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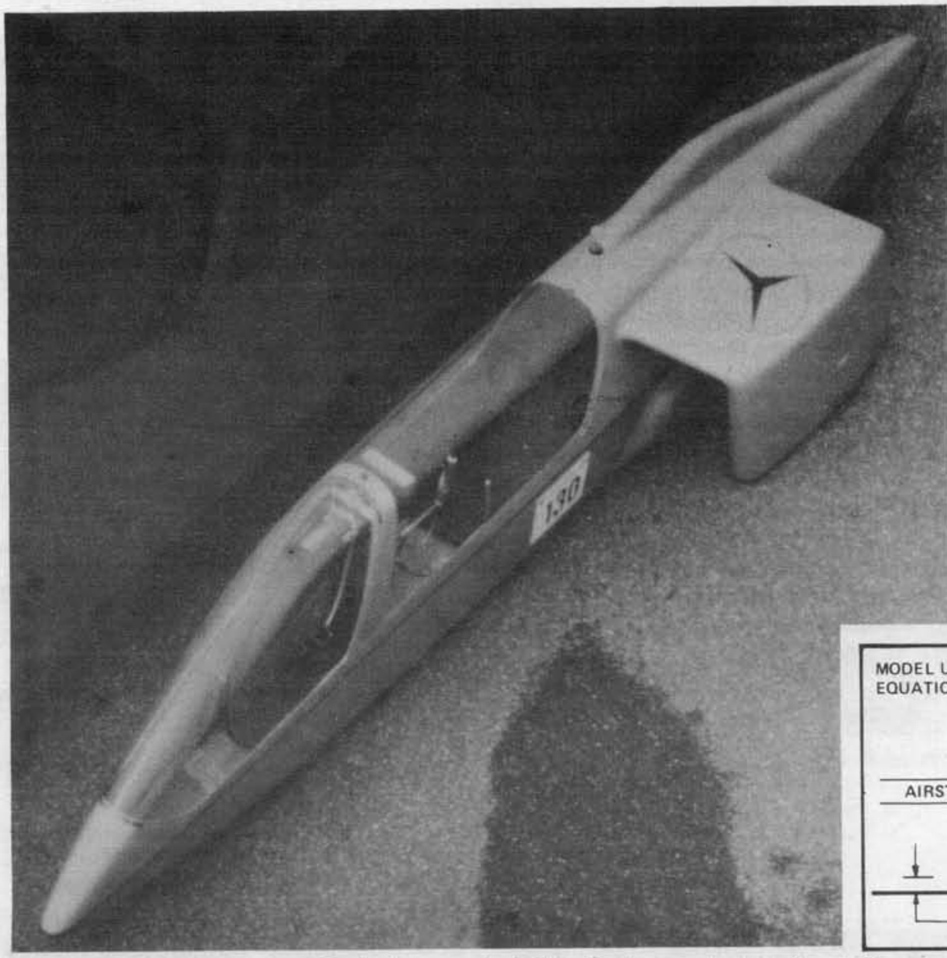
HUMAN POWER

1/4/80 Official IHPVA Newsletter ISSUE NO. 5 Spring, 1980



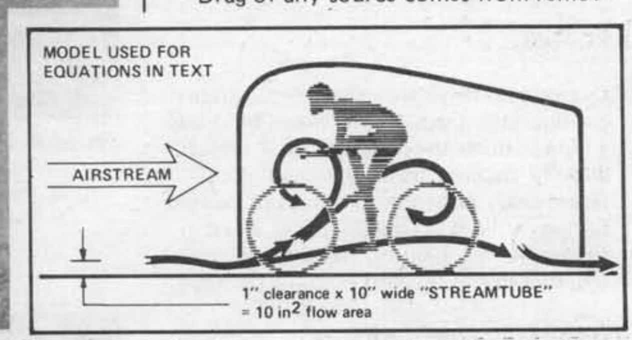
Who says styling and Aerodynamics don't go together? This diesel-powered vehicle (created by Mercedes-Benz, apprentices) uses bicycle wheels and tires and gets 2274.8 miles per gallon! We're featuring this vehicle to show that small, successfully streamlined vehicles need not be visually unappealing. - (D.H.).

DRAG ... Due to Internal Flow

(by Glen Brown, Technical Director IHPVA)

Calculations of power required for "well streamlined human-powered vehicles" invariably lead first time builders and those of us with short memories to predict that a particular design will exceed 50 mph with ease. But, every year we learn again that it's just not that easy. This article is intended to point out an additional source of drag not always included in power calculations. This major source of drag comes from internal flow.

Drag of any source comes from removing streamwise momentum from the flow relative to the vehicle. Internal flow causes drag by admitting air with initially high momentum into the interior of a vehicle (where some of the momentum is lost) and then discarding that air back into the airstream at a low velocity. Drag is in fact equal to the net change in momentum of the air. This can be represented by:



$$D = m\,(V - V_{out})$$

Where m is the mass flow of air through the interior of the vehicle, V is the free stream velocity and V_{out} is the velocity of the air that is discharged from the fairing.

1 This expression can be simplified for many vehicles because the sad fact is that V_{out} is nearly zero. Without presenting a vigorous proof of this statement, it is

