load Tapes

When building a balloon with long, vertical half gores, as generated from The Gore Pattern Spreadsheet, convention calls for building in

Table 1: A Summary of Envelope Measurements								
Row No.	*(All Measures are in Feet Unless Otherwise Noted)*	**Column 1**	**Column 2**	**Column 3**	**Column 4**	**Column 5**	**Column 6**	**Column 7**
	Envelope Category	**AX-4**	**AX-5**	**AX-6**	**AX-6**	**AX-7**	**AX-7**	**AX-7**
1	Envelope Volume *(in cubic feet)*	31,200	42,000	54,000	56,400	65,000	77,500	77,500
2	Number of Gores in Envelope	16	16	16	20	20	20	24
3	Length of Gore *(As cut with mouth and deflation port openings)*	49.40	54.10	60.50	60.00	64.41	67.80	67.50
4	Diameter of Deflation Spider Web *(see text)*	13.50	14.83	14.83	16.25	16.25	17.67	17.67
5	Parachute Diameter	16.75	18.08	18.08	20.58	20.58	21.67	21.67
6	Length of Parachute Suspension Lines	10.73	11.58	11.58	11.58	11.58	15.00	15.00
7	Diameter of Mouth	10.09	11.70	11.89	11.89	12.26	12.01	12.01
8	Maximum Width of Fabric Half Gore *(measured in inches)*	50.85	55.68	59.95	49.37	51.75	54.67	46.35
9	Placement of Load Tapes *(measured down from top of cut gore)*	6.50 16.00 26.50	7.00 17.34 29.82	8.00 20.50 32.50	9.00 19.00 32.00	9.66 19.66 34.66	12.50 21.50 36.50	12.50 21.50 36.50

some "rip stopping" capability. These are often in the form of horizontal load tapes placed around the circumference of the balloon. Traditionally, one tape is placed a short distance below the deflation port, in the high pressure area near the top of the envelope. Two additional tapes are generally placed equidistance above and below the equator. Large balloons, envelopes greater than 90,000 cubic feet, may require additional tapes as would envelopes utilizing any special pressurization techniques such as built in fans.

At least one manufacturer is placing a horizontal tape approximately 7 to 9 feet above the mouth opening. This tape permits making invisible repairs to damage in the "mouth." Repairs are made by replacing the entire panel area between seams and tapes.

As a starting point for builders using The Gore Pattern Spreadsheet, the two tapes near the equator can be placed at stations s=.46 and s=.64 for most sport size balloons.

The tape closest to the deflation port often performs double duty in that it is also used as an attachment point for a parachute top. When using a parachute top, the size and placement of that top may determine the placement of the top tape.

Row 9 in Table 1 displays placement of horizontal load tapes as summarized from various balloons. Each number represents the placement of a tape, measured in feet from the deflation port opening. Note that the values are dependent on the size of the deflation port. The top tape in the table has been placed assuming its use as a parachute attachment point.

Horizontal tapes may receive limited use on balloons that use multiple panel construction, as typified by the Cameron envelopes. In these cases, the horizontal seams are called upon to provide the "rip stopping" capability.

The use and effectiveness of horizontal load tapes is controversial. While some manufacturers, like Aerostar consider them essential, others, like Balloon Works take a different tact. For a different viewpoint, read the literature produced by The Balloon Works. Their balloons are multi-panel construction, like the Cameron, but they "edge" each envelope panel with a heavier "rip stopping" fabric to create a construction called "Flex-Net®." For a good summary of The Balloon Works position locate the original publication titled, *"The Balloon Works Presents: Concepts, From the designer's notebook."*

David Schaffer, former National and World Balloon Champion and engineer wrote a classic article titled "Fabric Strength and Tear Propagation." It discusses the loads on balloon fabric and the role of rip stopping mechanisms. The article appeared in pages 4-7 of *Ballooning* magazine for September-October 1981.

The Parachute Top

The parachute top is a well proven system, recognized by users as effective in its venting power and closely approximating the deflation speed of some other rapid dumping systems. With proper design, its operating loads are reasonable. Some early parachute designs were too large, resulting in excess operating loads. Manufacturers have solved these problems through a variety of means including the use of pulley systems and reduced parachute size.

