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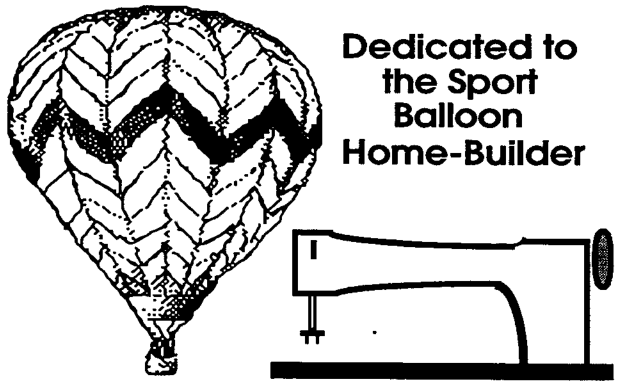


Dedicated to the Sport Balloon Home-Builder

Published five times per year-$12 per year

# THE BALLOON BUILDERS' JOURNAL

September-October 1997

## In This Issue



## Fuel Tanks as Basket Components

Fuel tanks are the strongest part of a basket system. One needs only to watch a drop test in which a fully loaded tank is dropped 20 feet onto concrete to quickly come to this realization.

Those flying Boland baskets and other similar designs recognize this fact. But these designs still consider fuel tanks as dead weight.

Why don't we instead, treat the fuel tank as a structural component of the basket. In other words, rather than putting a tank into, or hanging it from the basket, make it part of the basket.

I have been developing a number of ideas around this concept. I took these questions to the Vermont EBAA meet in May, not expecting to find anyone who had experimented with this idea.

John Burk, from Mt. Holly, NJ proved me wrong. He has built such a basket. We will feature it in the next issue.

If like John, you have experimented with using fuel tanks as structural basket members, share your story and pictures with *BBJ*. We'll devote the next issue to submissions on this topic.

# Building *Tweetie Bird*

**By Dan Helmboldt**

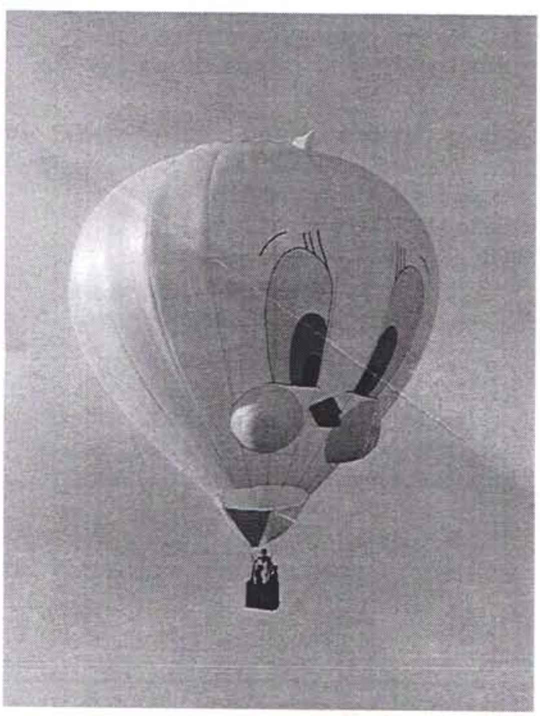
3144 20th. Avenue Ct., Greeley, CO 80631-8703

*Dan shows that a special shape balloon doesn't have to be complex.*

I started "Tweetie" in the middle of September, 1996. This is my third home built. I built "Memory Maker" in 1991 with little or no sewing experience. I sewed a flag for the chase trailer to carry, to make sure I knew what I was doing. (That is *after* I went back to the sewing store to have them show me how to thread the machine again).

I started with an old *Universal* sewing machine, but half way into it changed to a *Pfaff* because of a larger motor and better power. These were commercial single needle sewing machines, so I had to feed each seam through twice to complete the stitching. I was familiar with the machines and felt safer working with them

"Memory Maker" was built in 150 hours. However, some of the fun was lost in the process because I was losing my Crew Chief to cancer. I was sewing morning and night, and 8 hours per day on the weekends to complete it so he could see it.



Dan Helmboldt's special shape balloon *Tweetie Bird*. The actual balloon was constructed in short time. But working out some of the details, in particular, the shape of the cheeks took some effort.

We inflated it on a Friday to tie the parachute lines in and get everything set. We then took it to the subdivision where Wayne lived and inflated it at the "T" intersection at 8:00 a.m. on Saturday and walked it right down the street. Wayne looked it over and laid back down and died 18 hours later. Hence the name "Memory Maker" in his memory.

I have since built a second balloon with a friend. His balloon, but my help in cutting and sewing; much more relaxed and a heck of a lot more fun! This balloon also took 150 hours to construct.

