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HUMAN POWER

THE JOURNAL OF THE IHPVA ISSUE NO. 10 *Vol. 3, no. 1, spring, 1984.*

THE MONARCH (MIT).
Photo: Steve Finberg (c).

AIRCRAFT BUILDERS TAKE OFF

THIRD KREMER PRIZE CLAIMED BY MIT AERO STUDENTS

A plane called MONARCH, emerging from an earlier machine called CHRYSALIS that made an attempt on the second Kremer prize, was pedalled around a 1500-m triangular course at Hanscom Field, Bedford, MA on Friday May 11, 1984 in less than three minutes. The student group that had designed and built the plane claimed the third prize offered by British industrialist-philanthropist Henry Kremer.

The prize had been claimed before - see the article on the BIONIC BAT in this issue of HP. The plane, built by the California group led by Paul MacCready, had successfully flown around a similar course in September 1983, but the Royal Aeronautical Society disallowed the claim of a record because the storage nickel-cadmium cells were not completely run down at the start of the seven-minute human-powered charging period permitted before the flight. Pilot Parker MacCready graciously phoned John Langford, aero-astro graduate student leading the MIT effort, shortly after the May 11 flight. Last fall the situation appeared to be reversed, as Parker's apparently successful flight - and the demands of classes - stopped the MIT group's development of the

(continued on p. 3)

HUMAN POWER INTERNATIONAL

This issue of HP is largely given to reports and comments on the exciting Ninth International Human-Powered Speed Championships at Indianapolis in September-October 1983. They were assembled by former president Chuck Champlin and by Tom Healy, who had a principal part in the creation of the Indy chapter and the running of the magnificent events there. I took over editorship of HP from Tom because he is far too valuable working with the others in the Indianapolis chapter to make this year's tenth championships match their previous triumph.

For the next issue, which I hope will be out before this year's championships, I hope to have some highly skilled help: Rob Cotter, former VP and now living in Maine; Crispin Miller, original editor of BIKE TECH and now a graduate student at MIT; and Jim Papadopoulos, doing his doctorate at U Minnesota and MIT, have all offered enthusiastically to help, along with several others. Several people have offered papers, and we want more. Here are some guidelines; please write or phone if you can contribute something or know of someone who should be asked.

1. Articles in HUMAN POWER should be of long-term interest. Chuck Champlin has been producing HPV NEWS every month in a superhuman way, and short news items and interim reports belong there. If in doubt, send contributions to me, and I'll send them on to Chuck if it seems appropriate. I would let you know if I do.

2. We need to increase our coverage of human power in the air and on the water and, perhaps, under the water. We have asked for some articles in these areas for the next issue, but we need more.

3. We must become more international. There are groups growing rapidly in enthusiasm and size in Australia, Britain, Canada, Germany, Holland and South Africa and probably several other countries. We need more contributions from those areas. We also need to make ourselves more easily understandable. We are almost the only country still using old Imperial units. But even there we are inconsistent. We have 200-meter speed trials and give the results in mph. We also have quarter-mile sprints - why not 400 meters? Our writings are sometimes written in a vernacular so obscure that non-English-speakers must be totally confused. I have tried to add standard international units to values given in the articles in this issue even where the result has seemed somewhat clumsy - but what should be done about a 2 by 4? How would a German-speaker, for instance, look that up in a dictionary to find out what it is? When you send in contributions, keep our international readership in mind.

4. We could streamline our operations greatly if as many contributions as possible were sent in some computer-readable format. I must get advice on this. I know at least this: that if authors could send their pieces on five-inch (127-mm?) floppy disks in a format suitable for an IBM or a DEC PC I could save much labor.

5. Any of you who have written articles or papers for other publications will know that editors and publishers have almost unlimited power - to refuse, change or delay your work. We hereby proclaim a code of good practice: we will acknowledge all contributions within two weeks of receipt, and will inform authors of acceptance, rejection or modifications within four weeks. Test us!

David Gordon Wilson, editor

(Special thanks for help with this issue to Georgia Nagle, typing, and Crispin Miller, layout).

somewhat balky MONARCH. Frank Scarabino, the mechanical-engineering senior who was pilot and power plant, had difficulty in the "upright" riding position putting on extra power in the turns while at the same time manipulating the wing-warp and rudder controls. The long vertical pilot enclosure was adding serious separation drag in the turns. And the lack of a variable-pitch propeller put additional demands on power input.

When the news of the Roy.Ae.Soc. rejection of the BIONIC BAT record came in, the MIT students increased their design efforts. They went to a recumbent pilot position to reduce nacelle drag and to allow Scarabino freedom to use his hands and arms to manipulate the controls more easily. They converted the Larrabee propeller to variable-pitch. And they added ailerons. Scarabino trained on a recumbent ergometer for several months. As soon as the late New-England winter allowed it, the plane was rolled out. The combined improvements on last summer's MONARCH performance were dramatic. On the second day of flight testing, the batteries were run down to the millivolt level, Frank Scarabino charged them for about seven minutes, the prop was engaged, and the course was circumnavigated.

Another milestone for human power has been reached. Congratulations! Dave

THE BIONIC BAT *Photo: AeroVironment*

THE FLIGHT OF THE BIONIC BAT

By Lynn Tobias, VP-Air

As the sun touches the horizon and the winds subside for the evening, the Bat begins to stir within the cavernous shelter where it had sought relief from the heat of the day. Having rested, it now prepares for another evening's flight in search of its prey, the Kremer World speed Competition Prize.

This creature is the Bionic Bat, a mechanical extension and amplification of the human being at its controls, the human spirit which created it and the human energy which powers its flight. The Bat is the creation of a team led by Paul MacCready and stimulated by the latest prize offered by British philanthropist Henry Kremer for human-powered flight: 100,000 pounds sterling.

THE KREMER WORLD SPEED COMPETITION

The Kremer prize for a world record speed about a closed course is a total fund of 100,000 pounds sterling, with 20,000 pounds (about $30,000) going to the first competitor to fly the 1500- meter-perimeter triangular course in three minutes or less and 5000 pounds going to subsequent competitors who better the previous time by at least five percent. Thus, seventeen prizes may be awarded, with the first winner having to fly approximately 9m/s (20 miles per hour) to complete the course in three minutes. Previous winners are eligible for the subsequent prizes, although the winner of the last awarded prize must wait 12 months before being eligible to better his/her current record.

An interesting aspect of this competition is that the flight crew may store their own physical energy for a period of ten minutes immediately prior to the start of the timed flight, thus augmenting their real-time efforts.

The triangular course may degenerate to two turn points 750 meters apart with the entire heavier-than-air craft flying outside of the turn points and at least two meters above the ground both times it crosses the start/finish line. The aircraft must demonstrate its ability to fly the course in both directions, but only one flight must be timed.

THE BIONIC BAT

The Bionic Bat weighs 38 kg (84 pounds), has a wing span of 14.6m (48 feet) and a wing area of about 12.6m (136 square feet). It is constructed primarily of carbon-fiber/epoxy tubing, Kevlar, and expanded polystyrene foam and is covered with Mylar film. It employs an unpublished Liebeck airfoil and a prop designed at AeroVironment using Larrabee principles.

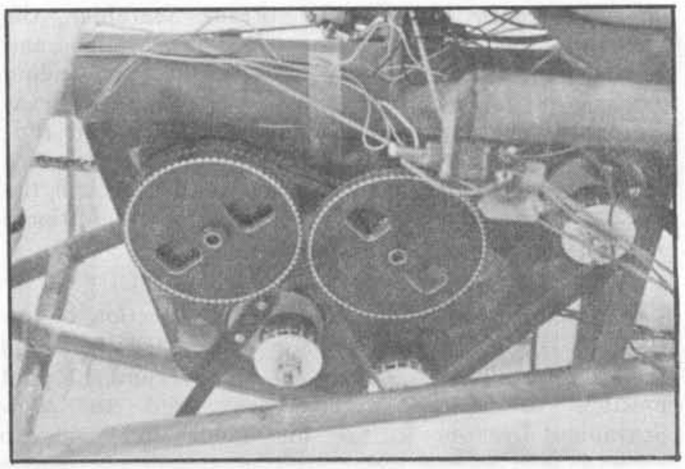
Unlike its predecessors, the Gossamer aircraft, the Bat is designed to withstand about 4"g"s, allowing it to fly safely in higher winds and more turbulence. Also, unlike the Gossamers' canard design, the Bat has conventional three-axis controls and layout, with an all-flying horizontal stabilizer, vertical stabilizer and rudder, and ailerons.

The pilot is pedalling standard bicycle pedals, so the aircraft is guided by three-axis hand controls. The pilot can also control the prop pitch through an electric servo. This is a model-airplane servo mounted on the prop hub and controlled through slip rings by a switch in the cockpit. An example of the spectrum of technology employed in the Bat is the servo counterweight, which is a complex-petrochemical-matrix composite: a piece of asphalt from the taxiway.

"Bionic" has come to mean an artificial mechanism incorporated into the operation of a biological structure. Hence the name of this craft, dictated by the competition's allowance of energy storage to augment the pilot. "Bat" may be considered an abbreviation for battery, but it is perhaps a more appropriate reference to a flying mammal that has angular wings and flits silently around near to the ground in quiet air at dusk.

The energy-storage system began as two radio-control electric model-airplane motors, a generator and 28 Ni-Cad "C" cells. Electrical storage was chosen for numerous reasons: low structural stresses, proven technology, off-the-shelf components, prior experience, and expedient to implement. In spite of an overall efficiency on the order of 25 percent, electric won over flywheels or elastic storage.

The motors were stock AstroFlight No. 40 motors capable of about 400 watts (one-half horsepower) at



GENERATOR AND ASSIST-MOTORS
Photo: Lynn John Tobias

24 volts. The generator was basically the same but with more windings. Power was transmitted through small Berg plastic cog belts.

The evolutionary process of testing brought about a number of changes. It was found that the pilot could not store enough energy during the 10 minutes to charge 28 batteries efficiently and thus power two motors. It was also learned that the small belts could not handle the impulsive loading of a person pedaling, and that two belts do not necessarily carry twice the load. Slight differences cause one belt to carry more than its share until it breaks, soon to be followed by the other.

After a month of flight testing, the system had become a single motor, 24 cells (about 1.1 kg, 2.5 pounds) and miniature 3.75-mm (0.1475-inch)-pitch roller chain. The power required to fly the Bat is about 450 watts (0.6 horsepower), 300 watts from the pilot and 150 watts from the motor. The pilot charged the batteries by disconnecting the Berg plastic/cable chains that drive the bicycle wheel and propeller, engaging the miniature chain to the generator and pedaling. To fly, he then removed the generator chain, put on the miniature motor chain, the propeller and wheel chains, and started to pedal down the runway. The change-over and door-closing took about a minute and the takeoff roll about 30 seconds, leaving 8.5 minutes for charging. That process could have been improved, but at the cost of weight, complexity and most important, development time.

