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HUMAN POWER

Official Publication of the INTERNATIONAL HUMAN POWERED VEHICLE ASSOCIATION, INC.

Volume 2 Number 1 ISSUE 8 Spring, 1982

Sam Kleinman Photo

1982 8th Speed Championships
Scientific Symposium
British Speed Challenge Results
Composites, part 2

1982 8th IHPSC

More Events, Better Facilities

The planning for the 1982 International Human Powered Speed Championships has begun. The event has been scheduled for Saturday and Sunday, October 2/3, 1982 at the Orange County International Raceway (OCIR), Irvine, California. The emphasis of this year's race will be on practical vehicles. In addition to the usual sprints and road races, several other special events promoting practical vehicles are planned.

The most notable of these events will be the Practical Human-Powered Vehicle competition. Vehicles will actually be ridden by a panel of judges, and evaluated for handling, safety, ease of pedalling, and carrying capacity. This competition will hopefully stimulate the development of practical, rather than racing, human powered vehicles. Other events scheduled include an electric race, an arms-only race, and a 10-speed bicycle spectator participation event (for more details on these events, see announcements below).

OCIR will be an excellent facility for most of the planned events, but since it is mainly a drag racing facility, run-up distance for the 200-m sprints may not be sufficient for the very fastest vehicles. Therefore, a day of record attempt speed trials will be held on Sunday, Oct. 3, 1982.

Help is needed for all phases of the organization and running of the '82 IHPSC. If you would like to volunteer, please call Lyn Tobias at (714) 897-8318, evenings.

Two New Events

1. *Quarter Mile Drag Races*

Which vehicle can cover a quarter mile in the shortest elapsed time? Which will accelerate to the highest velocity? Exciting head-to-head competition where light weight design and a full range of gearing are as important as streamlining—perhaps more so.

In addition to being a real crowd pleaser, a quarter mile drag racing event provides a much needed standardized form of human-power competition that can easily be conducted on a regional basis. There are hundreds of dragstrips spread around the country that already have sophisticated electronic timing equipment installed and calibrated.

This will be a landmark event that should really help the IHPVA grow nationally.

2. *Production Bike Speed Trials*

This new event is intended to encourage spectator participation in Human-Powered Events. Kids from 6 to 60 can bring their own bikes (10 speed, BMX, Cruisers, Unicycles, etc.) and compete for prizes in this fun event.

This will be an opportunity for spectators to accurately test their own capabilities and get answers to an important question the IHPVA has not provided them in the past. Namely, does aerodynamic streamlining really make any difference to the average person on his bicycle?

We plan to set up a separate quarter mile course adjacent to the drag strip, so that production bike riders can compare their accomplishments to those of the streamliners.

Furthermore, Glen Brown of ZZIP designs will loan us a quantity of ZZIPPER fairings so each entrant can make his own comparison runs with and without some basic streamlining. Glen has also graciously offered to provide some fairings for prizes and cover the expense of printing 10,000 flyer/entry forms that will be placed in bicycle stores.

3. *Help*

The above events have a tremendous potential in terms of spectator interest level and IHPVA growth.

I need several volunteers to 1) help finalize the rules for the new events, 2) help solve some of the problems I anticipate for the events, and 3) help promote, prepare, set up and run the events.

The IHPVA general meeting (announced elsewhere in this issue) is guaranteed to be very short so we can break off into working groups. I want to finalize the rules for the two new events, discuss the overall objectives, and delegate specific tasks at this time.

If you are a volunteer who can be counted on, please call DOUG MALEWICKI at (714) 559-7113 or write 14962 MERCED CIRCLE, IRVINE, CA 92714. I will rush you the proposed rules and anticipated problems for your review.

Speed Championships to Feature ELECTRIC RACE

A special event at the upcoming speed championships will be the ASTRO CHALLENGE electric vehicle race. Sponsored by Astro-Flight Inc., the ASTRO CHALLENGE will demonstrate the potential of ultra-low powered electric vehicles. The race will have a length of 10 kilometers, and will be run on the road racing course at OCIR. All competitors will use identical motors and battery packs, so the race will be a measure of machine efficiency only, and not the rider's athletic ability.

Astro-Flight Inc. will supply the motors and batteries at cost, and will provide technical assistance with drive mechanisms and electrical connections. Vehicles may run in both the human-powered events and the ASTRO CHALLENGE as long as the competitor can demonstrate to race officials that only electric power will be used in the electric race and only human power will be used in the other events.

For more information on the ASTRO CHALLENGE electric race, including technical information on the motor and battery to be used, send a self-addressed stamped envelope to:

Alec Brooks
125 S. Sierra Madre Blvd., #312
Pasadena, Calif. 91107

PRACTICAL VEHICLE Design Competition

The next IHPVA Championships will include a new category of competition designed to encourage development of practical Human Powered Vehicles for transportation. In contrast to other events, this contest will not be simply a race. HPV's will be ridden and judged by a panel of "experts" which will include: 1) a mechanical engineer, 2) a grandmother, and 3) a bicycle racer.

Not necessarily listed in their order of importance, Categories to be considered and judged will be:

1 utility and ability to carry light cargo
2 speed
3 ease of entry and exit
4 comfort
5 ventilation and protection from weather
6 appearance

Vehicles will be tested over a variety of conditions designed to simulate everyday year-round use—including a trip to and from the corner store for a small bag of groceries.

For further details about the rules, judging or other aspects of this competition, write to:

ALLAN ABBOTT
P.O. Box AA
Idyllwild, California, 92344

At long last . . . The HYDRO CHALLENGE

Watch these pages for developments regarding the first IHPVA Hydro Challenge. As our members have rewritten the books for Land- and Air-vehicles, we soon expect them to so with human-powered boats.

Presently, the fastest human-powered watercraft are oared shells which are raced over a 2000 meter course, standing start. FISA rules provide events for singles, doubles, fours and eights; women's competition is usually run on a shorter (100 m) course. The IHPCA has a proposal out and is looking for a sponsor(s). The Hydro Challenge will be held at the Long Beach Marine Stadium, perhaps as early as the fall, '82. Our regatta will include the usual FISA events plus a closed-circuit race around buoys to explore maneuverability. Rules? Only that the vehicles will derive their support from the water and must be human-powered. No form of stored energy will be allowed aboard save low-power batteries for communication devices or instrumentation.

Entry forms and other pertinent information will be sent to all IHPVA members. Start thinking about your watercraft designs: are there really more effective marine propulsion systems than oars?

For competition information or suggestions, contact:

Peter Boor, IHPVA Vice-President, Water
1203 Yale Avenue
Claremont, California 91711

Dick Hargrave

HUMAN POWER

Volume 2 Number 1
Spring, 1982

Published quarterly by the IHPVA for its members and others interested in promoting improvement, innovation and creativity in the design and development of human-powered vehicles as well as encouraging public interest in physical fitness and good health through exercise.

Until further notice, please address all correspondence relating to this publication c/o Mr. Stuart Huston, 7701 W. Warner Ave., L-167, Huntington Beach, CA 92647 USA. Communications to specific staff or officers will be forwarded.

LETTERS

Member's Forum

Send your comments to the IHPVA newsletter for publication.

Dear Members,

I have recently become a member of the IHPVA and would like to congratulate the competitors for their enthusiastic spirit and their accomplishments.

The fall '81 newsletter exemplified typical problems plaguing new and experimental competitions . . . Differences of opinion on the IHPVA events stem from not acknowledging the ramifications of expressed goals.

In Peter Selby's *Speed Championships; British View* and Lynn Tobias' *President's Message*, the views expressed tend towards establishing the IHPVA events as pro-oriented spectator sports. The use of public relations and marketing personnel to attract sponsors points in this direction too.

Dick Hargrave's editorial entitled "IPSOB" implies a different trend. Deregulation of events, coupled with Abbott type prizes promotes IHPVA events strictly as a scientific and technological endeavor. Dick uses a USAC ruling to illustrate how the turbine powered Indy racer was eliminated through regulation. And rightly so! Auto racing is a spectator sport where fans cheer on the drivers, and not the cars they drive. If auto racing were to be completely deregulated, fans of drivers would phase out and be replaced by devotees of science and technology. Sponsorship would then be discouraged, because the fans of science and technology never outnumber the sportsfans. The humanistic aspect of competition is what draws people to races or any other spectator sport.

Now for the question–which direction to choose? If the IHPVA remains a technological spectacle, public support will remain low, competitions will be dominated by a small group, and publicity will plateau (probably at present levels). If the IHPVA events tend towards a professional spectator sport, then the opposite will occur. . . .

Serafino Carri
121 Spring St.
Port Chester, N.Y. 10573

Dear Members, 6 January 1981

. . . When having a working lunch with the Guinness Book of Records people, the subject of the use of oxygen came up. Norris McWhirter, the editor, said he had done some considerable research in this, and he said that there were very real dangers of actual damage. He advised very strongly against the use of oxygen, or any other similar substance. I wrote to Sir Roger Bannister, who was the first man to break four minutes for the mile, and is now this country's leading specialist in sports medicine, to ask his views. A copy of his letter is enclosed. We would very much welcome any advice which members may have, but as things are, and unless strong points are raised, we are proposing to ban the use of oxygen in record attempts or at meetings and competitions.