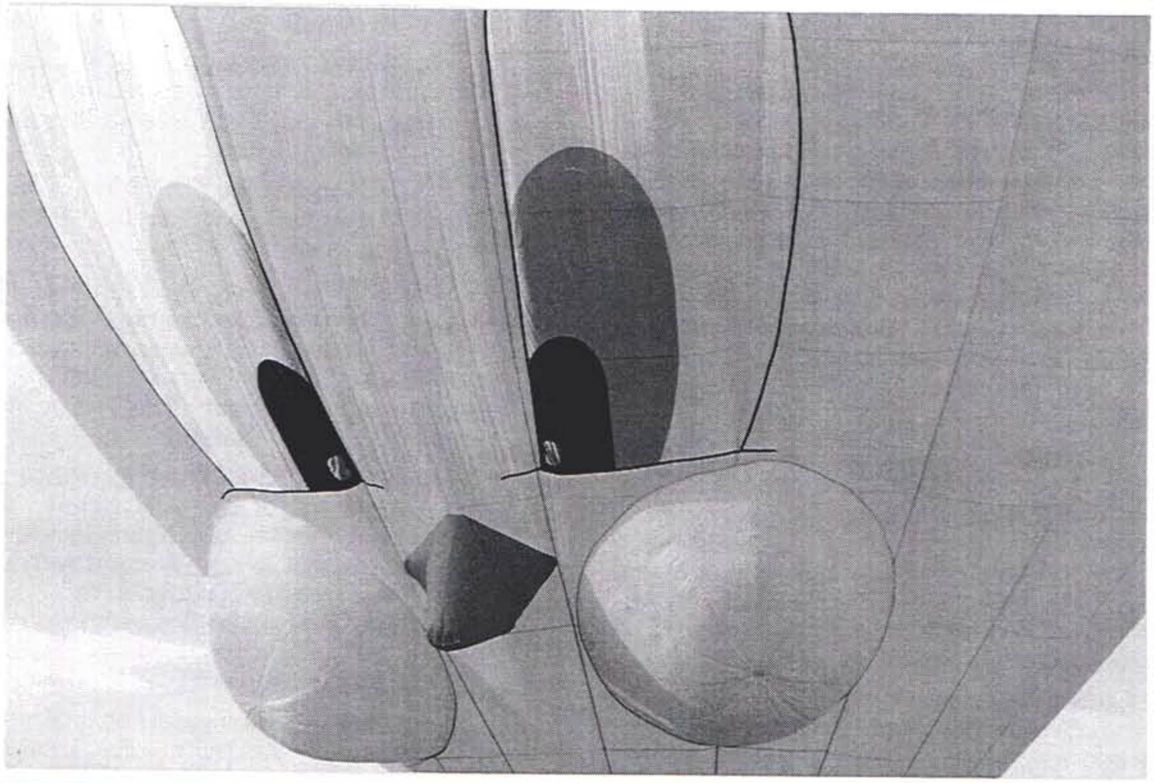
Since the second balloon was finished in 1993, I have played with the idea of building a "shaped" balloon. I wanted the challenge of construction. But I also realized my limitations of the shapes I could use. I didn't have a CAD that could run the design right to the cutting board.

I talked to the 7-Up™ balloon pilot and asked structural questions about having the load tape on the inside to maintain the cylinder shape. I talked to the Mickey Mouse™ pilot during a rally in Park City, UT, about the inflation ports on the ears, nose, etc. I also visited with the Hagar the Horrible™ pilot and gained information on the use of Velcro™ to ease deflation of the puffed out portions of an envelope.

Ice cream cones were out; I'd already seen one built. I explored a snowman. I talked to Tim Cole, a local pilot who flew the Atlantic in 1995. He also builds hot air and ammonia gas balloons. We ruled it out because of the weight factor compared to lift. Too bad, it was a great shape!

Then one day I got looking at a picture of Tweety™ and realized his head was basically a balloon shape. I went to the Warner Brothers Store and bought a plastic Tweety™ bird so I would have the dimensions and a 3-D look at his head and off I went.

Basically, I blew up that face from 4 inches to seven stories. I had pictures of the



This close-up photograph shows some details of construction for the eyes, cheeks and the beak. Read the text for more details.

"Memory Maker" on which I could draw "eyes" to see the placement, length and width and positioning for the rest of the face. Everything else was in my head.

The eyes turned out to be 20 feet tall and 9 1/2 feet wide. But its was cheeks that presented the biggest problem. A hemisphere, according to my calculations (and I didn't do too well in math in high school) was too "flat." It also appeared that the sides would come in too straight. There would be no "blending" into the face at all.

So I called the calculus instructor at our local community college and told him who I was, what I did, what I was building and that he could hang up the phone anytime he wanted.

I tried to explain to him over the phone what the problem was with using a hemisphere, but he didn't understand. I tried a different tack to make him "visualize" what I was trying to accomplish. No luck. So I flung caution to the wind and said "OK, don't arrest me for this, but a 14 foot diameter is a constant. It can be slightly smaller, but no larger. A hemisphere with a 14 foot diameter gives me an "A" cup...I need a "C" cup." And he immediately said "Oh, you need a parabola!!" I guess you just have to explain in a language "guys" can understand!. I didn't even know what a parabola was, but he said it needed it and I took him at his word.

We then discussed production of a pattern. Building the cheek like an igloo would work but would be more difficult. Built like a pie is cut would be easier for me because each piece would be the same. He then worked out this elaborate calculation and gave me a seven and a half foot "bullet" with width measurements every six inches to allow for construction. It was easy from that point on. I didn't know what it was going to look like yet...but it was easy.

