

HUMAN POWER

THE TECHNICAL JOURNAL OF THE IHPVA

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ALLAN ABBOTT UP ON THE FOILS OF THE FLYING FISH

IHPVA members shun conventions. In the air and on land the Kremer and Du-Pont prizes have brought about prodigious efforts. While nothing approaching orthodoxy can be discerned in the present generations of human-powered aircraft and land vehicles, at least the wilder variations have fallen along the way.

No prizes have been offered for new developments in human-powered boats. Although rather half-hearted invitations to builders of experimental water-craft have been published at some previous international speed trials, they were parties to which virtually no one came. The 1986 IHPVA-EXPO meetings was therefore the first truly international races for experimental human-powered boats. And because there has been little in the way of a weeding-out process, the variations in design were wide.

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HYDROFOIL BREAKS 2000-m RECORD IN VANCOUVER.

Wide variety of boats at EXPO-86 IHPVA.

By the standards of recent world fairs, EXPO-86 was a huge success. The attendance goal was passed in August, and the fair ran until early October, so that the government subsidy required was small. One of the features of EXPO-86 was the choice of transportation as an overall theme, and the selection of more specialized topics for various periods. For the week of August 24-30 the topic was "human-powered transportation". An agreement was reached with the IHPVA to conduct its annual races and speed trials in the Vancouver area, and to demonstrate human-powered boats at the EXPO site itself.

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IHPVA photos by Dave Wilson

HUMAN POWER - THE TECHNICAL JOURNAL OF THE
INTERNATIONAL HUMAN-POWERED-VEHICLE ASSOCIATION

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September, 1986

EDITORIAL.

This is written on my return from Vancouver, where a new and very high standard was set for IHPVA meets. Whereas up to now the annual international speed trials have been predominantly for land vehicles, the superb collaboration of Klaus Schmid and Tom McDonald, presidents of the Canadian and the Northwest HPV associations, and Bill Ellwyn of EXPO 86 special events added demonstrations of human-powered aircraft and boat races on a magnificent course.

The aircraft are described in the proceedings of the Third International Human-Powered-Vehicle Scientific Symposium, as are two of the exciting boats. I have reported on (almost) the whole range of boats in an article in this issue. Full results and a report of the whole meet should appear in the next HPV NEWS.

International president Paul MacCreedy announced the results of the special election of directors. These, and the full list of officers, will also be given in HPV NEWS. However, the new directors who were in Vancouver (all but one) met to choose a new IHPVA president, secretary and treasurer, who are:

PRESIDENT	Marti Daily
SECRETARY	Blake Davis
TREASURER	Bruce Rosenstiel

The IHPVA now has a new address:

IHPVA
P.O.Box 51255
INDIANAPOLIS, IN 46251-0255

and a new phone: 312 772 2073.

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The directors also voted to split the IHPVA, within about a year, into a true international HPVA, concerned only with relations among national associations, racing rules and so forth, and a USHPVA, which would be on an equal footing with the associations of other countries.

Marti Daily was and is the very effective president of the Indiana chapter, which hosted the international speed trials after successfully negotiating to hold them at the Indy-500 circuit and at three other beautiful local sites. She and her team have had added to their general major responsibilities those of forming a new body, as mentioned above, and of reaching agreement on new bylaws for both groups. They deserve our enthusiastic support.

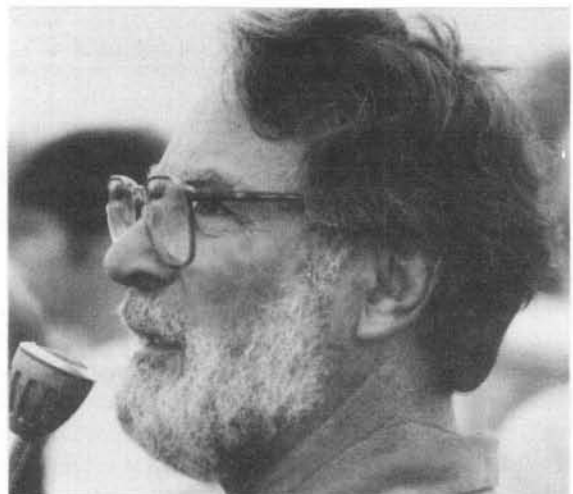
The retiring officers also deserve our heartfelt thanks for shepherding us to our present vibrant state: Glen Brown and Paul and Lois Des Jardins have shouldered the major part of the burden. May we not lose their counsel and contributions.

I would like to pay tribute to someone else who worked hard and long to produce this journal and HPV NEWS: Pat Cummings, who has moved to California and is starting her own business. She performed a dedicated and outstanding job for HUMAN POWER; I thank her and wish her well.