Yours sincerely,
Pete Selby,
London, England

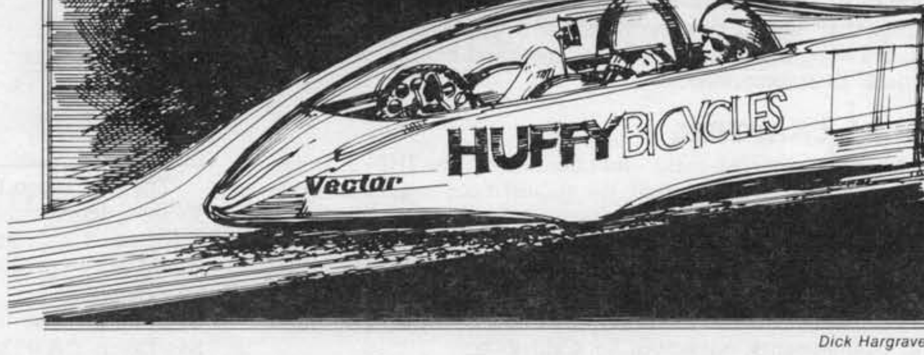
FROM SIR ROGER BANNISTER
22nd October 1981

Dear Mr. Selby,

Thank you for writing to me concerning the problem of the use of oxygen.

Though I am not an expert in this field the evidence seems to point to the fact that inhaling oxygen prior to a competitive event gives no significant advantage. The reason is that increase in the inspired oxygen tension only increases the dissolved oxygen which is a minimal part of the oxygen content of the blood most of it being held in association with haemoglobin. The practice of inhaling oxygen prior to severe exercise was introduced, I believe, by the Japanese before the War but was rapidly abandoned. I might add that the concept of using artificial means of this kind, even they prove to be ineffective, is something to be discouraged if not banned.

Yours sincerely,
Roger Bannister,
London, England



Dick Hargrave

President's Message

DONATIONS

We are very pleased to acknowledge the receipt of numerous and generous donations from our members. The extra funds will be extremely helpful in defraying the costs of the IHPSC and the publication of the newsletter. I hope to have the time to thank the people listed below more personally, but for now I want to take this opportunity to make their generosity known. Thank you.

Lawrence Akers
Robert Alexander
Glen Brown
Donald Campbell
Serafino Carri
Richard Coffey
Harold Curn
Roc Fleishman
William Frey
Craig Galer
Ben Grinhaug
John Hays
Irvin Housinger
John Humphrey
Stuart Huston
Hitashi Konno
J. R. Kunkle
Prof. H. E. Lessing
Jeffrey McGee
Thomas McKeown
Des Messenger
Arni Nashbar
Richard Newick
Rod Padrick
Art Pitkin
Chris Pollard
Bryce Ronnander
Peter Selby
Eugene Seymour
Charles Siple
Tom Swain
Willmot White
David Wiener
David Gordon Wilson

QUESTIONNAIRE RESPONSES

More than a third of the questionnaires have been returned and we are in the process of tabulating the data and we will report the results in the near future. The information will be very useful to us and we hope the rest of the forms will be returned soon (hopefully with as many renewals and donations!).

There have been quite a few good comments and suggestions, many of which I hope to personally respond to when the deluge subsides. In general, feelings about ultra-low power and regenerative braking have been about equally split between totally for or against our getting involved. To insure that the IHPVA is not led astray from its goals while still giving our members the opportunity and motivation for developing advanced and practical vehicles, we should probably spawn a sister organisation for ultra-low power. Since regenerative braking would be a means of redistributing the HUMAN power that has been input, I feel that it should be allowed for road and practical vehicle competitions but not for the sprints (to prevent the rider from pedalling at an easy pace for a protracted time to store enough energy for a burst through the traps). Of course the systems would have to zero stored energy at the beginning of road races and we may want to have separate classes for them. I am very much opposed to adding more regulations and thereby stifling creativity and development. I am sure that we can handle any problems that may arise.

Many members have suggested the creation of a compendium of past and present vehicle designs, specs and performance. Many would also like articles on construction techniques that have proven successful and also what dead-ends to avoid. I hope that more of our designers and builders will share some of their experiences.

LOCAL CHAPTERS

We have received many comments that the IHPVA is too California-oriented and that we should hold events in other parts of the country. I heartily agree. The problem we face is that the organisational work is done in California by volunteer local members who also have full-time jobs. Unfortunately, this precludes extensive travel and limits our capabilities to stage an event (which requires quite a few volunteers, contacts and arrangements) outside of So. California.

The solution is the formation of local chapters which can stage or host events in their area. These events may be quite small and informal initially (as were the first California events), but will grow quite rapidly. With this kind of local organisation, it should be quite possible to hold the IHPSC outside of California. In addition, local events will attract more competitors, sponsors and media. These races can be preliminaries to and help attract sponsors for the IHPSC and provide excellent practice, experience and deadlines for designers, builders and crews.

At present, our guidelines for local chapters are simply that they abide by the constitution and bylaws of the IHPVA (we'll send copies) and that sanction fees may be required for events (depending on the magnitude and sponsorship). We can also supply guidelines for organising a race.

We strongly encourage the formation of local chapters and that they hold meetings, put on events, solicit new members, increase the visibility of the IHPVA, contribute to the newsletter and promote the development of new and better ideas in the field of human powered transportation.

HELP WITH THE BOOKS

We still need someone to help set up and track our bookkeeping now that we are non-profit. We desperately need the assistance of a CPA and advice on legal and tax consequences of being non-profit. Although non-profit experience and So. California locality would be nice, we invite help, comments and advice on these matters from everyone.

KEEP IN TOUCH

Please write or call whenever you are so moved. If I've neglected to respond in any way, don't hesitate to prod me again—I've probably been distracted and need to be reminded.

Keep up the good work!

Lynn John Tobias
6372 Alexandria Dr. 714-896-4778 (W)
Huntington Beach, CA 92647 714-897-8318 (H)

MISSING PERSONS

Mailings to the addresses listed below have been returned as undeliverable. If you can supply corrections or inform these members that their mail is being returned, please do so.

BLANCHARD, WILLIAM C., JR.
P.O. Box 1043
Brandon, FL 33511

BONURA, LARRY
311 W. South Ave.
Emporia, KS 66801

COFFMAN, JIM
618 W. Baseline
Claremont, CA 91711

CONGER, WILLIAM S.
10463 Nutmeg
Cucamonga, CA 91730

GEORGE, H. V.
817 16th Street
Santa Monica, CA 90403

GRAVES, CLIFFORD
846 Prospect St.
La Jolla, CA 92037

HARTE, JIM
4607 Narrot St.
Torrance, CA 90503

HIPPELY, KEITH
Box 7531
Stanford, CA 94305

McDONALD, JULIE
5640 Ethel Way
Sacramento, CA 95824

MONROE, DONALD P.
12333 Texas Ave., No. 11
Los Angeles, CA 90025

ORRO, MARTIN
801 Hilgard Ave.
Los Angeles, CA 90024

REDMON, MARK
4645 McFarland
Riverside, CA 92506

WONG, WILLIE
435 W. Broadway
Vancouver, BC V5Y 1R4

The San Diego Chargers are interested in a Human Powered Vehicle demonstration during one of their football games at halftime. If your vehicle can perform on natural grass, and you would like to get involved call or write immediately:

Dan Gindling
1152 Oliver Ave. #3 (714)270-3478
San Diego, CA 92109 (714)298-1570

Dr. Allan Abbott is well-known in Human-Powered Vehicle circles as a designer and builder of HPV's and holder of the bicycles land speed record. In November he also became famous as the organizer of the first HPV technical symposium. The symposium, held at the Disneyland Hotel in Anaheim, California, was a resounding success. Packed into one very full day of presentations were speeches by practically every prominent person in human power. The single conference room was filled to capacity for each presentation.

Dr. Paul Schondorf, a German HPV designer, led off the presentations. Dr. Schondorf presented details of extensive HPV testing and design accomplished by German HPV and bicycle manufacturers, which far exceeded the technical level accomplished by American HPV designers. Paul presented data on spring suspension bicycles, and special test bicycles set up with fully variable geometry. He also presented excellent wind tunnel data. While most of his data applied to low-speed, upright ridden tri cycles and bicycles, popular in Germany, a lot of the data is applicable to high-performance HPV's. One interesting result of his tests was that minimum drag for low-profile shells occurred with the maximum shell thickness located only 15% of the length back from the nose. Paul also talked about coast-down tests with full-size vehicles, using a 70m course with timers accurate to .001 sec placed every 5m for 25m. His drag data showed a drag coefficient of .98 for a partially faired, upright vehicle, versus 1.13 for an unfaired vehicle. Drag coefficients for recumbent streamlined shapes were as low as .13. Dr. Schondorf also presented data on tire rolling coefficients. Using bicycles equipped with accelerometers mounted on the wheel hubs, acceleration loads were measured under a variety of road conditions. It was interesting to note that under rough conditions longitudinal g-loads exceeded vertical loads.