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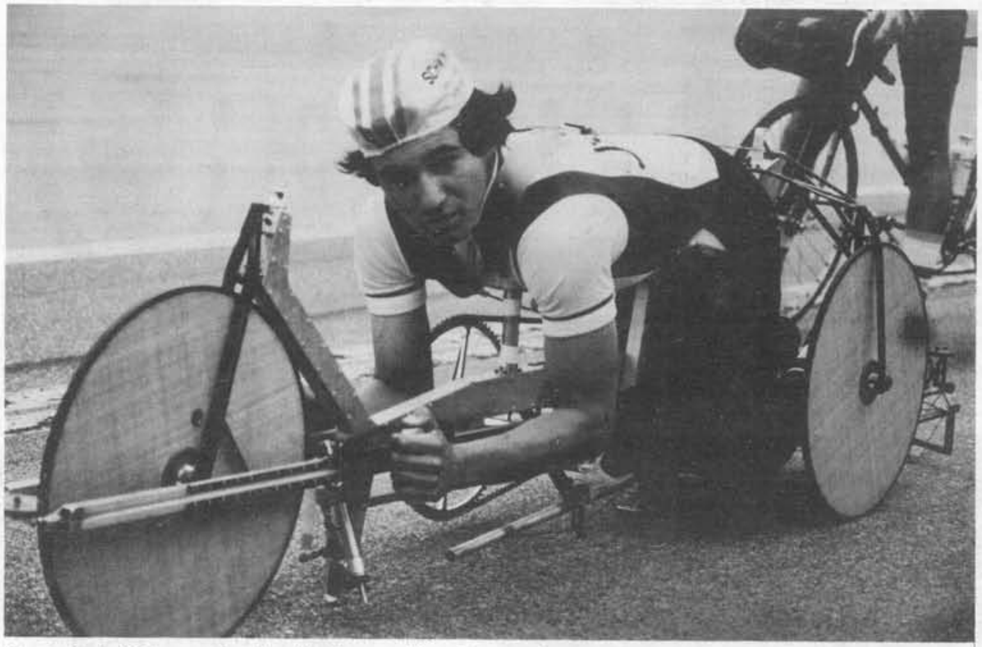
President's Message

My message for this newsletter is Racing. Our own Speed Championships, for which entry forms will soon be mailed, are scheduled for May 3/4 at Ontario Motor Speedway. Bill McCready, our Race Director, is planning as exciting an event as has ever been held. Tentative guests at the event will include our board member Wolfgang Gronen and his wife from Germany and Peter Selby and friends from England. Peter is scouting our event in preparation for a race of his own at Brighton, England, September 6, 1980. Lets give our overseas friends some record in speeds to shoot at.

Meanwhile in the background your officers are pursuing certain directions to ensure the longer term stability of the IHPVA. Among these are solicitation of gifts, grants and other financial assistance, and the legal proceedings involving incorporation and the granting of tax-exempt status.

I'm looking forward to seeing you all in May.

Peter Boor,
President



Mario Eskabido on the double linear-drive Dragonfly II.

DRAGONFLY II

SOME CONSTRUCTION DETAILS

(Text & photos by Steve Ball)

With my vehicles current track record of: crashes - 1, successful runs - 0, I feel poorly accredited to write an article on the design of human powered vehicles. I would, however, like to relate the techniques which proved successful in producing some of the more difficult components.

PLANS

Drawing up three view plans of possible configurations was greatly aided by using a human body template, photo 1, which allowed making scale drawings of different body positions. Overlays of desired fairing outlines on tracing paper aided in fitting the mechanism, fairing, and rider together in the smallest possible package.

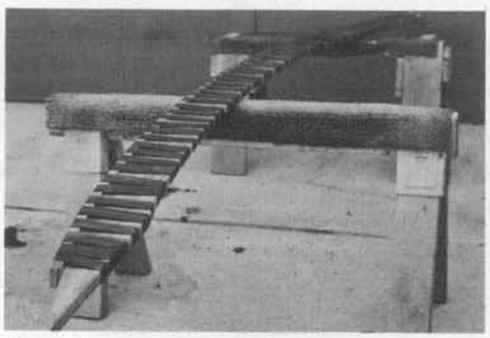


Photo 3

OVERSIZE SPROCKET

The sprocket teeth were cut into a 1/4 inch thick hard aluminum blank by a 1/4 inch diameter carbide tipped cutter in a woodworking router. A 1/2 inch pitch *steel* sprocket was used as a pattern (available in 60, 70, 72, 80, 84, 96 and 112 tooth sizes from local Power Transmission Supply houses – my 80 tooth pattern cost about $18.00). The periphery of the blank can be cut to tooth thickness using the router on a pivot arm (take light cuts and wear goggles). Then a 1/4 inch diameter follower was rigged to the router base, concentric with and below the carbide cutter (see photo 2). The blank and pattern were fastened together with flat head bolts and the center of the pattern was marked on the blank. Oversize tooth profiles were rough cut on the blank (to minimize the cut required with the router. The teeth were then finish-cut by tracing the pattern outline with the follower. The spoke pattern (for weight reduction) was then sawed out with a sabre saw.

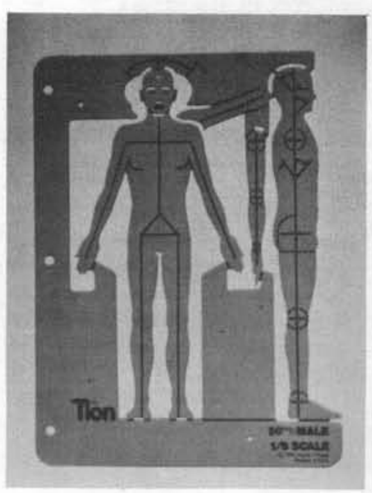


Photo 1

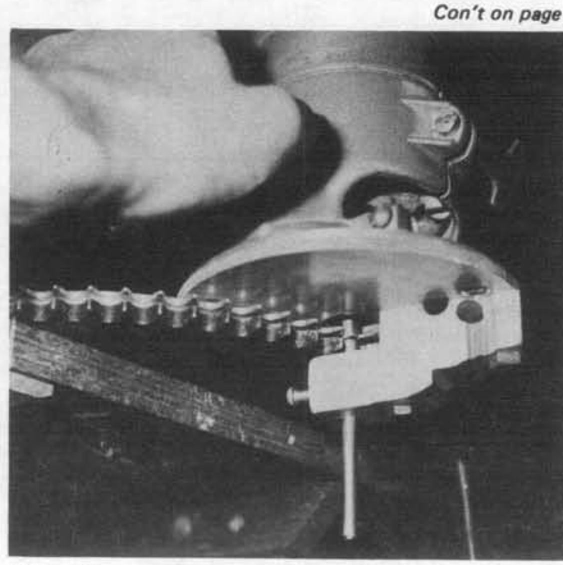


Photo 2

FAIRING FRAMEWORK

The fairing stringers were constructed from laminated sitka spruce. Using wood eliminated two problems associated with an all aluminum tube frame. First, the "MONOKOTE" model airplane covering heat bonded readily to the spruce. Second, the airfoil contours came out identical and true since all pieces were glued up on the same form and because the stringers did not have to be sprung into position on the bulkheads.

