The INFLATOCOOKBOOK was first published in Jan. 1971 by Ant Farm. It was our attempt to gather information and skills learned in process and present it in an easily accessible format. That INFLATOCOOKBOOK came loose leaf in a vinyl binder that we fabricated in our warehouse in Sausalito. The first printing was 2000 copies.

The experiences that qualified us as 'Inflato-experts' occurred over an 18 month period in which we designed, built, and erected inflatables for a variety of clients and situations. Charley Tilford showed Ant Farm how to make fast, cheap inflatables out of polyethylene and tape and support them with used fans from Goodwill. That was in the fall of 1969. The first one built was the largest, a 100' x 100' white pillow that was built for the ill fated Wild West Festival in San Francisco, then after being turned down for Stewart Brand's Liferaft Earth Event, finally had its day at Altamont. There followed a year in which we built numerous demo-inflatables at schools, conferences, festivals and gatherings around the state of California and beyond.

ANT FARM at that time was: Andy Shapiro, Kelly Gloger, Fred Unterseher, Hudson Marquez, Chip Lord, Doug Hurr, Michael Wright, Curtis Schreier, Joe Hall, and Doug Michels.

The INFLATOCOOKBOOK was written, designed, and put together by Chip Lord, Curtis Schreier, Andy Shapiro, Hudson Marquez, Doug Hurr, Doug Michels with help from: Sylvia Dreyfu., Charley Tilford, and Sotiti Kkritilakis.

This SECOND PRINTING (July 1973) takes on a new form for ease of printing and distribution. It gets a new cover and binding, and some material has been omitted for update. Still it is a good buy at the original price of 3.00$, only at one place; that's Box 471 San Francisco Calif 94101
The World's Largest Snake Alphabet
Electrosis-instant media &
The Universal Mass Consumption Grid
Erection American shopping centers
Livin' & jivin' - a & b
or university automatons/sto. - c & d
Ultrasonic media blasts from d
Blow it up - e
The World's Largest Snake eats
videoscreens - f & g 5 man crew
explores limits, blows up buildings,
destroy Fat City, build real City
Solar energy, dreams, envisy
mobilitytomorrow AND
we give 10X energy credits with fillup.

WORLD'S LARGEST SNAKE

MEDIA VAN

ENTRANCE

OIL MASSAGE

ENTRANCE DETAIL

WORLD'S LARGEST, SNAKE TRUCK SECTION

SECTION at CADDY

SECTION at CLOUD

SNAKE RATTLE & ROLL ROOM

57 CADDY
1. Tape strips of poly together into a large square.

2. Fold edges over and tape.

3. Make tube for fan, inflate & cut entry slit...spend the night together.
Most plastic available comes in sheets or rolls. Here are several methods of making yellow shapes from essentially two rolls, two rolls, continuous strip. Use with care.

1. Place 2 rolls in a straight line to form a circle.
2. Place 2 rolls in a straight line to form a square.
3. Place 2 rolls in a straight line to form a triangle.

STICK ME ON TURTLE

CUT ME OUT

GLUE ME

To make a flat piece of plastic, use a flat surface and a continuous strip. Roll the strip into a tube and glue the ends together.

90° - flat toe

less than 90° - pointed toe
COLOR
The most easily available colors are clear and black (used in concrete construction work) but white and colored poly can also be found. Clear is decidedly magical. Its drawbacks are that it gets tremendously hot inside if there is sun and it is a hot day. It can cook the people inside and the goods underneath. This can be turned to good edification in cool weather for solar cover, or in winter weather for good water environments, seenas baths, oil massages, etc. Be careful of leaving a clear bubble on a green lawn for too long as it will stain the grass in its own juice. In five to ten hours if the sun is hot. White reflects heat, but it gets very bright inside. You can project on it at night or bounce colored lights around inside it. One good design compromise is a half white/half clear bubble — you can put the clear side up to the sun or the clear side up cool on a cloudy day. It's best to find shade, or bring your own — a big parachute over a bubble helps a great deal on hot days. Frosted poly is best for rear projection, while for front projection (although white will work for rear projection — it just isn't quite as bright an image). Some poly sells as clear is what is called "natural" which is slightly frosted, although not frosted enough to work well for rear projection. With usage, clear becomes frosted — you can facilitate the process by rubbing it until the static charge picks up dust. Colored poly gives a fine colored light inside. Sources for colored poly are 1) sheetrock or paint or hardware stores. 2) Manufacturers of gas station and used lot binnies. Bengman Banners in San Francisco stocks nine colors in 36" width (4 foot) and sells it for $0.03/lbs. 4) Union Carbide will make any color for you in lots of 5,000 lbs. It is possible to buy colors that they already have in 1,000 lbs. lots.

CONTACT PAPER (the stuff you put on floor)
It's good reinforcing for places that get heavy stress or traffic, like doors and where the floors meet. REINFORCED POLY (See Sears catalog page.) This is fine, strong stuff, although a little difficult to tape due to texture. There is also a company in Houston named Griffin who produce this stuff. I don't know how their prices compare.

TAPE PROCESS
This is best worked out by you, partly depending on the number of people you have taping together. AVOID WRINKLES in the tape as the wrinkles will gather water, particularly when the bubble is left uninflated in the rain. This will eventually destroy the bond of any of these tapes.

HEAT SEALING
Someone from Oregon says: you can seal poly with a regular clothes iron (Telfon if possible). The quality of the seam varies greatly with the skill of the person who is seaming, so practice first. I saw a dome bubble that got destroyed by the wind as the seams had been heat-sealed this way by amateurs. Put a couple pieces are cardboard together upright under the overlapping edges and run the iron along them smoothly and evenly.