Glen Brown is best known for the first extensive practical application of streamlining—the *Zipper* bicycle fairing. His presentation covered the possibilities of future markets for HPV products. He examined the market segments including the "Racer," who is only interested in racing, the "Recreational Rider," who is only interested in looking like a racer, and the "Tourist," who is after a functional bike—probably not an HPV just yet. He also looked at the "Commuter," who is less bound by tradition, and would be interested in HPV's, and the "Non-Enthusiast," who is interested in the technology, but who would resist high prices. Glen also noted the public's increased awareness of streamlining—largely due to automobile advertising, but noted the skepticism over the recent "aerodynamic" bicycle parts. Glen recommended that the best sales approach for the new HPV industry would be via direct sales to the public, due to the large costs in going through normal bicycle distribution channels.

Alec Brooks presented some interesting topics in HPV design. He is a fluid dynamicist and HPV designer from Pasadena. Alec stressed the fact that adding riders in a multiple-rider vehicle does not increase power while keeping drag constant. In fact, the increased surface area of a long, thin multi-rider vehicle may cause considerable drag, and some thought ought to be given to designing multiple-rider vehicles to maintain the ideal shape (at HPV velocities)—a body shape with a fineness ratio of 3 to 4:1.

Talking on the practicality of human-powered aircraft, the dean of HPA's, Dr. Paul McCready, gave little hope for the dreamers. He noted that a low-power aircraft must be exceedingly large and light—hence fragile. The *Gossamer Condor* (first to fly a 1-mile figure 8 under human power) required .37 HP to fly for 5 minutes. The *Gossamer Albatross* required .25 HP and .37 HP in turbulent air, for the human-powered flight across the English Channel. These aircraft, however, could only stand fractional gust G-loads before collapsing. The *Solar Challenger*, however, was built to full aircraft structural requirements, but weighed 217 lbs and required 1.33 HP to fly under solar power. The unfortunate equation for power requirements is that power equals weight to the 3/2 power, divided by the aircraft wing span.

David Gordon Wilson, MIT Professor and noted promoter of recumbent bicycles, presented a discussion of HPV technology needing further research. He noted that most data on human power output vs time is suspect, especially since long training is required on any new equipment before its effect on power output can be measured. He also noted that the human power data for rowing is probably invalid, since ergometers are usually set up with a sliding seat, similar to rowing shells. However, in boats the operator really does not move—the boat moves beneath him. Ergometers should therefore be set up with a fixed seat and moving feet. Dr. Wilson also noted that while maximum power output in cycling may occur at 80-90 RPM,

(cont'd on page 11)

1981 HUMAN POWERED VEHICLE SCIENTIFIC SYMPOSIUM

by TOM MILKIE
TECHNICAL EDITOR

George Uveges Photo

Dr. Allan Abbott, symposium organizer.

SILENT CYCLECARS IN SUSSEX

by KEVIN M. DESMOND
London, England

The Second Aspro Clear Speed Challenge, as organised by Peter Selby, together with sponsors, Nicholas Laboratories Ltd to the tune of £40,000, and homologated by the International Human Powered Vehicle Association, was held on the weekend of 5th/6th September in Sussex, England. Prize money totalled an attractive £8,000. Day One involved speed attempts; Day Two saw a circuit road race.

The venue for Day One was the English South Coast town of Brighton, and in particular the Madeira Drive, which runs along the seafront, parallel to the English Channel. No more historic a track could have been chosen. When in 1896, the Locomotives and Highways Act was officially revised, the "Emancipated" motor car pioneers made a celebratory run from London to the Madeira Drive. From 1905, speed trials for motor cars, "noisy things", were held along the Madeira Drive, involving such drivers as the Hon Charles Rolls (of Rolls-Royce and formerly a cycle racing champion) and such now-forgotten marques as the Phoenix!

The course along Madeira Drive involves a push-start of no more than 15 metres, then a run-up of 700 metres before entering the measured 200 metres. Timing was by Seiko, to 1/100th of a second, using a quartz crystal apparatus.

It is fairly well-known that the Flying 200 metres Record for a solo "humanobile"/"velocar"/"cyclecar" is 58.89 mph, created in the Autumn of 1980 by the *Vector* tricycle from Anaheim, California. The multi-rider record is also held by a Vector at 62.92 mph. These records were set a few hundred feet above sea level, and with a long run-up.

When the first Aspro Clear Speed Challenge was held in 1980 along Madeira Drive, there was a brisk northerly wind blowing across a certain section of the course, and several vehicles came to grief. The Vector tandem set the fastest speed at 47.44 mph, while the Vector single was timed at 46.55 mph.32. On that occasion there were entries from Holland and Germany, with the remaining machines having been built in the United Kingdom. Earlier this year, the British single tricyclecar, *Poppy Flyer III* created a British National Record of 49.2 mph after two whole days of attempts on a runway at RAF/USAF Greenham Common in Berkshire. Her predecessor, *Poppy Flyer II* had set a speed of 54.89 mph at the 7th International Human Powered Speed Championships at Pomona Speedway, California, using a run up which sloped slightly downhill.

On Saturday 5th September, the weather conditions in sea-level Brighton were perfect. There was virtually no wind and an Indian Summer temperature of 70-80°F. The 34 competitors who had arrived knew that to break world records, their time through the 200 metres would have to be below 8 seconds. All the runs that day were above 9 seconds and many above 10 seconds.

Again it was a repeat victory for the Vectors. This time the Vector tandem humanobile achieved 48.25 mph, while the Vector solo machine reached 47.23 mph. However the speed difference between the 1st and 4th placed tandem vehicle hardly varied: 7.43 up to 8.49 mph. For solos, the reverse trend: 4.9 mph down to 3.08 mph. So the singles contest was a closer one.

By looking in more detail at the times of some of these vehicles, we can perhaps gauge comparatively why their riders can consistently push them to over 40mph, bearing in mind the fact that the fastest speed ever set by a conventional racing bicycle, on a glass smooth track in the rarified air of Mexico City, is only 42.2 mph, a record which has remained unbroken since 1962.

Bear in mind that for these attempts, there can be no motorpacing, no advantageous echeloning of riders, stored energy systems such as flywheels, pre-stressed springs, powered cylinders, pressure tanks, electric steering devices or electric stabilisation devices.

To take the most successful humanobiles first: The Vectors have been evolved by a group of Southern Californians: John Spiker, Dan Fernadez, Alan Voigt, and former folk-singer, Doug Unkrey of the Versatron Research Corporation, Anaheim. The streamlined bodyshells are derived from low-speed airfoils developed in the 1940's; a combination of compound curves and wing design integrated to wrap round the human, to have the lowest frontal area and give the least amount of drag. In other words, laminar flow counts.

Cockpit windows are Lexan, a virtually unbreakable plastic. The remainder of the shell is fiberglass with interior lightweight aluminum

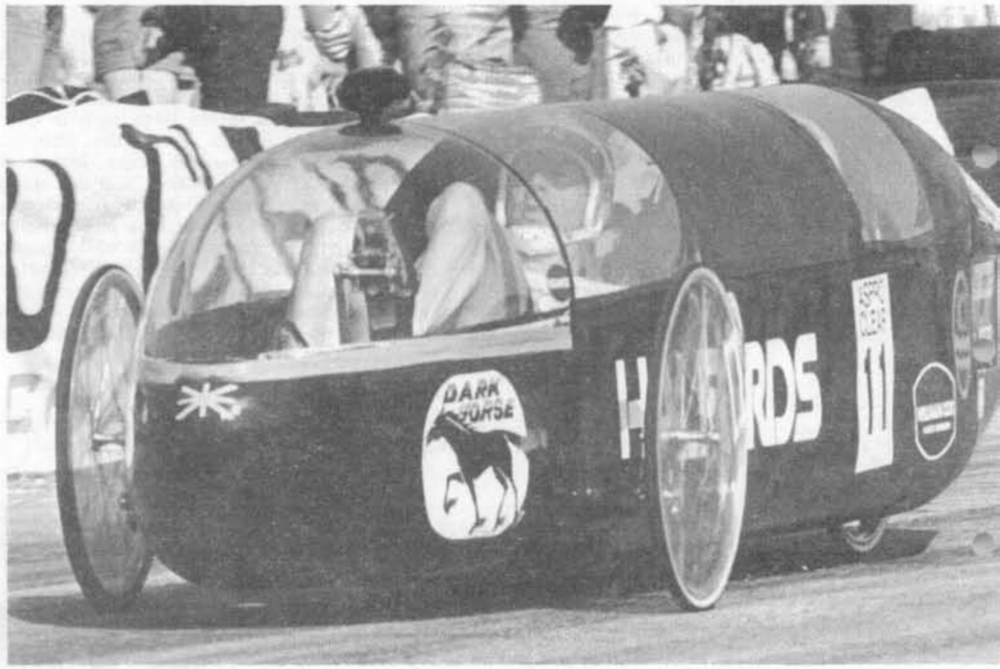
Chester Kyle

THE SPEED TRIALS

No.	Vehicle Name	M.P.H.
	Single Rider Vehicles	
34	Vector Single II	47.23
20	Poppy Flier III	46.45
33	Vector Single I	46.30
2	S.H. Sanderson	44.15
36	Jim Blackburn Design	43.26
3	Windcheetah	42.84
40	Genesis	42.04
	Multiple Rider Vehicles	
35	Vector Tandem	48.25
11	Dark Horse	45.13
37	Phoenix	43.68
25	Hawker/Hudspith	39.76
41	White Horse	38.10
12	Webb Hughes	37.97