The cutting out process was far easier than the previous balloons because it was all one color. I cut out the Bird in 17 hours, less than the previous two "patterned" balloons. I placed two eight foot tables side by side, and length–on so I could pull three fabric pieces out, then cut all at one time. The fabric roll was placed over a pipe and pulled off just like a paper towel.

My sewing room was a vacant space at the Greeley Mall. I manage the Mall so it gave me the flexibility to use this space.

During the construction process we were able to lay out the three gores which contained an eye, in the common area of the mall. This allowed us to verify placement, take out the wrinkles, trace the eye on the yellow fabric and even clip it in place. We then dragged it back into the sewing room and sewed from the bottom to the top, leaving three feet unsewn at the radius. When the eye was finished it allowed any slack to be taken out in a "pie" piece tuck at the very top of the eye.

The bill was a cone with the bottom cut off. While a cone is circular, at its base, the bill was constructed by sewing the cone on in a diamond base pattern. This was to help the bill keep its shape. I attached Velcro on the mouth, at the bottom of the bill, to facilitate deflation. The cheeks also had Velcro deflation panels about two feet long.

I wasn't too sure about the shape of the bill, however it would have been the easiest to fix should it need adjustment. I could have pulled it through the inflation port hole, trimmed and resewn it and stuffed it back.

Tweetie's top notch is four feet tall and is dwarfed by the size of the head.

I built three gores and worked the left eye and cheek out, sewed it on and considered it finished. I then attached another gore and attached the beak and top notch. Three more gores to attach the right eye and cheek were then attached to the first four. Then I built the rest of the head. This kept a minimum amount of material under the arm of the sewing machine and made construction easier.

Licensing: I called Warner Brothers three times during December, 1995, trying to get necessary paperwork (if any) accomplished. They wouldn't call me back. I wrote them a letter–certified with return receipt requested–and told them of my plans. I stated that I had tried to contact them but if I didn't hear from them in thirty days with either a confirmation, denial, or necessary paper work, I would proceed.

That was January 1995 and they never called or wrote. I had the guy in charge of licensing's signature. It would not be used for commercial use; recreational flying only. I am also certain that there is enough difference in the appearance that it really isn't an issue.

My balloon has a significant variation from the cartoon character. The shapes are different, but children still associate my envelope with the real thing.

The balloon has provided a lot of fun especially for children. Even the FAA has gotten into the act.

My FAA inspector had a real sense of humor. He came out wearing a Warner Brothers tie displaying various cartoon characters. He signed off the aircraft logbook using a Tweety Bird™ pen from his grandchild at last Christmas.

We flew Erie Airpark and landed on the runway waiting for the ground crew. A father brought three children between the ages of four and seven. We deflated the balloon. The youngest one asked "Daddy, where did the birdy go, I want to pet the birdy?" The little one couldn't comprehend that the fabric was the birdy.

It has been an accomplishment of a long term goal to do this but my problem now is I'm having "sewing withdrawal!" Anyone out there want a balloon built?!

We have notes and some video footage of procedures that I would be happy to copy for anyone who could use them.

**Special Note to Builders**

Do not approach *Performance Textiles , Inc.* for the purchase of, or inquires about balloon fabric. (This company is a major producer of lightweight fabrics like Soarcoat™ and Exacta-Chute™.) They are very much opposed to the use of their products, be that first or second grade textiles, in amateur built balloons. They will let you know that position in no, uncertain terms. Their stated position is that the liability exposure does not warrant the risk of providing fabric for our needs.

I had the chance to discuss their company position with representatives who were present at Albuquerque, last fall. At that time they were cordial, but clear in stating their position. I am now hearing from readers that inquires are being responded to in a more direct and terse manner. Give them some space.

*We don't need to push these buttons- Editor*

# Low Cost Envelope Temperature Gauge


## By Phil MacNutt

4909 Great Divide Drive, Austin, TX 78736-1004


*This envelope temperature gauge is intended for the builder with some hobby electronics experience. Here is a good winter project to help fill those cold non-flying days.*

Last year I built an electronic envelope temperature system that has worked quite well for me. Although it wound up being more complicated than I first anticipated (as all projects are), the results were worth it.

I chose the Motorola MTS102 semiconductor as the temperature sensor. There are probably a dozen sensor possibilities, but I chose the MTS102 due to these facts, in that it is,

Very linear,

Has a wide temperature range (-40° to 300°F),

has a fast thermal time constant,

Is cheap,

Is simple to interface.

Cameron and Balloon Works use them in their envelopes, I have checked.

The one drawback to the MTS102 is that it may be difficult to find, especially in remote areas. Calling Motorola sales directly is how I got mine. Make sure they send you a data sheet. I called the Motorola sales office in Phoenix 800-521-6274.

I chose the LM324 op amp because it is a single power supply amplifier. Normal dual supply amps would require two batteries for power (+9 and -9 volts.) The 324 is probably not the best amp in the world, but I'd hate to have to haul around double batteries.

With R1 and R2 chosen to provide 8:1 gain, this circuit provides 10 millivolts per degree F of output. Setting R1 to 120kΩ and R2 to 15kΩ does the job quite nicely. It is best to use 1% tolerance resisters where possible to assure the most accurate output. If you use 10% tolerance resistors everywhere, the error will stack up and hurt reporting accuracy.