POLYESTER
Slightly mitered is a good reflective surface and very magical. 2 mil mylar is roughly equivalent in strength to 6 or 8 mil poly and can be taped together like poly. John Reeves in Boston got a quantity of it from Elsar Industries in Revere, Mass. for $2.00/sq.ft. He had to do a lot of talking to get it at that price. There are a lot of companies producing mylar now, but we haven't investigated. Again, let us know what you find out.

Building supply stores are the most widespread sources of polyethylene (good last minute, Saturday sources) but packaging houses and concrete construction supply companies usually are cheaper and carry a larger stock of different weight and sizes of black and clear. They can usually order white (in San Francisco area, the Visqueen distributor has white).

Best prices we've found in the San Francisco Area (per sq.ft.)

<table>
<thead>
<tr>
<th>WEIGHT</th>
<th>CLEAR</th>
<th>WHITE</th>
<th>BLACK</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 mil</td>
<td>14</td>
<td>26</td>
<td>11</td>
</tr>
<tr>
<td>6 mil</td>
<td>15.5</td>
<td>N.A.</td>
<td>14.5</td>
</tr>
<tr>
<td>8 mil</td>
<td>2.2</td>
<td>N.A.</td>
<td>2.2</td>
</tr>
</tbody>
</table>

(Note: Prices in San Francisco aren't low for building materials. Price per square foot doesn't seem to increase for larger size pieces. White only comes in 4 mil.)

Also see attached Sears price list.

TAPE or: TAPE
Polyethylene can be heat-sealed, but we use tape because it eliminates hardware, can be used in the field, and the technique can be mastered by large numbers of people. The most common kind of tape is 2" poly tape available from most polyethylene outlets, but it's not the best. Good tape comes in wider sizes, and is much stronger (if the seam is taped well, the poly will not rip before the seam).

Mr. Zimmer is a fine guy. He doesn't like to fill orders smaller than $100. He can send an order by UPS air freight to San Francisco in three days. He will put his 9 mil vinyl tape for use on polyethylene to any width. Price is $1.20/inch of width for a 36 yard roll in any color except clear which comes in 4" only and is about $4.50/roll. The 4" clear stuff is very good for the spot, patching. 3" width is good in the colored tape. Jim Cook (who has a good deal of experience in poly inflatables which he usually pretty open to sharing) sells 4" wide polyethylene tape (36 yard rolls) which is also excellent tape. The price is comparable to Aristos on 4" clear but the service isn't quite as fast.

Let us know of any other good sources and we will publish the info.

SAFETY CODES AND THE FIRE ARMS
from Tenille Structures, Volume One by Free Ott: "... pneumatic buildings are safer than any other form of structure. The main advantage of the pneumatically stretched membrane is its small weight; even with spans of more than 100m, the weight of the structure does not exceed 3kg/m². Even if the compressed air supply should fail, it would take a long time for large envelopes to collapse, since the enclosed air can leak out only slowly. Even large holes and tears are not dangerous. Although the pressure drop quite rapidly, the force due to the weight of the membrane is so small that, in large inflatables, it may take days before the enclosed air escapes even if the openings are large."

"We've never had any injuries due to structural failure. Fire codes are necessary, witness circus tent fire tragedies. They are usually primarily concerned with exits in public structures. Polyethylene inflatables have a virtual fireproof exit because anyone can rip him out way, but this is sometimes hard to communicate to any type of exit. He will also want to test the fire resistance of the membrane itself, usually by holding a small piece of it over a bunsen burner for ten seconds, then removing it. If it remains burning for more than two seconds it is not considered self-extinguishing. However, when the polyethylene is inflated, the structure has internal pressure which works to extinguish the flame as soon as it burns through the membrane. (Charley Tilford in New York has done research on this and has a film of his efforts.) Try to explain this. We put up inflatables in public structures with mixed success — we did not get approval from the San Leandro Fire Marshal for Stewart Brand's hangar show, but we did get approval (with the diligent aid of Dr. Frank Oppenheimer) for an intermedia event in the Palace of Fine Arts in San Francisco. We didn't consult a fire marshal before Aftalmot, but remember you are responsible for the safety of your structure.

Good things to talk about with Fire Marshals:
1) self-extinguishing properties of inflated polyethylene
2) rip through exit doors (thinness of the poly)
3) huge number of doors, valve-controlled
4) length of time required to deflate the building with holes in it
5) the pressure at which the buildings turn
6) the number of O.S.M.A. people on the job
7) how powerful your back up fan is (this is a must for public events)
Since polyethylene is so light (1200 sq.ft, of 4 mil weighs about 20 lbs), a fan usually is a better air source than a blower. A blower gives more pressure than is necessary to support the weight. Blowers tend to be high-pressure, low-volume air sources; fans give out more air at lower pressure. In measuring the output of a fan or blower there are two considerations: number of cubic feet per minute (CFM) of air delivered and the static pressure at which that air is delivered. A water manometer is an easy way to measure static pressure.

A manometer will give you a lot of interesting and useful information about your bubble. Wind effects, for example, do not always increase the pressure inside the bubble (see Anodizing section). You can tell how much pressure your seams will withstand. Make your seams strong enough to withstand 2½" pressure, because wind loading is best withstand by maintaining a tight skin. If the skin isn't tight, the wind will make a sail in the side of the bubble and then you are at the wind's mercy.

Remember that for a public event it is necessary to have a back-up fan that will support the whole bubble if the number one fan should fail. Each fan must be capable of supplying at least 5 CFM/person and inflate the bubble. Having a working generator on hand is a good idea if your power source is at all dubious. (We have panicked when a fuse inside a locked building blew.)

A good source of fans and specifications on fans is Granger's Nautical chain of dealers. They sell a large variety of fans and blowers, each listed in their catalog with its output. I usually try to match up a used fan I am buying with something in their catalog for an output estimate. To get a catalog or buy from them you have to show company credentials or a purchase order. But it is worth the hassle as their prices are around 1/2 to 3/5 retail. A new fan is usually cheaper than a used one in the long run if you get it wholesale, but any fan you can get for free can be made to work. (Be aware of used fans for public events, though, unless you are sure the fan is good.)