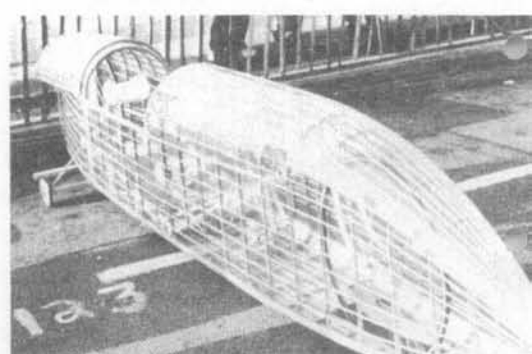
THE ROAD RACE

No.	Vehicle Name	M.P.H.
	Single Rider Vehicles	
34	Vector Single 2	35.04
33	Vector Single 1	33.36
36	Jim Blackburn Design	32.37
24	Hawker/Hudspith	29.58
40	Genesis	26.98
21	Philip Webster	26.62
3	Windcheetah	25.00
7	Poppy Flier 2	24.35
16	Rapide 1	24.06
5	Univ. of Warwick	23.25
31	Georges Mochet 1	22.79
13	Glen Sprocker	21.[illegible]
1	Third Boston Scout	16.55
19	Avatar 2000	16.26
4	Britax	16.04
39	Transition 3	
	Multiple Rider Vehicles	
35	Vector Tandem	32.11
37	Phoenix Cal Poly	26.74
11	Dark Horse	25.92
12	Webb/Hughes	24.18
41	White Horse	23.66
17	Ken Rogers	22.[illegible]
9	Highview Hurricane	22.04



Hughes/Webb tandem, "Dark Horse" beat Phoenix, but not Vector. 2nd place, 45.13 mph. Crowr

The winning Vector tandem. 48.25 mph.



Mr. Sanderson's fourth place single. 44.15 mph.

tubing for support. Tricycle framework is mild steel, not chromium-molybdenum. The two 24 inch front wheels are steered, and there is a single 27 inch wheel at the back. The high pressure cotton/silk tyres are capable of taking up to 165 lbs psi pressure.

Vectors have a 120 sprocket up front, their chain going down and below the rider through a series of rollers, protected by aluminum sheeting, to a conventional 5-speed derailleur at the rear. With the rider less than 2 inches off the ground, the centre of gravity is very low. The lowest gear is a 24 and the highest a 12. When in high gear, one revolution on the front crank will take the humanobile 60ft. One Vector is powered by pedalling with both hands and feet.

Dimensions of the Vector Tandem: Overall length 151 inches; Height 33 inches; Width 25 inches. Overall Vehicle Weight 85 lb. Frontal Area 4.7 sq feet. The Vector solo is 35 inches shorter, one inch lower, the same width and 21 lbs lighter.

As a Vector goes down the road, the amount of a drag it induces is about the same as a rear-view mirror on the outside of a truck:

Jim Gentes (Cupertino, CA) brought his trike to fifth place at Brighton. 43.26 mph.

Poppy Flyer III — less than one mph behind Vector.

Polytech's ASME student entry, "Phoenix". Third place, 43.68 mph.

Ken Bird's GENESIS, with "Kamm" tail configuration.

Crown Photo

Vector Single II. Fastest solo of the lot: 47.23 mph.

Glen Sprocker's "Falcon", managed 12th place in Road Race.

0.01. In 1980 the Vector tandem travelled between Stockton and Sacramento, California, on Interstate 5 at an average speed of 50.5 mph for 42 miles.

Not counting the thousands of man-hours involved, one Vector cost the Anaheim team 5,000 dollars. They now have a stable of six of these machines, and are indeed offering them for sale. The price tag to own the fastest human powered machine is some $10,000.

The *Phoenix* achieved 43.68 mph on the Saturday. This is the product of the largest and most ambitious project ever attempted by members of the Californian Polytechnic's ASME Student Section. From a mechanically faulty tandem called Ripley, and its ashes came the Phoenix, not only designed for out-and-out speed, but for circuit racing, 100-mile races and an attempt to set a Transcontinental record next year.

Designers Steve Blair and Andy Tao began by making six half-scale 6ft models. With access to a 400ft hallway, they set up a laser timing system, then using a giant slingshot, they catapulted the models down the hallway at 60mph. Following a comparative analysis, modifications were made to the more efficient models, such as making some ride closer to the ground than others. All results were plotted on a computer and analysed.

The resulting tandem, Phoenix, measures 174 inches in overall length; 25 inches wide; 36 inches top-to-ground; 90 lbs weight; frontal area 5.32 sq ft. There is a 100-tooth 16-inch diameter gearwheel, 6 gears; three 27-inch wheels; tyres 120 lbs psi. Two riders: 31-year-old Jan Russell from Van Nuys (6ft 3") and 29-year-old Butch Stinton from Simi Valley (6ft 2"). Messrs Russell and Stinton ride back-to-back. The materials of Phoenix's body shell are fibreglass, carbon graphite and Kevlar.

Twenty-one members of Cal-Poly worked together on this vehicle; 40 companies helped with sponsorship, including World Airways, Alcoa Aluminum, Atlantic Richfield, Kaiser Steel, Hendrickson's Bikes, Hughes Helicopters, Westinghouse etc.

Although England has only been in the human-powered vehicle race for two years, there was equally sophisticated technology on this side of the Atlantic.

The largest British chain of cycle distributors and car accessories, Halfords of Redditch, produced their *Dark Horse* tandem which came 2nd behind the Vector tandem with 45.13 mph. With both riders facing forward, the body shape had to be fairly long but simple: no constantly changing curves. A third-scale wind tunnel model was made from plywood and filler and test by Dr. Geoff Howell at Warwick University's Department of Engineering, renowned for its involvement with high-speed train design. Half a dozen tests were done to find the drag co-efficient in a zero yaw, then under yaw conditions. A drag co-efficient of 0.12 was achieved.

181 inches in overall length; height 30 inches; width 24 inches, the Dark Horse uses two steerable 24-inch wheels in front and a 27-inch rear wheel. Total weight of vehicle 120 lbs.

The one-off cross-braced centre frame was made entirely from Reynolds 531 tubing and a system of linked gearing gives a massive top gear of 216 inches (movement on the road per pedal revolution)—nearly double the top gear on a normal tandem.

Once seated in the vehicle, the covering with its precision made perspex canopy and Dialene shell, leaves only one inch of headroom. It was ridden by its designers, David Hughes and Tony Webb. Before Brighton, Dark Horse was timed by its police escort on the Coventry By-Pass at 51mph.

Another beautifully-built British solo machine was designed, built and ridden by 23-year-old Simon Sanderson from Brancaster Staithe, East Anglia and a member of the Norwich Amateur Bicycle Club. This was compactly fitted into a plywood case, easily lifted off the roof rack of his car.

165 inches in overall length; width 18 inches; height 30 inches; overall weight 37 lb; frontal area 444 sq in. the Sanderson body-shell was of airship shape, known in the aerospace world as NACA 1135. Its chassis tubing was in chromium-molybdenum steel, with other components from Germany, France, Spain and even the USSR. The shell was built of a delicate skeleton of superbly joined, fret-sawn plywood covered with see-through plastic sheeting. The only protrusions were two small outrigger wheels to maintain a quadricycle-type balance for the interior bicycle. Sanderson's reasoning was that as the vehicle picked up speed, the 6-inch diameter outrigger wheels would lift off the ground, allowing the 27-inch ultra narrow 3/4-inch sprint wheels to take over. Having achieved 44.15 mph at Brighton, Sanderson stated his intentions of looking into the possibilities of a Human-Powered Speed Record running on railway lines!

Ken Bird, a British manufacturer of racing cycles, turned up with his *Genesis,* which he admitted was a partial copy of the American Vector machines. He took advice on aerodynamics and made his solo machine wider at the back, having been told by a Professor that the angle at which the machine tapers off is impor-

(cont'd on page 10)

Composite Construction and Advanced Materials

by Jim Moynihan

This is the second part of an article published in MODEL BUILDER magazine, directed at the model airplane crowd. We present this article because it includes some very useful information on the use of composites.