As far as wire goes, I agree with the article you wrote in a previous *BBJ* article. I priced quality 18 gauge, 2 conductor cable from a local aircraft hanger, and it would have cost about $70 just for the wire. The *Aircraft Spruce* wire is a much better deal, although you do have to twist it yourself.

After a few flights with the system installed, I noticed that it performed quite well, but it always seemed to read about 10 to 15 degrees hotter than the theoretical charts indicate. I wrote it off as being error due to fabric porosity, humidity, etc. But it turns out that the sensor was hanging down too far from the fabric.

**Circuit Summary**

Boxes, (see page 6) marked by dotted lines, break up the circuit into four individual functions. Box A contains the sensors, which actually read the temperature. Box B contains the power supply which powers the entire circuit. Box C contains the digital readout which displays the temperature. Box D contains the amplifiers which isolate and adjust the sensor output for the readout.

**Circuit Detail**

Note: small numbers represent pinout numbers for the integrated circuit (IC) connections.

**Box A: Sensors**

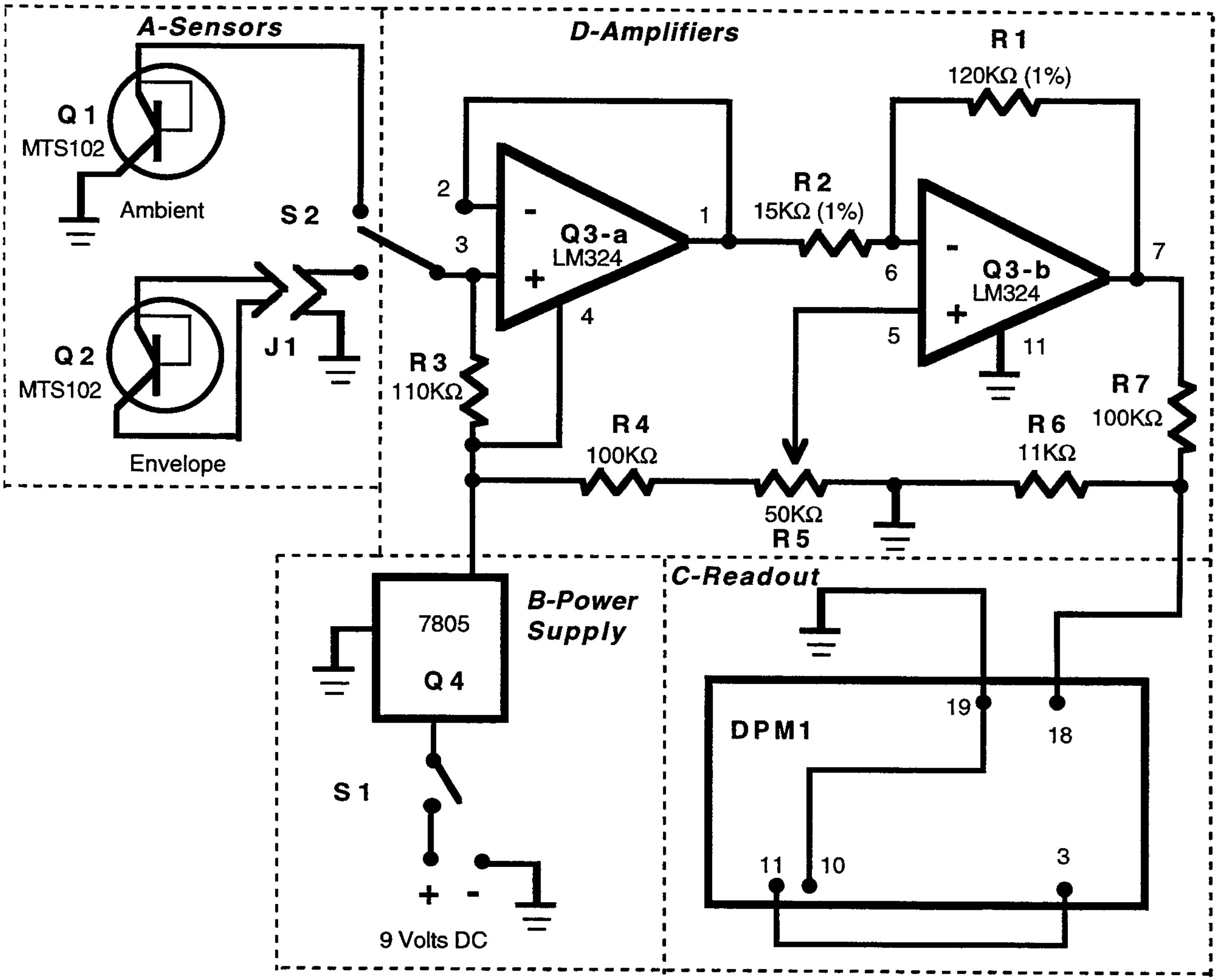
The schematic diagram displays two sensors. Q1 reads the ambient temperature. Q2 reads the envelope temperature. The sensors are selected by a single pole, double throw switch S2. If only envelope temperature is desired, S2 and Q1 can be eliminated. [These sensors are essentially NPN transistors with two leads shorted together to make them operate as a diode. In fact 2N2222 transistors could be used instead of the MTS102-Editor]

The envelope sensor is attached by wire to a jack, J1, which plugs into the meter unit. This allows the meter unit to be disconnected from the envelope. The jack can be any reliable jack like a earphone or phono jack. Note one side of the sensor is connected to common ground so a shielded cable can be used. The wire to the envelope sensor should be of a high temperature type. Selection of sensor wire was discussed in *BBJ* #21.