If you want to bring continued vigor to the IHPVA, recruit more members. I had letters from several people who responded to the last appeal with gift subscriptions to friends and relatives, and recommendations to others. Can anyone claim to have brought in a dozen new members? Let us know, and be honored!

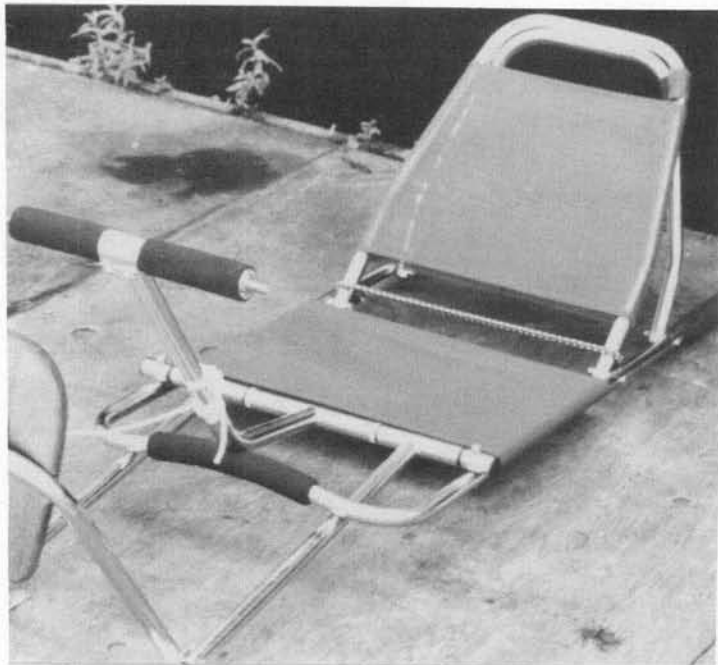
Dave Wilson

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IHPVA CO-FOUNDER JACK LAMBIE GIVING AN INFORMATIVE COMMENTARY

There was, however, unanimity in one respect. No designer wanted the rider to face backward, as in conventional rowing or sculling. Most of the boats were pedalled and propeller-driven. A right-angle drive is, therefore, almost a requirement ("almost", because there have been designs in which the rider travelled sideways, thus simplifying the power train and complicating almost everything else). Once a right-angle drive has been accepted, it is as easy to have the rider face forward as backward.



THE KYROW SEAT AND PROPULSION UNIT

But before I cover the screw-propelled boats, I want to mention a sculled boat in which the sculler faces forward. You will say that there's nothing too remarkable in that. People have been inventing mechanisms to allow people to row or scull facing forward for decades. When I and two associates were making shells in the 1960s, we dreamed up several possibilities, all no doubt having been thought of before. What seems to me to be remarkable about Kyrow, "a fast-forward experience", is that the inventors, Don and Lauren Haskins, have a strong patent, and that the realization of the concept is a nicely produced simple design that works beautifully. The whole unit can be dropped into a shell or kayak or other small boat. The feet and the arms contribute. There is no sliding seat, so that small boats do not develop a pitching action. It looks easy and fun to use. In the 250-m flying-start trials, the two Kyrows were not as fast as a traditional kayak (about 86 versus 54 seconds), but the hulls weren't chosen for speed and the scullers weren't champions. The address is:

HH Industries; PO Box 1195 El Toro, CA 92630.

Another converted kayak used a propeller, but in an unusual way. Fred Tatch of Automation Northwest (3735 N. Massachusetts, Portland OR 97227) made a clever drop-in unit that employs arm and leg power to turn a propeller (through one-way clutches) that can swivel about its axis through 360 degrees. Thus the boat had remarkable manouverability, being able to slide sideways into the dock. Fred used another virtue of one-way clutches: the gear ratio can be changed through the equivalent of 20 - 250 inches. There's little point in so wide a range, of course, but I like some variation. Whenever I try out someone's pedalled device I usually find that I'd like a gear ratio about 30-percent higher. In this boat one can get it. Fred is, like most of the participants, looking for financial backing or licensing. He has patented his device.

All the propeller drives using a right-angle drive employed either bevel gears or twisted chains. The gears were all, apparently, made by Jon Knapp (1501 West Dry Creek, Healdsburg, CA 95448). For about \$350 he supplies the gear, crank axle (to which the user attaches his/her favorite bicycle cranks and pedals), the prop-drive shaft, universal, stern gland, thrust bearing and either a 15- or a 17-inch prop.



THE KNAPP WHISTLER

The chain drives were generally a step-up of about four-to-one by a standard bike chainwheel to a countershaft. The output end carried 0.25-inch or 6-mm-pitch chain that would pass down a streamlined strut, twisting through 90 degrees to drive the propeller. Some secondary chains were formed into a Mobius loop - ie one link was opened and re-riveted with the chain at 180 degrees to its normal alignment. This helps the chain in its 90-degree turn.