• Before getting into the good stuff, we would like to acknowledge our source of wood data presented in the previous installment. It was taken from *Wood Handbook: Wood As An Engineering Material.* This book is by the Forest Products Laboratory of the Forest Service, U.S. Department of Agriculture, Handbook No. 72. It can be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402 and is Stock No. 0100-03200. Ours is several years old and cost $7.85. So much for that.

Now haul out the last issue and refer to the materials data table, and let's learn from it. This will be painless but very fruitful. First of all, we listed many materials in order to more vividly illustrate the basic differences of the more prominent products used today. Many don't interest us and will be ignored at this time. For openers, let us compare balsa and spruce so you get the idea of what the table can be used for. Notice the ratio of tensile strengths; 3.45 to 1. Next, look at the compressive maximums and divide again; 3.6 to 1. The Modulus of Elasticity is next at 2.82 to 1. Weight is always interesting to us and a check here shows a 3.11 to 1 relationship. Isn't it interesting to see that all the parameters are about 3 to 1! Right off the bat we can be sure that spruce is three times stronger than balsa in all departments. But it is also three times heavier. However, if we reduce the cross section AREA of a balsa part by 2/3 we can use spruce to get equal strength at the same weight. Obviously, we pay much less for the spruce.

Not all comparisons of materials are as neat as balsa/spruce, as we shall see. Comparing spruce with T-6 aluminum alloy leaves little doubt why aircraft designers turned to aluminum as soon as it became economically available. At 160 times the tensile strength of spruce, twice the compressive strength and 6-1/2 times as stiff, the increase in weight was a small price to pay. Of course, many other factors are also taken into consideration with real aircraft, such as temperature limitations, creep, fatigue etc. The weight "penalty" really wasn't all that bad, because aluminum made monocoque structure economically feasible too.

From the previous two comparisons, you get the idea that the table really can tell you something. This is great, but the really important thing is to put it to use. Now look at the really mind boggling characteristics of E-Glass, Kevlar, and Pan Base Carbon Fiber. We picked these three in particular because we can get our hands on these materials now. The rest are in such short supply that a priority is required to be able to buy them, due to defense requirements and aerospace programs. All three exhibit roughly the same high tensile strength . . . almost 10 times aluminum and no contest with spruce. Again comparing aluminum, they are lighter and with almost 4 times the compressive capability. Now the Modulus; Kevlar twice that of E-Glass and carbon fiber almost twice that of Kevlar! Now the really neat thing to appreciate here is that, unlike wood and aluminum, etc., we can inter-mix these three materials in a resin matrix to take advantage of the best or most desirable property of each. As an example, we at AEROLITE PRODUCTS INC. produce a sandwich, or laminate as we call it, of E-Glass and carbon fibers and epoxy. See Figure 5 and photos. This utilizes the high Modulus of carbon fiber with the high tensile and impact resistance of the E-Glass.

This is all very interesting, but what the heck do we do with it? We'll show you that next, confining our remarks at this time to carbon fiber applications. Before going any further, look at Figure 2. This is how materials behave when they are loaded. Here we show a simple rectangular beam which could be a wing spar as well. The neutral axis passes through the geometric center of the beam. For the purists, it passes through the centroid of the beam, which, except for simple geometric shapes, is rarely the geometric center. Oops, we said in the beginning that we would keep this simple. But just so you know, all the fibers of the material below this line are in tension and all those above it are in compression. The fibers along the neutral axis are not loaded in any way. The outermost fibers are at maximum tension and compression, and as you move toward the neutral axis, the fibers are loaded in a ratio of their distance from the neutral axis.

Figure 3 shows a typical lift distribution on a rectangular shaped wing. Below that is a bending moment diagram. New terminology, bending moment: Using our patented simple explanation system, the bending moment is the leverage the load is applying to the wing structure. Lay a stick on the floor. Place your foot on top of it at one end. Holding it down with your foot, pick up the other end and keep heaving. You are applying a bending moment. This is simply the sum of the load at any point multiplied by the distance from that point to the wing root. This is a simplification of sorts because it is really a square root function for uniform loads such as wing lift. The point to note is that it is ALWAYS A MAXIMUM AT THE WING ROOT. Since that is true, we need more spar here than anywhere else. But equally important is that we DO NOT need as much anywhere else. More on this later.

To see what's what in the real world, we tested a series of wing spars. Here we present Series 18 of those tested which are 1/4 by 1/2 inch in cross section and 24 inches long. To show a comparison of advanced materials, we also show the performance of an AEROLITE 2-meter glider spar which is only .085 x 1/2, but made of pure carbon fiber and epoxy. We

TABLE OF SOME DATA FROM AEROLITE TEST SERIES 18, MATERIALS TEST 25519-80, SPARS

Remember, 1 oz. = 28.35 gm.

DESCRIPTION OF SPAR	CURVE	MAX LOAD	MAX DEFLECT	TOTAL WEIGHT	REINFORC. WEIGHT	EPOXY WEIGHT	LOAD CARRIED AT (IN OZ.) DIFFERENT DEFLEC. 1/2"	1"	1-1/2"
*7.6#/cubic ft. balsa	H	11.5 oz.	1.7"	5.5 gm	none	none	5	8	10.5
*Same balsa as above coated both sides with Hobby Poxy 2	I	11.5 oz	2.05"	7.0 gm	none	1.5 gm	4	7	9
*Same balsa with tow both sides with Hobby Poxy 2	G	42.0 oz	2.4"	12.0 gm	4.59 gm	1.9 gm	9.0	18	27
*Same balsa with laminate one side with Hobby Poxy 2	F	50.0 oz	2.75"	12.5 gm	4.5 gm	2.5 gm	10.5	20	29.5
*Same balsa with laminate both sides with epoxy	E	96.0 oz	3.24"	16.5 gm	9.0 gm	2.0 gm	15.0	30.0	44.0
*Nice straight grained spruce	D	107.0 oz (This spar failed prematurely at 93 oz., see text.)	5.20"	22.5 gm	none	none	16.0	31.0	46.0
*Same spruce with laminate both sides	C	138.0 oz (This spar failed prematurely at 114 oz., see text.)	3.95"	34.0 gm	9.0 gm	2.5 gm	24.0	48.0	72.0
.085 x .5 Aerolite pure carbon/epoxy spar stock	B	166.5 oz	2.65"	23.0 gm	none	none	44.0	86.0	118.0
Giant Scale E-Glass .0595 wall epoxy tube spar 10 = .468; 00 = .587	A (24.22#)	387.5 oz	6.20"	71.0 gm	none	none	39.0	80.0	114.0

*All 1/4" x 1/2" x 24" loaded at 19" from support.

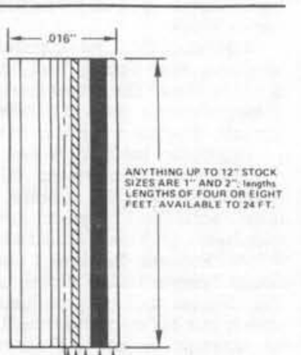
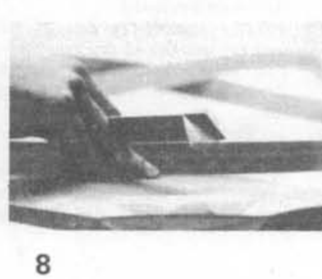


Fig. 5: Greatly enlarged cross section of Aerolite carbin fiber E-glass laminate. Material weighs .375 grams/sq. in. Epoxy used is totally compatible with Hobbypoxy 2 or any viscous C/A glues such as Super Jet.

One-inch wide laminate strip on a 12-inch wide sheet. Protective scrim cloth is peeled back.



Aerolite laminate. Note the glass pattern.

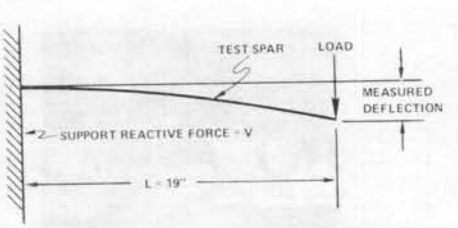


Fig. 1. An elementary diagram showing the procedure for testing all spars.

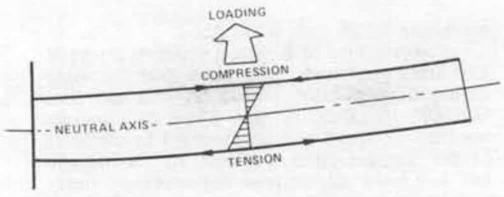


Fig. 2. Cantilever beam fixed at one end, showing location of principal stresses. Shaded area in center depicts the progressively higher stresses applied to fibers as you move from zero stress neutral axis to maximum stress fibers on the extreme surfaces.