**Box B: Power Supply**

A 9 volt battery provides power to the entire unit. The negative pole of the battery is grounded and the positive pole is

## MacNutt Temperature Gauge Schematic




connected to a switch, S1, which turns on and off the entire unit. The switch is connected to a voltage regulator, generically known as a 7805 unit. This unit provides a steady 5 volts to the rest of the circuitry. Because very little current is pulled from the battery the very small 78L05, transistor-size, voltage regulator can be used.

**Box C Digital Readout.**

The digital panel meter is a Jewell model JDPM202-ND. This is a 3.5 digit liquid crystal display (LCD) with a full range read of 2 volts. Three digits are used to read up to 300°F. It is powered by 5 volts from the voltage regulator (7805) The schematic diagram does not show the power supply connection. This meter can be purchased from *Digi-Key* for about $35. Read the detail which follows for an alternative meter.

**Box D: Amplifiers**

The two amplifiers, Q3-a and Q3-b are in the same IC chip. The LM324 is a 14 pin chip which contains four op-amps. For this circuit, only two of the internal amps are used. The LM324 (Radio Shack part number 276-1711) was chosen because unlike many op-amps which require both a positive and negative power supply, this chip requires only the positive power supply.

Q3-a is a unity gain buffer, a high impedance amplifier which isolates the sensors from the rest of the circuit.

Q3-b is an adjustable output amplifier. A 10 or 15 turn 50kΩ trimmer resistor sets the voltage into the op-amp, Q3-a, so that the output in the meter is accurate for the temperature read by the sensors. To ensure good meter accuracy, the resistors marked R1 and R2 should be precision units with 1% tolerance (or measured within 1%).

Resistors R6 and R7 create a voltage divider which reduces the voltage out from Q3-b by a value of 10. This is required because the circuit is set up to provide 10 millivolts out from each sensor for each degree. Thus at 250°F the voltage into the meter is 2.5 volts. But the meter will only read up to a maximum of 2.0 volts. By reducing the voltage, the temperature of 250°F is read as .250 volts.

**Construction Ideas**

The parts except for the envelope sensor wire, the sensors and readout meter are available at a local Radio Shack store.

The amplifiers can be constructed on a small circuit board. Radio Shack, for example, has a small board stock number 276-159 which is designed for small integrated circuit chips. A 14 pin socket should be soldered directly to the board. The resistors, pot and voltage regulator (78L05) can all be mounted directly on this board. The board can be mounted inside a small project box; Radio Shack also has a variety of these. The two switches should be mounted on the box surface, along with the jack (J1) and the digital readout.

Switch S2, which selects between ambient and envelope temperature could be a momentary contact (like Radio Shack 275-5149). This would allow it to be pressed to read ambient temperature. When released, it would return to envelope temperature. A push button switch is good for this application.

The entire unit can be powered by a regular 9 volt transistor radio battery. If battery backup is desired, two batteries can be installed in the case. Switch S1 could be replaced with a single pole double throw switch with a 'center off' position, like Radio Shack 275-654, to allow choosing one battery over the other. That feature is not shown in the schematic diagram.

The batteries can be installed using a battery mount clip, Radio Shack #270-326, or by using sticky backed Velcro™ purchased from a fabric store.

Radio Shack sells a multi-purpose digital display for about $17 which might be used for this project. Its available only by special order. Part number is RSU 11906948.

***Editor's Comments***

*BBJ, Issue 21, November-December 1996, presented a simple envelope temperature gauge. Included in that article is a discussion of sensor wire selection.*

*We recommend that a wire, with a Teflon™ or Tefzel™ coating, or other high temperature cover, be used for the sensor wire. A wire size of 18 to 22 is a reasonable size.*

*Aircraft Spruce and Specialty (telephone 800-824-1930) sells size 22 wire (part number 11-14522) for $.09 per foot for quantities over 100 feet.*

*For the amateur builder without electronics experience, that earlier article is probably a better choice as very little soldering or electronic construction is required.*

*For the amateur builder with a bit of electronics experience, Phil's project may be a good winter-time activity.*

*Most of the items to construct this project can be purchased from a local Radio Shack store. Check out their new 1998 catalog. It provides a much larger selection of electronic parts than found in previous years. Many of these new parts are not kept in store inventory, but delivered to the buyer by mail. These mail order parts have a parts number preceded with the letters "RSU."*

*There are tricks that electronic hobbyists use. For example, if a 1% tolerance resistor is called for, some builders will measure the resistance of their parts and select the one closest to the desired value. This requires an "ohmmeter," which is one of the measurements included in a digital multimeter. These instruments start at about $15, and are a basic tool in any household.*

*As we go to print we are finding that the MTS102 sensor is becoming hard to find. Builders who want that particular part may want to contact a local repair station, or pull a sensor from a retired balloon envelope. Note that Thunder & Colt, Cameron and Balloon Works have all used this particular sensor in their temperature gauges.*

*Several builders have had luck using common NPN transistors. The 2N2222 is available for less than a dollar in the plastic (TO-92) case. This is the same case used for the MTS102 sensor, so the time constant should be about right. For a slower response try the same transistor in the metal, TO-18 case.*

# Letters to the Editor and Other Bits of Information

### Sewing Machine Throttle

July 14, 1997
Bob

Great job on the last newsletter with Vermont coverage!