THE EASY
RIDER MAX
PEDALLED
KAYAK



TOM WIGGINS ON THE KNAPP SEA SABER

The Easy Rider Max kayak of Seattle (John and Floyd Hoensealer - sp?) used a Knapp drive, and performed very creditably - 77.9 s over the 250-m course. The Velocat, a catamaran with, I believe, a Knapp propeller and drive, took a little longer, 83.5 s. Jon Knapp's own Whistler, a traditional-looking nicely finished boat somewhat along the lines of an Adirondack guide boat, took 73.5s. Jon is better known for his Sea Saber, a proa with an outrigger balancing a shell with pedals and prop drive; with Tom Wiggins pedalling its time was 53.5s, about the same as the traditional kayak. Tom has been beating all comers in the open sea. In the sheltered conditions of Burnaby Lake the kayaks could keep pace and the shells could win. Jon and Tom produce both the Sea Saber and the Whistler for about \$2000 delivered.

Now we come to the exotic craft: the hydrofoils. I am first going to claim some credit for these - but just for being a catalyst. I added to my MIT thesis list a "fun project: design and build a single-rider

boat that could pass a Harvard eight on the Charles". Undergraduate Brad Brewster took up the challenge, and designed and partly built a pedalled hydrofoil. I gave his work some publicity in an article in TECHNOLOGY REVIEW and elsewhere, and soon several people in this country, Switzerland and in Britain were trying to put his ideas into practice. David Owers (Britain) achieved hydrofoil operation in his wherry-like boat "Foiled Again", and brought over to EXPO the equally punny "Third EXPOsure", one of the three hydrofoil designs using inflatable pontoons. Unfortunately his main foil (he used two in a ladder-foil arrangement, about 4-ft and 2-ft spans) broke off during the trip over, and he did not achieve foil-borne operation on the small foil remaining.

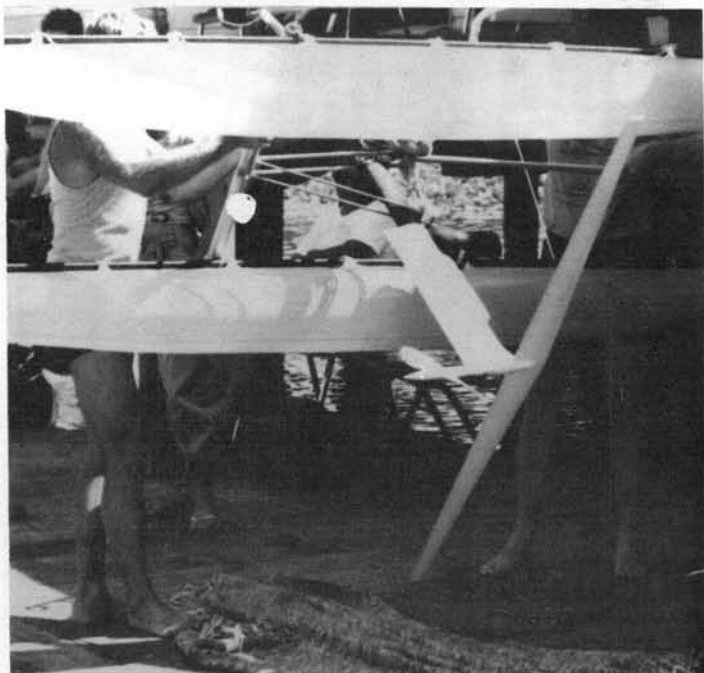


THEO SCHMIDT PEDALS THE AMPHIPED

Theo Schmidt brought the "Amphiped", on one version of which he had recently tried to bicycle from London to Paris, with the intention of crossing the Channel with the bike supported on inflatable pontoons and a screw lowered into the water. A long-duration storm in the Channel forced him eventually to give up.

The star of the show was the Flying Fish hydrofoil, designed, built and powered by Allan Abbott and Alec Brooks. This combination achieved fame in the fall of 1984 as the first known human-powered hydrofoil. In its first run it reached 12 mph. It was launched from ramps on the shore. This system meant that when it slowed to below foil-borne speed, it just sank.