In simple terms, the parachute top is a circular fabric panel that is held in a circular hole at the top of the envelope by internal envelope pressure. The top is so named because it looks like a parachute sitting in the top of the balloon. At equal points around the parachute circumference are loops to which are attached suspension lines. These lines are like suspension lines on a parachute. They come to a point below the parachute where they terminate to a rope. By pulling on this rope the pilot can pull down the parachute top permitting air to escape through the hole in the envelope. When released, the parachute will re-seat itself. It works like a sink stopper. The parachute also has tied to its circumferential loops centering lines, which attach the top to points on the upper interior of the envelope. These lines ensure that the parachute stays centered in the hole in the top of the envelope, and limit the distance that the top can be opened.

The parachute is prevented from flying out through the deflation port by two mechanisms, the centering lines and a "spider web" which is formed from the vertical load tapes on the envelope. These tapes come to a common point, either a circular ring or a commonly sewed cross over point at the very top of the envelope.

The operating loads on the parachute are a function of the size of the parachute, and the weight of the aircraft. Larger parachutes have heavier operating loads. As the size of the balloon goes up, the parachute size cannot increase proportionately or the loads may become excessive for pilot operation.

Some balloons, like Cameron, use a pulley system to increase the mechanical advantage of the pull. The pilot ends up pulling the operating line far more distance than the parachute opens but with considerably reduced operating load. Care needs to be taken when employing such devices. Pulleys must remain tangle free. Even simple rings through which the operating line passes can cause problems. The Balloon Works issued a warning (Service Bulletin L9, September 10, 1979) about a tangle problem with a parachute operating line and its guide ring. I recommend closely copying any pulley or ring guide system you might choose to use. Avoid possibilities of bound operating lines.

If you are using The Gore Pattern Spreadsheet, I would like to suggest two criteria for sizing of the parachute top. First, I would not exceed the Aerostar standard of 17.67 feet for the deflation port, as measured in the spider web, regardless of envelope size. Aerostar makes no deflation port larger than this for any parachute top. (Before a recent standardization policy for S55, S57 and S60 envelopes, involving a single size top, Aerostar built a 22 foot diameter port.) Second, I would not go down below station s=.88 on The Gore Pattern Spreadsheet. Let the smaller of these two criteria set the maximum size of your deflation port. The size of the deflation ports can be seen in row 4 of Table 1.

When I built *Castaway*, my 37,000 cubic foot envelope, I put a 17 foot deflation port in the aircraft. The venting power is tremendous, but I must exercise considerable caution in my opening times. It's very easy to partially deflate this envelope. Large tops may be appropriate in small balloons, but they require caution on the part of the pilot.

The parachute that fits in the deflation port can be sized using the data in Table 1, row 5. Generally speaking, the parachute diameter is 3 to 4 feet larger than the deflation port. If in doubt, I recommend building the parachute a bit large rather than too small. I think too large a parachute may reduce top efficiency as it constitutes a larger obstacle to air. But if you build a parachute too small it will leak or fail to cover the port opening.

Table 1 also displays length of suspension lines in row 6. The centering line length is not shown. I feel that a good fit requires some experimentation, particularly in a balloon built at home. By placing the center of the parachute top in contact with the center of the envelope spider web, the length to the tie off point (the stickmen) in the side of the envelope can be approximated. This distance may be a few inches too short. Cut your centering lines a couple of feet longer than you anticipate needing so as to permit final adjustment. Proper fitting will probably require several inflations of the envelope.

As noted above the centering lines attach to loops on the interior of the envelope. These loops may be placed at points around the top load tape, as shown in row 9 of Table 1. As already noted, this horizontal tape can perform dual service as a rip stopper and parachute attachment points. To simplify envelope assembly, I prefer to follow the Aerostar technique of creating "sticken" sewn to each non-taped vertical seam. The design of these stickmen is shown in their repair manual. Some builders prefer to create attachment points by sewing simple loops to the taped seams. In either case, your attachment point can be a junction of a vertical load tape and a circumferential (horizontal) load tape.

Note that I have oversimplified the discussion of deflation ports and parachute tops. There are differing philosophies on the transfer of loads in the tops of balloons. Aerostar, for example, transfers their flight loads to the vertical tapes by making the diameter of the spider web in the top of the envelope smaller than the diameter of the deflation port.