Dave Koenig just bought a Brother double needle, and he is complaining about the same thing that many other folks have complained about: no throttling, it is either wide open, or off. Have you come across any ideas for improving the throttling capabilities of these old machines?

Dave says that my 112w throttles much better than his machine. I think alot of it is genetic. I have great difficulty throttling, and then my wife Jean gets on the machine and makes it purr like a cat, with very smooth acceleration and deceleration. She has never used an industrial machine, and was perfect her very first try.

After building 2 balloons, I still cannot come close to her in this. What about you and Mari? Same thing?

See ya

Phil MacNutt
wmacnutt@carbomedics.com

*Phil,*

*Marianne has sewn since she was in her teens. Her experience shows in her sewing. She sews a balloon with the sewing machine running 'flat out.' So she could production sew balloons, tomorrow, if she wanted to.*

*Regarding throttle control on sewing machines. If a builder is uncomfortable with the high speed operation, the motor pulley could be reduced in size to reduce the full speed stitch rate. Depending on the adjustment available on the motor, this may require purchase of a new motor drive belt.*

*Most motors have a load spring which sets the tension on the clutch and also sets the foot pedal pressure. By reducing this spring tension, the clutch can be more easily throttled. However, this may eliminate the brake action. In other words, letting up on the pedal may result in machine coasting to a stop rather than abruptly stopping under spring-operated brake action. Brake action can be created by using the heel of the foot, so it isn't completely eliminated.*

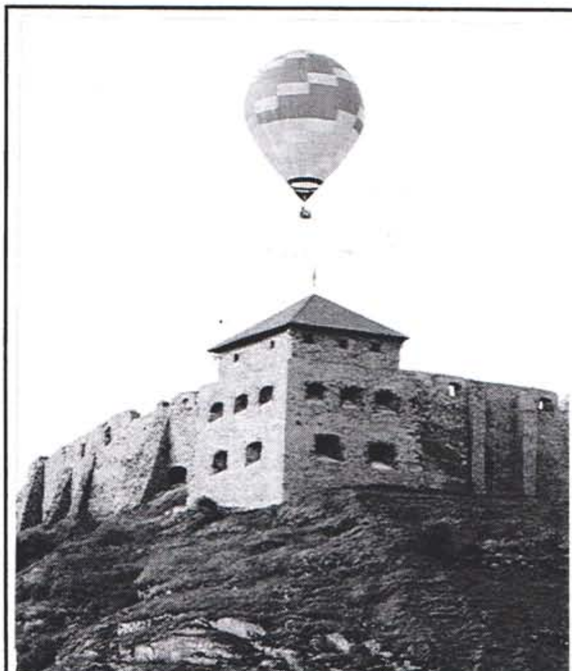
*The downside to this is that the 'panic switch' is eliminated. With the higher spring tension, just picking the foot up from the clutch pedal will create an immediate stop. With the lower tension, the needles may coast to a stop while wondering into 'unwanted territory.' I have heard of cases where this 'unwanted territory' was fingers. So I recommend that beginners keep the clutch tension high enough to keep braking active. -Editor*

### An American in Europe

Bob,

Enclosed is a picture of my homebuilt flying over Sumeg Castle in Hungary. The photo was taken in May. So far my balloon has flown in Spain, England, Poland, Slovakia, Hungary, Germany as well as the United States of America. She has 125 hours.

Bill Hawkins
SFTS CMR477 Box 538
APO AE 09165



Bill Hawkins flying his homebuilt balloon over Sumeg Castle in Hungary.

### Help Support Gas Ballooning

Bob

In some of the early issues, you did more articles on gas balloons. I'd really like to read more as it's been a long time. We need to do anything we can to keep gas ballooning alive.

Shane Robinson
3515 East Cinnamon Place
Springfield, MO 65809

*I agree. John Kugler was the author of those early gas balloon articles. Because of other issues in his life, he hasn't been able to contribute of late. I would very much like to receive contributions on flying gas. Editor.*

### Oregon Fatal Balloon Accident

Oregon recently suffered a fatal balloon accident, the first in the state since 1980. The circumstances of this accident are worth review by balloon builders.

The accident involved an Avian AX-9 aircraft carrying 7 passengers and a pilot. This system is rated for a gross weight of 2,500 pounds. The accident occurred as the vertical load tapes which attach the envelope to the basket, separated in quick succession.

No official report has yet been issued, so I am cautious about drawing conclusions.

One elderly passenger was killed in the fall, while the remaining passengers suffered primarily broken bones and some internal injuries. Large limbs in a fir tree helped break the fall which appears to have prevented more fatalities.