As with MacCready's earlier aircraft, the Bionic Bat is not in itself a practical vehicle, but an example of the technical development of efficient flight. Because of its greater speed and ruggedness, ease of assembly, and relatively small size, it is far closer than the huge, fragile Gossamer aircraft to vehicles for general use in carrying people aloft or performing long-duration and high-altitude flights. Compare its weight to the typical 110 kg (250 pounds) of an "Ultralight" aircraft, or its power to a similar-sized Cessna.

THE TEAM

Paul MacCready, IHPVA international president, is renowned as the "father of human-powered flight" for his developments of the Gossamer Condor and the Gossamer Albatross. The Condor won the first Kremer prize for human-powered flight in 1977, after numerous competitors had made attempts for 17 years. The Albatross won the Kremer prize for human-powered flight across the English Channel in 1979. MacCready then moved into electric-powered aircraft in 1980 with the Gossamer Penguin, the first man-carrying aircraft (though piloted by a woman) to fly on the direct power of the sun. In 1981, the solar-powered Solar Challenger flew 262 km (163 miles) from Paris to England at an altitude of 3350 m (11,000 feet). When the Kremer speed prize was offered, MacCready was ready to combine his experience of human- and electric-powered flight.

Part of MacCready's success has been the ability to draw together a team of extraordinarily talented people. The development of the Bionic Bat was directed by Martyn Cowley. The primary test pilot has been MacCready's son, Parker MacCready, with Roy Haggard sharing the flight duties. Taras Kiceniuk Jr. joined the project as chief engineer. Roger Sinsheimer developed the initial power system. The detailed design, construction and modification of the Bat was performed primarily by Martyn Cowley, Bill Dodson, Tyler MacCready and Parker MacCready.

Many others played key roles in the program, including Ray Morgan, James Burke, Bob Curtin Jr., Adam Curtin, Lance Inoue and Les King. Peter Lissaman, Robert Liebeck, Alec Brooks and Bart Hibbs all contributed to the aerodynamic design. William Richardson served as the principal observer, representative of the National Aeronautic Association. He was aided by Sam Duran, Janice Brown, Pete Plumb, Chuck Champlin and myself. The hangar facilities at Shafter Airport were provided by Nole Wilson.

Bob Boucher of AstroFlight Inc. supplied the generator/battery/motor system and served as a consultant. Boucher created the Sunrise aircraft in 1974, a 10-meter-span solar-powered aircraft, which was the first to take off and sustain flight on solar power alone. The Sunrise panels and motor were later used in the Gossamer Penguin. The two motors used in the Solar Challenger were also supplied by AstroFlight.

Bob Boucher has also been a strong supporter of the IHPVA, supplying motors, batteries and significant prizes for the Astro Challenges: electric-vehicle races held during previous IHPVA speed championships.

THE RECORD ATTEMPTS

The construction of the Bionic Bat took place in the AeroVironment facility in Simi Valley during July and August 1983. Flight tests began August 20 at Shafter Airport, 19 km (12 miles) northwest of Bakersfield, California, the site of the Gossamer Condor's record flight in 1977. Most of the flying was done near sunrise or sunset, when the winds were calm and the heat bearable.

After the engineering had been done, optimizing a vehicle such as this required patient testing, repairing broken parts, trying new designs and improvising for the drill bits sitting on the workbench 160 km (100 miles) due south.

There were quite a few incredibly beautiful evening flights, the Bat skimming almost silently towards the last red glow on the horizon. The only sounds were the rush of the chains and the pilot's callouts of voltages and currents. He was reading the meters with a penlight taped to the frame while the headlights of a following car tried to light the runway.

Most of the flight tests were flown by Parker. One of Parker's night flights was especially spectacular. I was riding in former IHPVA president

ROY HAGGARD, POWER PLANT
Photo: Lynn John Tobias

Peter Boor's car, shining a hand-held spotlight past the Bat on the taxiway ahead. Parker seemed to be concentrating on the instruments as he flew towards some parked cropdusters, so I played the light across the planes to be sure he saw them. As he approached within a few hundred feet, I tried to get his attention by flashing the light in the cockpit while the cars frantically honked their horns. But he was intent on the meters. When he finally glanced up, he banked into a turn which brought him within about fifty feet of the planes.

The decision to forego further flight tests that evening was readily agreed upon. The ground crew, two people on bicycles, towed the Bat back to the hangar.

On September 25, 1983, Parker MacCready flew the Bionic Bat around the prescribed course in two minutes and thirty-nine seconds. As required, the course was flown in the opposite direction on September 27 in two minutes and thirty-five seconds. Parker had stored his energy in a 1.4 kg (three-pound) battery pack by pedalling a generator for about eight-and-a-half minutes before taking off. The voltage left in the batteries was measured after the flight and found to be greater than before Parker had started to charge them. The batteries had been initially discharged to the point where the voltage began to fall off quickly (about 30 volts). This utilized the batteries in an efficient mode, but was not the method preferred nor anticipated by the sponsoring group, namely fully discharged (shorted) batteries. The flight documentation was submitted to the Man-Powered-Aircraft Group of the Royal Aeronautical Society, and I was informed on January 25, 1984 that the group had determined the attempt unacceptable to qualify for the record.

Since that time, MacCready's team has been pursuing further improvements to the Bat, with the goal of being able to discharge the batteries until they will no longer turn the prop before the energy storage is begun. They feel that with an Olympic-caliber athlete, it may be possible to fly the course without storing energy at all.

The problem is finding a first-class athlete who can fly an airplane while putting out a championship performance. Their efforts are showing success: on January 3, 1984, Parker flew the course in two minutes, forty-one seconds after running the batteries all the way down before the energy-storage phase. The attempt looked good until Parker came to a stop and reported that he heard a wheel scrape during a turn. Videotapes could not reveal if he had touched the ground or hit sagebrush, but they decided not to consider it a record attempt. Minor problems and weather have prevented attempts since then, but more are planned in the following days.

Since January 3, members of the team have been working on making the drive-train more efficient. They experimented with rubberized drive belts but found them less efficient, and have now installed spur gears. This direct gearing has also made the switch from generator to motor easier.

THE OTHER COMPETITORS

During the first flights last summer, the Bat team was working under the constant pressure of whispered reports of the progress of a team at MIT. Rumors had it that they too were already flight testing and may have already made record attempts. From what little more I have now heard, the MIT vehicle was not quite capable of flying the course before the students had to redirect their efforts to their studies, but work will continue as time permits.

The IHPVA has heard reports and rumors of other aircraft under development or flying in Germany, Japan, Canada, and the state of Washington. Details are not available or not approved for publication. An interesting approach has been suggested by Ilan Kroo of the NASA Ames Research Center: to store the energy on the ground in a large elastic bungee cord, by which a glider would be launched to cover the course in the desired time.

FUTURE ACTIVITIES IN HUMAN-POWERED FLIGHT

Although the Bionic Bat may have the initial speed prize wrapped up, the sixteen subsequent prizes of 5000 pounds are still available. The last few awards will be difficult to earn. If the first winner flies at the minimum of approximately 9 m/s (20 mph) and each successor improves the record by the minimum five percent, the seventeenth winner will have to fly at 19.5 m/s (43.66 mph) to earn the 5000-pound prize. The Bat will probably get the first prize with a speed of about 10 m/s (22.5 mph), forcing number 17 to go at 22 m/s (49.11 mph). And if each competitor were to give some margin by which to better each record, say seven percent, the final pilot will be puffing along at almost 30 m/s (67 mph). Nevertheless, the first few prizes are fairly certain to be won in the coming years as the current designs mature and materials and mechanisms improve.

There are other prizes available for human-powered flight. The original Kremer competition is still open for a non-American (Henry Kremer would prefer British!) aircraft. The American Helicopter Society is offering a prize of $10,000 for the first human-powered helicopter to hover for one minute three meters above the ground. At least one member of the flight crew must be non-rotating during the flight. I have heard that four competitors have applied and that at least two of them have operational machines, although I have not heard of any sustained and controlled flights. As with most of these competitions, money cannot be the prime motivator, for the machines will most certainly cost more than the prize will pay.

The IHPVA would very much like to help stimulate developments in human-powered flight, for example, by sponsoring competitions with prizes totalling hundreds of thousands of dollars. Unfortunately, we have not as yet devised a plan that would fit our budget (estimated at about $37 for the Air Division). We heartily welcome any suggestions on how we might promote activities in human-powered flight. Perhaps when enough aircraft are flying, we might hold "pylon" races in conjunction with the land and water championships!

If you have any information on any topic related to human-powered flight, please let me know at the address below. Everyone assumes that surely someone else has already informed the IHPVA of such activities, but unfortunately most of our information comes from rumors, off-hand remarks and after-the-fact news reports.

Keep reaching for the sky!

Lynn John Tobias, VP-Air, IHPVA
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MORE INFORMATION

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MAN-POWERED FLIGHT, by Keith Sherwin. (Model and Allied Publications, Watford, UK, 1975).

GOSSAMER ODYSSEY, by Morton Grosser. (Houghton Mifflin Co., Boston, MA, USA, 1981).

MAN-POWERED AIRCRAFT, by Don Dwiggins. (Tab Books, Blue Ridge Summit, PA, USA, 1979).

THE HISTORY OF MAN-POWERED FLIGHT, by David A. Reay. (Pergamon Press, Oxford, UK, 1977).

THE SABER PROA *Photo: Norm Benedict*

FIRST IHPVA BOAT REGATTA 3 December 83

by Norm Benedict

Coordinator for Water

Sandwiched between a congested schedule of rowing-shell runoffs and incoming bad weather, the first IHPVA Boat Regatta took place at Long Beach, California. And, while the three IHPVA competitors constituted a small number, the results were numerous and significant.

IHPVA entrants were (1) Bill Gaines with an outdrive kayak-type that experienced some early teething troubles; (2) IHPVA veterans Bill watson/Bart Hibbs/Charlie Sink with their newly-launched 9m (30') TRIREME, pedal-powered through an amidship pylon; and (3) partners Jon Knapp (Designer)/Tom Wiggins (motor) in a 6.7m (22') SABRE PROA with outrigger, pedal-driven through an angled shaft.

The SABRE PROA team has been quietly and methodically pitting their craft against all comers on the Pacific Coast for some time, and won the single IHPVA runoff handily. However, the TRIREME crew remains to be heard from in the future as their propeller pitch is adjustable and the three-man power

THE TRIREME *Photo: Norm Benedict*

output can be formidable. Previous design discussions had been limited to monohulls of displacement or semi-planing types, and the practicability of the SABRE PROA was notable particularly as this craft had also taken the measure of various ocean-going shells and Whitehalls in long-distance racing. The SABRE PROA team considers the typical 5m/s (11-12-mph) speeds of rowing shells to be quite beatable.