About the best fan we've used for medium-sized inflatables is Charley Tilden's old-time office fan that he talked the city of New York out of when they air-conditioned some offices. This fan is a 24" diameter, 1/8 h.p., direct-drive, two-speed fan with a cast-aluminum, three-propeller-blade and sturdy, close-mesh guard. This fan probably puts out about 5,000 CFM at 0" pressure and maybe 4,000 at 1/2" pressure. Having a strong guard on any fan is important if there are going to be any general public, little kids, or stone people.

Charley cut down the pedestrian so that the fan was near to the ground for more stability. The easiest way to attach the air tunnel to this type of fan is to tape it directly to the blade guard (another reason for a strong guard). Since the building will probably move around -- especially if there is no net and the bubble is on a hill or in the wind -- it is a good idea to make the air supply tunnel long enough so that the building can move without pulling the fan over. We've lost some good fans this way. (A good invention might be some skins on the bottom of your fans.)

Our best fan for large bubbles (used on the 100' pillow) is a four-foot diameter, six-blade, dc fan powered by a 1/8 h.p. motor. We scrounged this fan from a house that got air-conditioned. The original motor (1/8 h.p.) got burnt up by a faulty generator, so we test your voltage... if at all possible. If you are renting a generator get a rental place to test it for you. The replacement 1/8 h.p. motor we got handicapped all the fans and blowers we've gotten since has overloaded protection. This is simply a device inside the motor that shuts the motor off automatically when the overload shunts (due to overload, incorrect voltage, etc.). The page from the Craftsman Motor Selecting and Instruction Guide shows how motor speed relates to fan speed determined by pulley sizes. This is a good booklet you can get from Sears. (HOW TO SELECT AND INSTALL ELECTRIC MOTORS). The attic fan puts out about 15,000 CFM at 0" and approximately 12,000 at 1/2". A STONG mesh guard highly recommended. (3/4" screen is good. (Hinge pins are removable for transporting.)

Charley recommends this fan for medium to big inflatables. This frame is made with electrical conduit. Included are the specs for this fan from the Granger catalog.

**12" TO 24" VENTURI-FRAME EXHAUST FAN KITS**

**1300 to 6800 CFM, 1 & 3-Speed Totally Enclosed Dayton Motor, Aluminum Blades**

**$27.69**

**Get more information on this kit by writing to the following fans:**

- **Bragg Radial Fan**
- **Larin Fan**
- **Sevilla Radial Fan**

All the little fans in this kit range in size from 12" to 24" (1/3 to 3/4 hp). We put a 24" fan on our 40' X 100' sail that you see in this picture. The wind was so good that it took all of 20 minutes to stop it. We finally stopped it by cutting a 60' slit in the back side to release all the air. Imagining a sailboat with a sail that big will give you an idea of the magnitude of force involved. This was an extreme case of low pressure, but you get the idea...

**WARNING:**

**FUNKY GENERATORS, EAT FAN MOTORS**

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**WARNING:**

**FUNKY GENERATORS, EAT FAN MOTORS**
A belt should be just tight enough so that finger pressure midway between pulleys will deflect it about ⅛ inch. If too loose, slippage of the pulleys will wear it out. If too tight, it increases motor load and wear on the bearings.

**SELECTING PULLEYS**

V-pulleys are measured from edge to edge (not in groove). The following table gives you the speeds of driven pulleys when using various combinations of drive and driven pulley sizes (in inches).

<table>
<thead>
<tr>
<th>Ratio</th>
<th>1:1</th>
<th>1:2</th>
<th>1:3</th>
<th>1:4</th>
<th>1:5</th>
<th>1:6</th>
<th>1:7</th>
<th>1:8</th>
<th>1:9</th>
<th>1:10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>150</td>
<td>168</td>
<td>180</td>
<td>220</td>
<td>240</td>
<td>270</td>
<td>300</td>
<td>330</td>
<td>360</td>
<td>400</td>
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<td></td>
<td>180</td>
<td>200</td>
<td>210</td>
<td>270</td>
<td>300</td>
<td>330</td>
<td>360</td>
<td>390</td>
<td>420</td>
<td>450</td>
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<tr>
<td></td>
<td>240</td>
<td>268</td>
<td>280</td>
<td>350</td>
<td>380</td>
<td>410</td>
<td>440</td>
<td>470</td>
<td>500</td>
<td>530</td>
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<td></td>
<td>300</td>
<td>320</td>
<td>360</td>
<td>450</td>
<td>480</td>
<td>510</td>
<td>540</td>
<td>570</td>
<td>600</td>
<td>630</td>
</tr>
<tr>
<td></td>
<td>360</td>
<td>390</td>
<td>420</td>
<td>510</td>
<td>540</td>
<td>570</td>
<td>600</td>
<td>630</td>
<td>660</td>
<td>700</td>
</tr>
</tbody>
</table>

* UNISON pulley speed based on one of a 1725 rpm motor. For a 1500 rpm motor, adjust the speeds for figuring S.E.M.

**PRECAUTIONS THAT WILL SAVE YOUR MOTOR**

**DON'T OVERLOAD MOTOR**

Overheating a motor can burn it out. Don't expect it to run continuously overloaded.

**DON'T LET VOLTAGE DROP**

When voltage at motor drops, exactly the same thing happens as when the motor is overloaded. With too little "fuel" it is (as effect) overworked — burns up — and will burn out. Use ample size wiring.

**DON'T 'SUCCOTRACE' MOTOR**

If fine cuttings or dirt in a motor is restricted (by dirt, rugs or paper, or closing it up in a box) it overheats — may burn out. Keep motor clean and dry.