The new version used inflatable pontoons designed, I believe, by Theo Schmidt and made by Stewkie Aerodynamics (Manor Farm, Melbury Osmond, Dorset VT2-OLS, UK), and incorporated a beautiful carbon-fiber main foil and propeller. The front foil is steerable



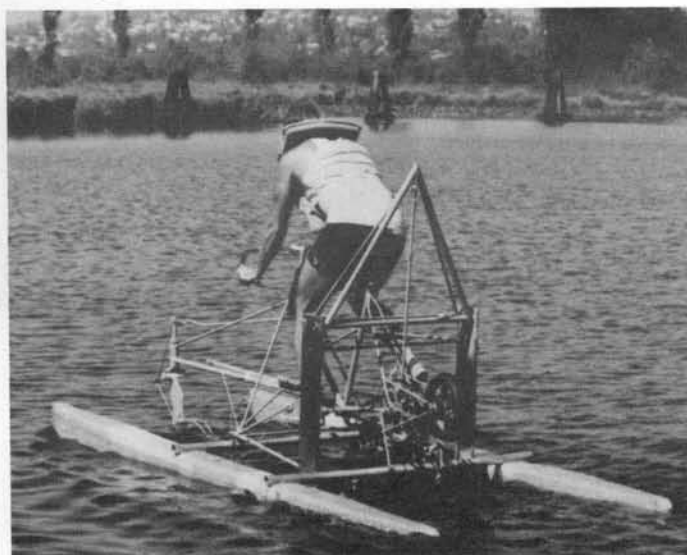
THE MAIN FOIL, PROPELLER AND STRUT OF THE FLYING FISH

from the handlebars, and the depth is controlled through linkage from a skimmer at the surface actuating a trailing-edge flap (or "aileron") on the foil. The analysis and design is nicely described in a paper by Alec Brooks - who has been entering winning machines since he was part of a student team as the IHPVA was being formed, and is part of the MacCready team that built the Gossamers, the Bionic Bat and the Pterosaur - called "The 20-Knot Human-Powered Water Craft", in the Third International Human-Powered-Vehicle Scientific Symposium (obtainable from the IHPVA, PO Box 51255, Indianapolis, IN 46251-0255, for about \$25). Allan Abbott is a physician, the first president of the IHPVA, the former holder of the world's paced bicycle speed record, and the first person to pedal a vehicle over 50 mph.



PARKER MACCREADY FOIL-BORNE

The Flying Fish is a remarkable sight. Only a few pedal strokes are needed to bring it up from its pontoons and to be foil-borne. The virtual absence of waves and spray is the most noticeable aspect. There is a little spray around the prop-shaft and the vertical strut. Otherwise it comes cruising coolly past fussier boats as if it, and possibly its rider, were not even straining. Allan covered the flying 250-m course in under 38.5s, and the standing-start 2000-m in 6min 39.3s, compared with the world rowing record of 6min 49s.



MUTINY ON THE BOUNDARY LAYER

The "funny boat" of the races was the flapping-wing hydrofoil ("Mutiny on the Boundary Layer") built by Parker MacCready, son of Paul MacCready and former pilot of the Bionic Bat (which won the second high-speed Kremer prize for HP-aircraft). His effort was stimulated by the team's work on the Smithsonian-sponsored development of the flapping-wing flying pterosaur (which will have been seen in most science magazines and TV programs by the end of the year). The main, rear, foil (about 5-6-ft span) is oscillated by the pedals through an amplitude of about 8 inches at about twice pedal-crank speed, changing incidence through each cycle. Despite a mechanism of considerable mass - an automobile flywheel is used to produce a smooth motion - Parker achieved foil-borne operation, although not over a long distance. This boat was a remarkable development, with potential considerable significance for the future. He describes the work in "Features of Flapping-wing Propulsion" in the Third-Symposium proceedings mentioned above.

Another oscillating-foil craft, not raced at Burnaby Lake but demonstrated at the EXPO site, was a kayak converted by Calvin Gongwer to propulsion by the lateral oscillation of two vertical foils at the stern. The system appeared to work smoothly and easily, and I

regret that circumstances (a bug or bugs) prevented me from trying it out. He has promised an article about the system in a future issue of HUMAN POWER. Also see Einar Jakobsen's article on foil propulsion in this issue.

Also at the EXPO demonstration site was the Hoyt-Harken Waterbug (HP vol. 3, no. 4, summer 1985), a beautiful pedalled screw-propelled production boat, now joined by the slightly larger Mallard (of which we hope to have a report in the next issue).

For a first meeting of experimental human-powered water-craft, this showed greater maturity and energy than I had expected. There were several boats that I would purchase in preference to a shell for personal use or to a dinghy for the family. The IHPVA is seeking a sponsor for prizes for developments in HPBs. If one is found, expect to see some remarkable progress in speed and utility of screw-propelled and flapping-wing craft, and of other types that are still just gleams in their inventors' eyes.

Dave Wilson

HPV-RELATED NEWS.

SOMA, subtitled "Engineering for the human body", is a new journal published by the ASME and edited by Ali A. Seireg of the University of Wisconsin. In vol.1, no.1, April 1986, a major article was "Optimum human power", by Craig J. Cornelius and Ali Seireg. They describe an ergometer, which they call a simulator, that "can produce some 12,000 motion patterns, be adjusted for different body postures, and continuously monitor all the significant physiological and mechanical data of the operator". Mechanicians will recognize the apparatus as a crank-slider system, with the pedal or hand-crank input located at some point in the plane of the slider link. The crank output goes to a brake through a universal joint that can be set at an angle giving a cyclic torque variation. Only the early results are given in this first article, principally confirming that the maximum force in a motion should be in phase with the maximum velocity. We await with much interest the data that should compare human power output from different motions.