Wind conditions at the time of the accident were minimal. The balloon had flown most of an hour and had covered only about three miles.

It is unclear as to why the basket separation occurred. The stitching in the vertical tapes, appears to have failed allowing the basket cables to disconnect. The comments we have heard suggest that this failure was **not** a manufacturer's defect.

The parachute operating line may have become entangled in the tall fir tree, which could have precipitated the accident.

This information is useful to builders, because it appears the cable to tape connection may be, or can become, a weak spot. We are aware of several instances in which baskets have separated from envelopes. These instances have involved both amateur built balloons as well as factory products.

Builders are encouraged to review their construction techniques to ensure there is adequate strength in the cable to envelope attachment points:

- Builders should copy proven attachment mechanisms. As an example of a design with "significant structural integrity," Aerostar utilizes a Forgecraft #54A90B2 fitting to attach the cable to the vertical load tape. The vertical tape assembly involves multiple layers of tape assembled with size 16 thread using a "4 point W" stitching arrangement. Details of this assembly can be found in the Aerostar repair manual kept by most repair stations.
- Other balloon manufacturers often use simpler attachment mechanisms, sometimes running the tape through a cable thimble. This arrangement has proven adequate.
- Consider the possibility that the proximity of heat to the load tape stitching may result in an eventual loss of thread strength. This may justify heavier thread at this location as well as heavier seam construction.
- Doublers, extra layer(s) of tape over the cable connection, are justified to protect the tape from abrasion.
- A builder proposing to use an innovative or unproven assembly design should seriously consider testing samples to failure.
- The horizontal tape in the envelope mouth should be substantial. I would not use a tape less than 1 inch wide, of 1,000 pound test strength and prefer an even wider tape on larger envelopes.

### Followup on Gore Layout Patterns

*In BBJ Issues 22 and 23, we revisited the Gore Pattern Spreadsheet, as presented in issue 1 of this publication. One of the key points made in those articles was that a continuous mathematical function, a polynomial equation, could be used to approximate the Smalley factors used to create gore patterns. An advantage of this approach is that the equation can be modified to allow the envelope shape to be altered.*

*Bob Nungester has taken up the challenge to create computer tools with these capabilities. For our mathematically astute readers, his comments are presented below. This is an exchange of letters between Bob and the BBJ editor.*

July 14, 1997

Subject: Smalley Factors

Bob:

Thanks for the literature on Smalley factors. I see that he developed two parametric differential equations (r and z vs. s) that were then solved to produce the factors. The paper didn't say what the value of K is that showed up in the integral to be minimized, but I came up with a totally different way of solving the problem anyway.

The good news is I developed a procedure to mathematically move in small steps along the surface of a theoretical balloon from the mouth to crown and calculate the force due to pressure, the resulting change in angle, and the "Smalley factor" at each step. It is an iterative procedure that requires an initial guess of the angle at the mouth and then checking if the calculations end at the crown with an angle of -90 degrees (a necessary boundary condition). The start angle is adjusted up or down and the calculations are repeated until the final angle equals -90 degrees.

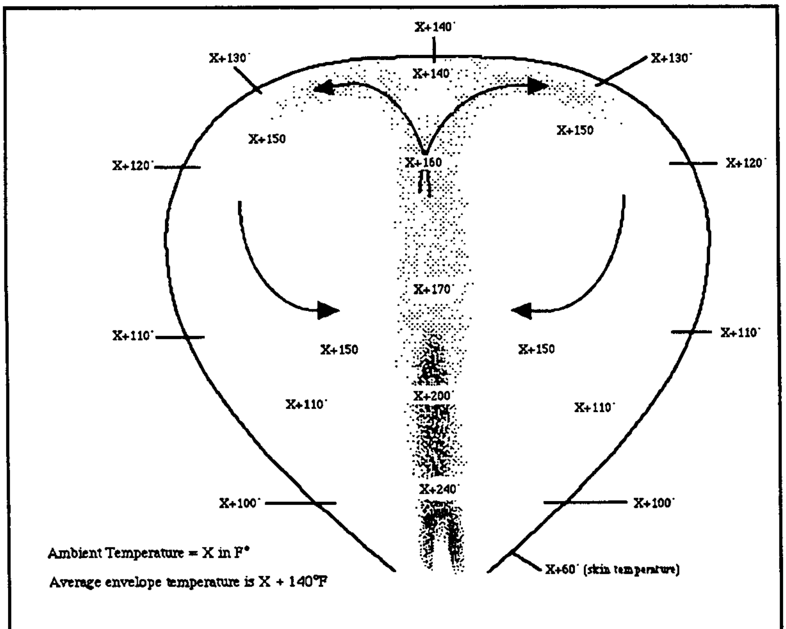
So far I've implemented the procedure in a spreadsheet with the iterative adjustments done manually just to prove that it works, but I'll be able to incorporate automatic iterations into a Visual Basic program so pushing a button will complete all necessary calculations.

The great news is that this method can also incorporate fabric weight and the fact that the mouth begins above the apex. This will allow anyone to generate factors, gore layouts, etc. to produce a natural shape (no circumferential stresses) balloon for any design load, fabric weight, equilibrium temperature (gas density), mouth size, etc!

