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HUMAN POWER

1-3x Official IHPVA Newsletter ISSUE 4 Fall 1979

George Naoum

Cousteau Faire — crowds jam-packed the pavilion where Gossamer Albatross (not visible) and 10 HPV's were displayed all day

President's Message

As I reflect on IHPVA activities of the past few months, the most significant area is the increased visibility of the Association. Here in Southern California, Al Abbott organized an exciting event in which the streamliners challenged the standard racing bicycles — an event that was broadcast live over television, complete with interviews of members. It was also filmed for later broadcast on Eyewitness LA, courtesy of David Kellogg, Producer and IHPVA member.

Next was IHPVA participation in the Cousteau Society's First Involvement Faire by staging a 22-mile criterium for the streamliners and a display of the vehicles and Gossamer Albatross II. Here, live from Ventura on the KNBC TV show Everywhere, Bryan Allen, myself and a parade of the streamliners were interviewed. This Ventura event also resulted in exposure via the October 28 edition of the New York Times.

Our next act will be a two-lap race around the oval at Ontario Motor Speedway prior to the main event of the LOS ANGELES TIMES 500 Grand National Stock Car race.

Memberships are well over 200, and we seem now financially secure enough to publish our Newsletter on a more regular basis. Watch for details of other events, such as an IHPVA fun day at Riverside Raceway, December 30 (courtesy of Bob Shipley), and the next annual IHPVSC at Ontario, tentatively scheduled for April 26-27. Ideas for the cham-

(Con't on Page 8)

IHPVA Winter Meet

December 30, Sunday

RIVERSIDE INTERNATIONAL RACEWAY

Purpose:

To learn from each other and to have a good time. Not necessarily to prove who's got the "best" machine.

Format:

Gates open at 7:30 a.m. No admission charge as we have use of the raceway for free. Be forewarned that this means no snack bar, no ambulance, etc. We'll try to arrange toilets.

At 4 p.m. there will be a Bring-your-own barbeque. The Riverside contingent will provide a keg or two. This will give us all a chance to get to know each other and shoot the breeze without trying to make the fairing fit right at the same time.

What we do between 7:30 and 4:00 is up to the participants to decide. We can race, do tuft testing, try out other machines or whatever.

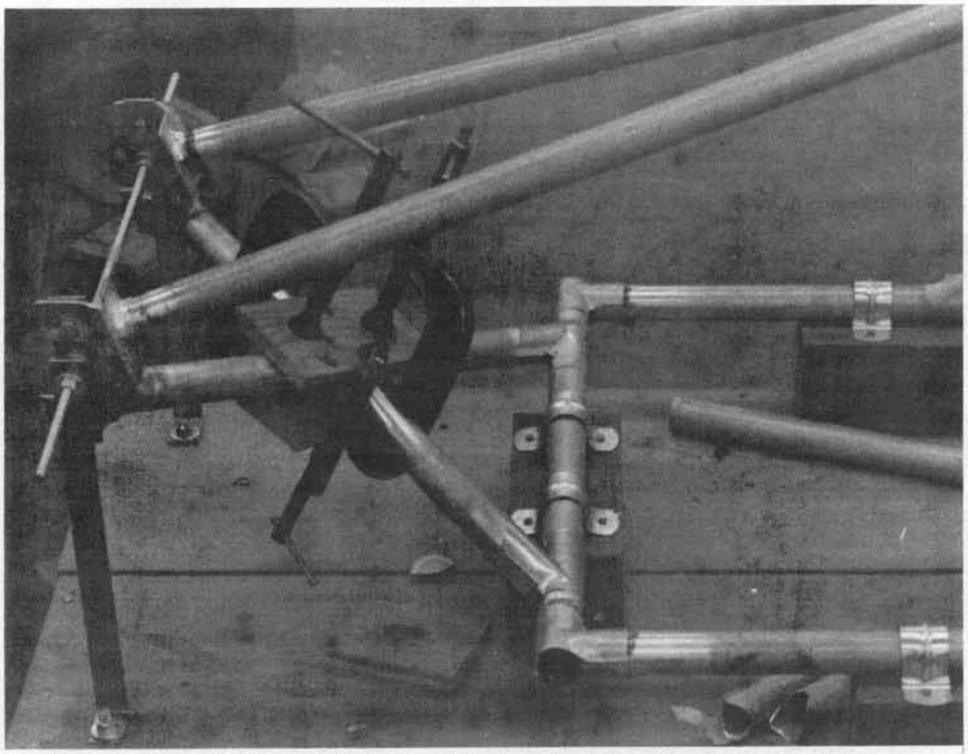
The Course:

A true road course. 2.5 miles (approx.) including a hill, an off-camber corner, and a corner that falls away downhill. There is also a drag strip, not flat enough for record attempts, but long enough for anyone. Should be good for spectators as most of the course can be seen from one turn.

RSVP Bob Shipley
Lil Henry's Bicycling Emporium
3613 Canyon Crest Dr.
Riverside, CA. 92507
(714) 682-9253

A SASE will get you directions, a map of the course with estimated elevations, course surface, etc. Comments and suggestions are welcome.