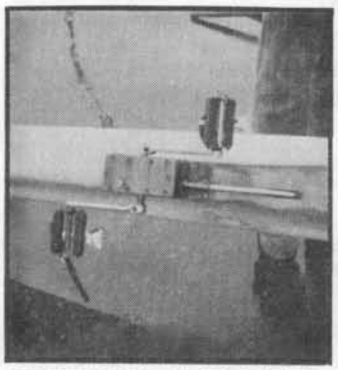
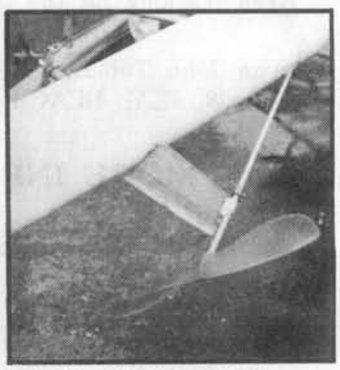
Constructive and revealing discussions among IHPVA entrants of their respective problems and approaches delineated propeller sizes of 18"x36" for one-man output and 24"x50" for a three-man output. Propellers were of conventional design, and it remains to be seen if advanced types of scimitar and skewed designs can make better utilization of human output in the 250-500-watt range. It would seem that development of the slim displacement-type hull with optimized power might make 7m/s (15+mph) a record-breaking practicality even in 1984.

Incoming mail reveals considerable hesitancy in undertaking design and construction of HPBs; the remarkable simplicity of the SABRE PROA consitutes a quantum step forward. The pedal-crank input at 65-70 rpm is translated through a simple gearbox to 250-275 propeller rpm. The SABRE PROA team is involved with constant experimentation and is considering selling components and technical information, so put them on your SASE mailing list at 2418 31st Ave, San Francisco, CA 94116. The SABRE PROA displaces about 27 kg (60 lbm) vs. the TRIREME's estimated 135+kg (300 lbm), but the latter's tripled power input remains to be exploited. One aspect of this and most other HPBs which most people will greatly appreciate is that one pedals facing forward at considerable speed compared to our historic rowing backwards with neck-straining forward glimpes to avoid objects.

IHPVA has received admirable support and interest from leading boating magazines. Pete Spectre, managing editor of the remarkable Wooden Boat magazine, P.O. Box 78, Brooklin, Maine 04616 has given us generous publicity. Thomas Baker, managing editor, Small Boat Journal, P.O. Box 400, Bennington, Vermont 05201, not only shows us interest but advises that a Small Boat Show will be held May 25-27, 1984 at Newport Yacht Center, Newport, Rhode Island, as a forum for HPB displays and competition against conventional boats. I'm predicting performances of oared boats will be surpassed quite early. We really must update our basic IHPVA logo.

For more design information, read the proceedings of the second HPV scientific symposium (see order form). John Leather, Royal Institution of Naval Architects, London, UK, writes that the RINA small-craft group is interested in reviewing papers for its international conference in November 1984. I'll continue to list reasonable design approaches for those interested; inquiries with SASEs will receive turnaround service from here.

As to upcoming HPB events - we must emphasize that such events are dependent upon records here of HPBs in construction or actual operation. So send in your activities and photos if possible and we'll either establish or coordinate water events in appropriate locales. After some years of planning I believe 1984 is going to be a breakthrough year for both practical and record-establishing human-powered boats.

ELEGANT SIMPLICITY OF THE SABER PROA

Photos: Norm Benedict

NEW WORLD RECORD

SET IN ARMS RACE

by Bill Warner

President

New England Handcycles

The first official Arms Race, an event designed especially for arm-powered vehicles, and held at the Human-Powered Speed Championships in Indianapolis in September 1983, produced a new arm-powered world speed record: 26.59 miles per hour. John Kearns and Al House, both from the University of Connecticut at Storrs, designed the two-wheel fully-faired machine as part of a senior-design-class competition.

The machine, ridden by Al House, has 24 speeds, and places the cranks together, rather than 180 degrees apart, in order to make it easier to crank and steer with the same assembly. The bicycle has a small ten-speed frame, with a custom-built front end, and 24" wheels to bring the seat height down.

The machine had a full fairing, which was quite impressive. Built from aluminum tubing, spruce, and heat-shrink Monocoat plastic, the upright riding position made it one of the tallest faired vehicles in the competition. In the true spirit of the Championships, the fairing was completed at the Airport Hilton the night before the race. Unfortunately, this left little time for speed testing of the final result, and Al never broke 13.4 m/s (30 mph), which was a disappointment. Tests in the airport parking lot with just the bottom skirt of the fairing showed great promise, but the full fairing turned out to have oscillation problems, and this severely limited how hard Al could crank, and kept his speed lower than he had accomplished without the fairing.

Second place went to Rory McCarthy of Bath, Maine, who rode a prototype trike from New England Handcycles, Inc., the sponsor of the Arms Race. The trike also had 24 speeds, as well as a full fairing. Made from aluminum tubing expoxied into aluminum castings, the machine had an aluminum fairing frame with standard Mylar coating. Since it wasn't heat-shrink material, the Mylar gave the trike a distinctive noise -- it sounded like a cookie sheet being banged with a spoon each time it hit even a small bump. Since there was a limit of two runs per machine, Rory and I each took one run, and, as expected, Rory turned in the faster time.

There is some rivalry between Rory McCarthy and Al House, as they are veterans of the arm-powered category in the 24-hour Pepsi Challenge Bike Marathon in New York's Central Park. Two years ago, Rory was alone in astonishing onlookers by cranking 249 km (155 miles) on his trike. In 1983, he had some competition: Al House rode over 241 km (150 miles) on his machine, and Jim Theis did likewise in his four-wheel crank-driven chair.

Jim is an engineer from Florida, and was the third entrant in the Arms Race. Jim has pioneered crank-driven wheelchairs, and has proven their superiority by beating world-class wheelchair athletes in wheelchair events. Since Jim will readily admit that he's no world-class athlete, it's clear that his crank-driven chair provides a significant advantage. In fact, Jim was disqualified from many wheelchair events for "unfair advantage", even though his chair meets the letter, if not the intent, of wheelchair-sports regulations.

Jim brought his "crank" chair, a pile of Styrofoam, some power tools, a Honda power generator, and much enthusiasm along with him in his van, which later became a mobile factory, as he worked into the night with his brother to complete his wheelchair fairing. Jim's work as a designer of specialized turbine engines kept him from being as far along on his fiberglass fairing as he wanted to be, so he made a daring decision to ride inside the Styrofoam mold, and shoot for fiberglass next year. It was a tight fit, since there were 50 mm (two inches) of white Styrofoam between him and what was supposed to be the inside of the fiberglass. Jim worked late into the second night, and more the next morning, and he completed the sculpture only to arrive at the 600-meter start line at exactly 2 pm -- closing time. Race officials, concerned about maintaining good relations with track management, stuck diligently to their promise to be done by 2 pm, and Jim missed his chance, literally by minutes. We hope to see him next year with "the real thing".

The day before the sprints, drag races at Raceway Park produced the most unusual match-up of the Arms Race -- a 24-speed, unfaired, stock trike from New England Handcycles, against one of the sleekest, fastest, fully-faired vehicles at the race: Dragonfly. Since any vehicle can enter the arms race as long as any available leg power isn't used, the Dragonfly, which is arm-and-foot-powered through linear drives, was ready to go. At the green light, the NEH trike left Dragonfly in the proverbial cloud of dust. Not geared for drag racing, let alone arms-only power, the Dragonfly was slow to accelerate. The trike peaked early at about 8 m/s (18 mph), but Dragonfly kept accelerating, and it passed the trike just before the finish -- by then it was going maybe 2 m/s (5 mph) faster.

So the first arms race was a great success -- records were broken, and a good time was had by all. We hope to be back next year to escalate the arms race and to break new records.

RORY MCCARTHY ROUNDS A TURN
Photo: Dan Bonwell

HPV COMPETITIONS OVERSEAS

by Doug Adamson

The Ninth International IHPSC capped a season of HPV competitions that included events in Holland and Great Britain. Guus van de Beek, an editor with Fiets, the Dutch cycling magazine that sponsored the race, reports on that race. Australian Doug Adamson, a member of the Nosey Ferrett Racing Team that fielded the Avatar Bluebell to win the 200-m bicycle speed record in 1982, was also on hand in Zandvoort. His comments are excerpted from the British cycling publication, Bicycle Magazine, with the permission of the former publisher, Richard Ballantine.

RAINY FIETSERS

by Guus van de Beek

Despite heavy promotion by Fiets magazine, a course guaranteed to garner heavy media exposure and a healthy prize list, the weekend of September 18, 1983 dawned with hard winds negating any chance of a record attempt, rain decreasing rider visibility and temperatures of 16 degrees Celsius keeping spectators away.

Nevertheless, European participants who arrived early for the first Dutch HPV race took a few test rides around the 4.2-km (2.5-miles) curvy motor-racing circuit September 17, before leaving their machines overnight in a hangar provided for that purpose.

Race day dawned with its share of problems in addition to the weather. Race officials were unfamiliar with HPV racing and had difficulty recognizing the vehicles. The lack of a uniform numbering system and the difficulty of numbering unfaired entrants caused problems with the timing. Some HPVs had no visible number and others had three.

The officials were not used to going by the name of the vehicle and reacted with panic at not knowing the name of the rider, which caused problems in feeding the correct information into the computer.

The five-lap road race started out untidily due to a group of twelve slow-moving Roulandts (Dutch mass-produced recumbents) that bunched up at the front of the group for promotional purposes. Though they initially impeded the streamlined vehicles they were soon passed and had no further impact on the outcome.

The Vector I, a German copy of the original American Vector, was the winner. This machine was fitted with two intermediate axles resulting in a power loss, but rider Gerhard Scheller, who placed 2nd in the kilometer event at the 1983 World Championships, more than made up for it.

Even though the promoter hired by Fiets did not do as professional a job as anticipated, and the weather was terrible and events poorly organized, the race was a success. It was covered by two television stations - one in its sports show and another in a program about industrial design. Holland is a cycling country, but also very conservative. The public reaction ranged from enthusiastic to very skeptical. Nevertheless several hundred enthusiastic spectators showed up despite the awful weather.

For this first event there were seven Dutch HPV designs. The contestants were very enthusiastic and all are planning to continue with the sport. We expect the participation to be even greater next year. Most likely, a TV station will organize a 200-m sprint event in the famous beach resort of Schevenigen. (Watch HPV NEWS for details.) It's just a question of time before a Dutch chapter of the IHPVA is established.

I would like to close with a comment about regulations. I would like to see a guideline issued about numbers. They should be easy to read and uniform in size. Until HPV races become more commonplace throughout the world (as we all hope they will) then such numbers are necessary so that officials who are unfamiliar with the vehicles can do their job correctly.

(Guus van de Beek, c/o Uitgeverij Fiets Lijnbaansgracht 309 1017, W.Z. Amsterdam Postbus 937 1000 AA Amsterdam, The Netherlands).