The form was sawed from 3/4 inch thick plywood. The desired outside contour was carefully laid out with allowance made for the finished stringer depth of 1/2 inch so that the outside edge of the form would mate with the inside surface of the stringer. The depth of the form was trimmed to about 4 inches. A 1 inch wide x approximately 40 foot strip of inner tube rubber was cut to be used for clamping during glueing.

The stringers were laminated up in three separate sections (right side, left side, and nose) which were later joined together with scarf joints. The sides had three .16 inch x 1 inch laminations (after glueing, the 1 inch dimension was rip sawed to make two pieces with a 3/8 inch x 1/2 inch section). Two part glue (with 3/4 hour minimum pot life) was brushed on mating surfaces and the three laminations and the form wrapped together with the inner tube rubber strip (photo 3).

The nose section of the stringers required a 1.5 inch radius bend. The four .12 inch x 1 inch laminations used were bent without breaking by first soaking them in water overnight afterwhich they were

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PRESSODYNE II

From Way-up to Way-down

(Text & photos by Alec Brooks)

After our participation in the '75 IHPSC, Mark Capron and I began thinking of various ways to improve upon the basic "Bun-Burner" configuration. Obvious improvements were to reduce the "Bun-Burner's" unmentionably high weight, and to clean up the fairing.

The biggest improvement, however, would be to reduce its size. The height of the fairing had been determined by the position of the rider's knees and feet as they went through the rotary pedal motion. To reduce this height the standard rotary crank was abandoned in favor of a linear drive system.

The original *Pressodyne,* or "stilts bicycle" was our first attempt to make use of a linear drive. The fairing was exceptionally small; 22 inches wide by 22 inches high by 8 feet long. Its surface area was only one-quarter of the "Bun-Burner's." It should have gone fast, but . . . the linear drive system was very inefficient. The pedals were connected via cables to roller clutches on a jackshaft in back. A standard chain drive connected the jackshaft to the rear wheel.

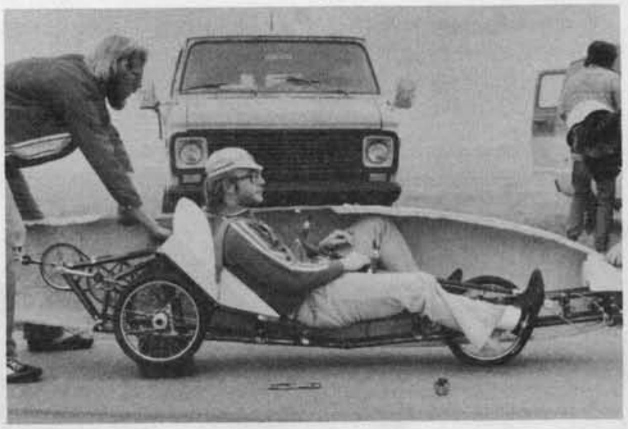
At the end of each stroke, the pedal would slam against the stop, wasting the energy of motion in the rider's legs. It didn't feel smooth, and certainly wasn't very efficient. Its best speed was a wobbly 38 mph.

After graduation in 1976, Mark went to Puerto Rico with the Navy, and I came to Pasadena to continue my career as a student. A couple of years later, a fellow student, Dave Sivertsen, and I began work on an even more exotic machine. It would be a linear hand and foot pedalled tricycle, with everything (including wheels) wedged into the same old *Pressodyne* fairing. Two weeks before the '78 race we drew up the plans. Construction started a week before the race – but we didn't quite get it finished. In '79, construction resumed a full two weeks before the race. Amazingly, the basic vehicle was completed early, allowing a couple of days for road testing.

On this new *Pressodyne,* the cables from the pedals are attached to a standard rotary crankset in back, resulting in a very smooth and natural pedaling motion. Steering is accomplished through fingertip shifters mounted on each hand pedal.

The rider, Brent Gilstrap, found that he had to stop power application to make steering corrections. (There is no freewheel, so steering must be accomplished as the hands are moving back and forth with the pedals.) Brent made one run on Saturday, on less than full power, at about 30 mph. Brent didn't feel well on Sunday, and decided not to try another run. We hope to have better results next year after further development and practice.

In retrospect, I believe we would have had better results if we had built a simple rotary crank machine, and devoted the extra time to develop a really good fairing.

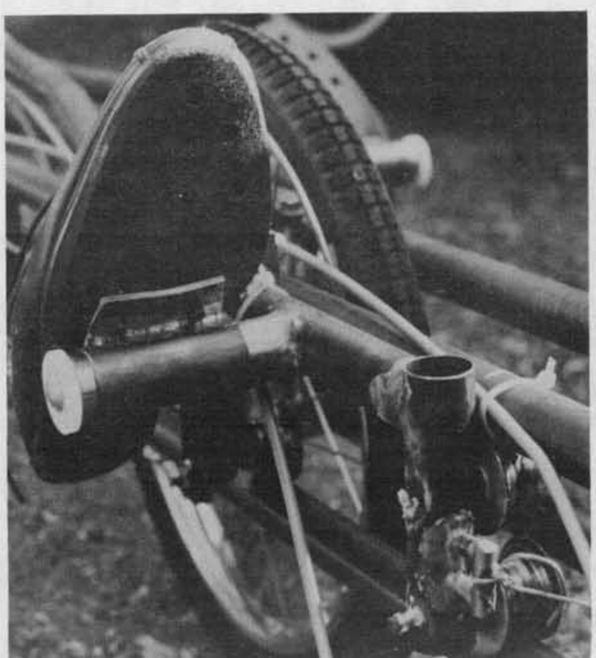


Brent and machine barely fit into fairing.