If used where wood chips, dust, etc., can enter into blow out the interior with dry compressed air — or use a vacuum cleaner.

**GROUND MOTOR PROPERLY**

The motor frame should be connected by wire of same size used in line to motor, to a suitable ground (water pipe or a grounding rod properly installed) — both to protect you, and to protect the motor in case of an internal short circuit.

**LUBRICATE MOTOR PROPERLY**

Motors with bronze bearings do require occasional lubrication — but not too frequent an exercise. Never lubricate bearings unless you have the manufacturer's directions. Add a few drops each month. Too much oil can cause trouble by getting out of the bearing into the motor.

**USE RE-SET PROPERLY**

If you have an overload protector with a manual reset button, always wait for motor to cool before using the reset. Never hammer the reset (if it seems to "stick"), as this will break off the switch parts. Any trouble with resetting will probably be due to dust between the contacts — and blowing away the dust, or simply holding the buttons in firmly, will correct this.

**SIZING FAN**

Figuring out what size fan to use, in a more thorough way than just referring to the chart, it involves taking into consideration all the demands on the fan. These are:

1) The pressure at which the bubble will be injected into the air. This is determined by the size and shape of the bubble in relation to the wind. This is dealt with in the "Anchoring" chapter. Running pressure is about 1 lb/sq. ft. (1/5" pressure in a water manometer). Under heavy wind as much as 2 lb/sq. ft. may be needed.

2) Heat calculations. Unless you have access to a giant heating or cooling system, your only controls over the temperature inside will be: a. color of the polyethylene — clear gets the warmest, white is coolest b. shade — getting the bubble into the shade is by far the easiest and generally the most successful way to cool a bubble; frequently this is impossible, though c. how much air you pass through the bubble — these calculations are primarily what we are dealing with below.

3) How fast you want to inflate the bubble. It is unusual that you would want to inflate the bubble so fast that the size fan required would be larger than that required by the cooling requirements. But if you do use this as a design factor, take a rough estimate of the volume of the bubble (in cubic feet), divide by the number of minutes you want to take to inflate the bubble, and the quotient is the required CFM output for the fan.

<table>
<thead>
<tr>
<th>Volume (ft³)</th>
<th>Inflation Time (min)</th>
<th>CFM required</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>2500</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>1500</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>1000</td>
</tr>
</tbody>
</table>

The specifications we are trying to get for the fan can be expressed as a performance curve. All the figures being dealt with here are approximations, so you will have to adjust your bubble operating condition according to what feels right when the bubble is up (more holes, choking the fan tunnel with a string, etc.). This curve is different for each fan. We will give as an example here the approximate curve for the 24" Venturi-Frame Exhaust Fan from the Granger catalog.

*Using the given working pressure of a bubble to be 1", this particular fan will be putting out about 3600 CFM.*
In order to arrive at how much air the fan is going to put into the bubble and how much area of holes it will take for this air to pass through the bubble while maintaining the proper pressure in the bubble requires a series of calculations. Since the amount of air we are going to pass through depends on the heating and cooling requirements, we must figure out what conditions are going to make it hotter and how much hotter, then balance this with the factors that are going to cool the bubble.

**HEATING FACTORS**
1) sunshine
2) people inside
3) conduction through the bubble skin
4) passing air through the bubble

**COOLING FACTORS**

How to figure these follows:

1) **HEAT GAIN DUE TO SUNSHINE**

Heat gain due to sunshine is **Very Approximately 300 BTU/sq.ft./hr.** of direct sunshine (sun at 90 degrees to the surface of the bubble). Heat drops off towards sunset or as the angle the sun makes with the surface of the bubble diminishes.

It should be noted that if you're using white polyethylene, which you should be if you're doing anything in the sun in hot weather, the heat gain will be somewhat less, but we will design for the maximum heat so we will have a little more cooling power than necessary rather than a little less...

2) **HEAT GAIN DUE TO PEOPLE INSIDE**

Heat gain due to people inside is very approximately 400 - 1000 BTU/person/hr. This depends on the level of activity of the people. If the bubble is going to be in full sun, this figure will be negligible compared with the heat gain due to the sun.

3) **HEAT LOSS DUE CONDUCTION THROUGH THE BUBBLE SKIN**

\[ Q = (A) (1/T) (U) \]

- \( Q \) = conduction loss in BTU/hr
- \( A \) = surface area of the bubble (not counting that which is on the ground)
- \( T \) = the difference in temperature inside and outside the bubble in degrees Fahrenheit
- \( U \) = heat transfer coefficient for polyethylene (about 1.2)

4) **HEAT LOSS DUE TO PASSING AIR THROUGH THE BUBBLE**

\[ Q_{air} = (W)(C_p)(T) \]

- \( Q_{air} \) = heat loss in BTU/hr
- \( W \) = cubic ft. of air moved per hour
- \( C_p \) = heat capacity of air (about .016 BTU/°F)
- \( T \) = difference between inside and outside temperature in degrees Fahrenheit

Now in order to use these figures, add together all the gains from heat and people, subtract from this the heat loss due to conduction, and solve the 4th formula for \( W \) or the amount of air you are going to have to move.

\[ P_g = \frac{\text{Pa} \times (a)^{\frac{a}{2}}}{2G} \]

- \( P_g \) = pressure drop at a hole (about 1lb/ft²)
- \( a \) = density of air which is about .07 lb/ft³
- \( V \) = air velocity at the hole (in ft/sec.)
- \( G \) = acceleration due to gravity
- \( 2G = 64 \text{ ft/sec}^2 \)

Within the figures for \( V \) are the variables we are playing with:

\[ V = \left( \frac{\text{CFM at which fan is operating}}{\text{square feet of opening}} \right) \]

Example:

50'x50' pillow, white on top. To be used in daytime - maximum exposure to the sun will be about half the pillow getting 45 degree angle sun for noon hours. There will probably be about 100 people at medium to high activity as there will be rock music. Outside temperature is about 60 Fahrenheit - temperatures up to 90° F are acceptable inside. O.K. Little sketches are helpful for getting rough estimates so...