AUSSIE IN ZANDVOORT, by Doug Adamson

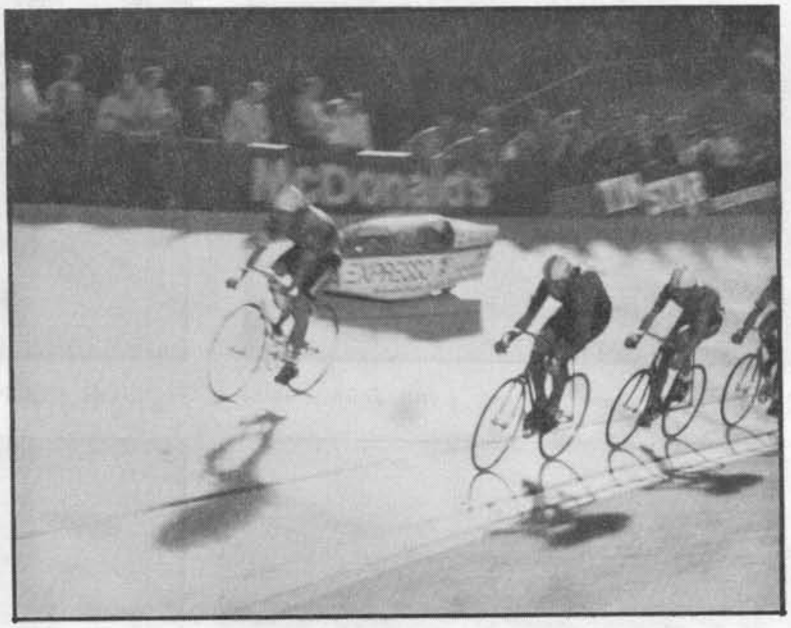
Our Dutch hosts and fellow competitors were very pleased to see a large British turnout. There were also vehicles from as far apart as Spain, Germany and Scotland.

Cold, wet and windy Sunday mornings are hardly prime spectator time for any sporting event, let alone a minority sport such as HPV racing. Would you believe that at 9:30 a.m. there were in excess of 500 hardy souls braving the elements in the stands? Heartening stuff.

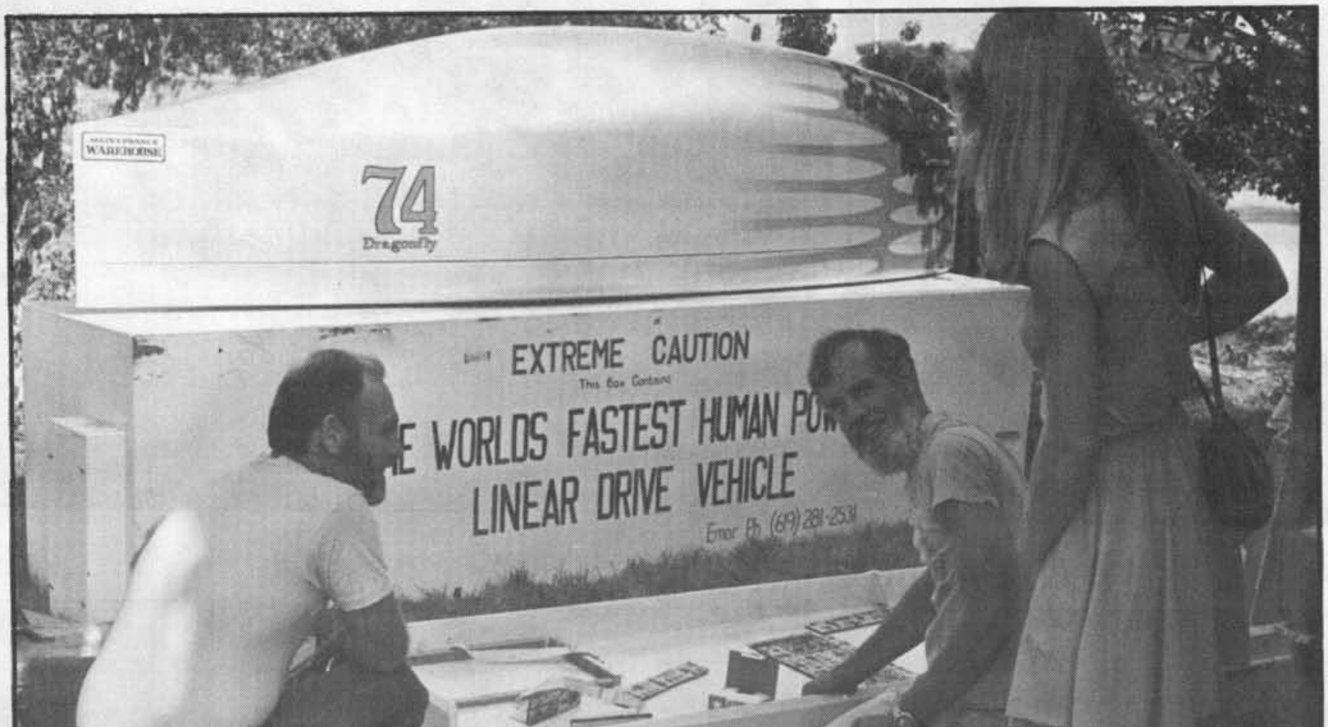
(cont. on p. 15)

INDY PHOTOS

OVERVIEW OF INDY
Photo: Lynn John Tobias



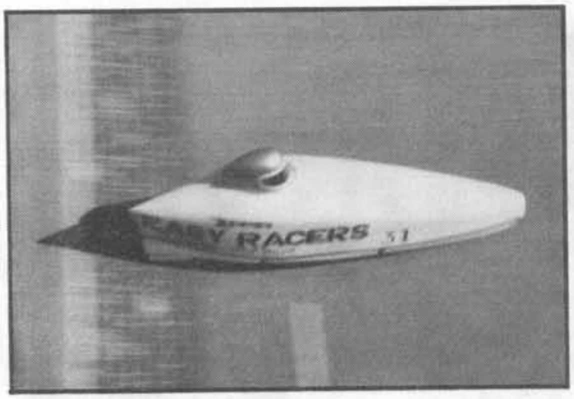
EXPRESSO OVERTAKING TRACK RACERS AT VELODROME
Photo: Lynn John Tobias



STEVE BALL UNWRAPPING DRAGONFLY

We greatly appreciate some superb photography by Dan Bonwell, Chuck Champlin, James Guilford, Lynn John Tobias, and anonymous artists. Coverage of the actual events and of the construction of some of the vehicles can be found in articles in this issue and in recent HP NEWS.

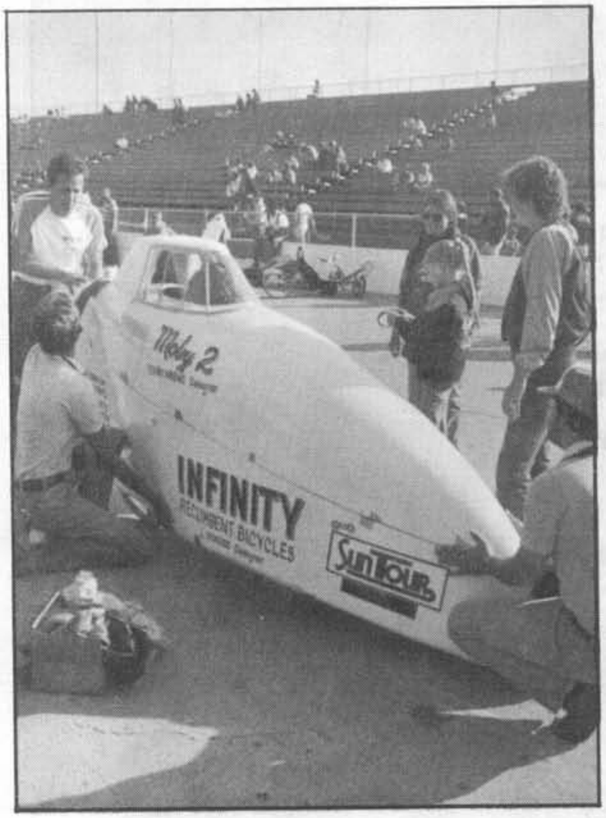
MORE IND



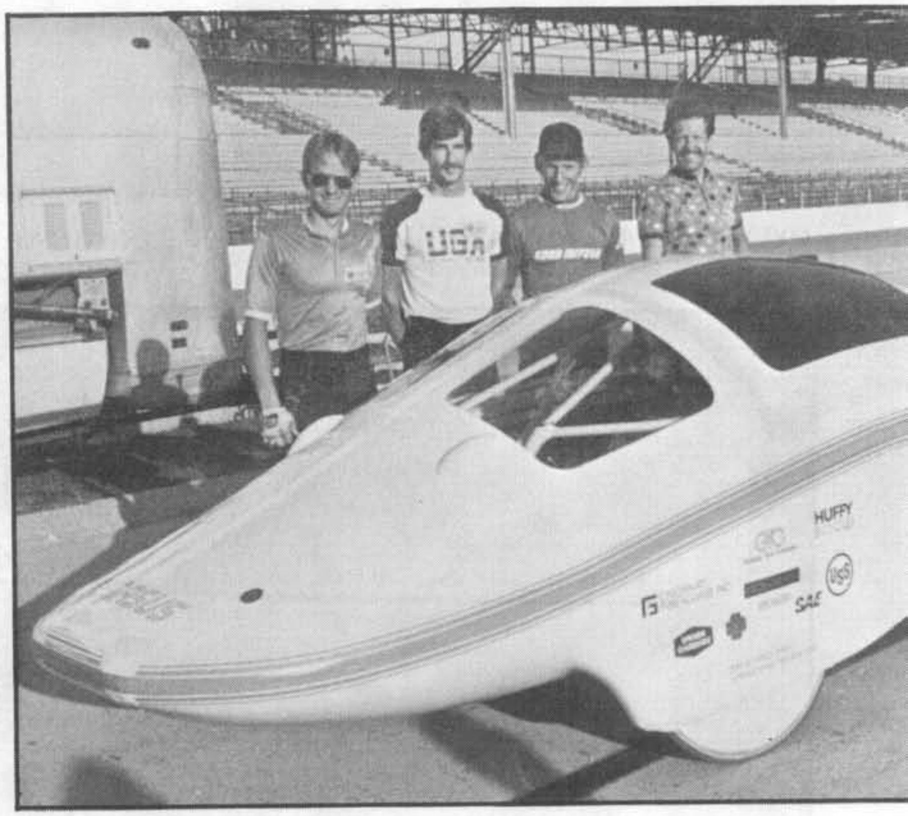
EASY RACER *Photo: Lynn John Tobias*

TENSOR PACKAGING *Photo: James Guilford*

LE MANS START



MOBY 2 INFINITY *Photo: James Guilford*



PEGASUS AND CREW

Photo:

Photo: Lynn John Tobias

Photo: Lynn John Tobias

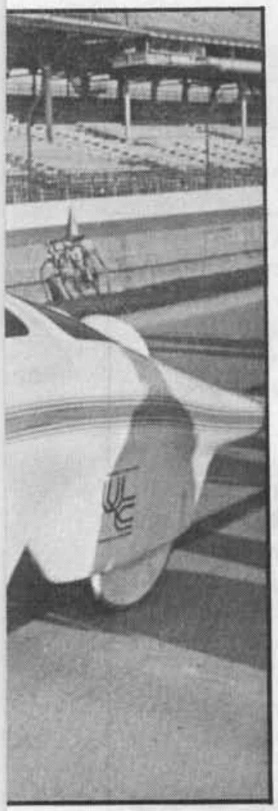
ALLAN ABBOTT ON

Y PHOTOS

'hoto: James Guilford

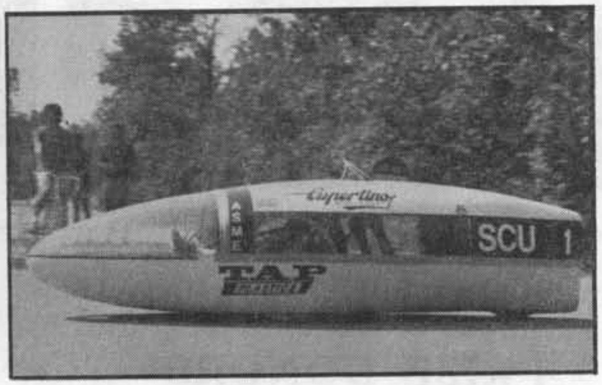
COUNTERPOINT AT SPEED James Guilford

AEROCOUPE Photo: James Guilford

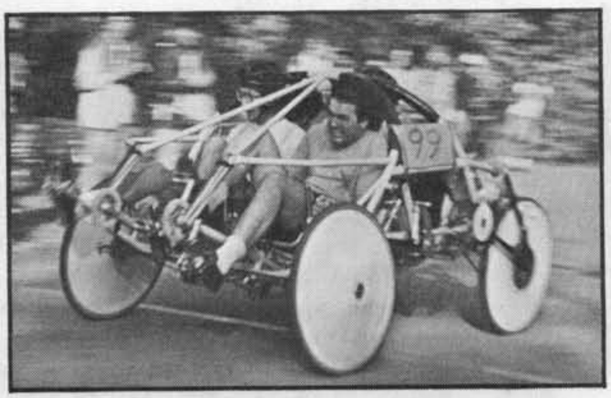


James Guilford

James Guilford
LIGHTNING X2 CHALLENGING EXPRESSO



SCU 1 ASME Photo: James Guilford

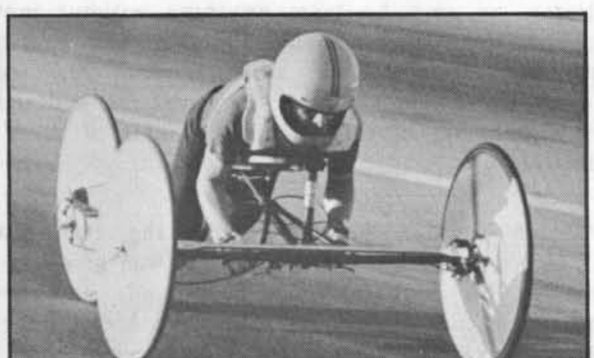


PEGASUS IN THE PARK James Guilford

DOG CHASING RECUMBENT
Photo: James Guilford

ASY RIDER Tobias

Anon.



PRONE UNFAIRED TRIKE Photo: Dan Bonwell

MORE INDY PHOTOS

Photo: Lynn John Tobias

Photo: Lynn John Tobias

EXPRESSO AND SCU ASME *Photo: James Guil ford*

SALUTE TO PRIZE DONORS

The Ninth Speed Championships were enlivened by the most lucrative prize list yet.

Much of the prize money came from George Hammond II of Santa Barbara, California: designer, entrepreneur and fan of the new age of engineering represented by HPVs. He is the founder of the George Hammond Perpetual Hang-Gliding Meet held in June and July each summer in the beautiful coastal mountains of Santa Barbara. Hammond established the meet two years ago in the name of his late father, and has watched it grow into one of the major competitions of the sport.

Hammond says he loves anything without motors - sail boats, bicycles, hang gliders - and sees real value in the mechanical advances that may come through HPV races. "And" he says, "as a designer, I love the looks of the machines. Some of them are beautiful."

George donated $2,000 towards the event itself, and $2,000 in prizes. Some of that was given in the name of his brother, Seth Hammond, and Seth's company in Santa Barbara, Specialty Metal Fabrication. George also saluted the Indiana chapter of the IHPVA, which worked so hard planning the races.

Another kind donor of prize money was Frederic Lang, an inventor from Pennsylvania. After an eleven-year battle in the courts to protect his patent on Polystrand, plastic-sheathed cable that reinforces prestressed concrete, Lang won some large settlements from the patent infringers. He has decided to give virtually all of the money to some deserving causes. He donated $1,000 toward the practical-vehicle competition and road races.

William Ott of Tustin, California, gave $500 for the weekend's fastest vehicle - White Lighning - and Paul Nanos of Indianapolis gave $200 for design excellence: this went to Steve Ball and Dragonfly of San Diego. John and Carol Ewalt of San Carlos, California, gave $100 toward a road race, right at the track.

The IHPVA and the Indiana chapter express their very sincere appreciation to the donors for their generous contributions.

CHUCK CHAMPLIN THANKS GEORGE HAMMOND II FOR HIS PRIZE DONATIONS

(From p.10)

This was the first wet HPV event anyone could remember and it showed up a number of flaws in some machines. Having wheels inside the body shell is great for speed, but the spray from wet roads tends to be thrown onto the windscreen and obscures the rider's vision.

Even though typhoon-like winds meant record runs in the 200-meter event would not be possible, the German Vector posted 20.9 m/s (46.75 mph). Halford's Dark Horse, the only two-rider vehicle present, hit 20.6 m/s (46 mph) but had a lot of trouble stopping in the limited distance before the curve.

Duncan Lawrie's Mobey Slick, basically a standard bicycle with a full-fairing, recorded 18.5 m/s (41.29 mph) before being blown over just outside the timing traps. Dave Marsh in Poppy Flier had trouble seeing where he was going and could manage only 18.4 m/s (41.1 mph).

So apart from the lousy weather it was a successful first event and augurs well for the future. If it stays in its mid-September time slot it will fit nicely into the proposed international "circuit" of HPV racing.

(Doug Adamson c/o Bicycle Magazine 89-91 Bayham St. London, N.W. 1 U.K.)

HPV RACE RESULTS AT THE ZANDVOORT CIRCUIT, HOLLAND

SEPTEMBER 17-18, 1983

RIDER	VEHICLE	FASTEST SPEED m/s
Gerhard Scheller/D	Vector I	20.81
Trevir Bull/Dave Sinar/GB	Dark Horse	20.45
Duncan Lawrie/GB	Mobey Slick	18.36
Richard Grace/GB	Poppy Flyer II	18.25
Jim Iccrus/Dave Jones/GB	Dragonfly	17.86
XXX	Vector II	17.33
Andy Pegg/GB	Windcheetah SL I	16.84
Dave Marsh/GB	Pace International	16.33
Simon Sanderson/GB	Simon Sanderson	15.65
Bas Korfer/NL	Roulandt 1	14.98
Andre Verleum/NL	A.O.D.2	14.83
Marc Vermaning/NL	Batavus	14.12
Ronald Piton/NL	Velerique	14.07
Rob V.D Zalm/NL	Vincent	13.96
?		13.93
Ferry Hessels/NL	C.C.J.Moritz	12.83
?		12.82
R.Kramer/NL	Handyped	12.56
Joseph Mora/E	Joseph Mora	12.04
F.C.Gelswijck/NL	F.C. Gelswijck	11.22

OSCAR EGG'S TAIL-CONE FAIRING

PARTIALLY FAIRED HPVs

by Terry Hreno, Indiana Chapter

Terry Hreno, designer of the Moby fiberglass fairing used by Team Infinity at the 9th IHPSC, is the director of special events, a new office for the IHPVA. His duties will include organizing 24-hour record attempts, cross-country time trials and establishing a prize for the first 1609-km (1,000-mile) day. He was one of the prime movers behind implementing different fairing categories at the 9th IHPSC. Here he reviews the reasons behind the move, gives an overview of partial fairings and poses some questions that will have to be addressed if the development of partially streamlined vehicles as a separate class is to be encouraged. As this is being edited (May 1984) an IHPVA committee is reviewing the rules again following a large number of suggestions for change made after the publication of provisional rules in HPV NEWS.

BACKGROUND

Partial fairings offer a starting point for what appears to be the new focus for the IHPVA. The annual speed championships were established as an unlimited proving ground to provide a forum for ideas to be tested. We have improved top speeds tremendously in the past nine years, but the focus is shifting more towards practical applications. Now that we know what to do, where do we go with it?

An examination of streamlined bikes in the early part of the century shows that most early HPVs were actually what would be considered partially-faired.

In 1913 Etienne Bunau Varilla's Velo Torpille was ridden by Marcel Berthet to a speed of 14.5 m/s (32.5 mph) for a 5-km distance, 1 m/s (2-mph) faster than the existing record. Although the vehicle has been described as a fully-faired vehicle, photos show little or no covering of wheels, crankset or the rider's head and legs.

The first known race between faired vehicles was in 1914 in Berlin between the Brennabor Fish and the Goricke Bomb. Although these enclosed the riders' heads, photos show open lower sections and no enclosure of wheels, cranksets or legs.

Marcel Berthet reappeared in 1933 in the Velodyne, a full body shell with an open bottom. At the same time, a Swiss, Oscar Egg, started building a series of streamliners. Both the Egg and Berthet vehicles were capable of distances of about 4.8 km (thirty miles) for an hour attempt, about 3 km (2 miles) better than conventional bikes.

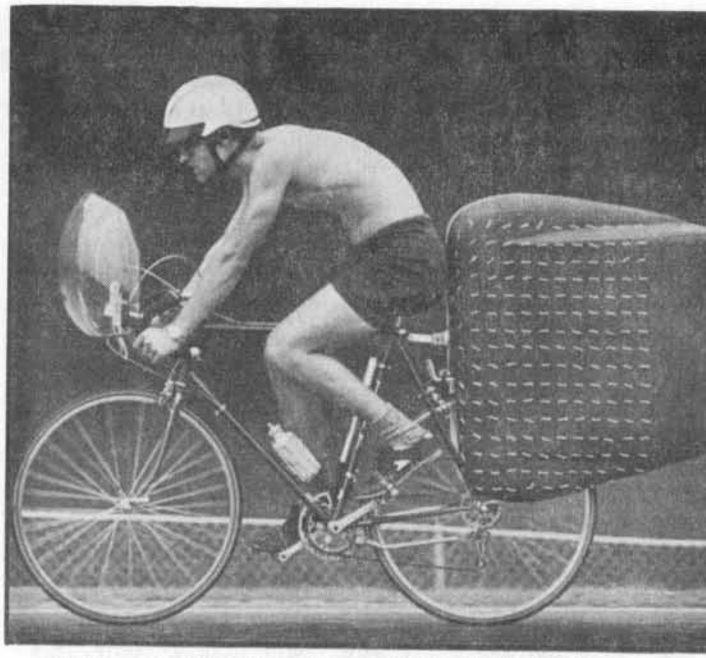
One of Egg's interesting efforts was a tail-cone-only fairing which Francis Faure used to set a 48-kilometer one-hour record. In 1961, John Carline rode Oscar Egg's Sputnik, a full-upper-bodied bike with an open bottom and exposed wheels, to 16.7 m/s (37.3 mps) for a 1.6 km (one-mile) course. This was about 2.2 m/s (five mph) faster than a conventional bicycle of the day.