Other papers in the first issue of SOMA are on astronaut simulation, fiberoptics in medicine, tools of biokinematics, shoes and socks, orthopedic implants, and sports equipment for the handicapped.

BIKE TECH.

The spring, 1986, issue starts with an article by IHPVA members ("Fusion") Leisha Peterson and Kelly



THE FOIL PROPELLED KAYAK PROA OF CALVIN GONGWER

Londry on finite-element structural analysis; and Mike Burrows on carbon-fiber monocoque frame design. Bill Mathauser writes on his new hydraulic brakes; and there is a favorable review of the fourth edition of Sutherland's Handbook for Bicycle Mechanics.

The fall issue starts with an article about HPUVs - "U" for utility, including a photo of Falk Riess and Rainer Pivitt with their bike trailer, which we will mention elsewhere. There's a short piece on pedalling with a particular four-bar linkage, without any data on advantages or disadvantages of such a linkage. Some good research on wet and dry braking is reported from Germany, though it was not correlated with other work and in some respects did not go as far. The other major article is on frame alignment.

CONTRIBUTIONS INVITED!

Your contributions to HUMAN POWER are always welcome (but we don't guarantee to publish everything). The categories are major articles (up to 4000 words); reports (2000 words); technical comments, reviews of books or new technology (1000 words); and letters (500 words). If you would like a guide to contributors, write for it. If you can send your contribution on a 5-1/2-inch diskette in ASCII text it would save me much work, but send it in any form you like so long as it is absolutely clear.

Dave

David Gordon Wilson, 15 Kennedy Rd, CAMBRIDGE, MA 02138

FOIL PROPULSION AT SEA

Einar Jakobsen

Since 1978 we have been working in Norway on a principle for propulsion at sea which we have called "The Foil Propeller" (patented in the U.S.A.). The main goal for the development has been to utilize wave power for propulsion. The foil can also be driven by engine power with a very high efficiency. For demonstration purposes we have also made a small catamaran with muscle-driven foil propulsion. This goes quite fast, and it has impressed many onlookers. The craft is made for demonstrations, and the foil is driven by hand. In a practical design foot operation would be preferred.

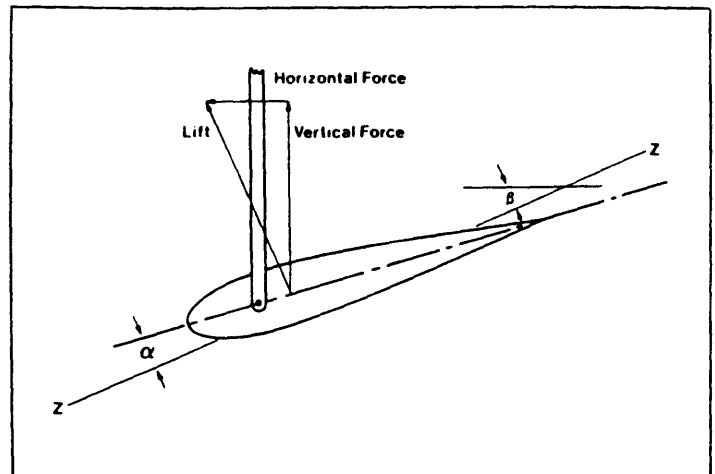
The conventional screw propeller and its propulsion efficiency.

A screw propeller cannot reach a high efficiency unless the area of the propeller disk is relatively large. The propeller, in order to give the necessary propulsion force to the ship, must accelerate water rearwards. The smaller the diameter (and area) of the propeller, the higher the velocity that this water must be given. The water is also put into rotation. This water thus contains kinetic energy which represents loss. Kinetic energy is proportional to V^2 , and a propeller covering a larger area can give the pushing force needed by accelerating a greater amount of water up to a lower speed. The loss will then be smaller.

In the last few years high priority has been given to developing systems using screw propellers with larger diameters, but there are obvious practical limits to this. For small ships and boats the propulsion efficiency of conventional propellers is often as low as 50-60%.

Working principle of THE FOIL PROPELLER
(See Figure)

The leading edge of a streamlined wing is mounted on a pivot. This in turn is connected to a supporting structure. The wing is equipped with an elastic, mechanical force, always trying to bring the wing back to its neutral, horizontal position. This force may be a hydraulic or pneumatic, or (as used on our models, and on our muscle-driven catamaran) steel springs. When the supporting structure is moved downwards, the trailing edge of the wing will deflect upwards, and it will thus exert a forward thrust on the supporting structure. If the arrangement is



The principle of foil propulsion.

connected to a moving boat in waves, the boat will transfer its vertical movement to the wing. And as the wing is situated at a depth where wave height is smaller than at the surface, it will be moved in relation to the water in its vicinity. A forward thrust will be present both when the wing is moved down, and when it is moved up.