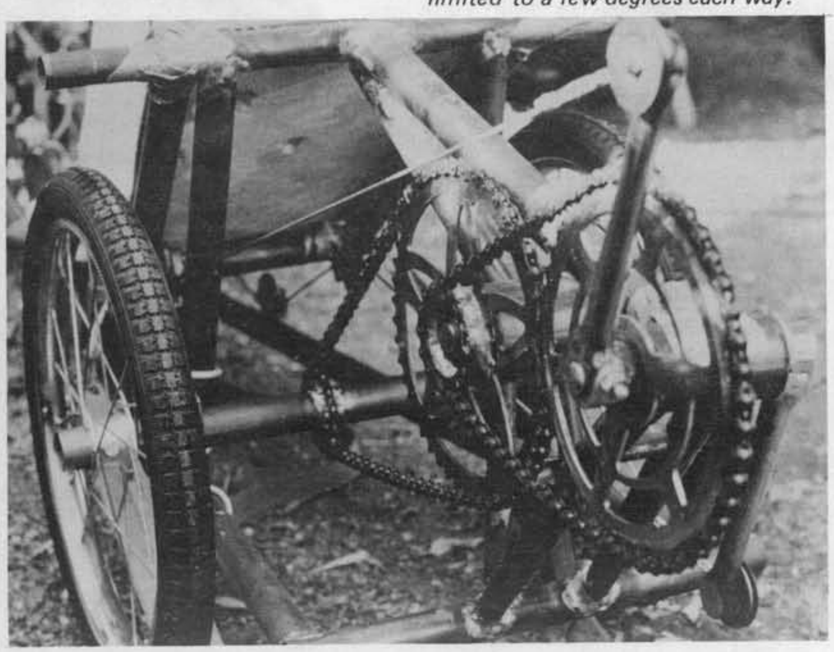
Pressodyne I: Way-up

Pressodyne II: Way-down

Pedals and front wheel. Steering is limited to a few degrees each way.



Close-up of pedal. Note aluminum rollers and pull-back cable.



Final drive. Chains in series provide 90 rpm at 50 mph. No freewheel, no brakes!

The Triflex Speed Vehicle . . . . a Lightweight, Highly Maneuverable Roadracer

(by Jim Gentes)

Description

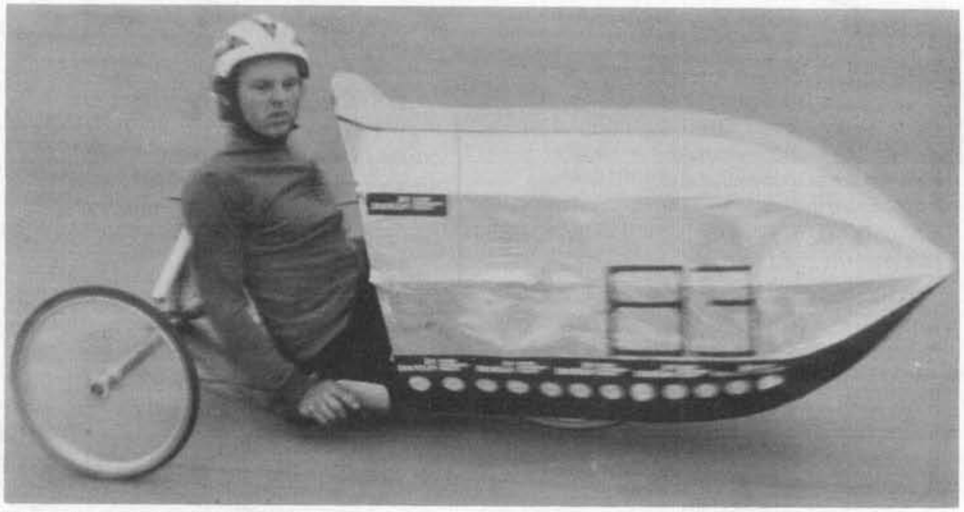
The Triflex Speed Vehicle is a leanable recumbent tricycle that was designed for the road race and hour record events. The rider sits in a recumbent position two inches off the ground. The cranks are located at the front of the vehicle and power the front 27" wheel which rests between the rider's legs. You need long legs and a fender for protection to operate this vehicle. Behind the rider is the steering pivot axis that runs through the rear axle. The axle is 36 inches wide and has two 18 inch sew-up wheels connected to it. There are two control levers, one on each side of the cockpit, that assist in stabilizing and turning the vehicle. Two screen door shock absorbers attach to the rear axle via the seat back support, providing roll resistance in the turns. The Triflex has a wheel base of 36" and with fairing weighs 32 lb.

Steering

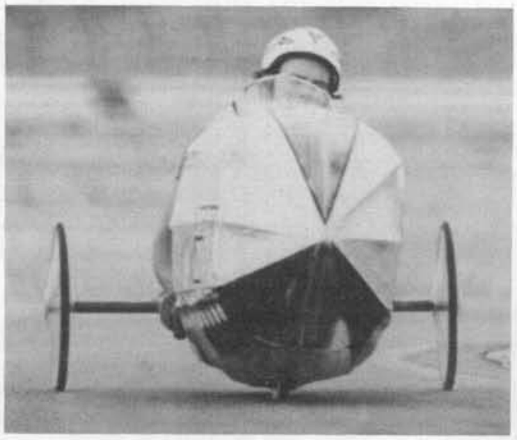
The uniqueness of this vehicle is in its steering mechanism. The vehicle turns because the front section of the frame which includes the cranks, front wheel and rider, twist as you lean into a turn causing the front wheel to track in the direction you lean. To go straight you pull back equally on the control levers locking the rear axle. The rear axle has a ½" steel pin that runs through it and is supported by two needle bearings and two thrust bearings that constitute the pivot unit. The steel pin is brazed to a support pillar that is part of the frame. The frame and rider pendulum from this pivot point allowing the rider to lean into the turns and making the vehicle follow. The frame pillar sits at 72° and controls the turning ability. At 90° vertical the frame would twist but wouldn't turn, and at 45° the vehicle would turn tight 10' circles. The setting of this angle required months of experimentation and is critical in maintaining vehicle control.

The Beginning

The Triflex Speed Vehicle is a product of a year long senior, industrial design project at San Jose State University. I have been interested in streamlined vehicles since I began USCF Bicycle Racing in 1974. My boss, Jim Blackburn, and my Professor, Jack Crist, had returned from a Design Conference at Asilomar in Monterey, California and after hearing Paul McCready's talk on the Gossamer Condor, they encouraged me to design a vehicle for the IHPVA contest. Jim Blackburn Designs offered to sponsor me through the use of the shop and through team support. Specialized Bicycle Imports

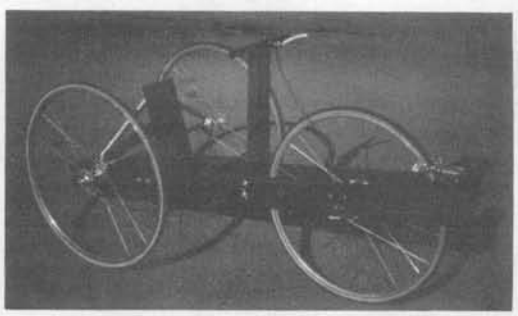


Chris Wiscavage on the Triflex S.V. at speed.