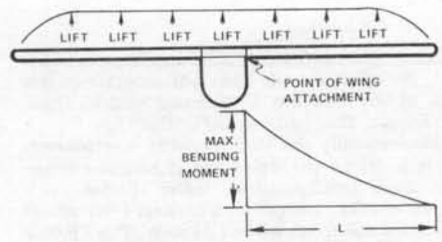


Fig. 3. General lift distribution on rectangular wing, and variation of bending movement with span from point of wing attachment. Note max bending movement is ALWAYS at the wing root.

also show an AEROLITE giant scale spar made of E-Glass and epoxy. This is a tubular spar with an OD of .581 inches, ID of .468 inch and is centerless ground to these dimensions. The 1/4 by 1/2 spars are balsa and spruce. The balsa was light stock but normally used as spar material, but it really doesn't matter too much because we were looking for comparisons anyway. The spruce was nice straight grained stock by Midwest and purchased from a local hobby shop as stock material. Both woods were tested as is and with carbon fiber tow and our AEROLITE laminate as we shall see. These were tested as cantilever beams, and load and deflection were measured as shown in Figure 1, until they failed. The point of failure gives us the ability to determine the maximum bending moment as a finite number. Equating this number to the bending moment relationship of a uniformly loaded beam, such as a wing structure, let's calculate the wing loading the given spar will tolerate at a very PREDICTABLE deflection. More on this later, but it gets juicy doesn't it?

All the balsa spars were identical stock cut from the same sheet. The spruce was also identical stock cut from a six-foot piece. At least 12 points of load and deflection were taken and plotted for each spar to generate the curves in Figure 6. A great amount of observation took place as well, together with some high speed photography.

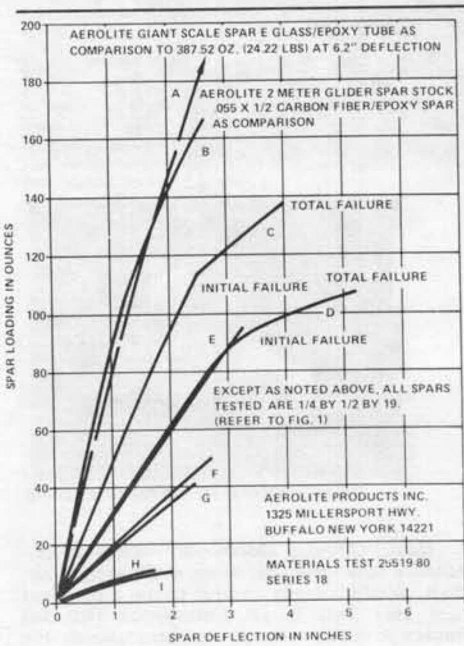
Now look at Figure 6 and Figure 7. Figure 7 is a tabulation of some results of the tests and describes the spars tested and what the hybrid reinforcement consisted of. Wherever tow or laminate is indicated, it was applied only to the 1/2-inch side of the spar. The 1/4-inch "edge" or narrow dimension was never reinforced in any test in this series.

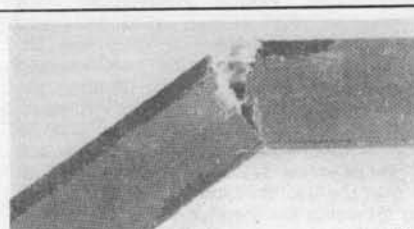
The reinforcement process is simple, but it should be explained here to kill off the old wives tales we've heard about the difficulty of working with this material. We produce the laminate using high temperature and pressure equipment, in sheets one foot wide and 24 feet long. We then cut it to four and eight-foot lengths and slit it to one and two-inch widths. It has what is called a "scrim" cloth facing which easily peels off. The cloth is applied to help protect the surface in shipment. The laminate utilizes an epoxy resin system that is totally compatible with Hobby Poxy 2 so that you can use it easily. Any of the viscous C/A (cyanoacrylates) work equally well, but we like the time element afforded by epoxy for laminating. Any C/A can be used really. A light sanding of the laminate to clean it is good practice, but nothing more. How simple can you get?

The tow is applied in much the same way. Since it is harder to handle, we put the epoxy on the fibers as they lie on the paper they are packed in. Now wet the wood with epoxy (very light coat) and place the wetted fiber tow on the wet wood surface. Peel off the paper and lay a sheet of Saran wrap on top of the wet fibers and weight with a flat board or bar until cured. No sweat! The whole secret to imparting stiffness to parts with carbon fiber is to keep the fibers straight and running the length of the part. This is called unidirectional fiber orientation. Much can be done by variations of orientation in terms of predictable flexure, and we do this with our carbon fiber pushrods. The laminate is also unidirectional as we produce it with all the fibers running the length of it. We have tested hundreds of laminated spars and other parts which have been reinforced as described and have yet to experience a single failure of the tow or laminate bond to the parent material. 'Nuff said on that.

Back to Figure 7. Note how the simple addition of either tow or one side of laminate doubled the load carrying capability of the balsa. Laminate on both sides of the balsa allowed four times the load to be applied. Spruce all by itself is not too shabby either, being comparable to balsa with both sides laminated. But the weights tell us that the balsa with laminate is 72% LIGHTER! The laminate allowed all spars to carry much more load at the same deflection, or controversy, deflect much less at the same load. This was expected, but to what degree we were not sure. Note too that the primary failure was in compression in every case. The spruce failed and took a permanent set. Then, with further loading, it failed in shear with total delamination of the wood fibers. But notice too from the photos that our theory of the neutral axis has been dramatically proven. This mode of failure was also true of the balsa spars, but happened very quickly and was not possible to plot.

Now look at pure composite material, the .085 x 1/2 AEROLITE carbon spar. With only 34% of the cross section area of the other spars and the same weight as spruce alone, it will carry 2.75 times as much as spruce, almost 9 times as much as balsa alone, and almost 3 times as much as reinforced balsa. Look the curves over and come to a lot of your own conclusions. We are trying to present a lot of useful data from which you may draw your own conclusions and use your own judgement to apply this knowledge to the solution of your own problems. You will notice the tabular data listed loads at only three deflections. Our reason for this is that any wing that begins to bend even this much is failing internally somewhere, whether the spar is still in one piece or not. We'll delve into some more of that next time. In the meantime, if you have any questions, write to me at AEROLITE PRODUCTS, INC., 1325 Millersport Hwy., Buffalo, NY 14221. •





left

right

(Above) Close-up of balsa/laminate spar failure (left) and spruce/laminate failure (right). Similar except that balsa fails straight across (simultaneously) because of low tensile strength of balsa fibers.

(Above) Carbon fiber yarn. Only 12,000 filaments. Care to count them?

(Top) Carbon fiber tow as it comes off the reel.

tant, provided the air does not separate at the back of the machine. Critics said that by making Genesis, Bird had lost 20% efficiency.

Mechanically the bird machine was interesting; it is driven through three chains in a cross-over drive configuration, using special "L"-shaped cranks. Length 125 inches. Rear wheel 27 inches and front wheels 24 inch. The £5,000 Genesis achieved a speed of 42.04 mph.

Most of these tricyclecars had the 2-front/1 rear wheel configuration. Not so Warwick University's own entry, which had two wheels at the back and outside the bodyshell, but aerodynamically faired in with polystyrene. Despite its wide track, the frontal area—0.4 square metres—was still less than the Vectors, evolved as it was from high-speed train shapes. Weighting only 50 lbs, this wooden monocoque construction achieved only 34 mph.

Another fascinating approach was the 130-inch *Windcheetah,* developed by a four-man team headed by Mike Burrows of Burrows Engineering, Norwich. Built at a cost of £450, measuring 20-inches wide, 30 inches high and weighing 65 lbs., the silver-foiled, double-edge axe-shaped canopy was separate from its tubular tricycle chassis. It was fitted with brushes along its bottom to clean up the ground effect. With two small square windows, it gave its rider, Andy Pegg, very little visibility. Brighton Best: 42.84 mph.

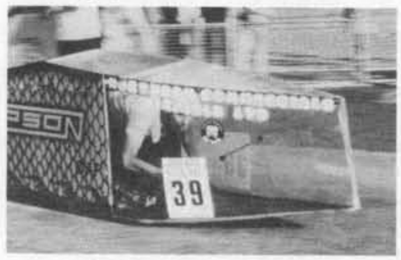
One must not leave out the holder of the British National Record of 49.2 mph, the solo Poppy Flyer III, again a reverse three-wheeler built by Jaymic Engineering of Cromer, Norfolk. With a unique, 24-inch 140-tooth frontal gear-wheel specially made by Royce Racing, Hampshire, Poppy Flyer III's dimensions are 174 inches in overall length; width 18 inches and height 30 inches. Its streamlined bodyshell, slightly longer in the nose than other competitors, was made of foam-reinforced glassfibre, with overhead, specially moulded Plexiglass canopies. It has two 24-inch alloy-rimmed wheels 12-inches apart and one 18 inch front wheel. A six-speed gearbox with Huert Juberlee changer was mounted upside down on the subframe. Total Weight 60 lbs. 46.45 mph at Brighton gave the III second place.