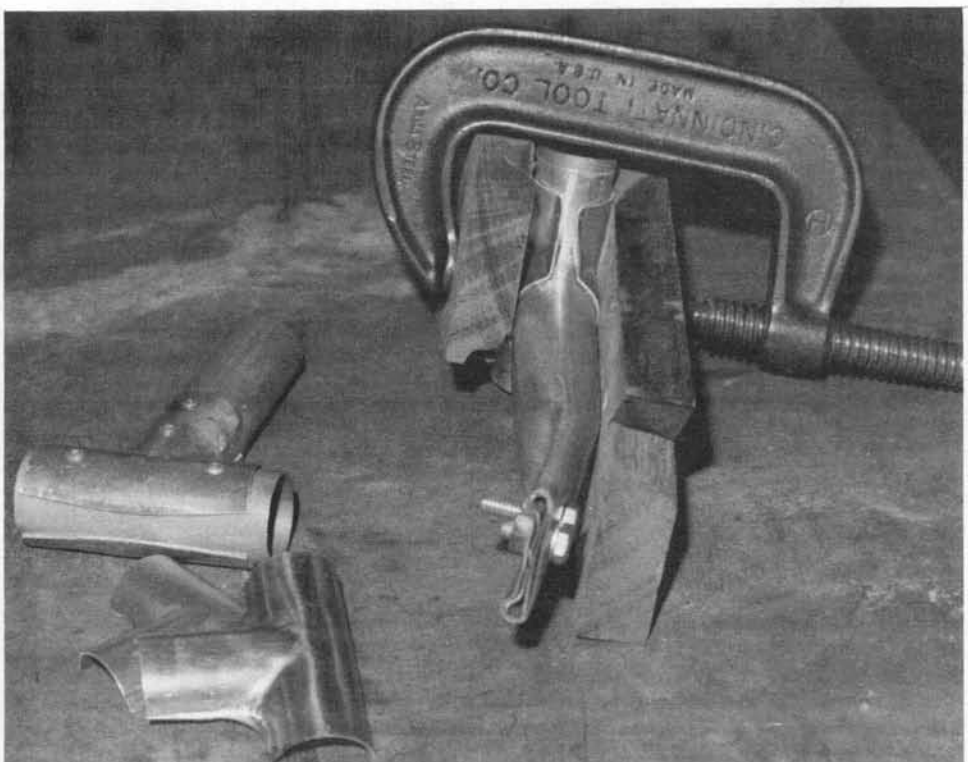
P.S. There is a possibility of TV coverage. We in Riverside are inclined to keep this very relaxed, and are in favor of letting the TV people work around us rather than vice versa. Let us know what you think.



Upside-down shot of White Lightning's tail-end on jigs. Note four butted and five lugged epoxy-bonded joints. Chris Dreike

Bonding Aluminum Successfully

(by Chris Dreike, Co-owner/builder of
Abbott Prizewinning "White Lightening"



Test joint in clamps. Finished lugs in foreground. What appears to be pop-rivited experiment behind lugs. Chris Dreike

Bonding aluminum to aluminum or another surface is a simple process if the proper steps are taken to prepare the aluminum. Commercially, and in Aerospace applications, the aluminum is subjected to Chromic Acid etching and special anodizing techniques to clean the surfaces to be bonded. These processes are not available to the average person. There is, however, a technique that we discovered while building "White Lightning" that produces a very good quality bond.

First of all, if you are going to do some bonding, you must understand that the surfaces to be bonded must be chemically clean! In the case of aluminum this means an oxide free surface. Aluminum quickly oxidizes to a depth of a few molecules in a very short time, typically an hour or two. This invisible layer will prevent a good bond – thus, speed is essential in this process I am going to describe.

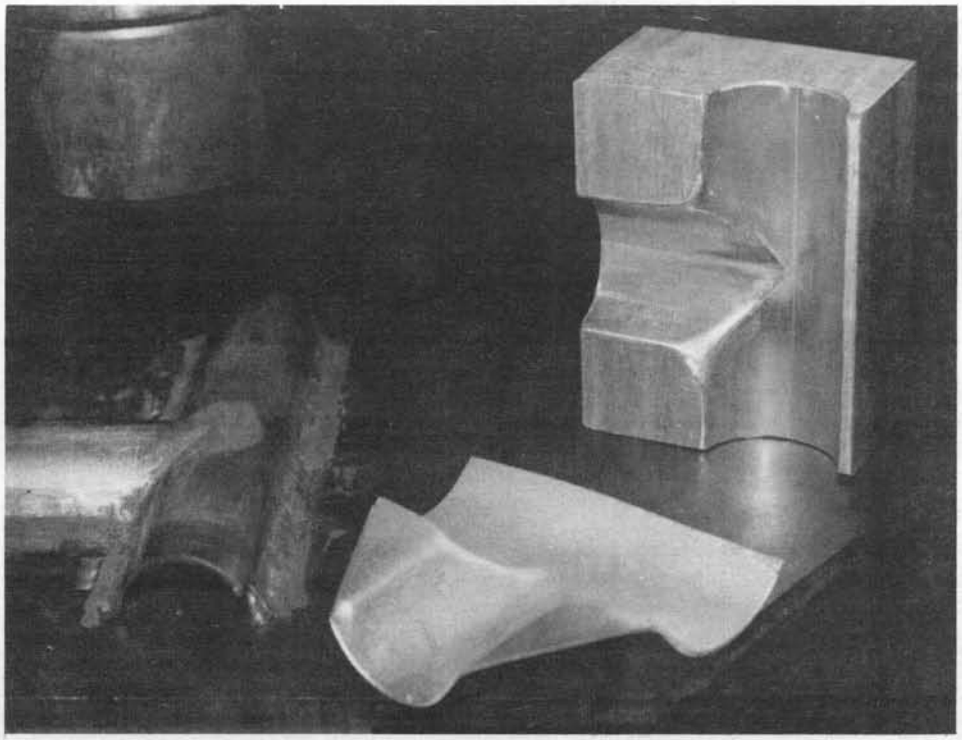
The materials you will need are:

1. Mild solvent (nacahol, lacquer thinner, etc.)
2. Sandpaper: 220 grit
3. Scouring powder (Ajax or Comet work well)
4. Tap water
5. Distilled water (make sure it is distilled and not deionized)
6. Hair blow-drier or heat gun.
7. 2-part epoxy (it is best to purchase this at a plastics shop in pint size or larger cans about $3 – $7/pint.

Caution: *When using solvents, epoxy and plastic resins, work in a well ventilated area.* **Do not smoke or eat** *until after washing your hands thoroughly. Uncured plastic resins can be quite toxic over long periods of time. Symptoms of poisoning are slow to appear and can take years to dissipate.*

Here is how to do it.

1. Clean surfaces to be bonded with a clean rag and the solvent.
2. Sand the bonding surface until it shines.
3. Pour a small amount of scouring powder into your hand, add a few drops of water to make a workable paste, and . .
4. Apply this to your bonding surface.
5. Now scrub the bonding surface for 30 seconds to one minute. The paste will turn gray-black. You may use your hands in this step.
6. Now, using a strong stream of tap water, flush away the scouring powder. DO NOT TOUCH THE BONDING AREA!
7. If you touch the bonding area, don't bother with step 8. Start over with step 3.
8. Wash away the tap water with the distilled water. It only takes a light rinse. DON'T TOUCH.
9. Hold the piece such that the bonding surface is in the vertical plane (so the water will run off).
10. The water should appear as a solid sheet coating the surface. After a min-

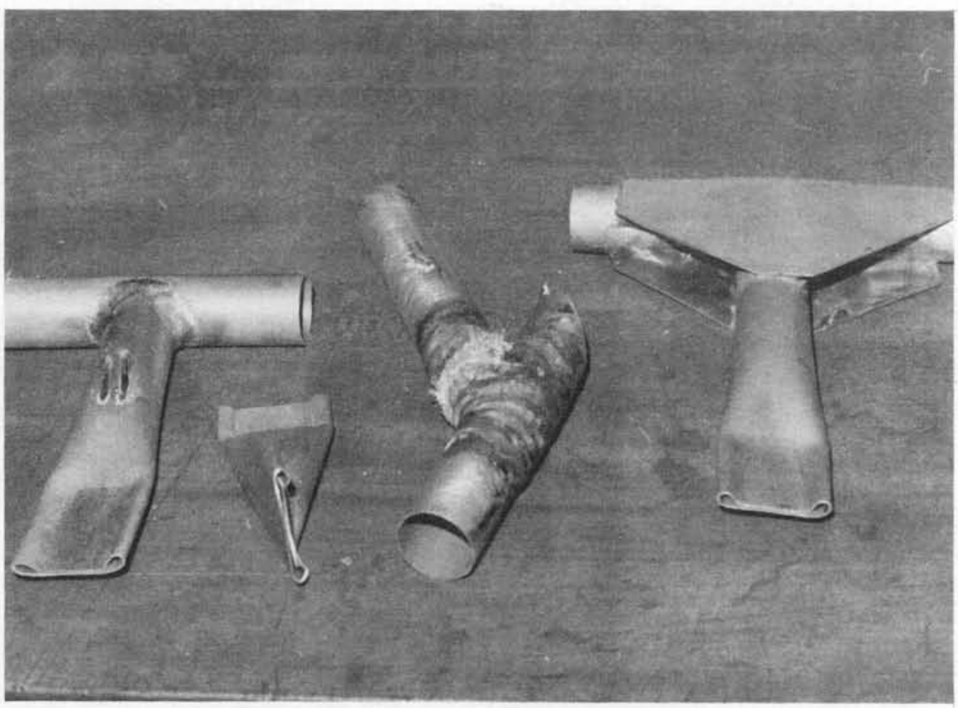


Male (steel tube welded to plate) and female (aluminum block) dies used to make lugs. Untrimmed example shown. Chris Dreike

ute or so the top edge of the clean surface will start to dry as the water runs downward. This is an indication of a surface clean enough to bond. If the water beads up, start over at step 3.

11. Being careful not to touch the bonding area, dry the part with the vlow dryer.
12. Mix the epoxy according to the manufacturer's directions. This too, is important for a good bond.
13. Assemble the parts with the epoxy, clamp or hold position for the proper period of time.
14. Epoxy produces its highest bond strength if the bond line is only .001" to .005" thick, so make sure your parts fit together well.
15. Your bond strength with this method will be 800 to 1200 pound per square inch in tension and compression. Shear strength will be slightly lower.

Good luck and try a few bonds before you try working on a project. It took a lot of trial and a lot of error before we found this process. "White Lightening" contains about 25 bonded joints.