1) Sun gain - 2500 sq ft
   - 1250 sq ft exposed to 45 degree sun
   - (see chart) 350,000 BTU/hr/sq ft. at 1250
   - \[ \frac{1250 \times 150}{187,500} \text{ BTU gain/hr from sun} \]

2) Body heat gain \[ 9,000 \text{ BTU/hr/person} \]
   - Generating 500 BTU/hr/person = \[ \frac{90,000 \text{ BTU gain per hr}}{300} \]

3) Conduction Loss - \[ 0.00147U \]
   - \( U = (350)(20)(1.2) = 85,000 \text{ BTU/hr} \)
   - Loss from conduction \[ \text{Max} \]
   - \[ 187,500 + 90,000 = 85,000 + \frac{150}{P_m} \]
   - Total Gain per hour.

Max opening = 4.5 sq ft.

Two medium-size fans (around 5000 CFM) might be a good solution, providing good control over the axial air-flow as well as a double blower system.

\[ \text{Max} \text{ opening} = 4.5 \text{ sq ft.} \]

Rough guess your door openings \[ \text{Max} \text{ opening} \] a bit smaller to allow for the inevitable tears which will increase the area of air leakage.
ANCHORING

If your inflatable is going to be put outdoors in any wind, it will need an anchoring system. For small volume (500 sq.ft. of floor area or less) interior weights should work; otherwise, they could be sand bags or water bags. Larger structures require heavier anchoring. There are a number of ways of doing it: integrally milk tie downs, buried edge, weighted edges, taped edge, or tension net anchors. Buried edge is good for a semi-permanent installation where you can dig a trench. A taped edge is good for a small installation on a smooth floor; tie downs and tension nets are good for sites with existing things to tie to (trees, fire hydrants, etc.) where it would be easy to drive tent stakes or augers.

The anchoring system must withstand not only wind loading but also the internal air pressure of the structure. Precise structural calculations should be left to 2 engineers, 3 Ph.D. mathematicians, and a computer, but a little rough math can give you a close enough estimate of what anchors to use. We will deal first with inflation pressure and then with wind loads.

PRESSURE LOAD... On any surface that is curved in one direction, i.e., a cylinder or a long pillow, the tension per unit of width is equal to the internal pressure multiplied by the radius of curvature. Work in pounds and feet. Some ball-park figures on figuring pressure: the highest pressure you are likely to get with a powerful direct drive fan is 2 pounds per sq. ft. (520/sq. ft.). A normal working pressure is 1lb/sq. ft. (2.5psi). On a water monometer, 1" of water equals 1lb/sq. ft. (see monometer drawing). Indoors you can keep a structure up with as little as 1lb/sq. ft.

Make a sketch of the shape, find the radius of curvature by making a section through it, on this diagram the tension equals pressure times radius of curvature. The tension is the downward force you need per foot of edge.

\[ T/ft = \pi (P/R_c) \]

\[ T/ft \quad \text{downward force needed per foot of edge} \]

\[ P \quad \text{pressure (in lbs/sq. ft.)} \]

\[ R_c \quad \text{radius of curvature (in feet)} \]

EXAMPLE: The Earth Day Bubble by Charley Tilden in New York City was 200' x 60', radius of curvature was 300'. The anchors were parking meters spaced 5' along the long edges (the 200' dimension). The pressure which the bubble was designed to withstand was 2lbs/sq. ft. The ropes spanned between parking meters so that the load on each rope was (tension per foot of width) x (space between meters). Tension = (300')(2lbs/sq. ft.) and tension per rope = (300')(2lbs/sq. ft.) = 600 lbs. per rope. 2500 lbs test 3/8" inch dial nylon rope was used.

If you want to do an inflatable with the weighted edge (instead of a plastic floor): find the total downward force required, then divide by the perimeter to get force required per unit length of the perimeter.

WINDLOADING

To figure windloads: find the area of resistance the structure presents to the wind, (length x height). The horizontal force from the wind blowing on the structure can be up to 10lbs/sq. ft. depending on the shape of the structure and the wind velocity. A lower, more shallow-topping profile will create less resistance (and will create more negative pressure on the leeward side of the bubble.

Bubbles I presents a large area to the wind. The negative pressure is concentrated on the back side. (This negative pressure is created the same way as lift is created by an airplane wing.) Bubbles II and III are actually getting some lift help from the wind. Bubble III would probably need less fan pressure in the wind because of the negative pressure on the outside created by the wind blowing over the low profile. A structure to be left up for more than a day, an afternoon (or a structure for an event which you don't want to have to put up or take down due to high wind) should be designed for 10lbs/sq. ft. pressure. For a structure 50' long and 15' high, the design force would be (50')(15')(10lbs/sq. ft.) which is 7500 lbs force on the structure.

FORMULA (area of the bubble 10lbs/sq. ft.) wind load

If 7500 lbs seems like a lot, think of the force on just the minimal area your body presents to the wind in a good, high wind.

TOTAL LOAD

This wind load must be added to the inflation load to get the total load that the anchoring system has to counteract. It is possible that the whole wind load could be on one anchor point (such as a square pitch with a square net anchored down at each corner presents one corner to the wind), then the total wind load must be added to the inflation load on each anchor. If the wind is coming directly against one side, then the windload divided by the number of anchors that will be under tension should be added to the inflation load for each anchor.

TYPES OF ANCHORING SYSTEMS

These systems have the structural advantage of distributing the forces evenly around the whole perimeter of the building. We used one with pieces of pipe taped into the edge over a watered environment so that we were able to remove the inflatable by lifting it over the bed without having to move the water bed which weighed 3000 lbs. Because the plastic floor is eliminated, this type of inflatable would also be good for a greenhouse, storage facility, pool cover, etc. These types might tend to last longer, too, because they are more static so people probably wouldn't walk through the walls or otherwise freak out at the expense of the plastic.