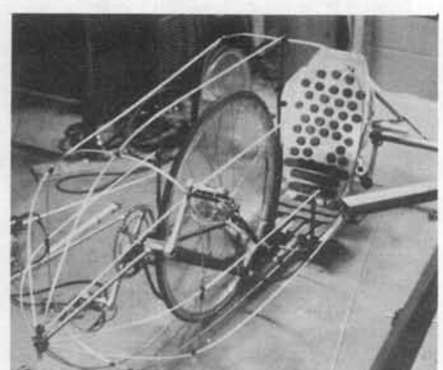
Chris around the esses during Road Race. Note Tilt.

Close-up of steering linkage showing axle, pivot, shocks, and control bars.



1st wooden (!) mock-up. Coaster model used for maneuverability tests.

Nice workmanship on this front-mounted bottom bracket - (D.H.)



Uncovered fairing framework. Note foam buttons on seat back (to allow for air circulation).

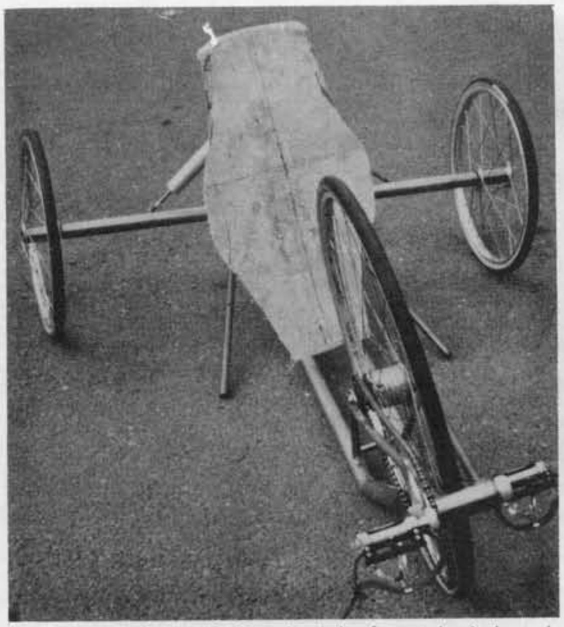
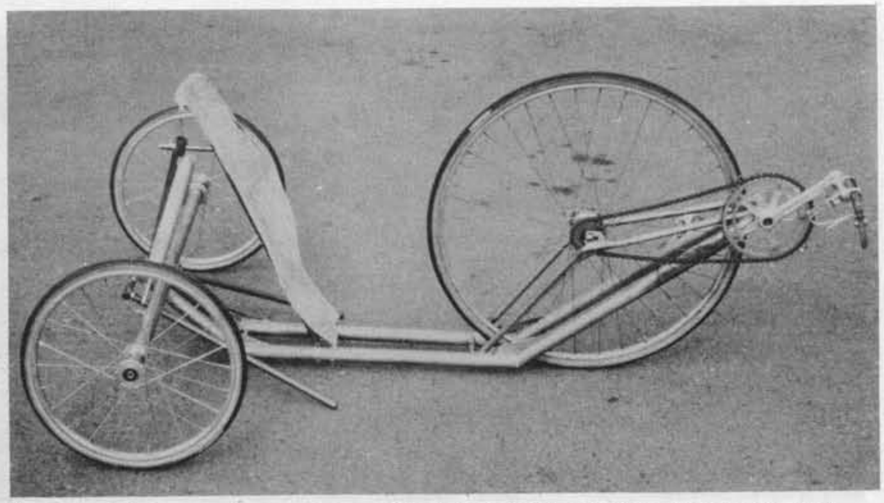


Photo speaks for itself: Steering is by front wheel pivoted behind rider.



Very simple frame construction keeps weight low, make nice graphic statement in and of itself.

provided hard to get parts like 18" sew-up wheels, and The Bicycle Outfitter provided more parts including the rider, Chris Wiscavage. My goal was to design, build and race a vehicle in the hour record and road race events. My emphasis was on these events because it 's challenging to build a vehicle that would be practical on twisting roads.

Development

I chose a tricycle configuration because I wanted the vehicle to be stable in strong winds and I didn't want to worry about the fairing hitting the ground in the turns. I chose a recumbent position because I wanted a small frontal area. The problem was to design a 3 wheeled vehicle that can be steered while cranking with the hands and feet. I tested three concepts with wooden full scale mock-ups: A big wheel type tricycle that liked to tip over, a standard tricycle that also tipped over, and a leanable tricycle using a skateboard truck that suffered from speed wobbles. The leanable tricycle appeared the most promising allowing for both hand and foot cranking.

The idea of the leanable tricycle was to overcome the tipping problems of a conventional tricycle by being able to lean into turns, shifting the center of gravity so that you don't tip over. I had limited success with the wooden mock-up and went to a pedal version tricycle out of steel tubing. The 27" front drive wheel remained but the rear wheels were reduced to 18" giving a lower center of gravity, increasing cornering ability and creating more elbow room. There were problems, the vehicle was scary to ride, it suffered from speed wobbles and had a tendency to tip over during cornering. At this point the engineering problems seemed to compound and not much headway was being made. The idea worked but not very well. The skateboard truck was doomed!

My boss and sponsor, Jim Blackburn, returned from a bike show in Anaheim with information on a "Skatecycle." A leanable tricycle that works! This inspired me and I continued working, the skatecycle is a tricycle with two small go-cart wheels in the rear and a 24" front wheel. The front of the frame pivots off of the rear axle via a variable pivot axis. You can change the pivot axis of the rear axle by a control lever. To go straight you shift a lever and to turn you shift it back depending on how tight you want to turn.