Some early and very unsuccessful bonded joints. Chris Dreike

George Naoum

How to Finish Second

(by Paul Van Valkenburgh)

The Aeroshell Team of Ralph Therrio and I have developed the most successfully crash-proven vehicles in the IHPVA. The streamlined hand-and-foot powered quadracycle has now crashed four times at 20 to 45 mph, and the standard upright fairing has crashed once, without so much as a scratch on the rider. The problems have all been mechanical: a blowout, a caught steering cable, a broken support, and this year a camera crew in a shutoff area. However, even before the race this year, I had made the decision to retire the machine – win, lose, or draw – and the crash merely insures the decision. While the top speed straightaway racers are sensational, they aren't practical for real world riding. From now on, aeroshell streamliners are going to be streetworthy. Even if they turn out uncompetitive in the road race, they will be safe enough to ride to the track, race, and ride home again. The next year will be spent developing an inflatable production version of the standard upright fairing, and I may enter a dozen of them in the next race, if I can find enough strong, bold riders. We have had bad luck and good luck (two first and two seconds in the single-rider class). But no individuals' fortunes are as important as the success of the organization and the promotion of human power. As I told one reporter, the day will come when we will see a cyclist pedal a streamlined shell from San Francisco to Los Angeles in one day.

Editorial Note:

Our *"HUMAN POWER"* staff photographer, George Naoum, is willing to photograph any vehicle or other human powered project, finished or during construction – free of charge – for documentary purposes, and for publication in *"HUMAN POWER"*. He may be reached by phone at (213) 281-0061, or write to:

George Naoum
P.O. Box 2255
Alhambra, CA 91803

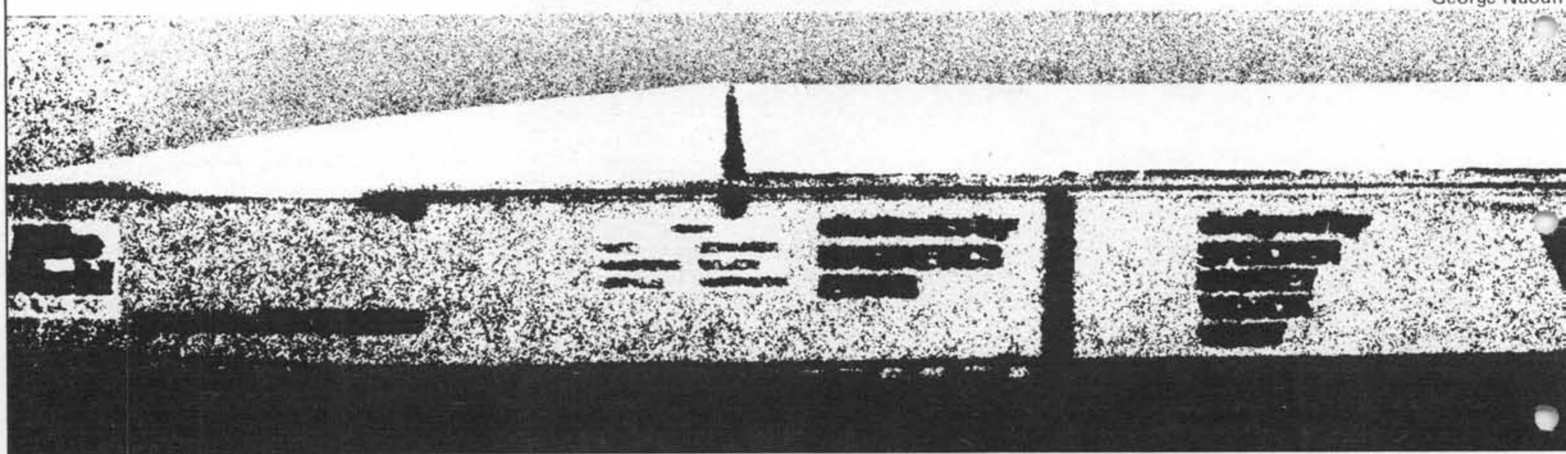
VECTOR!

the World's Fastest Human Powered Vehicle

Part 2

(by Al Voigt, Steve Wojcik and John Speicher)

George Naoum



Analysis of the Vehicle

Just how fast can human powered vehicles go? Without friction or aerodynamic drag on a special track in space, a strong person – developing an average of 0.5 horsepower – could reach speeds over 600 mph, but only after cranking for almost 3 hours! The reason it takes so long to reach these speeds is that kinetic energy is stored as the vehicles' speed is increased. The stored energy is proportional to the mass of the vehicle times the velocity squared,

$$KE = 1/2\, MV^2$$

Where KE (Kinetic Energy) is in foot-pounds, m (mass) is in slugs, and V (Velocity) is in feet per second. This kinetic energy effect will show up throughout this analysis. During the remainder of this article we will cover some of the interesting aspects of human powered vehicle design.

Re: Figure 1

One of the hardest parts of the design of a human powered vehicle is determining the power capacity of the riders. This is a study in itself. We used an empirical technique. By taking the vehicle data for "White Lightening" and matching rider-estimated data to actual race performance data we obtained our first estimates of rider horsepower versus time. Upgrading these based on "Vector's" performance results in the array of Figure 1.