My spreadsheet shows the comparison of my calculations to Smalley's factors. The largest error is less than 2%. My calculations were done using a step size of one foot on a 90,000 cubic foot balloon, so I may reduce the step size to improve accuracy.

I tried the calculations with a few different densities for the same total lift and the shape factors change very little (possibly not at all in an exact solution). I'll study this further, but it looks like the lifting gas density may only affect the overall size of the balloon, not the shape for any given design lift. This is probably why my calculations agree so closely with Smalley's, considering that his were based on a much less dense gas than hot air.

Another interesting point is the design mouth angle. My calculations, like Smalley's, show an angle of about 50 degrees. I measured about 15 photographs taken of various balloons and the angles on all of them were between 38 and 40 degrees, just as mentioned in the last *BBJ*. I suspect that the difference is due partly to the fact that balloons are almost always flown considerably below design lift and design temperature, and partly due to the non-uniform temperature profile in the balloon.




This is my rendition of the heat distribution as presented in the article by Pohl. See text for more discussion.-*Editor*

Do you know if anyone has ever measured the temperature profile in a balloon? [*See drawing, left–Editor*] This may be a major factor affecting balloon shape. If so, it will be easy to incorporate this into my program also.

I'll keep you informed of how I'm doing on the program. It'll probably take a few months of spare time, especially during flying season, but I'll start working on it in the near future.

Bob Nungester

BNUNGEST@raychem.com

*July 15, 1997*
*Bob,*

*It sounds like you are replicating Smalley's design work, with additional design considerations. As mentioned in the last issue of BBJ I also feel the difference between the 50 degree Smalley mouth angle and the 38 to 40 degree angles seen in hot air balloons is due to the temperature variation in the envelope. This is probably more accurately reflected in the temperature effect on internal pressure in the envelope. The hot air balloon has the highest internal pressure at the top, which then diminishes to being equal to the atmospheric pressure at the point of the mouth opening.*

*I believe Karl Stefan performed some early heat distribution studies of hot air balloons. This was published in a text by Russel A Pohl, Assistant Chief Engineer, for Raven Industries: "Applications of Hot-air Balloons to Scientific Programs." This text was prepared for publication in December 1963. It may have been published in The "Journal of Scientific Ballooning" at about that time. I believe that was the journal for National Center for Atmospheric Research (NCAR) in Boulder, CO, under the auspices of the National Science Foundation.*

*I suspect balloon manufacturers have produced more recent analysis of heat distribution, but have not published the data.*

*Mark West, who is one bright engineer, as well as president of Aerostar, recently wrote a "Technically Speaking", Aerostar's quarterly newsletter on technical issues. The issue for the Fourth Quarter of 1996 discusses envelope temperatures and their measurement. Your local Aerostar dealer or repair station should have a copy for your review.*

*We have discussed envelope boundary layers in previous issues of BBJ. To summarize, balloon fabric is a poor heat insulator, so the air in close contact to the fabric cools more rapidly than the air deep inside the envelope. Because of the friction of the fabric surface, the air near the fabric has a tendency to remain stationary. These factors result in the fabric being immersed in cooler air than the average balloon internal temperature. In fact, the skin temperature can be as much as 50°F cooler than the average interior temperature.*

*These factors help contribute to extended fabric life. They also explain why a rise in temperature, when payload and ambient temperature remain the same, is an indication that the envelope is getting old.*

*The drawing shown on page 10 has always confused me somewhat. Envelope temperature is dynamic, if only because the burner is operated at regular intervals which really shakes up the internal heat distribution. When the burner is operated, a column of heat rises in the envelope. This takes several seconds to reach the envelope top, after which it rolls around and down the envelope sides.*

*This action results in a loss of boundary layer so that higher temperatures come into contact with the fabric surface, for a few seconds. This temporary impact can be dramatic. I recently placed a sensor, about a third of the way down the envelope surface, and about 2 inches from the surface. This was in my small balloon (38,000 cubic feet), flying with a 10 million BTU burner. Normal flying temperature was 210°F, but after a three second 'burn', the temperature would jump to over 300°F for 2 or 3 seconds. It would then return back to the normal operating temperature.*

*My readings were taken with a very rapid response (glass diode) sensor with no heat sink to dampen (slow down) the response time. So I am convinced the spikes in temperature were real.*

*As we noted earlier in this issue, balloon temperature gauges have a fairly slow response time. Pilots don't want to see these rapid swings in temperature but want to see the general trends in temperature change.*

*Nevertheless, your balloon probably undergoes the rapid heat spikes. They just aren't reported on your temperature gauge. I am curious as to how much these spikes contribute to the overall deterioration of balloon fabric. Editor*

**Sources Listed in This Issue**

**Newark Electronics** has regional offices in 43 states, located in major metropolitan areas. Check your telephone white pages.

**Aircraft Spruce and Specialty Company**, Box 424, Fullerton, CA 92632 Telephone 714-870-7315

**Digi-Key Electronics**, 701 Brooks Ave. S, P.O. Box 677, Thief River Falls, MN 56071. Telephone 800-344-4539.

Addendum: The following material was not part of the original publication.

The following three photos display *Tweetie*, a special shaped balloon discussed starting on page 2.