Immediately I contacted the designers and tried to get plans. However, they were hard to get. Eventually I duplicated their system from looking at their brochure. It worked. However, I didn't like the idea of having to shift for the turns. I experimented with various pivot angles until I found one that would permit wide turns to be made with maximum body lean. One problem still remained: wobble. To remedy this screen door shocks were added to the axle and the back of the seat. The shocks helped baffle body shift in the straights and provided resistance in the turns. The bottom bracket was lowered to where the pedal cleared the ground by 1" in the turns. Two control levers that ran underneath the rear axle and attached to the frame assisted in cornering. By pushing on one lever and pulling on the other you can pull yourself up out of the turns. With the control levers added and time diminishing, the addition of hand power was shelved until next year. I drew up the final plans and began construction of the triflex speed vehicle.

In the final version everything was simplified and lightened. The major change was in increasing the rear axle length from 26" to 36". This insured the vehicle would not tip over. Lighter tubing, 4130 steel aircraft was used throughout the frame and resulted in a light, 8 lb frame. The shell was constructed of 3/16" aluminum rod that was bound with electrical tape at the joints. It was covered with heat shrink Monocote Mylar. The fairing only partially covers the vehicle due to construction delays.

Credit must be given to Chris Wiscavage, who entered the hour record and road race events with no more than a mile of road training! We lost our first rider due to knee problems, Chris replacing him in the last days. Chris encountered a few problems during the races, most notable the uncomfortable seating unit and some problems with the control lever.

Looking back, the Triflex Speed Vehicle performed very well. The steering system worked so well that the road course at Ontario was too easy for the turning capability of the vehicle. A tighter course would have been ideal.

Planned for next year is a fully enclosed fairing, a more comfortable seating unit, and hand cranking. I have plenty of time to train, so . . . look out Ron Skarin!

General Specs:

Road Weight: 32 lb
Without Fairing: 28 lb
Weight Dist (with Rider): 45%/55%
Body Pitch (in turns): 30°
Turn Radius: 25 ft
Ground Clearance - Straights: 1½"
Turns: 1/8"

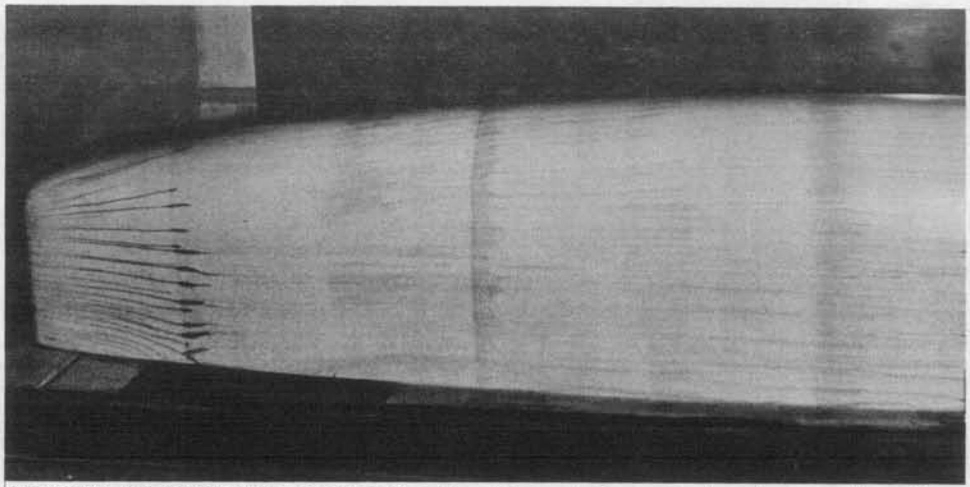
Drive Train:

J.C. Higgins 3 speed hub: 49 X 16

Thrill Factor: 89%

Sponsors:

Jim Blackburn Designs, Campbell, CA
Specialized Bicycle Imports, Campbell, CA
The Bicycle Outfitter, Los Altos, CA



(Fig. 6) No. 2 in the wind tunnel test section. An oil-type paint is used to show the streamlines. The lines curve down in the front due to the suction slot used to draw off the boundary layer on the wind tunnel floor.

The Wind Tunnel Testing of White Lightning

(Text & Photos by Tim Brummer)

In October 1976, myself and two other students at Northrop University began discussing the feasibility of constructing a Human Powered Vehicle for the annual IHPVA race the following May. The design was finalized and frame construction was started in March. One week before the race the vehicle was ridden for the first time and we started to think about a body. A shell was hastily formed by taping clear plastic sheets over aluminum formers and was completed the morning of the race. The end result looked like a wet caterpillar and visibility was non-existent, but we still managed a credible 47.9 mph for 3rd place.

Realizing that a proper body shape would greatly increase the vehicle performance, I began investigating different shapes in June of 1977. It was decided to use the existing frame as it had proven both reliable and stable, and to shape a body around it. After some research I decided upon a 66-012 laminar flow airfoil, as it fit the frame nicely and had a very low drag coefficient. A 1/5 scale drawing was made for a wind tunnel model, with loft lines at various stations. Our original shape (Model No. 1) had a round bottom cross section and was mirrored somewhat in a horizontal plane so that the top matched the bottom, similar to Allan Abbott's machine. The entire body was a compound curve, with wheel pants and bulges for the front rider's heels. (See Figure 3). The forward wheel covering was designed to turn with the wheel for steering.

The model was built during the summer of 1977 in the school workshop. It was carved from a solid piece of pine, which was laminated from 4 pieces of 2 x 6 boards. Rough cuts were made using a band saw. The final shape was obtained by hours of planing and sanding. To ensure that the proper shape was obtained, the model was constantly checked against metal templates (Figure 2). Two metal fittings were glued flush with the bottom of the model to provide attachment to the force balance of the wind tunnel.

The model was finished with sanding sealer and four coats of white enamel. The final coat was fine-sanded with 400-grit sandpaper.

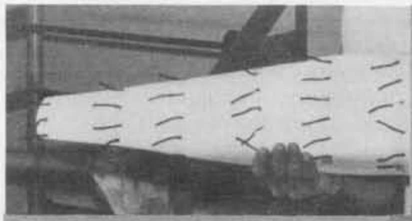
Wind tunnel testing of the model began in September of 1977. The Northrup University subsonic wind tunnel was used to conduct the experiments. The wind tunnel was built by students from an earlier class and is constructed mainly of wood. Power from a 100 HP electric fan produces velocities of up to 200 mph in the test section, which measures approximately 2 feet square and 4 feet long. Air loads acting against the model are transferred to the force-balance by metal rods.