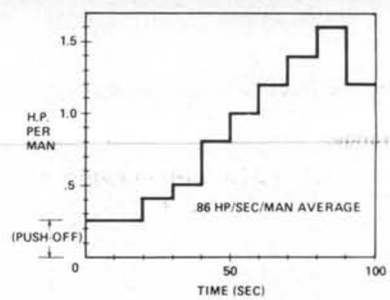


FIGURE 1 H.P. PROFILE

These data are somewhat higher than generally accepted but seem to match the vehicle performances and have been checked by us on 2 independently written computer programs. These are average power numbers which means that the "arms and legs" riders are putting out somewhat more in order to compensate for the "legs only" front rider. Our dyno measurements on several "non-biker" athletes showed a large advantage for "arms and legs" over "legs only" for the prone position. Well over 25 to 30% increases were measured. This will be smaller for trained bicyclists but should still be very significant.

The profile of power vs time was determined by interactive work on the computer, along with some common sense. Note that the HP increases as the run progresses until the riders "burn-out" at 90 seconds, about 0.8 miles from the push off point. They are still able to deliver roughly 1.2 HP for the last 10 seconds of our hypothetical 100 second run. These are only educated guesses and we would welcome any other comparative data. Notice also, that if the power is held at a constant level throughout the run the vehicle will accelerate quickly initially but fail to achieve as high a top speed (as will be shown in Figure 2).

In order to provide a basis for comparison we have used this same HP array throughout the remainder of this article. To actually achieve the optimum speed this power curve should be varied to match the particular vehicle (and rider) characteristics.

One last note on implementing the human power profile during a speed run: it must be an approximation since it relies on the riders being able to sense their own power output. The feedback is provided as they watch their speed at various check points throughout the run.

RE: Figure 2

Using the power array of Figure 1 we can plot the velocity profile for the "Vector" as it was in the 1979 race. See Figure 2. We have also projected the performance of the next year's model (Vector 80) with envisioned potential improvements in drag, weight and friction.

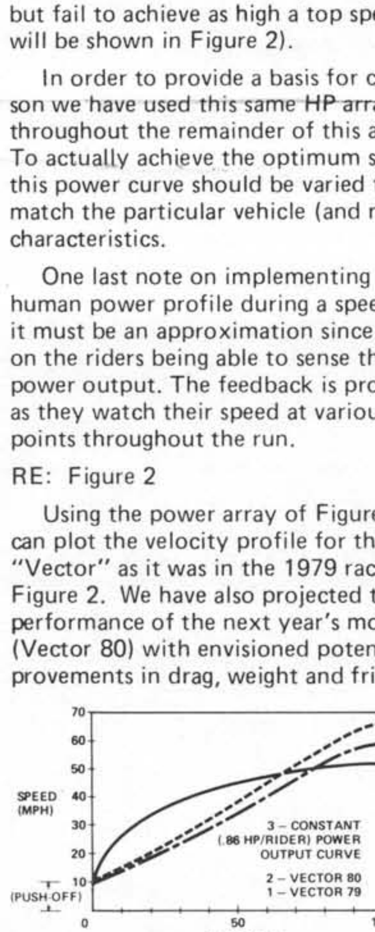


FIGURE 2 VELOCITY PROFILE

Although the peak speed of 64 mph seems high by today's standards it is computed by the same program that predicted the

"Vector 79" performance to be between 58 and 60 mph top speed. Our final run had a peak speed of 58 mph and we are certain that the Vector 79 will go 60 mph with a little more rider practice and fine tuning.

Re: Figure 3

We have so far talked about the 3 man "Vector" design. Now let's see what happens with various numbers of riders. Figure 3 shows the velocity profiles for Vector-type machines using a minimum frontal area (3 sq ft) design and minimum wetted area. The wetted area and vehicle weight (30 to 35 lb/man) vary according to the number of riders and will be close to those for well engineered lightweight machines.

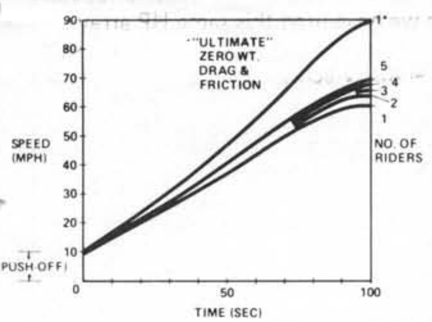


FIGURE 3 NO. OF RIDERS VS. SPEED

Clearly, there is a distinct performance advantage to a multiple rider vehicle. A 3 man machine will run 5 to 6 mph faster than a single and about 2 mph faster than a tandem of equivalent design. Notice that a five man machine will be about 2 mph faster than the triplet. The effort required for building 4 or 5 man machines and obtaining and training good riders for them must be weighed against the potential advantages.

Re: Figure 4

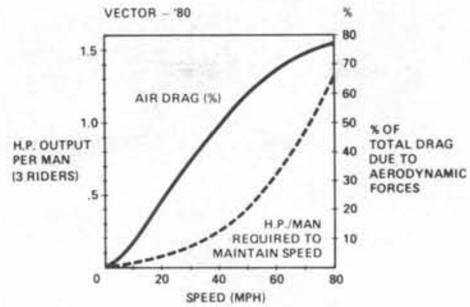


FIGURE 4 POWER + DRAG VS. SPEED

At this point some general background on the nature of rolling vehicle drag is in order. The power required to overcome drag is usually represented by the third order polynominal $C_1+C_2V+C_3V^2+C_4V^3$ where V is the vehicle velocity, $C_1=0$, C_2 and C_3 are static and viscous wheel drag coefficients and C_4 is related to aerodynamic drag. One can see from this equation that the wheel drag is dominant at low speeds but that the air drag increases with the speed cubed and thus is dominate at high speeds. Figure 4 contains a curve indicating the fraction of the total drag attributable to aerodynamic effects over a speed range.