WEIGHTED EDGE

Weighted Edge is anything heavy that can be laid on the edge of the plastic or taped into the edge. See illustration.

I saw an interesting inflatable that John Reaves did in the Summer Thing program in Boston that was an inflated hemisphere (out of 2 mill silver mylar) that tied down to a piece of telephone cable that he had gotten the phone company to denote. A 20' diameter circle of this phone cable weighed about 20 lbs. The phone company usually just chops it up and melts it down again. John's bubble leaked air between the cable and the edge of the plastic. This could be desirable if you want to collect a lot of air, but if you have pressure problems a flap could be taped on inside the bubble, like on giant Bird-Air and most commercial inflatables. A section of the detail might look like this.

Looking at the elevation drawing of this, notice the catenary curves between each tied-down point. This is the natural configuration the line between two weighted points on an inflatable, so it will strengthen your bubble to actually cut a curve to an approximate shape, reinforce the edge by taping a piece of cord into the edge and running the tie-down loops through the string. This will distribute the force of the tie-downs through the whole edge of the inflatable, rather than gathering the stress at the point where the tie-down meets the edge of the plastic. This will minimize wrinkles and tears due to concentrated stress. Inflatables that are to be tied to stakes can be made in the same way as this.
ANCHORING

Buried Edge
Jim Cook at H.T. McGill Co., in Houston, showed us this method of burying edges. He has had extensive experience with it. His company has done polyethylene swimming pool covers, Christmas tree warehouses, and other stuff. The holes in the bottom are important. Unless they are there, the underground poly collects water, makes mud, and the lubricated plastic slips out of the ground.

Frame Edge
Jim Cook also showed us pictures of a system he did with two by four frames. Wrap the poly at least one time all the way around the smaller piece of wood before nailing or bolting this org to the 2 X 4. The frame will act as tension ring containing the inflation pressure, as well as acting as a hold-down against the wind.

Taped Ropes
This is one of the few ways to make a poly bubble that has a plastic floor without a net. Another way is to just put some heavy things like people or bricks wrapped in something soft inside the bubble while inflating it.

THE 30' NYLON PILLOW, while requires fewer water spaced cords in the net, becomes the maximal in strength. This net is of 10,000 lb. Strapping held by 10,000 lb., 5/8" copper.

Photo by Mike Miller

Nets
Advantages of a plastic-floor building with a net are portability, total enclosure, large inflatables, and ease of construction of the anchoring system. In a large inflatable, it would be difficult to make a connection between a tie-down rope and polyethylene that could withstand the great forces on the bubble. Nets can also be very beautiful.

To design your net, make a model of your bubble and start playing with string. If you can, set up the model somewhere that you can nail into the floor (like a piece of plywood) to simulate anchoring points. If you already have a site for the bubble picked out, put nails in where there are natural anchors, like parking meters or trees or cars. If you are going to use your own augers, then you are totally free to do anything with the net, spider webs, star shapes, giant grids, whatever .... To test your model, get the fan that is going to hold up your big bubble and use it in a wind source. This testing can be very informative if you vary the wind and the pressure inside the inflatable. Nylon string (hardware store) is a nice model material.

Building a net can be a major job. We made a 100' x 100' net with a 5-foot grid by stacking down all the horizontal ropes, then tying slip knots every 5 feet in each rope, slipping the vertical ropes through and popping the knots.

The knots at the edge of the net were just square knots, tied onto loops in the edge rope. If you are tying knots, think about knots that don't involve slipping the whole rope through each knot.

The 100' pillow net: Our first net was this 100' square. We used parachute cord for the bulk of the net, 3/16" nylon rope for the 2nd, 3rd, and 4th ropes from the edge, and 3/8" nylon rope for the edge. At each corner we had a 1" D-ring to avoid the rope rubbing and cutting itself at this stress point. From the D-ring to the anchor we used some 10,000 lb. nylon strapping that we got from a surplus store with a double D-ring on the end so that we could tighten and loosen the net. Tightening the net in the wind helped quite a bit in lowering the profile of the surface presented to the wind. We used 10,000 lb. augers. Charley Tillford has since made another 100' pillow out of 6 mil poly (the original was 4 mil) using a net with 20' squares instead of 5' squares.

RoPE StreNGTH
Charley sends from New York the accompanying approximate rope strength chart:

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<th>Breaking Point</th>
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<td>Parachute</td>
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<tr>
<td>3/4&quot;</td>
<td>1000 lb.</td>
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<tr>
<td>5/16&quot;</td>
<td>1800 lb.</td>
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<tr>
<td>3/8&quot;</td>
<td>2800 lb.</td>
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<tr>
<td>5/8&quot;</td>
<td>4000 lb.</td>
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<tr>
<td>3/4&quot;</td>
<td>7000 lb.</td>
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<tr>
<td>5/8&quot;</td>
<td>10,000 lb.</td>
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Anchors
We got our 10,000 lb. augers from a telephone supply co. in Houston. Telephone supply co.'s are generally a good source for these. These augers are about 6 feet tall, A.B. Chance Co., Jersey Ave., New Brunswick, N.J. has 10,000 lb. (1"X66" shaft, 8" helix) augers for about $8.15. Big augers generally have an eye at the top that you stick a long (6') heavy pipe through and twist them into the ground. This generally takes 2 people. Small bubbles can be anchored with dog-anchors which cost about $1.25 each from a pet store or hardware store. Trees, light poles, fire hydrants, parking meters, cars, etc., are still the cheapest.