The force balance assembly measures lift, drag, and moment forces using electronic load cells, and displays the results on a digital readout processor. To simulate ground effects as much as possible, the model was mounted close to the wind tunnel test section floor, and the boundary layer of air on the board was removed by a suction slot at the nose of the model.

The tests on Model No. 1 consisted of measuring the lift and drag forces at varying air speeds and ground clearance heights. It was found that the drag coefficient (C_D) decreased with increasing speed (Reynolds numbers, or R_n). The C_D also obtained for Model No. 1 was .061 with a ground clearance of .10 inches (½" for the full scale vehicle) at a R_n of 1,000,000.

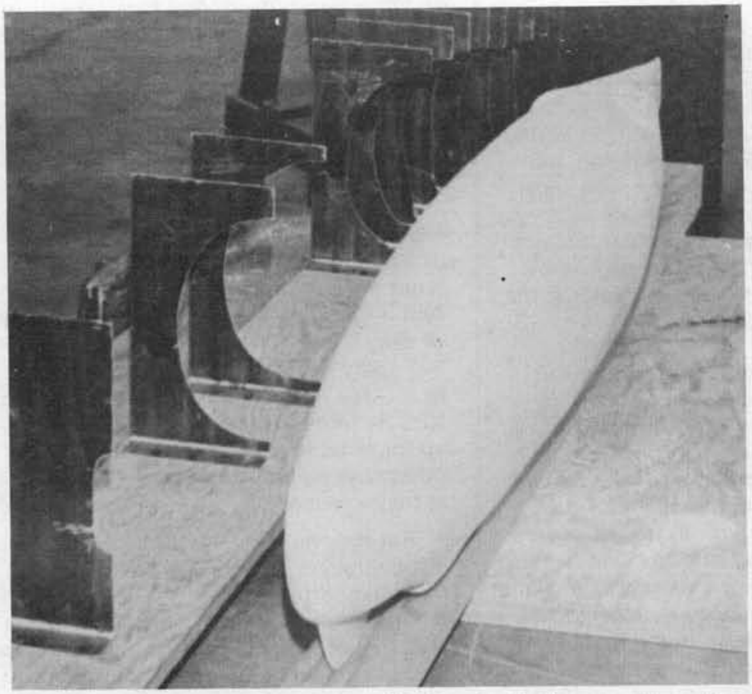
Flow visualization tests were also conducted using yarn tufts taped to the model. It was during these tests that large separation areas were noted on the lower rear part of the model, particularly between the wheel pants. After numerous modifications with clay, it was decided to eliminate the wheel pants and to add material to the lower part of the tail. The rear part of the model was modified and the resulting configuration designated Model No. 1A (Figure 4). Tests showed that the separated area was greatly reduced and that the C_D was considerably lowered. A minimum C_D of .030 was recorded at a R_n of 1,000,000 and a ground clearance of 10 inches.

At this time it was realized that we had developed a very low drag shape, but that it was going to prove to be very difficult to build a full scale vehicle with similar lines. With the added requirement of a simple as well as low drag shape in mind, a new body was designed. The new shape had flat sides, a square cross-section at the bottom, and a compound curve only on the top. Although patterned after the same NACA 66-012 airfoil as Model No. 1A, the new configuration had approximately 5% more frontal area than Model No. 1A due to the flat sides and bottom. A new model (designated No. 2) was built using the same methods as Model No. 1. The fabrication and testing of Model No. 2 was done as an Aero Lab project, with the assistance of another Aero student, Roy Dunn.



(Fig. 4) No. 1A showing how the bottom rear has been brought down to eliminate the wheel pants and large separation area. The yarn tufts are for flow visualization in the wind tunnel.

(Fig. 3) No. 1 before testing. Note the wheel pants and "Stinger" tail. Rods protruding from the bottom of the model are for securing the model to the wind tunnel force balance.



(Fig. 2) No. 1 in the shop after construction. Board with sheet metal templates was used to assure the model had the desired shape. Some templates were removed in this photograph.

The test procedure was the same as for Model No. 1, with the results being somewhat parallel. The C_D decreased as the ground clearance decreased and R_n increased. The lowest C_D obtained was .025 at a R_n of 1,000,000 and .10 inches ground clearance. This gives a slightly lower drag than model No. 1A, in spite of the increased frontal area. Being very pleased with these results, it was decided to use Shape No. 2 as the basis for the full scale vehicle.

As plans were being made to construct the full scale body, some thought was given to rider ventilation. Experience with our original plastic body the previous year showed that an enclosed body shell was very uncomfortable due to an excessive heat buildup. It was decided that Model No. 2 should be modified to test the effects that ventilation would have on the vehicle drag.

Two NACA type flush inlet scoops were cut into the upper part of the model. These scoops were connected to each other and to two outlets by large internal passages. One outlet was located on the top rear of the vehicle, while the other insulated the rear wheel cutouts on the bottom. NACA flush inlet scoops were chosen because of their low drag and high pressure recovery. They were placed on the top of the vehicle just forward of the riders' heads so as to give maximum cooling and eliminate the possibility of sucking up foreign matter. The scoops on the model each had an inlet area of .5 sq. in. (12.5 sq. in. for the full-scale vehicle). Wind tunnel tests, however, showed the drag increased 76% to a C_D of .044. An increase this large could not be tolerated on the actual vehicle. The scoops on the full-scale body were therefore hinged so they could be closed off during the acceleration and timing phases and opened during the deceleration period for cooling.

While I was conducting tests with the scoops on Model No. 2, Roy Dunn had constructed and was testing Model No. 3. This model was configured similar to Model No. 2 but was based on a NACA 0010-35 airfoil. As a result the model was thinner and longer, with the length being 4.4 ft. as compared to 4 ft. for Model No. 2. Testing showed this shape would yield no improvement over Model No. 2 as the minimum C_D was .032 at a R_n of 800,000.