There was an historic entry from France, with a machine whose bodyshell design was based on a machine, which belonged to the almost legendary pre-War cycling champion, Francois Faure. In March 1939, Faure rode his Mochet-designed velocar to 57 Km/h over the Flying Kilometre at the Winter Velodrome, Paris. Now Mochet turned up at Brighton with his pre-war "bicyclette carenee": 2.45 metres long; 1 metre high; 0.45 metres wide, weighing 24 Kg and with a frontal area of 0.36 square metres. 31-year-old touring cyclist Alberto Fantino, who had also built the bodyshell, was able, using this pre-war design, to achieve a maximum 35.24 mph at Brighton.

See paragraph above.

A large crowd at Brighton watched the total 110 attempts which took place that Saturday during a seven-hour period. It was sad that *GROUP VELOCITY,* the 336-inch five-man machine designed and constructed by students of the Massachusetts Institute of Technology had not been able to raise the necessary funds to bring their exciting concept over to England.

I was a close eye-witness to one of the only two crashes of the day. This involved Philip Webster from Yorkshire. His purple and white bicycle is 1 metre high and 50 cm wide, enclosed on a very vertical albeit streamlined fiberglass shell. It had front wheel steering and a front-wheel drive. As Webster approached the Measured 200 Metres at almost 30 mph, his machine began to wobble from side to side. This wobble increased until the vehicle keeled over onto its side and then skidded and spun across the track. The machine was only scratched, Webster unhurt; he went on to clock 32.30 mph.



Following prize-giving, a tape-recorded seminar was held at the Chichester Lodge Motel. Dr. Chester Kyle, Head of the Mechanical Engineering Faculty at California State University, was one of the guest speakers. Dr. Kyle was one of the first to experiment in California, back in the early 1970's, with the streamline-shelled bicycle. Together with an aeronautics consultant called Jack Lambie, they founded the Human-Powered Vehicle Association (now 600-strong) and their annual, sanctioned Speed Championships. Also there as guest was Dr. Alex Moulton, pioneer of the small-wheeled Moulton bicycle in the 1960's. Moulton expressed his firm belief that the IHPVA movement was still in a great period of creative infancy, as had been the horseless carriage and the flying machine in the early 1900's. He insisted that the less the number of official regulations set down for these contests, the greater would be the chance for creative innovation. He added,

"I think the great question is whether an ordinary bicycle can ever allow for the recumbent position of the rider so as to retain minimal frontal area. There is also a tremenous problem ahead of all these designers regarding transmission. With enormous gear ratios and great chain wheels for such high speeds, the limitation of the chain transmission is becoming apparent; perhaps some form of hydraulic drive might be considered."

Dr. Kyle commented: "Unfortunately you haven't yet seen the practical street machine—something practical for everyday use in England, where it rains, snows, is foggy and the rider exercising in the cockpit would give off a great deal moisture in a fogged-up interior. He has to run through puddles, to break, to turn, to go up steep hills. It is an engineering problem

Crown Photo

to solve all these problems that is equivalent to designing and developing a fine motorcycle or small automobile, and would involve a multi-million dollar investment programme. The competitors here have spent only a few thousand dollars at the most. I think that it would take either the price of gasoline rising to $20-40 per gallon or official Governmental legislature before the public and the manufacturers would actually use human-powered vehicles in large numbers. Perhaps the answers would be a hybrid where the stresses of uphill-pedalling could be born by a pedal-pressure sensitive electric motor. Resources will become scarce, so scarce that you will not be able to afford to waste valuable high-quality energy such as gasoline just burning it."

Discussion also ranged to the dangers of incorporating flywheels, spinning at 6,000 rpm inside human-powered vehicles; of the usefulness of initiating a hillclimb and endurance contests to promote development of these vehicles; and of improving the overall efficiency of the competing vehicles.

Day Two of the Aspro Speed Challenge took place some 30 miles west of Brighton at the former Motor Racing Circuit of Goodwood, on a vast estate, comprising a horse racecourse, and golf course, owned by the Duke of Richmond and Gordon. For twenty years, this 2.2 mile circuit had resounded to the deafening roar of Grand Prix Ferraris, Maseratis and Jaguars, increasing the lap speed record from 90 up to 125 mph until the whole track became too dangerous and the Duke said no more in 1966.

LeMans Start at Goodwood.

Crown Photo

Poppy Flyer II set up for road racing.

Now "Glorious Goodwood" although still echoing to engine roar from small private aircraft, would become witness to the most silent race ever held in its history—the first for human-powered vehicles ever held outside the

(cont'd on page 12)

maximum efficiency occurs at 50-60 RPM, so gearing must be set up with the task in mind. Dr. Wilson suggested many areas for research. In the field of aerodynamics he suggested studying the relative merits of flat bottom, skirted vehicles, versus smooth-shaped vehicles; the aerodynamics of outrigger wheels; and crosswind effects.

The *Vector* vehicles are probably the best known and most successful HPV's. *Vector* designer Al Voigt, a Systems Engineer, presented some data and future projections derived from the Versatron *Vectors*. Al showed how a *Vector* vehicle surpasses a typical 10-speed when acceleration requirements are limited. It was interesting to note that even going up a 5% grade the heavier *Vector* outperforms a 10-speed when speeds are above 15 mph. And going downhill, the *Vector* "cruises" at *90 mph*. Al presented data on the *Vector*, showing a drag coefficient of .11. He estimated that the "Ultimate Vector" would have a drag coefficient of .09.

Bill Watson, Greg Johnson, and Steve Ball each gave presentations on the development and construction of their HPV's. Bill Watson's 2-wheel recumbent was covered with a mylar on aluminum tube shell. The frame sported a 60 degree head tube, and enough ground clearance for high-banked turns. Cross-wind effects were considerable on this vehicle, sometimes requiring an aerodynamic "stall" to turn into the wind. Solar overheating was a problem until the clear mylar was painted. Greg Johnson's successful prone 2-wheeler was also made with an aluminum tube and mylar shell on a lowered 10-speed frame. The prone position allows compact power train and steering systems, with a total vehicle weight of 34 lb. Steve Ball's amazing prone, arm and leg linear motion drive vehicle was a marvel in engineering. Using a sort of miniature "Nautilus Machine," Steve's linear motion drives a bicycle gear through a cable wrapped about an asymmetric cam. The varying cam shape allows smooth, low-loss end-of-stroke motion for arms and legs. He also developed a lightweight binocular periscope for looking forward while lying prone in the vehicle.

Chet Kyle then talked about the extensive experimental data he has acquired on ergometry as a Professor of Mechanical Engineering at Cal. State University at Long Beach. He conducted tests using friction ergometers, inertia wheel ergometers, running up stairs, and running up ramps to measure human power. Dr. Kyle noted that traditional power vs time data can be greatly surpassed by some athletes. The average cyclist, for instance, puts out .4 HP for 3.5 minutes, while Eddy Merckx's was measured at .61 HP for 1 hr. Dr. Kyle noted that the slight differences between bicycle and ergometer riding postures affect the power output. His data also showed that recumbent and prone riding were 96% and 94%, respectively, as

George Uveges Photo

Steve Ball, San Diego, CA, describing his linear-drive system.

efficient as the normal bicycle posture. His data also indicated that using elliptical sprockets had little effect on power output.

As a consultant on automobile engineering, Paul Van Valkenburgh was able to show a film he produced for the Department of Transportation on 3-wheeled vehicles. He studied the cornering capabilities of a number of 3-wheeled automobiles, and the effects of bumps and crosswinds. 2-forward and 2-rear wheel configuration showed unstable oversteer problems. Weight distribution, suspension, and adequate caster were more important than the effects of 3 versus 4 wheel configurations, however. Paul has prepared a paper on the results of this testing, which should be available shortly.

The next presentation was by Dr. Joe Mastropaolo, an Aerospace Physiologist, who talked about the training of the "power plant" for the *Gossamer* aircraft. His diet for Bryan Allan consisted of the Basic Four foods, a minimum of fat, added starch, and no additional vitamins, protein, etc. Dr. Mastropaolo noted the temperature problems of human powered flight. The human body operates best at 39 degrees C, but the maximum temperature is only 41 degrees C. Special heat training, however, can extend that capability, by training the body to sweat more. The *Gossamer* aircraft had 180 square cm of inlet ports for cooling, despite the aerodynamic losses. Dr. Mastropaolo explained the detailed training program for Bryan, noting a 23% improvement in performance in 5 months, with 1 hr/day training on the ergometer.

Tim Brummer and Chris Breke presented a history of the construction of the *White Lightning*, the former world record holding double HPV. The frame was constructed of epoxied aluminum tubing (not recommended) after a plastic tubing prototype was made. Wind tunnel tests on scale models produced dubious results, but did show the presence of vortices at the sharp bottom corners of the White Lightning, and showed a 76% increase in drag when cooling scoops were added. The shell was made from ¼" nomex honeycomb layed over a forming plug made from plaster over chicken wire. Pre-impregnated fiberglass was draped over the honeycomb, and heat cured, resulting in an extremely light, 25 lb body. Coastdown tests were run on the finished vehicle by filming the speedometer with a movie camera, then counting frames to determine the deceleration rate.