Current efforts in PFs continue with similar results. A review of the 200-meter, the 600/200-meter and the 1/4-mile (400-m) sprints at the 9th IHPSC reveals the following performances for fully faired (FF), partially faired (PF) and unfaired (UF) vehicles.

		PERCENTAGE OF VEHICLES	TOP SPEED meter/sec (mph)	SLOW SPE
200m	FF	15	24.1 (54.0)	15.2 (34
	PF	7	16.1 (36.0)	12.1 (27
	UF	6	14.1 (31.5)	12.4 (27
600/200m	FF	8	19.8 (44.4)	11.4 (25
	PF	6	15.2 (33.9)	12.7 (28
	UF	4	13.7 (30.7	11.6 (25
1/4mile	FF	12	18.2 (40.7)	13.1 (29
	PF	10	14.3 (31.9)	10.5 (23
	UF	4	13.7 (30.7)	11.6 (25

In all cases, the FFs show a considerable speed advantage over the other classes while PFs show higher top speeds in all events over UFs.

These results are also being borne out in several independent tests. For example, Zzipper-fairing designer Glen Brown outfitted a conventional bike with a Zzipper and a fabric body girdle. Jim Woodhead, 36, rode such a bike 648 km (403 miles) from San Francisco to Los Angeles, in 21 hours, 10 minutes, nearly three hours better than the record held by a team of riders.



TOM BASTNAGEL'S PARTIAL FAIRINGS
Photo: Rick Fadden

Brown claims that the Zzipper/girdle combination maintains stability in 13.4-m/s (30-mph) crosswinds. The Zzipper fairing alone is said to offer a 22% drag reduction at 15 m/s (34 mph). (Needless to state, these figures have been disputed by others).

A similar experiment in drag reduction was performed in 1982 by a Purdue University senior, Tom Bastnagel, now an engineer with Pratt & Whitney. Bastnagel combined a Zzipper fairing with a solid tail fairing reminiscent of Oscar Egg's Velo Fuse. At 8.9 m/s (20 mph) he found a 5.3% drag reduction on a conventional bike with a Zzipper fairing; an 8.7% reduction with tail fairing alone; a 17.1% reduction with both, and a 24.4% reduction with both fairings and the rider in a racing crouch.

An analysis of the effects of partial streamlining on motorcycles was written by Ray Battersby in the July, 1976 issue of "Cycle" magazine.

The early efforts of Berthet, Egg, et al, are now being verified in the Human-Powered Speed Championships on the open road by Brown and Woodhead and in the lab and on the computer by people like Tom Bastnagel. At this point, the hard data of past and present stop and the questions of what the future holds begin.

But a sad fact about all the early efforts mentioned is that they went without official recognition. The PF class is an attempt to make sure that current efforts in that direction are spared a similar fate.

Much development potential lies ahead for PFs. As street vehicles, they offer greater ease of handling, superior entry, less sensitivity to crosswinds and lower cost than fully faired vehicles.

Tom Bastnagel feels that his rear fairing can be reduced in size by a third with no increase in drag. He sees the PF as the practical "everyman's approach" to streamlining.

Glen Brown suggests fabric fairings that can be rolled up and placed into a pocket if severe crosswinds are encountered.

Even now, no acceptable category for partially-faired vehicles exists.

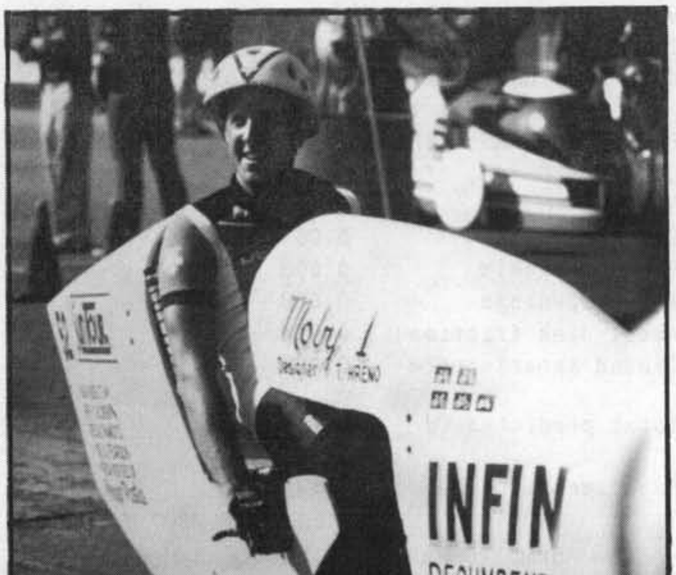
A partially-faired class was used for the first time at the 9th IHPVA Speed Championships in Indianapolis. The rules stipulated that the rider was to be fully exposed when viewed from the side.

The purpose of this rule was to allow ease of entry and to provide a way for bicycle riders to get their feet on the ground, But in spite of its intent, this definition of PFs is poor.

Before you accuse me of undue harshness, be advised that the author of this article and the author of the rule are one and the same. In other words, I'm allowed to be hard on myself.

But the current rule favors vehicles like my Moby 1. Poor rear-fairing performance limited the top speed at the 1/4-mile (400-m) sprints to about 13.4 m/s (30 mph). Tim Brummer's similar design went 16.3 m/s (36.54 mph) in the '82 IHPSC. At Indy in 1983, John Lebsack's Gator went 16.1 m/s (36 mph) in the 200-meter sprints, was the fastest PF at the Major Taylor Velodrome, and the fastest PF at the LeMans-start road race at Indianapolis Raceway Park.

The rule also ignored Spandex-faired vehicles like those of Glen Brown or Murray Wilmerding. Murray's Spandex-covered Infinity was the fastest PF at the paced road race, at the practical-vehicle races at Eagle Creek Park and at the 400m (1/4-mile) sprints. The top of Murray's bike is covered, but the bottom is open. The flexible fabric allows easy entry.



MOBY 1 INFINITY

The rule also ignores the trikes. Do vehicles like Mark Murphy's Aerocoupe need to have the rider fully exposed from the side to facilitate entry?

What constitutes a good definition of PFs?

The IHPVA's current rule was an attempt to avoid the problems of using complicated formulae to calculate fairing area. A requirement that a PF be one-half or one-third open has been proposed. Should this opening be measured from the side view or from the top view? Should it vary for two wheels or three? How can half of the area of a shape like a zucchini squash be calculated?

Another proposal involves using photographs or drawings of the vehicle glued to heavy poster board. These could be cut out by the competitors and furnished to the officials. The cutouts could be held in front of the vehicle to determine closed and open areas. Weighing the cutouts would then give a comparison of their sizes. A similar method is used to calculate the wing area of model airplanes in contests.

This poses another problem. How is the open area of the vehicle to be determined?

Oscar Egg's Sputnik and Chet Kyle's Teledyne streamliners provide an illustration. Both vehicles are similar, except that Kyle's fairing extends about one foot closer to the ground. If viewed from the side, Sputnik has exposed wheels and crankset. Are wheels and crankset areas considered the open parts of the fairing? Or, is the area in front and behind the wheels (which is covered on the Kyle vehicle) also considered open area?

Yet another approach is the function-oriented definition. For examples: "anything the rider doesn't have to climb into," "anything that doesn't open or close;" "the rider must be afforded a full field of vision," and so forth.

The problem of a definition may be the most important factor in encouraging the development of PFs. As an organization, we must examine the question about PFs. Should fabric fairings and rigid fairings be run in separate classes? Is a Vector with the center section of the canopy removed a legitimate PF?

Without a definition which is workable for both builders and officials, we can give only a little more recognition to PFs than that received by Berther, Egg and Varilla.

Without a good definition, efforts like Murray Wilmerding's elegant solution to partial streamlining may go unrecognized, because technically Murray's vehicle was illegal.

HPV SCIENTIFIC SYMPOSIUM

by Tom Milkie

The second Scientific Symposium on human-powered vehicles, held October 22, 1983 at the Long Beach Convention Center in Southern California, proved to be as successful as the first, two years ago. Once again organized by Allan Abbott and the IHPVA, the event consisted of many short presentations packed into a full day. The printed proceedings from the symposium should be available by the time this review is published.

Chuck Champlin, IHPVA president, led off the symposium by giving a rundown on the past year's events and plans for the future.

HUMAN-POWERED FLIGHT

Paul MacCready, the designer of most of the world's successful human-powered aircraft, then followed up with the first revelations of the newest MacCready machine, the Bionic Bat. This design is his response to the latest prize offered by British philanthropist Henry Kremer for the first human- powered aircraft to exceed 8.95 m/s (20 mph) over a 1.5-km (approx. one-mile) course, where 10 minutes of stored energy is permitted. Paul's son Parker piloted the Bat to a potential world record and prize-winning run on September 25, 1983. (The Royal Aeronautical Society's Kremer-prize committee has since disallowed the flight because of uncertainty about the initial state of charge of the battery used.) This vehicle weighs 38.1 kg (84 lbm) and has a 4.59 g load capability. By comparison, the Gossamer Condor was stressed only to 1.1 "g"s, and the Gossamer Albatross to 1.8 "g"s. The energy storage was via 24 Nicad batteries, with a separate generator and motor. This energy-storage method is only 25% efficient, but is far superior to rubber-band (and other) storage methods. MacCready's team developed methods of maintaining equal charge on all batteries, and developed a variable-pitch prop, crucial tasks for the success of the aircraft. Other attempts at this latest prize include an attempt by Ian Kroo of San Francisco, using a slingshot device with no propeller; a Seattle, Washington, group with a rubber-band-powered device; an MIT student group also using battery storage and a Bat-like airplane; and a Japanese team with a rubber-band-powered ship. First prize of 20,000 pounds is being offered by Henry Kremer, through the (British) Royal Aeronautical Society. Additional prizes of 5000 pounds are offered for later speed records which exceed the previous record by 5%.

Paul MacCready also discussed the future of human- powered flight. He felt that a power input of at least 2.2 kw (3 hp) is necessary for practical flight at altitude because of the need to design for relatively high "g" loads and moderate cruising speeds. Our enthusiasm for human power should not blind us to the outstanding energy-storage capability of chemical fuels and the power density of internal-combustion engines. He also suggested a new contest for non-human, animal-powered flight, with a requirement that the animal be "happy" when it lands.

LAND VEHICLES - AERODYNAMICS

Dan Fernandes, General Dynamics aerodynamicist, a member of the Vector team, gave some details of his analysis of the Vector vehicles. Using source-and-doublet flowfield generation, Dan produced three-dimensional flow analyses of the Vector (1980) design, including ground effects -- probably the only analysis of this level of any HPV. One very interesting result of his analysis is that the proximity of the ground to the smooth underside of the Vector produces not only increased drag near the nose, but also increased thrust at the rear. The net result is that ground effects are responsible for only about 3.2% of the total estimated drag of the Vector. Total-drag estimates were substantiated by roll-down tests on the vehicle. Dan's final analysis showed the contributions to total drag given in the table.