It must be remembered that the drag coefficients noted were for the scale models tested in the wind tunnel, and are useful in comparing one model shape to the next. These results are not applicable, however, to a full scale vehicle due to the effects of a stationary ground plane, body joints, shape irregularities, and other factors. In coasting tests with the full scale White Lightning, a C_D of .110 at a R_n of 900,000 was obtained. This is an increase over the C_D of the wind tunnel model by a factor of four.

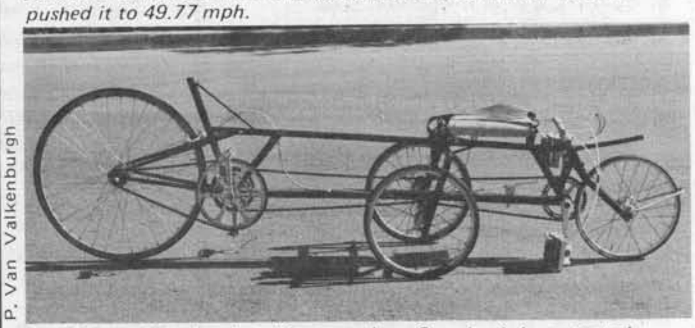
Much wind tunnel testing remains to be done to find the ideal body for a human powered vehicle. Investigation of the effects of a ground plane stationary to the air stream is one important area to study. I believe failure to do this in our wind tunnel studies effected the results considerably. Also, correlation studies between actual vehicles and wind tunnel models should be done. With further aerodynamic research and a proper engineering approach, I believe human powered vehicles can be built with speed capabilities in excess of 70 mph.

Aeroshell Answers

by Paul Van Valkenburgh

George J. Naoum

Aeroshell in its 1979 form with parachute brakes. Ralph Therrio pushed it to 49.77 mph.



P. Van Valkenburgh

Bare frame of the hand and foot cranker. Steering is by patented cable system.

The Aeroshell streamlined fairings have generated enough mail to justify a written explanation of their past, present and future. The standard upright version has been around for four years, running 46.5 mph to finish second in the singles in 1976. Since then it has been primarily run in road races (second at the Tustin Dog Days road race) because the new prone Aeroshell II has been so much faster. The prone, hand-and-foot powered quadracycle Aeroshell II has already been well described in word and photo, so we will concentrate here on the conventional upright version.

Seven "upper" Aeroshells have been built, including four rigid (two opaque and two transparent) and three inflatable ones. All of these have the same teardrop shape, and rest on the rider's body without touching the bicycle at all. Four rigid plastic "lower" Aeroshells have been built, including two opaque plastic, one transparent plastic, and one cardboard. These attach to the bicycle frame and enclose it to the top of the tires.

All of the plastic Aeroshells are constructed by vacuum-forming thermoplastics (ABS, Butyrate, or Vinyl) over plaster molds in a four by six foot oven. Although this technique lends itself to mass production, factors such as the cost of the material, the cost of the molds, and the availability of ovens make the end result rather expensive. Custom-built in limited quantities, they would have to be sold for 2-300 dollars. That might be acceptable, except that still more development work is necessary at this time.

The advantages of the rigid upright Aeroshell have been obvious in past races. In the first place, it's been the fastest standard bicycle in either straightaway or road races. In addition, it's been easy to get in and out of in a hurry, it provides

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Drag *(Con't from page 1)*

sufficient at this point to note that the bottom edge of an open bottom fairing is essentially an orifice and, as with most sudden expansions, one velocity head is lost in the process. The expression for drag under these conditions becomes:

$D = mV$ (sometimes known as sink drag)

or $D \cdot (\rho AV)V$

Where D is drag in pounds, ρ = air density at 50 mph, and A is opening area.

At 50 mph, $\frac{D}{A} = .087 \text{ lb/in}^2$

and $\frac{\text{Power}}{A} = .0027 \text{ DVmph} = .012 \text{ Bhp/in}^2$

Now the problem is in estimating A. This is not so easy for an open bottom fairing because most of the area between the fairing and the ground is used by the very slow outgoing air while the A in the equation refers only to the area of the "streamtube" that actually enters the fairing. The picture is further complicated by the angle of the fairing and other factors that make accurate estimates impossible. However, an open bottomed fairing could easily have a "streamtube" of 10 in^2, giving an increment in power required of .12 Bhp. Suffice it to say that never has fresh air come at such a high price!

(Con't from page 2)

pliant enough to wrap over the same form used for glueing. 1 inch wide strips of common window screen were sandwiched between the wet laminations (and also on the form) to allow air circulation and speed up the drying process. The inner tube strip served as a clamp during drying (about 1 day). Once dry the laminations held the shape of the form and were glued together in the same manner as the other pieces.

– Steve, like all other authors in this newsletter, have written articles by request. If it weren't for members willing to take the time to write, we wouldn't have any newsletter at all. My personal thanks to all of you who have made such great contributions to HUMAN POWER. And to all of those who haven't: please consider your thoughts (in the form of an article or open letter) more than welcome. We want and need your input, complimentary or critical; your techniques for designing or building; or anything at all that will be of some interest to our readers. Just write it, include photos (black & white best, please no slides), drawings, etc. and send to Paul Van Valkenburgh or me.

Thank you.

Dick Hargrave

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Aeroshall *(Con't from page 7)*

good visibility and conspicuity, and it's proven to be controllable in 15-20 mph gusts and crosswinds. Finally, in accidental crashes, it has protected the rider from both impact and road burns.

Now, the disadvantages. It's bulky enough to be a nuisance, in either storage or transportation. Visibility to the rear is not easy, even with rearview mirrors. And it does weigh something, even though air drag is more important in most cases. But oddly enough, the biggest question – heat – has not proven to be a great problem. Reduced drag has more than made up for reduced circulation, and most riders have had no complaints – as long as they kep moving.

But the real reason why these minor difficulties are not being worked on is that a far better concept is in the works: the inflatable Aeroshell. This version eliminates all of the above disadvantages except lack of circulation, or heat. Ironically, this could be the primary advantage in winter riding, such as ordinary commuting. So far, all of the inflatable prototypes have been hand made, and therefore expensive and not too attractive. But the current fuel situation justifies rapid development for production, and we may have a marketable product for under a hundred dollars within the next year.

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