Kim Aaron is a PhD student at Cal Tech, and presented the most professional wind tunnel data on HPV's. His tests were on fairings for upright bicycles, with various vertical gaps in the fairing. His data also showed that the effect of ground interference was to increase drag by up to 300%.

The Shimano film on aerodynamic bicycle components was also shown. Each bicycle component was shown with its "aerodynamic" version from Shimano, with drag data and fancy smoke test shots of each item.

The area of water-borne HPV's is only now starting to gain interest. Randy Ice, an avid oarsman, discussed the existing rowing sports. A special IHPVA boat race may be scheduled for next summer in Long Beach, California. Randy also talked about the latest rowing design where the seat is fixed to the boat (unlike current racing sculls) and the feet are mounted to moving oarlocks. Bill Watson and Alec Brooks showed some of the advanced HPV

(cont'd on page 12)

Dr. Paul Schondorf, guest-speaker.

George Uveges Photo

IHPVA co-founder, Dr. Kyle.

1984 Olympic Bicycle Design Project

The IHPVA has probably gotten itself involved in designing aerodynamically improved bicycles for the 1984 US Olympic Team. Until the past two years, the ICF (International Cycling Federation) did not permit aerodynamically shaped components or clothing. Now, more and more bicycles are appearing at international races with teardrop shaped tubing and streamlined components. So far, US manufacturers have not joined the trend toward aerodynamic cycles, but this may change.

On January 24 and 25, 1982, Dr. Ed Burke, the US Olympic Cycling Team physiologist, called together a group of scientists at the Olympic Training Center, in Colorado Springs, Colorado, to see how science might improve the performance of our elite cyclists. Invited consultants were Dr. Bob Gregor—Biomechanics, UCLA, Dr. Peter Cavanaugh—Biomechanics, Penn State University, Dr. Peter Francis—Biomechanics, San Diego State University (Dr. Francis is an IHPVA member, and worked with Steve Ball on the linear-drive HPV, Dragon Fly II), Mario La Fortune—Biomechanics, Penn State and Dr. Chester Kyle—Mechanical Engineering, California State University, Long Beach (and past president IHPVA).

The biomechanics group had some positive research results showing how pedaling efficiency might be improved by slight changes in technique. They plan to try their techniques experimentally on experienced racing cyclists, and will also seek other ways of improving the aerobic efficiency of pursuit and time trial cyclists.

Chester Kyle offered the services of some of the top IHPVA aerodynamicists to design, test and build a complete aerodynamic equipment system for the American Olympic competitors in the following events:

1. 4000 m Individual Pursuit
2. 4000 m Team Pursuit
3. 100 K Team Time Trial

Many of the components in the system can be modified or improved without great expense. However, the design of an integrated aerodynamic bicycle within the Olympic Rules will require considerable financial support. Therefore, they are looking for an American manufacturer(s) to sponsor the Research and Development necessary under the guidance of the IHPVA group.

Since many quality items just aren't produced in the USA, it was felt that the US Olympic Team bicycles would probably have to utilize many components from non-US manufacturers. However, as a matter of policy, it was strongly felt that the frame and other feasible system components should be of US manufacture. Therefore, members of the group are presently seeking financial backing from leading members of the American bicycle manufacturing community.

To date, Chester Kyle, Dr. Paul MacCready (winner of the two Kremer Prizes for human powered flight), Paul Van Valkenburgh (several times winner of the IHPSC), and Dr. Peter Francis have agreed to work on the project. Others will be brought into the project as new areas of expertise are required.

At present, the group is examining rules, the present state of the art, concepts and ideas.

If you have any suggestions that might help in the design project, they will be most welcome. Please contact:

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California State University,
Long Beach, CA 90840
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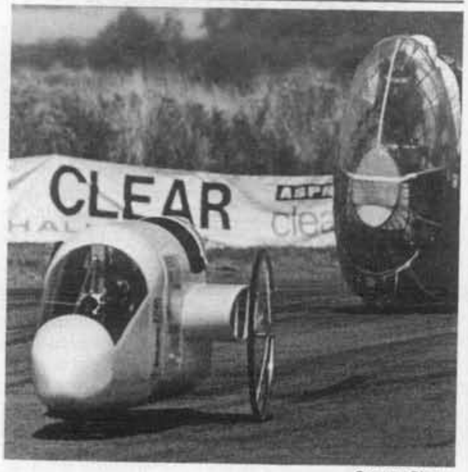
CYCLECARS *(from page 10)*



Crown Photo

USA. Ironically there would be a start as used in the famous French sportscar race at Le Mans: The riders stood on one side of the track with their vehicles parked on the other side. On the fall of the Flag, they ran across, were helped to climb in and pedalled madly away! But in contrast to Le Mans, they did so very quietly.

24 out of the 35 at Brighton took the Starter's Flag, dropped by Nils Clemencin, the Managing Director of Nicholas Laboratories Ltd. The first away was the French Mochet machine in only 27 seconds, while the slowest took three-and-a-half minutes before it was off round the circuit.

Race distance of fifteen laps computed 33 miles. As competitors took the famous Goodwood corners, unknown to the cycling fraternity–Madgwick, Fordwater, St. Mary's, Lavant, Woodcote, Paddock Bend, a number of practical considerations came into play.

With the Start at 11.55 a.m., the sun was nearing full height, and as the hour wore on, with temperatures rising towards 80°F, competitors in their badly ventilated cockpits were sweating badly. One of Dark Horse's riders described it as like putting one's head in a polythene bag and jumping up and down in a sauna. Several vehicles ran with their cockpit canopies off. The Phoenix on the other hand, made full efficient use of the air intake designed and built into its cockpit canopy and was leading the tandems for a large part of the race.

The sharpest corner–Paddock Bend–saw some vehicles coasting round, while others continued pedalling. The Webster machine repeated its instability and went skidding round on its side. Despite a cut elbow, Phil Webster pressed on courageously. Sammy Sanderson rolled his fragile vehicle, ripping it to shreds and cutting open both arms. But he brought it back into the pits in pedalling condition.

Once again, it was a victory for both the Vector single and the Vector Tandem. After consistently lapping at 3 minutes 54, the Vector Single II was first over the line after 59.57 minutes of continuous pedalling, averaging 35.04 mph, followed by the Vector Single I at 33.36 mph. Speeds of those that followed ranged down to 16mph, although many never completed the full fifteen laps due to the sweltering heat. Organiser Peter Selby felt that some consideration should be given to lowering of the number of laps to avoid future serious heat exhaustion.

As competitors returned home to all corners of Britain, California and France, many felt that another positive step had been made towards the development and introduction of human-powered vehicles into the public awareness.

Kevin M. Desmond
London, England.
12/16/81

Vector's removable hand-cranks proved heavy, slower than other Vectors at Brighton.

SYMPOSIUM *(from page 11)*

technology of ancient triremes with up to 1000 oarsmen, and some of the history of water HPV's, including pedal-powered submarines. Alec Brooks noted the good power efficiency possible with long boats. He recommended hydrofoil hulls for vehicles with less than 6 people, and displacement hulls for more than 12 people. He also recommended efficient propeller power instead of oars. Jack Lambie, an experienced cyclist and HPVer, talked about a proposed Japanese water vehicle. He noted the potential of different types of hulls–hydrofoils, displacement hulls, and submerged hulls. Submerged hulls show some promise by providing bouyancy while adding very little wave drag due to a minimum area breaking the surface.

A couple of panel discussions were also held at the symposium, but these were limited by time constraints. Discussions centered on the practicality of HPV's as land transportation. The conclusions were largely negative–current Vector-type HPV's were too specialized for street use, although upright vehicles and two-wheel recumbents are more likely to be successful.

The symposium was a definite success and much useful data was passed on to the eager audience. Proceedings, including transcripts of the presentations, will be available soon. Dr. Abbott plans on making this symposium a bi-annual event, as it will certainly continue to be an important focal point for the science of human power.

Symposium Proceedings

Proceedings of the First HPV Scientific Symposium held November 1981, Anaheim, CA, are now available. Complete scientific papers, presentations, photos, and charts from the leaders in all fields of HPV development:

LAND: Chester Kyle, PhD, Al Voight, David Gordon Wilson, PhD, Prof. Paul Schöndorf (Germany), Paul VanValkenburg, Alec Brooks, PhD, Bill Watson, John Speicher, Alex Moulton (England), Kim Aaron, Chris Dreike, Tim Brummer, Steve Ball, Greg Johnson, Shimano.

WATER: Bill Watson, Shields Bishop, Philip Thiel, Kohtaro Horiuchi (Japan), Jack Lambie, Randy Ice.

AIR: Paul MacCready, PhD.

EXERCISE PHYSIOLOGY: Joe Mastropaolo, PhD, also: Complete proceedings, HPV Symposium, Goodwood, England, Sept. 81. Nearly 200 pages: $15.00 US + $1.60 US postage/handling. Make check to IHPVA.

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