In their S-55A, for example, my field measurements show that the spider web forms a circle that is 10 to 11 inches smaller than the diameter of the deflation port. This results in a "scalloped" look to the deflation port tape between the vertical load tapes. This signifies that the port tape is under only localized air pressure loads. Transferring the flight loads to the vertical tape contributes to their envelopes having a flat appearance across the very top of the balloon. One writer has also informed me that it makes the fitting of a parachute top more difficult.

Not all balloon manufacturers appear to share this approach. Just looking at a Cameron top, one gets the impression that the tape lining the deflation port tape is under significant load. This would be a good topic for a future article. Readers with knowledge in this area are invited to submit their comments.

Once you have determined the size of the deflation port, the configuration of the gore layout pattern is complete. By transferring the mouth and deflation port cutoffs to the pattern, a final pattern can be created from which to cut fabric. I prefer to "tweak" the mouth or port values as necessary to give me a gore pattern length of even measure. There are numerous calculations still to be made in balloon construction. It is easier performing calculations with a gore pattern 67 feet, 6 inches long rather than 67 feet, 2¼ inches long.

Closing Comments

Table 1 was created from a review of factory produced balloons and calculations using the Gore Pattern Worksheet. From this review I have concluded that there are dramatic differences in design characteristics by different balloon manufacturers. In many ways I have found it difficult to locate consistent design elements across different brands of aircraft. This seems to suggest that the builder has considerable leeway in the design of an envelope.

Column 6 in Table 1 should be especially interesting to the home builder. Using the Gore Pattern Spreadsheet I have designed a full size AX-7 envelope (77,500 cubic feet) using 20 gores. This envelope can be produced in 60 inch wide fabric. The sizing for the mouth and top in this envelope have been developed from data in column 7 which are modeled after the Aerostar S-55A.

A 20 gore configuration might be considered for larger balloons. Using full width of 60 inch fabric, a builder could construct a full size AX-8 (105,400 cubic feet) in a 20 gore format.

For the builder using a Balloon Works basket, an 18 gore envelope is practical because of the basket's three-point hookup. Using 60 inch wide fabric an envelope of 75,500 cubic feet can be constructed using full fabric width. Check it out in The Gore Pattern Spreadsheet.

A future issue we will take our gore pattern dimensions and transfer them to a full size pattern from which we can actually cut out fabric for an envelope.

Comments on Information Access and Liability

By Bob LeDoux

Where does the new homebuilder look for technical information? How do you go about getting a picture of the range and types of balloon design? Where do you get good technical information about building a balloon? The following are the editor's thoughts on these topics as well as some comments on the product liability issue that faces us all.

Every now and then I visit our one and only "local" (200 miles away) repair station to review their library of technical material. I've been doing this for a number of years. Their library consists primarily of repair manuals. These manuals, called Continued Airworthiness Instructions, are developed by manufacturers as a requirement of FAR Part 31 which is the federal regulation on airworthiness for balloons. Part 31 requires that these manuals cover such issues as the manufacturers' specifications for airworthiness limits, approved repair procedures, and inspections after a hard landing. The repair manual is the technical link between the manufacturer and balloon owners and repairmen.

On review of most repair manuals one discovers that much is left out. The information is generally limited to that necessary to keep aircraft flying. Some manuals assume that parts, including fabric panels, are purchased from the manufacturer rather than being fabricated in a repair station.

Suppose you are a builder fascinated by the beauty of a bulbous gore balloon like the Cameron Viva®. Where would you go to get technical details about that model of balloon? If you think the Cameron repair manual will give you construction details you are sadly mistaken. Their manual does not contain fundamental data like gore panel dimensions. Letters to Cameron (as I have written) are very politely answered but do not include the requested information. One repairman advised me to buy a complete set of replacement panels for an entire gore if I wanted to build a copy of a Viva envelope.

Cameron's position is not unique. Most manufacturers are secretive about the details of their balloon design. Their world is a very competitive market. Repair manuals are for repair stations and repair stations don't manufacture balloons. So where is the prospective home builder to find technical material?

Fortunately for us there is an exception to this picture. If you are new to the home building scene and wish to have a good overall manual of proven design and techniques, spend $60 to buy *Aerostar's Continued Airworthiness Instructions* (ACAI). In it you will find most all of the general and detail information for building your own balloon. This manual is not intended as a set of building plans and therefore requires some study. But the information is there.