PREDICTED DRAG-COEFFICIENT COMPONENTS

Skin friction	0.069
Exposed wheels	0.008
Wheel openings	0.058
Wheel-disk friction	0.014
Ground interference	0.005
Total predicted Cd	0.154
Experimental value	0.14

(This drag coefficient is based on frontal area. Another form of drag coefficient is based on surface area).

Glen Brown of ZZipper-fairing fame presented some ideas for reducing ground-effect losses. Glen suggested HPV bodies that are flared outward at the skirt, to isolate underbody pressure. To solve the ground-effect problem for two-wheel vehicles, Glen suggested tall vehicles with low-cross-section wheel fairings. This technique allows a good aerodynamic shape, minimal area near the ground to cause ground interference, yet would maintain a small overall vehicle cross-section area. This would also keep the mass of the vehicle high off the ground, which is important for two-wheel- vehicle stability.

Aerodynamics promoter extraordinaire Doug Malewicki woke up the audience with a dynamic presentation on jet motorcycles, John Howard's paced bicycle-speed-record attempt, nuclear-war games, and...human-powered vehicles. He presented a paper written with Chet Kyle and Al Gross for the December 1983 issue of Scientific American. Doug presented some astute observations on the human-power-output curve, and expanded on the Kyle table of drag on various bicycle configurations. His table includes the drag of "perfect" bicycles and "perfect" fairings, and combinations useful for judging the potential benefits of various technological improvements in human power.

Chet Kyle himself presented more data on his efforts to produce winning Olympic bicycles. Extensive wind-tunnel tests were conducted with the support of Alex Moulton of Britain. The tests showed drag decreases with slight yaw angles for faired bikes and streamlined-tube frames. due to the "sailing" effect. Small front wheels (24 inch) aid in allowing bicycles to draft closer together. Data on wheels show only slight reduction in drag with oval-rim wheels, but large reductions with covered wheels. The drag of human hair was found to be significant. A sleek new helmet was developed which produces very low drag. Magnanimously (or quixotically), the helmet was given to the Russian team, who used it to set a new world record.

Joe Mastropaolo, professor at Cal State Long Beach, and known for his training of Bryan Allen for the Gossamer human-powered-aircraft flights, presented the results of his scientific training techniques on cyclists, kayakers, and swimmers. Training consists of measured efforts on ergometers, in restrained boats, or using other power-absorbing devices. For short, intense events, Joe Mastropaolo has achieved performance increases of 1-4% per week over months of training.

Extensive studies on the biomechanics of pedalling were presented by Maury Hull of the University of California at Davis. Using a mathematical model of leg motion, he discovered strong sensitivity of hip moment to pedalling rate. Knee motion, however, was less sensitive to rpm. Since hip moments relate directly to muscle use, his data help explain how spinning improves power output, and indicate how pedal motion might be redesigned for better human efficiency.

The Shimano Biopace and other non-circular chainwheels were described by Fred Delong, author of "DELONG'S GUIDE" and contributing editor of BIKE-TECH. He related the results of experiments with various elliptical chain-ring gears at various phase angles. He found less knee strain on hills to be especially significant with non-circular chainwheels. Larry Brown gave details of the Bio-Cam and the newer Power-Cam. These devices reduce energy wasted in crank tension by reducing force variations during the pedalling stroke. Performance improvements are most dramatic with maximum output efforts. Larry also described the use of instrumentation mounted on pedals. He felt that this type of instrumentation, coupled with the use of flywheels, was far superior in measuring human output to standard ergometer testing.

INNOVATIVE BICYCLES

After completing an exhaustive study of the last 100 years of development in folding bicycles, David Hon described and demonstrated his recently developed model. He noted that fore-and-aft rigidity is more important than lateral rigidity in a folding bicycle. His folding bike can be carried or pushed on a caster wheel. The design also incorporates an ingenious folding crank arm.

A short history of recumbent-bicycle designs and the evolution of the Avatar 2000 were presented by Dave Wilson of MIT. He discovered that recumbents with high front-wheel loading were difficult to handle in snow and soft ground. Designs with up to 70 percent of the static weight on the front wheel have been built. They may have 100 percent of the weight on the front wheel during braking. The Avatar 2000 has only 31 percent on the front, versus 40 percent for a normal ten-speed, which greatly enhances safety. Dave noted among the several claimed advantages of recumbents the ability to pedal through a turn, to stop in traffic with both feet on the ground, and improved neck, back and eye comfort due to body position.

Tim Brummer, co-designer of the record-setting White Lightning, described the design and construction of the Lightning X2, his faired recumbent bicycle that won the speed trials for bicycles this year. A full Kevlar fairing was made using a plaster male and fiberglass female mold. The 17-kg (38-lbm) vehicle has a clever trap door for foot launches and an easy-opening shell. Tim recommends a 1115-mm (44-inch) wheelbase for recumbent bicycles.

HPV TECHNOLOGY

Several people spoke on technology for land vehicles. Chet Kyle showed slides of construction techniques for fairings. Besides the well-known Mylar-and-tubing and fiberglass-molding techniques, he described the use of carved Styrofoam blocks and the use of foam-plastic sandwich board for two-dimensional surfaces.

Scott Rowe of the Red Shift team described the construction of a graphite-reinforced foam-Kevlar-sandwich monocoque vehicle. To make the sheet foam conform to a three-dimensional shape, a mosaic of foam pieces was cut and fitted to the shell. The monocoque construction uses the shell strength to replace the frame, and allows for efficient volume usage.

John Whitehead and Eric Edwards presented theory and practical experience in the use of rear-wheel steering for tricycles. Advantages of better aerodynamics due to smaller wheel holes, and a simpler drive system, are possible if dynamic problems can be avoided. John's eigenvalue analysis showed the possibility of a stable rear-wheel-steered vehicle with the use of trail (tire-contact patch ahead of the pivot point) and steering damping. If the pivot point is behind the rear wheel the disconcerting effect of sudden left movement when steering right can be reduced. Eric built prototypes and then his successful Pegasus vehicle. After solving weight-distribution problems, he has achieved 26.8 m/s (60 mph) (with a tail wind) without stability problems.

PRACTICAL VEHICLES

Several papers were presented covering aspects of practical vehicles. Paul MacCready talked about energy storage as an important item for practical HPVs. A simple regenerative brake could be made using a rubber band and weighing only 1.4-2.3 kg (3 to 5 lbm). This would be extremely useful for stop-and-go bicycling.

Dan Kirshner presented a paper addressing the practicality of aerodynamic streamlining on commuting vehicles, which must accelerate and go up hills. His analysis showed that even at commuting speeds and in fairly hilly terrain, the weight penalty for many aerodynamic devices would be worth the gain. Dan has produced a computer program to compare trade-offs.

Danny Pavish presented Gardner Martin's thoughts on their experiences with the Easy Racer recumbent. Gardner felt that recumbent bikes will not replace ten-speed bicycles, but will fill a special need. A truly practical vehicle should be able to share the road, carry groceries, be car-toppable, and be "as safe as a ten-speed".

HUMAN-POWERED WATER VEHICLES

Alec Brooks presented a review of current efforts in human-powered water vehicles. Propeller-driven boats are inherently more efficient (80-90 percent) than oars (60-70%) but the current 50-meter record of 5.6 m/s (12.5 mph) was won on an oared scull. At this speed skin friction predominates, although wave drag is becoming significant. The optimum scull is 9.1 m by 355 mm (30 ft by 10 inches) for a single sculler. Wetted area can be reduced by putting bouyancy under water - hence the design of underwater pods. Wave drag can be significantly reduced by operating in very shallow water. Human-powered hydrofoils are possible, and some have been attempted. Alec described the designs of propeller-driven catamaran and outrigger HPBs. He also noted that vehicle speed theoretically increases without limit with increasing crew size.

Fred DeLong also contributed to the water-vehicle presentations with a description of the efforts of Yvon Le Caer, a cyclist, to pedal himself across the English Channel. Le Caer has built a 40-kg, 5.8-m (87-lbm, 19-ft) catamaran HPB that he has pedalled 96 km (60 miles) from the Bahama Islands to Florida at night.

INTERNATIONAL HPVs

Paul Schondorf, professor at Koln Technical University, presented a review of the current progress of HPVs in Germany, and details on the ideal dimensions for recumbent bicycles. He described the Treio, a three-wheel upright recumbent. This design is not popular, and suffers in cross winds. The Velerique, a fully faired three-wheel HPV is being produced in quantity: an impressive slide was shown of a yard full of fairings. However, the DM2000 cost, the quality of the frame construction, and the closeness to the ground would seem to limit the potential success of this design. The Dutch Roulandt and Paul Schondorf's own Muscooter two-wheel recumbents were also shown. His criteria for a successful recumbent bicycle covered all principal measurements. A seat height of 400 to 500 mm was recommended, and a wheelbase of 1100 mm. He recommended direct steering systems and a maximum weight of 13.6 kg (30 lbm).

The symposium included a short question-and-answer session, but, as in the first, 1981, symposium, the day was tightly filled with many short presentations. A more relaxed or varied agenda could be recommended for future symposiums. However, this second symposium was a great success and a large volume of new information on human power was presented.

THE DEVELOPMENT OF "THE WORLD'S FASTEST BICYCLE," LIGHTNING X-2

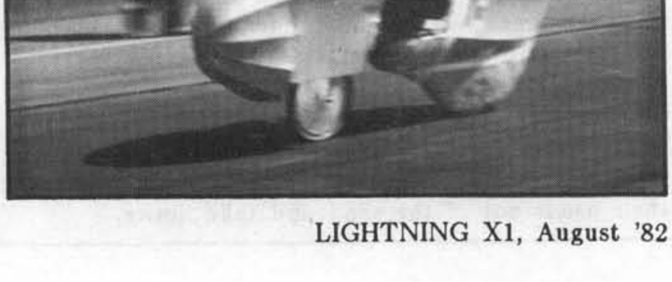
by Tim Brummer

Many of the ideas and motivation for building Lightning X-2 began with my involvement with White Lightning, the record-setting fully faired tandem tricycle. While students at Northrop University, Don Guichard, Chris Dreike and I did all of the development and test riding for White Lightning.