When you have your bubble up and the wind comes up, tighten your net and increase your inflation pressure. The increased air pressure will keep the side of the bubble from caving in and the tightened net will decrease the area presented to the wind. (See photo of bubble about to take us all for a ride in Air Supply Section.)*
With these new Arf Farm Components you can:
already
do what most of the designs have been done
already
for you. These components are designed to be inserted into the
curves, tube bends, and fans, etc.

Curved tees, 45° angles, and fans can be easily be fitted into the
structure at your convenience. All the pieces are
made of high-strength vinyl, completely flexible
and easy to assemble.

Flat or nearly flat tees can be used to:

Rigi-Flex Fan Tunnels

Power Blanket + Fan Patch

Zipper Hatchways

Access Panels

To find out how to do this one, just take apart one old pair of pants

Plan ahead so that the most complex
tunnels can be
fitted before
the major pillows are taped up.

Make up a few joints ahead of
time with care.

They can be easily taped
into straight lengths of plastic
during the mad rush of

Final
Construction

Taping reinforces
seams.
Wrinkles in your pillow mean the plastic skin is stressed along the wrinkles. There are little or no stresses the other way.

A slit cut across the wrinkles will tend to spread open and leak air. Not recommended.

A flap taped behind a circular or oval hole is larger than a crawl-through size will automatically close due to the air pressure inside.

Curvature determines stress: a tiny plastic hose can hold a hundred pounds pressure and a huge weather balloon has a pressure barely above atmospheric. Yet the stresses on both the hose wall and the balloon skin may be the same—the tiny tube wall is sharply curved and the weather balloon surface is flatter. If the earth were a giant balloon, imagine how little pressure would be needed inside to close the horizon so tight!

Make a little cube out of thin plastic sheet. Then inflate. The corners sharply curved, hang only while the midpoints are taut enough to burst. But better, these areas take more stress. The cube tries to become a sphere—a shape in which the skin curves in an equal amount in all directions. Clearly, the best shape is a sphere, and these pages are devoted to getting as close to spherical as possible with flat materials.

Airing or hula hoop taped around a circular hole will become a self-closing door if it is located so it rests flat on the ground when no one is entering.

1.57d

length of tunnel circumference of donut

3.14d

diameter of tunnel

d

circumference of donut

Hot Lips—A floopy donut at the end of a low pressure tunnel, when connected to the blower, small holes admit air to the tunnel from the lips, thereby inflating it.

ENTRY

Geometrically

Making the length of the gores equal to the circumference of the base gives a half-spherical shape.

GORE
METHOD

Get ideas from: peeling tangentees, weather balloons, inner tubes, beach balls, inflatable warehouses, globes, world globes.
PNEUMATICS - A KEY TECHNOLOGY IN HYBRID STRUCTURING

After seeing Mr. Bird's impressive achievements and hearing Mr. Lundy's enthusiasm, we wish to introduce a note of constructive pessimism. Pneumatically, I consider the application in the field of structures - of pneumatic technology is too widespread involved with splicing normal structural and shelter problems. The air-filled enclosure of swimming pools or protection of traditional construction work is extremely useful, such structures are of a great importance, and can well result in the following actions which are detrimental to increasing the development of pneumatic technology:

- Over-emphasis may be given to the static siting of air structures.
- Direct cost comparisons with traditional structures may be made.
- The fixed period of accommodation available with air structures may only be exploited for disaster or random-use of air structures.

All these actions can retard the investigation of new applications requiring improved and more complex air structures. In addition the development of new materials and fabrication techniques should be related to new applications rather than concentrating on the perfection of existing applications since these new applications are still extremely arbitrary.

While space exploration and defence programs provide a valuable technical "spin-off" of the development of air-structure technology, the mass utilisation is likely to restrict, in the near future, the technological advance of air-structured related to civil and social activities. Too many architects and designers wait to see what NASA and various Defence programmes produce. This conference must increase the content and frequency of exchange between scientists, engineers, manufacturers, architects, planners and social advisors. An immediate task could be to agree on the semantic definition of the various structures and systems we are now discussing (air-supported structures; air-inflated structures; air structures; pneumatic membrane structures; sealed pneumatic structures).

In this paper, references to air structures include air-supported and air-inflated structures, together with air-controlled and air-tensioned structures. In addition, we must keep mutually aware of the alteration of attitudes of authorities and others to the employment of air structures. In September 1965 the Department of Architecture and Civic Design of the Greater London Council refused to license a high-pressure air-beam structure for temporary use as a place of public entertainment on the grounds that it constituted merely "a tent without poles or framework". In December 1965 the same department of the GLC were prepared to consider the use of the identical structure on receipt of calculations related to stability. Only when a continuous exchange is established can individual groups - in my case architects and physical planners - make accurate and aesthetically demanding demands on air-structure technology. At some stage of the conference I list some aspects of this technology which are of particular interest to me as an architect:

a) Multi-membrane construction which enables variable pressurisation and containment (cf. paper by R. Sillard).

b) The availability and performance specification of transparent membranes.

c) The control of light and radiation by both membrane, intermembrane construction and contained gases or liquids (cf. papers by R. Sillard and N. Lambi).

d) The containment of granular substances between membranes to control humidity, sound transmission, etc.

e) The capacity of controlled air movement through the material of the membranes. Such a possibility enables changes in the normal methods of fuel air evacuation.

f) Multi-layer bonding enabling variable control of construction. Such hybrid construction can enable the simultaneous use of high pressure sealed volumes and low pressure air-supported volumes.

g) Ultrasonic bonding enabling an increased variation of membrane material. An increased use of various materials is urgently required not only to enable varying structural performance specifications to be met but also to achieve varying textural qualities.

h) Further information on the performance of high and low pressure structures in movement. The existing UK inflatable vehicle transporter which both protects the vehicle and propels it on the Hovercraft principle is an example of this. Movement must include the employment of the Hovercraft or Ground Effect Machine (G E M) principle.

i) Self-packaging, deflation, of large volume membranes.

j) A new method of costing air-structures which is related to the variation of use and not merely material and unit plant cost. Any mechanical plant, pumps, blowers etc. must be accepted as a structural element. The variation and individual control of volumes singly or in combination enables the separation of membranes related to the elimination of particular adverse conditions (cf. paper by R. Sillard).