The speed of the boat is normally considerably higher than its vertical speed of movement, so the deflection angle of the wing is not large. But this angle is kept as long as the vertical movement is taking place, and in full scale this may have a duration of seconds. As shown in the figure (vertical movement of the wing downwards), the wing will follow the line Z-Z, which is a result of horizontal and vertical speed. The elastic, mechanical force will give the wing its angle of attack, α and thus lifting force.

- Relation between wavelength and wave period in deep waters:

$$\lambda = \frac{T^2 g}{2\pi} \text{ metres}$$
- Wave velocity: $V_w = \frac{g T}{2\pi} = \frac{\lambda}{T}$
- Wave group velocity: $V_g = \frac{V_w}{2}$
- Wave power, $K = H^2 T$ kW/m wave front
- The generation of lift by a flying wing:

$$L = 0.5 \times \delta \times C_L \times V_f^2 \times S \text{ (Newtons)}$$

where g = gravitational acceleration of 9.82ms^{-2}
 λ = wave length (m) from crest to crest
 H = wave height (m) from trough to crest
 π = 3.14
 T = wave period in seconds
 λ = density of medium (kgm^{-3}) (seawater = 1026)
 C_L = coefficient of lift
 V_f = speed of wing (m/s)
 S = area of wing (m^2)

Formulae of interest.



THE AUTHOR OPERATING HIS FOIL -PROPELLED CATAMARAN

Photo by Bjorn Fjortoft, Oslo

Foil loading (lift)

At a speed of 12 knots (6 m/s) a wing of 1 m^2 can be loaded by 13 kN (2,500 lbf). From the figure it can be seen that the sine and cosine to the gliding angle, β , multiplied by the lift, will give the forces in horizontal and vertical directions. A foil with a gliding angle of 20 degrees as mentioned above, will give a propulsive force of 4.4 kN (990 lbf). From this it can be seen that the foils do not necessarily have to be large to give valuable assistance to propulsion.

Muscle-driven foils

Nature itself has over a long time developed propulsion systems based on wings "flying" in water: many whales and fishes have very efficient tail propulsion, and can achieve high speeds. The tuna-fish has been recorded reaching speeds of 40 knots (20 m/s). Interestingly, the shape of the tails of the fastest of these animals seems important: it is like a crescent-moon, often referred to as a "lunate" tail. The tunny, the mackerel-shark lamna, and the dolphin, all unrelated, have developed a similar type of caudal fin. And it is intriguing that the fastest fish and whales have the smallest tails.

Vertical movement in relation to the surrounding water is needed to give propelling force. This can be achieved by vessel motion such as pitching, heaving and rolling. It can also come from the vertical movement of the waves themselves on the foil. However, in our wave tests the best results have come from pitching and heaving. The vertical movement can, clearly, also be induced by moving the wing using engine or human power, and results in a very high efficiency.

Theoretical and practical work has been done at Chalmers University, Gotenburg, with the aim of finding out how efficient driven foil propellers can be. J. Lunde discovered that more than 90 percent efficiency may be achieved (94 percent theoretically), and practical tests with rather primitive equipment gave up to 75.9 per cent.

The propulsion efficiency of the foil propeller is high compared with the frequently found values of under 60 percent found with many screw propeller systems today. The efficiency is comparable to, and possibly higher than, the Larrabee-type of propeller designed for minimum induced drag, but may have a more suitable shape (wide but requiring less depth)

than a large-diameter propeller. Thus, large quantities of fuel can be saved by using engine-driven foils, even if no wave power is available. And foil propulsion may be particularly suited for human-powered propulsion, in competition with the use of oars and pedal-driven craft. We have prototypes already built.

Test results from wave-powered propulsion

Since 1978 the equivalent of \$600,000 has been used for research and development of the principle of foil propulsion, and about half of this has come from governmental sources in Norway. During tests made by the people at the Hydrodynamic Laboratories, Trondheim, in 1980, a 1.03-m model boat reached a speed close to 2 knots (1 m/s) in head seas. This showed that a full-scale counterpart at times would have achieved higher speeds than if driven by its engine.

In 1979 we started tests with different foil systems on a 8.2-m (27-ft) boat in open seas, and have reached up to 6 knots (3 m/s) using wave power alone.