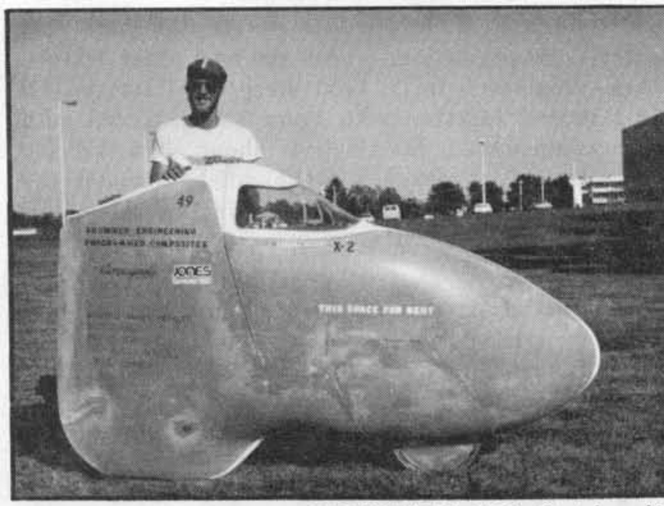
It was always an exhilarating ride to crank that vehicle up to 22+m/s (50+ mph) on our test road behind Los Angeles International Airport, especially when a back tire would blow. (Initially, we had a problem with the fairing rubbing.) This might sound dangerous but the machine would simply settle down and slide to a stop with very little damage. We would just put on another sew-up and take off again.

However, it wasn't very practical to take White Lightning down to the corner grocery store since it had a ground clearance of 13mm (1/2 inch) and a 24-m (80') turning radius. I can recall one instance when we rode down to the hardware store to buy a small part. We had to stop to get out and to pick the trike up to get around normal street corners.

During 1979, another Northrop student, Roc Fleishman, contacted us to say that he wanted to build a single-rider HPV suitable for street use. We



LIGHTNING X1, August '82



LIGHTNING X-2, October '83

came up with a design that is more maneuverable and higher off the ground than White Lightning; we called it Roc's Rock-it. It has a three-wheel layout with one 24" wheel in front and two 18" rear wheels.

The front wheel is driven with a five-speed set up. The rear wheels not only steer the bike, but also allow it to lean while going around corners. It takes quite a bit of time to master the unique steering arrangement. The best speed to date is 20m/s (45 mph). With a better fairing I am sure it would go over 22m/s (50 mph).

It turns out that the main problem is that the seat is too low for street use, even though the rider's head is 200 mm (8 inches) higher than on White Lightning. Riding along on the street looking at car hubcaps can be disconcerting, but Roc does ride it around on the L.A. bike paths quite a bit.

Meanwhile, back at the drawing board, a recumbent bicycle seemed to be the best since one can get the seat up high enough to be safe and still be narrow enough to ride along the shoulder of a highway and not halfway out in the lane. After some analysis, a wheelbase similar to that of a standard bike seemed best. I could not see making a single-rider recumbent with a wheelbase of a standard tandem. And after riding a Hypercycle and experiencing its poor handling, I wanted to avoid making it with a short wheelbase.

One problem my bike does have, however, is that one's feet hit the front wheel on slow, tight corners or U-turns. But after a little practice, one develops a pedaling technique to overcome this design trade-off.

The first bike I made was a 22-kg (50-lbm) adjustable monster that used some parts from a bike I bought for $25 in a junkyard. I rode it around for some time and it helped me decide the best seat position, crank position, wheelbase and other factors. I then progressed to a 4130 steel-tube-frame model that I brazed together with brass and outfitted with better components. It weighed about 13.6 kg (30 lbm). Though I mounted the handlebars under the seat, I feel that having the bars over the knees, as on the X-2, gives better control for fast maneuvering.

Progress during this stage was slow since I had purchased a used house and was spending a lot of time and money fixing it up. I also had to rebuild the engine of my car. During August of 1982, some friends of mine asked if I was going to race at the upcoming Human Power Speed Championships in Orange County. It sounded like fun but I knew my bike wouldn't stand a chance without a fairing. So I quickly threw together a partial fairing made of aluminum tubing and Mylar.

The bike was really Lightning X-1 although not advertised as such. It turned a not-so-fast 16.5 m/s (37 mph) in the 600/200-meter event. In the drag race, I did have the pleasure of beating a standard bike equipped with a Zzipper fairing. During the road race a friend slid out on some gravel in a turn and put the bike out of further competition. A Vector later slid out in the same corner.

In 1983 I decided to make an improved frame using what I had learned from my previous bike. I ride this bike around quite extensively and have gone on a few weekend trips of 100 miles or more.

In May, I was at Don Guichard's house watching the Indy 500 on TV. We got to talking about the upcoming HPV Championships and Don said he could probably get some Kevlar donated if I wanted to make a fairing for my bike.

I drew up a fully-enclosed body design that fit nicely around my bike. I had decided early-on that the rider should be able to get into the bike and start it himself, since I was going to be doing all of the test riding myself with no support crew. That is why X-2 has its unique "landing-gear doors" that open automatically when your feet hit them.

Then there was the long and arduous task of making the body molds. Fortunately, I had some help from about five kids aged 9 to 12 in my neighborhood, especially during the plastering part. All I had to do was feed them ice cream.

I constructed the base of my molds from 2" x 6" wood (about 50 x 150 mm) and 3/4" (12 mm) plywood. I placed aluminum templates with 6" (150 mm) spacing on this. Plaster was then applied between the templates to a depth of 25 mm (one inch). About four plaster applicaions are required from rough to smooth. After the plaster dried, I spent many hours sanding and painting with primer to achieve a good surface.

The next step was to lay-up a fiberglass female mold on the plaster male (see photo). I made the glass about 3 mm (1/8") thick. I took the molds down to Los Angeles where Don helped me make the body parts at Programmed Composites, where he works. We used ovens to cure the epoxy in the Kevlar at 120C (250F). Don had gotten the Kevlar donated and we used some honeycomb core left over from White Lightning. The face sheets and the core are layed-up and cured together in one step, with the resin in the face sheets being sufficient to bond them to the core.

Making the parts took us three 16-hour days. Mold release was a problem as the body parts stuck to the mold and it took an extra full day to get them out. I took the parts back to my garage where I glued them together, bonded some supporting structure inside and made all the cut-outs.

The next step was to attach the fairing to my bike. About the only change I made to the bike itself was to increase its gearing size. I took the completed vehicle out for its first test run two days before sending it to Indianapolis.

I shipped it to Indy in the fiberglass female molds since I didn't have time to make a regular shipping crate. All the hassle I went through getting a trucking company to ship it is a story in itself: it almost didn't get sent. My first day in Indianapolis, one day before the racing started, I was lucky enough to meet Carl Sundquist. If it hadn't been for his athletic abilities, the record of 24.49 m/s (54.78 mph) would not have been set. When the timers announced his record time it made all my months of hard work worthwhile.

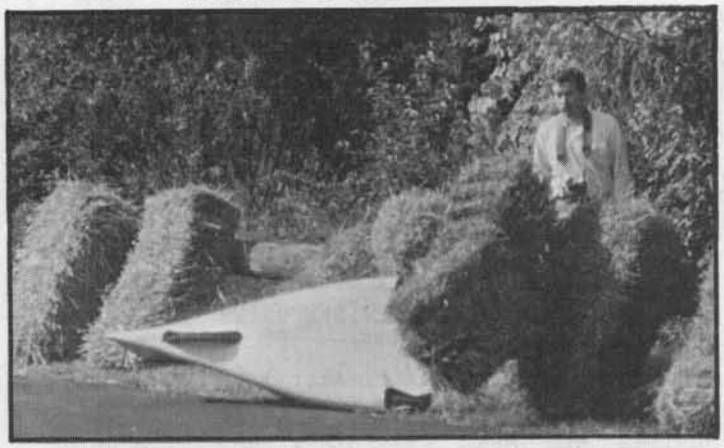
About the only negative feeling I have about this whole episode is the blase attitude of the bicycle industry. Before I started making my body, I wrote to twenty bicycle companies and component suppliers concerning sponsorships. The smaller ones at least wrote back and wished me good luck; the larger ones didn't even reply.

The amazing thing is that on Lightning X-2 even I, an average weekend bike rider, could go out and beat the world's best riders of conventional bikes anytime.

Maybe if all you readers told your friends to buy recumbents, then the bike manufacturers might get their heads out of the sand and take notice.

NOTICES

SAFETY RESEARCH



HAYBALE IMPACT *Photo: Dan Bonwell*

In an effort to compile data on HPV accidents, we have included a survey in this issue of HP. We would like to have reports from riders, builders and bystanders so that we may increase safety in future. Supplemental information and photos are very welcome. Reports of even minor incidents are valuable. Send them to: HPSR, RFD 1, Box 84A, WALDOBORO, ME 04572.

RIDE A RECUMBENT THIS YEAR

Step-by-step easy-to-follow instructions on how to build a recumbent (of the Avatar or Infinity type) using three old bike frames. Send check for $11 payable to Robert Cotter to PLANS, RFD 1, BOX 84A, WALDOBORO, ME 04572.

TEN-SPEED FAIRINGS

A limited number of ten-speed fairings will be available to IHPVA members only. These fairings are larger than most, covering hands and head for warmer, drier winter riding, and allow effective streamlining. The fairings ("Bubbles") are lightweight, constructed of impact-resistant Lexan and come complete with aluminum mounting hardware. "Bubbles" are also excellent for other purposes: eg Eric Edwards' "Pegasus" head piece; Bruce Penhall's formula race-car windshield. Allow 6-8 weeks for delivery. Send a check for $60 payable to Robert Cotter to BUBBLES, RFD 1, BOX 84A, WALDOBORO, ME 04572.

ACCIDENT SURVEY

Supine Prone Other(specify)

2 wheeler Trike Quad Other

Size and placement of wheels

Unfaired Partially Faired Fully faired

Fairing materials

Design of fairing Height Weight Width

Rider Height Weight Experience riding vehicle

Method of steering

Braking Designer

Road surface Weather conditions

Type of Road/Track

Accident with another vehicle? Type?

Approximate speeds (you): (Other vehicle):

Details Date

How did design of vehicle help/hinder?

In what ways could design of vehicle be improved?

Compare to conventional bike

Injuries

Damage to vehicle/s

Rider error? Vehicle error? Other

Were there helmets? Lights? Reflectors? Flag?

Vehicle color Was vehicle for street or race use?

Was there an additional energy source; type/location

Name and address

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IHPVA ORDER FORM

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M1H	BICYCLING SCIENCE, second ed., hdcover	20.00	
M2	BICYCLES AND TRICYCLES, softbd.	8.95*	
	(*five or more: $8.50 each)		
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GKM	AERODYNAMICS OF HPVs (Sci.Amer.)	1.50	
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$7.00 per book, air
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NOTES ON MERCHANDISE

TEE SHIRTS:
1981, 7th IHPSC, blue (B), light blue (LB), gold (G), black & burgundy (B&B); sizes: S, M, L, XL.

1982, 8th IHPSC, yellow, medium size (Y, M) beige, medium & extra large (BG, M or XL)

1983, 9th IHPSC, grey with IHPVA logo, sizes: S, M, L, XL

BICYCLING SCIENCE, second edition, by Frank Rowland Whitt and David Gordon Wilson. Human power output, resistances, requirements, HPVs etc.

BICYCLES AND TRICYCLES, by Archibald Sharp. Definitive in 1896 and still used as a standard. Dynamics, stress calculations, gearing etc.

NEW PERFORMANCE GRAPHS, by Douglas Malewicki, IHPVA. Power requirements of various aerodynamic shapes, and other useful information.