I doubt that balloon manufacturers want us building aircraft from their repair manuals. They would prefer we buy their product. There may also be legal liability concerns. It is unlikely but possible that some person could build a balloon from a repair manual, then blame the manufacturer if he or she were injured in the aircraft. But current evidence suggests that special protection exists when homebuilding is involved. Let me elaborate:

The 1970's was the heyday of American light airplane manufacturing. Almost 15,000 single engine airplanes were built in 1978. Now the likes of Piper, Cessna and Beech make less than 1,000 aircraft per year. In 1988, according to the Experimental Aircraft Association (EAA), more homebuilt single engine airplanes were added to the FAA registry then factory built airplanes. A major contributor of this decline has been product liability. Persons injured or estates of those killed in aircraft have managed to collect big, in some cases, multi-million dollar judgments against the airplane manufacturer. This occurs even when pilot error remains the primary cause of an accident. This is the "deep pockets" theory at work. (Today, product liability insurance can account for as much as 30% to 70% of an aircraft selling price.)

A new industry has grown to replace the factory built airplane. The new products are "kit planes." A number of small factories are now producing airplane kits, which are assembled by the buyer. I have talked to a number of these kit producers and a unique liability picture has developed. This industry has witnessed a special form of protection from law suits. Over the last few years juries have been reluctant to award damages to the family of a person injured or killed in an aircraft he or she built. There appears to be an applied assumption that when you build and then fly, you are knowingly accepting some unusual risks. This position appears further supported by the FAA who classify the aircraft builder as its "manufacturer."

I think this picture holds true for balloon construction. If an individual chooses to use a repair manual to build a balloon and is then injured in that aircraft, there appears to be a big gap between that aircraft builder and the repair manual publisher.

While I appreciate the technical material in repair manuals I hope they are the starting point and not the ending point of balloon technology. With dozens of innovative builders each building his or her own definition of a balloon, we should see new levels of innovation. If we follow in the footsteps of the small airplane industry, we may one day soon see manufacturers looking to home builders for the latest in developments. In the United States today, there are probably fewer than a dozen engineers working specifically on hot air balloon technology.

Back to our discussion of the builder's library. Another book that belongs in the beginning builder's library is *Ballooning* by Dick Wirth and Jerry Young. This text was written for the general press but has an excellent review of balloon technology. Though the text was originally published in 1980 it continues to provide a broad overview relevant even today. Some of his historical material makes one appreciate how far balloon technology has come.

For the reader who wishes to have a text that includes some material of a theoretical bent, try Don Cameron's book, *Ballooning Handbook.* It has a chapter on advanced flying techniques which includes a number of formulae and charts on such factors as calculating balloon lifting force and fuel consumption.

The major manufacturers have all put out a variety of technical material, generally mixed in with sales hype. The Balloon Works, *Concepts*, mentioned elsewhere in this issue is good if you can find it. Aerostar puts out, on an irregular basis, a publication called *Technically Speaking*. This publication deals with specialty topics in greater depth than covered in sales literature or a repair manual. Often the topics involve an engineer's perspective. These are for sale to the public, and are provided free of charge to Aerostar registered owners.

On page 11 is a bibliography of books and articles for the homebuilder. The list is short because little has been written for the amateur balloon constructor.

AEROQUIP FUEL HOSE PROBLEMS: Aerostar encountered a leaking fuel hose problem which prompted Service Bulletin #132, issued on August 12, 1993. This bulletin states that a hose leak was found during preflight. Inspection of the hose revealed a fine slit inside the tube. While the hose in question came from Aerostar stock, we should consider the possibility that non-Aerostar hose assemblies may also be suspect. All suspect hose material was manufactured during calendar year 1992 and has one of the following identifications printed on the side of the hose:

AEROQUIP FC321-06 UL 5/16 LP-GAS HOSE 350 MAX. OPER. PSI 1Q92

AEROQUIP FC321-06 UL 5/16 LP-GAS HOSE 350 MAX. OPER. PSI 2Q92

AEROQUIP FC321-06 UL 5/16 LP-GAS HOSE 350 MAX. OPER. PSI 3Q92

AEROQUIP FC321-06 UL 5/16 LP-GAS HOSE 350 MAX. OPER. PSI 4Q92

The last four characters (1Q92, 2Q92, 3Q92, 4Q92) denote the quarter in the year during which the hose was manufactured. Hoses with other markings are not covered by this Service Bulletin. *(Here is a good reason to keep the balloon manufacturer of your burner, basket and tanks advised of your address even when an amateur-built envelope is flying over the basket.)*

If you have a question about the safety of your fuel hoses, contact your local repair station for details. Owners of Raven/Aerostar baskets who have not received this bulletin should contact Aerostar International, 1812 "E" Avenue, Sioux Falls, SD 57104; ATTN: Dee M. Rose.