We are trying to find reliable data on fuel savings through the use of relatively small auxiliary foils. A 180-tonnes, 20 m-long research vessel, "KYSTFANGST", belonging to the Institute of Fishery Technology Research in Trondheim, was used for a test of two foils, each of 1.5 m². In this case the foils were tested as an auxiliary propulsion means, to see if the same speed could be maintained with less engine power. The total foil area was in this case only 2.6 per cent of the deck area of the vessel. Despite the small foils, the propulsive force many times exceeded 4000 lbf (20 kN), and gave 15-22 per cent of the needed propulsion in 3-m waves.

Full-scale tests are time consuming and costly, and the change of wave conditions from one day to the next add to the difficulties. As a continuation of the "KYSTFANGST" test using auxiliary propulsion from waves, we have engaged VERITEC (Det Norske Veritas) to make a computer simulation of different ships and boats equipped with foils at sea. VERITEC is a well recognized company, having experts on the simulation of ships' behavior in different waves.

VERITEC has published two reports, the later in August, '86, and the results have surprised us all.

A 180-m, 50.000-tonnes ship, moving against average waves of the north Atlantic at a speed of 17 knots (8.7 m/s) would save 61 per cent of the fuel (foil area 4 per cent of the water-line area of ship).



MS. JAKOBSEN HOLDS THE OSCILLATING FOIL

A fishing vessel of 40-m length, equipped with two foils at the bow with a total area of 6 per cent of the water-line area of vessel, would be able to move against average North-Sea waves at a speed of at least 8 knots (4 m/s), without the use of its engine. The roll angle would be dampened up to 36 per cent.

Conclusions

Ocean waves contain vast amounts of power, about ten times more concentrated than in winds. VERITEC reports, and our tests, have shown that ships and boats could save huge amounts of fuel by the utilization of wave power for propulsion. Work at Chalmers University shows that high propulsion efficiency can be achieved by the powered foil propeller.

A small hybrid craft, foil propelled by human power and wave power should be of interest.

Einar Jakobsen
Wave Control CO.
Roven, N-1920
Sorumsand, Norway

POTENTIAL FOR THE EVOLUTION OF A NEW SPECIES

Paul MacCready

Almost a century ago, after several decades of design innovations, the conventional bicycle emerged with its two equal-size tangent-tension-spoke wheels, pneumatic tires, and chain-driven rear wheel. The modern bicycle differs from this ancestor only in detail; except for the gear shift, the changes would scarcely be detectable to the casual observer. One reason the 1886 and 1890 bicycles are similar is that the 1890 version was so good, being efficient, safe, easy to ride, and simple and inexpensive to build. Another reason is that bicycle competitions, which tend to set technological standards, dictated that the vehicle not be improved to give a rider an unfair advantage. Like a species of animal, the multitude of these satisfactory bicycles fitted well their broadly based and economically driven "ecological niche" and the design evolved only very slowly and in minor ways as the decades went by.

A modern view of natural evolution has a new species sometimes evolving out of a stable, established species via a major, rapid, adaptive change. The phenomenon is labeled "punctuated equilibrium". In a suggested scenario a small group, in a circumstance where different ecological pressures are found to be especially favorable to certain inheritable genetic aberrations. The genes of the odd superior individual in the large population get submerged in a massive gene pool and have little effect. But in a new, small, isolated ecological niche, the superior individual's superiority can be relatively more important for survival, the individual's genes will be less diluted in the small population, and in relatively few generations a new species can evolve. Eventually the new species may even spill over into the large original ecological niche and prove to be competitively superior there and completely supplant the original species.

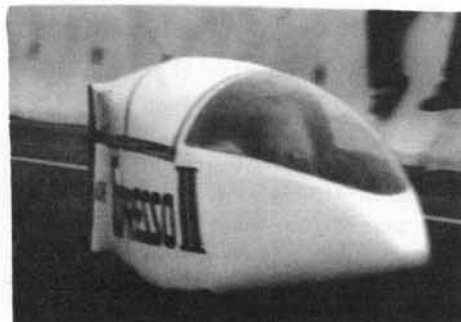
In 1975, the International Human-Powered-Vehicle Association (IHPVA) was formed to stimulate the development of fast human-powered vehicles without the inhibiting effects of rules. The sole criterion of success was "going fast", with no concern about the mechanism or configuration. The resulting evolution of new designs was rapid, as a small number of inventors (initially in Southern California) found what worked in his new isolated "ecological niche". Fantastic speeds are now being achieved: equilibrium was "punctuated".

After a few years of strictly speed competitions, IHPVA added competitions for "practical" vehicles, thus establishing a broader "ecological niche". The definition of "practical" is still in a state of flux, as are the criteria for judging the vehicles, but the overall aim is clear: a human-powered vehicle which offers safety, speed, versatility, comfort, and economy, and which would be attractive both to commuters and long-distance riders. The designs evolving from the practical-vehicle competitions so far have fallen far short of achieving the overall aim, but the competition stimulates further refinement. It is an important subject inasmuch as human-powered vehicles, which help with health, recreation, and transportation, will play an increasing role as civilization edges toward accommodation with the ecology and resources of our limited globe.