The curve labeled HP/man in Figure 4 indicates the power required to maintain a particular speed without vehicle acceleration or deceleration. The HP numbers are surprisingly low. This fact highlights the effects of kinetic energy on the acceleration run. It also shows that if the machine were towed up to 80 mph and released, the riders could maintain this speed for approximately 20 to 40 seconds.

Re: Figure 5

This curve shows the effects of increasing the frontal area (and thus the air drag) of the machine while holding all the other vehicle parameters (including the wetted area) constant. This might happen if one were to move the riders from our in-line configuration thus shortening the machine but increasing the frontal area. The aerodynamic drag coefficient is assumed constant for all cases. As one might expect, the lowest frontal area machine is the fastest. There is a good probability that some of the "laminar flow" bodies* may have drag coefficients lower than our minimum frontal area, constant cross-section body.

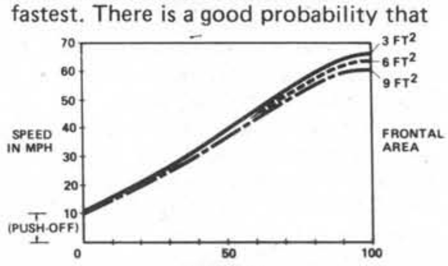


FIGURE 5 FRONTAL AREA VS. SPEED FOR NON-LAMINAR FLOW BODIES

*Aeroshell (#2) Single, "White Lightening" (#8) Tandem, and "Lightnin' Rod" (#55) Tandem

What about next year and the future? Next year should see 100 km/hr (62+ mph) surpassed. What is the ultimate limit for an earth-bound vehicle? Figure 3 shows the performance of an "ultimate" zero vehicle weight machine with zero frictional and dynamic drag ridden by a 180 lb rider producing the HP array of Figure 1. The top speed is 89 mph. The speed is limited by the kinetic energy effects mentioned earlier. Of course as the frictions and drags come down and speeds go up, longer acceleration times and distances will be advantageous. The HP array would be progressively lengthened to optimize the peak velocity.

With the correct design, speeds over 70 mph are certainly reasonable. Beyond that it will depend on getting super low drag laminar flow airfoils to work while in close proximity to the ground and its flow disturbing effects. As far as we know the technology in this area is very limited and possibly the human powered vehicle development is some of the only practical work being done in this area. Certainly potentially tremendous payoffs are possible, not only for human powered vehicles but for super-high efficiency ground transport vehicles of many kinds. For instance, a typical automobile uses one-half its power to overcome aerodynamic drag at only 40 mph. It should be possible to double its miles per gallon at a steady 70 mph just by streamlining the body correctly.

Maybe we could get some government funding for prizes for alternate vehicle efficiency and speed contests thereby encouraging free enterprise to solve problems quickly and efficiently. This would keep the United States from remaining a chronic oil importer, while using much of this expensive oil for nothing more than pushing around a lot of air.

Evolution of a Record

First Single Rider Vehicle in History to Break the 50 MPH Barrier: 50.85 mph May 6, 1979

(by Sandra Sims-Martin)

Gardner Martin's and Nathan Dean's prone bicycle, "Jaws" (the single machine that finally broke 50 mph [50.84]) has been around since the first Speed Championships and going a little faster each year. Despite the fact that Jaws moved up in the placings each year, few considered it a contender. A slow second in 1978 at 46.75 mph, it didn't seem to have anything special going for it. A product of eyeball engineering and shade tree mechanics, "Jaws" has no laminar flow shell, no state-of-the-art materials, no hand cranks, no stable platform, and compared to some, a small gear at 140 inches (68T crank to a 13T freewheel).

Gardner Martin

Fred Markham climbing in Belly-Bike at velodrome in Northern California. Aircraft-like appearance of this fairing accented by cockpit canopy and "anti-glare" panel.

Our goal since 1975 has been to break 50 mph. We didn't necessarily expect to be the first – and we never, never expected the record to stand so long. The story of Jaws is the saga of how to attack a record *piecemeal.*

We did have some racing experience. At 17, Gardner was already a winning drag racer, building and driving his own machines. True to the times that are rapidly becoming disenchanted with fossil power, Gardner first raced fast cars, then fast motorcycles, and now fast bicycles – an appropriate progression. He approaches building human powered vehicles the same way he approached building dragsters: as an exercise in packaging.

IHPVA

Mike Butler taking off on that fateful run, April 5, 1975. . .

IHPVA

. . . and landing – ouch! Lotsa Road-Rash, but he was okay otherwise.

Jaws frame design hasn't changed much since the '75 Championships. It was built of junk bicycle parts with a few garden tractor and motorcycle parts thrown in. There's nothing remarkable about it. The support for the rider's body is a fiberglass piece formed by using a motorcycle gas tank as a mold.