Bibliography for the Homebuilder

The following is a list of books and articles of use to the homebuilder. The list is limited. Readers are invited to contribute material for inclusion into a master list to be published later.

"Experimental Aeronaut," Brian Boland, *Ballooning*. Refer to Brian's recent column in this magazine. He combines practical ideas with some very experimental thoughts.

"Time in Your Tanks," by Maury Sullivan, *Balloon Life*, March 1992, pp 16-19. Article on factors associated with fuel consumption.

"New Gas Balloons Meet," John Kugler and Brad Larson, *Ballooning,* Fall 1992, pp 12-13. Article on ammonia balloons.

"Barnstorming on a Magic Carpet," Tracey Barnes, *Ballooning*, Spring 1991, pp 20-23. Article on his new personal gas blimp.

"Sizing Your New System," Frank Hines, *Balloon Life*, April 1991, pp 18-19. Discusses choosing the size of a balloon system.

"Repair Station," Paul Stumpf, *Balloon Life*, recent issues. Paul discusses technical issues from viewpoint of repairman. Good material for the builder.

"Out of the Ground and Into the Sky," Ruth Ludwig, *Ballooning*, Summer 1991, pp 4-5. Article on ammonia balloons.

"Duration Record Set in NH_3," Victoria Cole, *Ballooning,* Winter 1991, p 5. Note on ammonia ballooning.

"Experimental Aeronaut, Collapsible Baskets," Brian Boland, *Ballooning*, Winter 1991, pp 21-22. Article on building break-down baskets.

"NH_3–It's a Gas, Gas, Gas, Victoria Cole," *Balloon Life*, June 1991, pp 16-19. Article on ammonia balloons.

"Ideas for a First Time Home-Built Balloon Project," Bob LeDoux, *Balloon Life*, May 1989, pp 9-11 and June 1989, pp 14-18. Two articles on traits for successful builders and considerations of a first time builder.

It Flies!," Scott Gardiner, *Ballooning*, Winter 1988, pp 11-12. Article by homebuilder on his experiences.

"The Forces and Pressures of Balloon Flight," William G. Phillips, *Balloon Life*, February 1987, pp 31-35. Article on pressure distribution inside an envelope.

"The Lady," Maureen Mullen, *Balloon Life*, August 1986, pp 17-19. Article on building the full size balloon of the Statute of Liberty.

"Populsion (sic) by Venting of Lifting Gas," Karl Stefan, *Ballooning*, Spring 1985, p 26. Horizontal motion, relative to the ground, is obtained by using a side vent.

"Paraphernalia, Aerostatica," Brian Boland, *Ballooning*. A series of articles in the late 1970's of interest to builder.

"Fabric Strength and Tear Propagation," David Schaffer, *Ballooning*, September-October 1981, pp 4-7. Classic article on importance of fabric tear strength and how tears propagate.

"Have you Considered a Small Balloon?," Bob LeDoux, *Balloon Life*, April 1992. Article on the advantages of flying a small balloon.

"Down One Donut," Bruce Comstock, *Ballooning*, Fall 1993, pp 12-13. Article by competition pilot on his first experiences at ammonia balloon flying.

A Chilly Reception in Chile," Bill Arras, *Ballooning*, Fall 1993, pp 24-25. Bill discusses taking his homebuilt ultralight balloon to Chile and flying with minimal support equipment. Inflations were made without a fan.

Ballooning Handbook, Don Cameron, Pelham Books, 1980. A basic text book from the English point of view. While some of the material is dated, some theory, technology and historical notes are worth reviewing.

Ballooning, Dick Wirth & Jerry Young. Random House, 1980. One of the best texts written for the general public which has volumes of technical material of use to the new builder. Does well at comparing the different philosophies of balloon manufacturers.

Aerostar's Continuing Airworthiness Instructions. Aerostar International. This is the best instructional text for the builder. From this manual, all essential general and detail information can be found from which to build a balloon. The manual costs $60, and is updated on a regular basis. Purchase from a local Aerostar dealer.