As roofs, walls and floors no longer exist in the conventional sense, their pneumatic equivalents no longer need to provide the additive structural support normally required. Only collective stability is required and the air one breathes can become the major structural force. This being so, the interior fittings or divisions of such structures become relatively more permanent (see the interior of Lundy Bird US Atomic Energy Commission's travelling exhibit).

Movement of such internal parts must also be investigated. The use of air pallets for such intermittent movement is extremely valid. The use of an air-conditioning plant as the structural pressure feel is only one example of the advantage of co-ordinated use of air-structure technology. Methods of cleaning and movement related to the whole or part of the structure should also be included.

In the past major urban congestion areas were served by large permanent structures providing mass accommodation or shelter such as the Roman Circus, the Medieval Cathedral, the Market Hall and the Sports Stadium. With the use of air-structures such permanence is not required and so the additional restrictions of the fixed site should now be avoided. In effect, large air-structures can enable planners to reverse the pattern of traditional urban congestion and servicing nodes found in existing towns or cities. In new proposed urban settlements such nodes need no longer be permanent generators of fixed urban patterning.

Three of air-structures to provide short-term small and medium sized social facilities enables the siting of short-term mobile housing to complement or to be independent of towns offering similar facilities.

Air structures are already used to provide industrial production space particularly where the demand for such space is likely to fluctuate. Thus in effect we already have the mobile factory, but it must be further developed and improved.

Work on disaster control and emergency planning has, over the past years, produced a wide range of accurate exploitations and applications such as fabricants, disaster control centres and GEMS or hovercraft. However, such uses of air structures have not yet been seen as a method of reducing the dependence of emergency planning. That is, they have not been valued as a potential asset to society enabling rapid yet variable control and community movement. Such realisation, backed by increasing design and development work, can enable air structures to contribute to a higher degree of sensibility in the society's continuous control of the physical environment.

This conference and the possibilities of future exchange that it has created must assist in establishing new priorities for future work. While I accept the fact that development of new products is not the mainspring of the desire to achieve higher accuracy in the immediate tasks must not impair our realisation of the future potential.

Pneumatics, as far as partial or total structuring is concerned, are likely to stagnate less this is realised. The field of valid application has scarcely been touched.

The development of a distinct, interaction and location of activities that require buildings is no longer a sufficient brief.

The quantitative assessment of the valid social life related to particular location must also be made and designed for.

This then is the major role for air structures now and in the future.
Faculty Urges U.C. Control of Air Labs

Some dared to enter, others just gaped at this huge plastic air container in lower Sproul Plaza at the U.C. Campus.

Breathing—That’s Their Bag

MILPITAS—A 40-by-60-foot plastic bag was the theater, stage and prop yesterday for a chillingly realistic bit of theater about a day when the air becomes too polluted to breathe.

"Air Emergency" was conceived and built by a Sanmateo County "family" of dropout members of the Air Force. The commune, touring American campuses with their Clean Air Pod (CAP 1000) performed in outdoor settings at the University of California campus as part of a three-day Environmental Teach-in.

As an air raid siren drew U.C. students to lower Sproul Plaza, a monotone loudspeaker voice interrupted them that "an air failure" had occurred and those who couldn’t escape from the pollution would die within 15 minutes.

The voice invited spectators to take shelter in the CAP 1000 which, it said, had been tested "in Akron under government contract." The six-system inflatable CAP 1000 also removes deadly pollutants, the voice stated.

Those who didn’t go into CAP 1000 were given "negative census forms" to fill out before dying.

White-jacketed Air Force members wearing gas masks affixed small yellow clacks to spectators’ foreheads. "These are sensors which can be monitored by a Human Resources Satellite which is tracking your final movements," it was amably explained by a man called "P-359," who described himself as a "human mental programed only to answer questions from the press."

The teach-in concludes today.
HY-TEK

December 2, 1970

Still seeking/searching for ways to increase the network. We have to stop
trucking, tiny home a few months to produce the Infaltracookbook, to study
the mobile lifestyle, get some money to advance the art, keep everybody
comfortable, rest up, that's why we need the TRUCK STOP. Institutions
in the dominant culture burden our mobility/growth, yet what we are talking
about is an institution a communications network of places like ours, where
media nomads can pull off the road, learn College Credit, sleep a truck...

The nomad is a peculiar animal. He (big n'burly/with hair grown in/putlower)
travels either in a tribe (the thunder of thousandthrumminghoofs/for alone in
a never-ending search for nutrients. Were he to remain in one place he would
surely perish because (why don't you find a place and bered/forever) he would
never renew the culture he supplies nutrients to his system (here again/and
in that he's a survivalist) it can't supply other needs necessary for survival, thus
he seeks out multifunctional inputs from many environments (willambilad-
betterbeings/growpowarna) and trades his services as an information transformer
(forever/thoughtfrontiers). Today it may appear that there is a sampling of many
entities in a given region, the media (Goode/nightriders) is only similar with
environmenal context (how/does the world see him). Nomads need two
sources from those who "speak your language" (approach Edge/psyc/drop
and say/what) that may provide bare necessities to expand. Sometimes it is our
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**PNEUMADS 4321**

**FANTASY 10987654321**

**THE INFLATO-NETWORK**

(as we know it)

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**BUZZLE PRIMER-philosophy**

for an inflationable college and a knif of feasibility report from: Roruk Ekstrom AIA 10351 Barcan Circle Columbia MD.

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**COMMERCIAL INFLATABLE BAND-PICTURES**

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A.B. Chance Co.

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