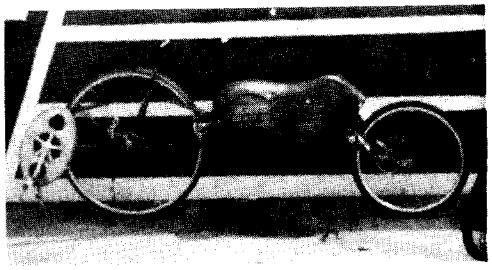
The major change was in 1977 in response to an inherent instability problem. Gardner and Nate extended the frame in order to move the rear wheel behind the cranks instead of in front of them. This moved the wheel from between the rider's legs to behind them. After experimenting they also changed the steering angle to a 55^{o} head angle with fork tips raked for one inch of positive trail. The two changes solved the handling problem. Both were done through trial and error.

The biggest changes in reference to speed have been in the streamlining. In '75 we ran with just a fiberglass nosecone molded from a Vincent Black Shadow gas tank. 1979 was the first year Jaws ran with complete streamlining. The basis of the streamlining is a fiberglas shell augmented by cardboard and duct tape.

Working with fiberglas is a slow and tedious process. Using the original nosecone as a base, we built a framework of wooden strips converging to a point in the rear. The idea was to build a smooth, small, package with as little side area as possible. First the cloth was laid up over the framework and resined. Then we sanded and filled until smooth. When this plug was perfect, the process began again – to make a female mold from the plug. After the mold was made, standard fiberglassing procedures were used to get a product from the mold.

We chose and remained with fiberglas because it was readily available, we were all experienced at working it, and it makes a rigid shell. After a crash at speed during the original Championships when a rider lost a lot of skin, safety became a very important factor. We would have liked to experiement with other rigid constructions, but lacking budget or tools, we couldn't.

In '76 we were sidelined because our rider was hospitalized. In '77 we ran with

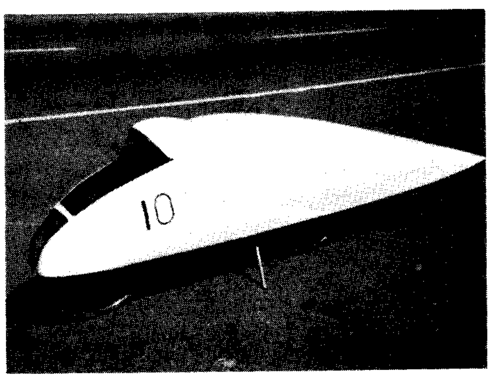


Dick Hargrave

1976 mods: elliptical chainring, smaller (20") front wheel, no mini-fairing.

3/4 streamlining. Half of each wheel, the rider's knees, and the top of the back wheel were hanging out churning up the air. Still, we moved from somewhere near last up to 6th place at 42.65 mph. Partial streamlining is better than nothing.

We knew all we had to do was add sides, a bottom, and a top wheel cover to be really ready to race. We didn't make it in time. By the '78 IHPSC, the cardboard sides which extended the shell almost to the ground were in place. We still didn't have a bottom or wheel cover. But that year, we got a real piece of luck when we connected with Fred Markham.



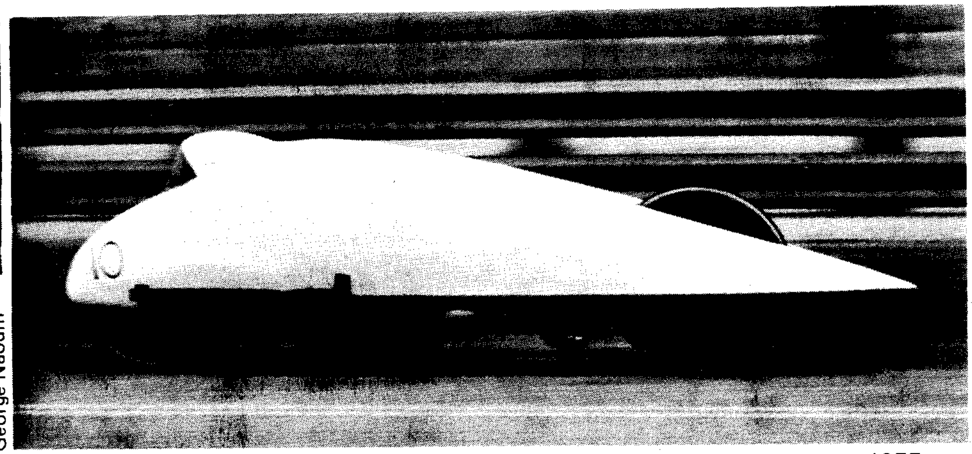
Gardner Martin

Shot of what may have been experimental in-line(!) three wheeler. Rear wheel missing (1977).

Fred was a member of the '76 Olympic Team, has been on the National A Team since '76, and has collected five silver and three bronze medals in the past four Nationals. Last year at the World's in Munich (sea level) he turned a kilo in 1.08 minutes. The only American who has ever done a faster kilo was Jack Simes at the '68 Olympics in Mexico City (8000 ft.) at 1.05 minutes.

No other cyclist in the country could have broken 50 in Jaws this year. Fred not only has speed, he has a facility and control on Jaws that none of our several other riders demonstrated. It's impossible to overstress the advantage of having a rider who is right for a particular vehicle.

When Fred rode to 2nd place (46.75 mph) in '78, we were certain he could break 50 in '79. We did little in the past year. We finally completed the streamlining, then concentrated on small improvements to customize the bike to Fred and make it generally better to ride. We shortened the frame just a little to get a touch more turning clearance. We



George Naoum

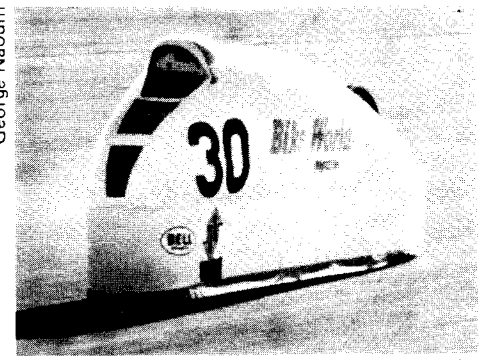
Rear wheel behind cranks: instant stability. 6th place at 3rd Speed Champs, 1977 42.65 mph.

added padding to the seat and shoulder rests. We installed a two speed cluster so Fred could start at 98 inches and only have to push 140 inches after he got rolling.

Fred's gone faster every time he's run Jaws. He is positive he can get still more speed out of it. Fred wanted to continue running after he set the current record. We were unwilling unless it was necessary. There had already been a close call on Saturday. On his first run the back tire blew right before the time traps. Incredibly, Fred was able to ride it out and maneuvered right through the traps and up to his catcher.

After '78 we asked Fred if we should convert to a trike so he wouldn't have to worry about balance. He wasn't interested. He says stability is no problem. On the thrill of going over 50 stretched out on two wheels he says he doesn't get much sensation. "I don't notice the ground rushing past or anything like that. I'm concentrating on my pace and my timing so I can get the most speed for the 200 meters. I probably miss the fun. The high point is stopping. When you're moving that fast, stopping can be difficult with only one brake." (We've promised Fred two brakes next year.)

If Jaws is used as an example, then obviously the way to win is to spend a lot of time after each race discussing what has to be done and then wait until the race is a month away before starting to do it. That way you insure that you won't get



George Naoum

1978. Added fairing bottom 46.85 mph

finished in time and you'll be forced to race half completed and wait for next year.

Actually, it has advantages. You get a chance to learn from your mistakes and make changes without having the time to get involved in a major rebuild. You also get a chance to learn from the only human powered vehicle experts in the world. Anything you don't know can be learned at the IHPSC because nearly everyone, fast or slow, is willing to share their knowledge.

The trial and error method of adding something each year has certain psychological advantages, too. It eliminates some frustration. Since Jaws was never designed on paper, we never had to try and determine why it only went X fast when the "figures" proved it should go XX fast. We didn't have any figures. Each year we knew why we didn't go any faster than we did – because we weren't finished yet!

Gardner Martin

"Jaws" in 1979 configuration on No. Cal. velodrome. May look similar to '78 on the outside, but 50.84 mph run talks about REFINEMENT.

pionships include the possibility of boats on the small lakes in the infield and an aircraft.

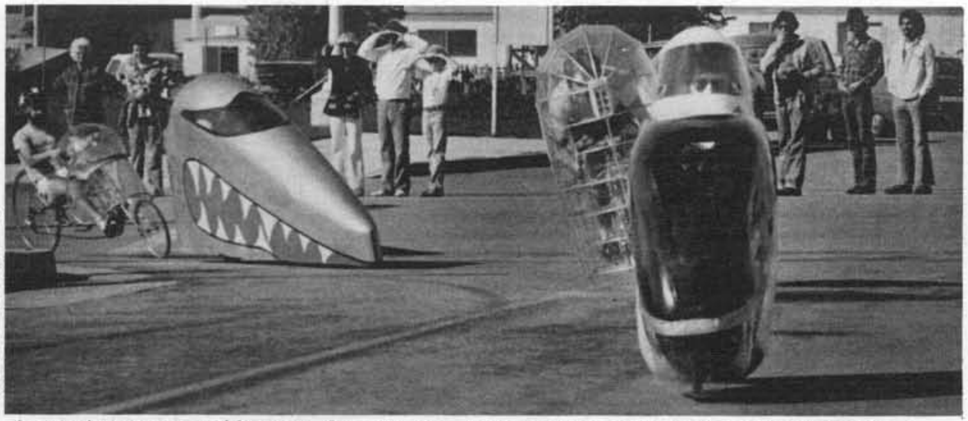
The types of events held at Tustin and Ventura are bringing into focus again a couple of other areas that are worth reflection:

- The streamliners are demonstrably faster than the standards.
- On a criterium course, two wheels are best because the ability to lean into the turns adds to the speed.
- The roadable bikes, usually singles, are crowd pleasers in action.

Nothing very earth-shaking here, except that nobody should feel eclipsed by the big sprint vehicles going 55 mph plus.

My apologies to those of our Board of Directors whose names were inadvertently omitted from the recent membership list. Those omissions were an oversight; a corrected list will be mailed later.

Peter Boor
IHPVA President



Anacleto M. Rapping

Around turn one at Ventura, October 20. Leading, is eventual winner Fred Markham, riding Gardner Martin's No. 30. Hot on his tail are, from right, Pat Huber, Kurtis Miller and Danny Pavish riding a semi-faired Martin-built vehicle.

Anacleto M. Rapping

Dick Lewis' new triple at Ventura. Geared way too high for such a short course with an uphill leg, this vehicle will do much better at Ontario, on the 2.5 mile Oval.

HUMAN POWER

Official IHPVA Newsletter Summer, 1979

Except as noted, all photos courtesy of George Naoum,
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Edited and Produced by Paul VanValkenburgh and Dick Hargrave

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