Improving the process of stimulating- innovation is one of the high points of the last quarter century of bicycling. Within the ordinary bicycle field there have occasionally been isolated pioneers showing that streamlined fairings permit higher speeds or that unusual configurations show promise for meeting a specific customer's desires, but such aberrations had negligible impact in relation to the mass of conventional bicycles. Serious developments were economically driven, and tended to be ones which could be comfortably assimilated into the mainstream: the ten-speed derailleur, improved brakes, miscellaneous accessories, etc. The IHPVA has introduced an enthusiasm for generating significant change. There has been too little time to make the IHPVA impact clear, but it is a good bet that many persons in the year 2000 will be riding a new species of advanced bicycles (or tricycles) because of the efforts of the IHPVA.

Paul MacCready
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825 Myrtle Avenue
Monrovia, CA 95060

(This was written for the anniversary issue of BICYCLING)



EXPRESSO
EVOLVES IN
VANCOUVER

LETTERS TO HUMAN POWER.

I'd like to clarify a few things regarding my tube-frame design for two-wheeled supine recumbents, described in HP v.4 no.4, fall 1985, p.7. This is particularly in response to Jim Roberts' comments in HP v.5 no.2, summer 1986, p.13. I think that the stiffer a frame is against pedalling forces, the better. If I want to measure frame flexibility to find where it is bending I build an extra-flexible frame. It feels as if I'm pedalling a very heavy bike, and it can barely be coaxed up small hills. I assume that if more pedalling stiffness is desired on a flimsy frame, then more pedalling stiffness would be desired on a stiffer frame, as I see no new rules coming into play.

Roberts wants to smooth out his pedal stroke by using a springy frame, but it would be better to improve the stroke in the crank mechanism, such as with Shimano Bio-Pace, Sugino Cycloid, Houdaille Power-Cam, etc..

If the seat on a supine bike were well up off the ground, it would be necessary to make the frame stiff along two lines, one from the seat to the bottom bracket, the other from the bottom bracket to the rear axle. This gives a rather complicated structure. By lowering the seat as close as we can get to the frame, these two lines almost merge into one, so that a single tube can be used. Admittedly the tube will still need more vertical stiffness than lateral - my crude tests suggest the ideal would be an oval-shaped tube about 30 percent taller than it is wide - but not enough to justify adding a second tube. A tube frame of the same pedalling stiffness will have less vertical stiffness, making a small but (to me) noticeable improvement in ride.

In an attempt to lower the seat right down to the frame my latest test bike routes the upper part of the chain down through the frame, sliding on a piece of Delrin self-lubricating plastic. This caused more problems than it solved; in addition to the greater complexity, the chain would actually pull the middle of the frame upwards under pedal pressure, increasing frame flex.

Incidentally, a lot of Roberts' steering problems on rough roads would be solved by just putting on a wider back wheel.

Charles Brown, c/o 22928 Oxford, DEARBORN, MI 48124

I sent Charles Brown's letter to Jim Roberts for rebuttal, but Jim wrote that "I don't think HP is the place for argument, but rather exposition". He did say, though, that he didn't agree with Charles on the wheel-width question. On another matter, Jim wrote:

"We aren't looking at what is going on closely enough by way of proprietary products. To some extent, we need reviews of what is hot or different, not assuming that all members live in the middle of a major American city, awash with fruity technology. . ."

It's dangerous to make a casual, and therefore possibly biased, review of new technology, but I would love to publish careful, well-documented reviews. Send them in to me at 15 Kennedy Road, CAMBRIDGE, MA 02138.

Dave Wilson

THE MEDICAL AND SCIENTIFIC ASPECTS OF CYCLING.

A two-day congress held with the 1986 World Cycling Championships in Colorado Springs four days after our own Third Scientific Symposium on Human-Powered Vehicles had some speakers in common, including Paul MacCready, Chet Kyle and Antonio Dal Monte. I will not try to review their papers, because I hope that all of you will buy or borrow the IHPVA Symposium proceedings when they become available (Allan Abbott, who did a superb job organizing the symposium, estimates October). Here are what I selected as highlights of the first day of the Congress. (Unfortunately I could not stay for the second day).

David Costill discussed the nutritional demands of cycling. He maintained that there are fads that do not stand up to examination: for instance, that the body needs to be supplied with an electrolyte replacement. The principal needs of athletes undergoing strenuous exercise for period of a few hours are for water and glucose. He was quite open about being associated with Coca Cola in the launch of a new drink for athletes. He also said that a carbohydrate meal before exercise is good, but not within 30-45 minutes. The athlete should start replacing liquid well before he/she feels any need for it.

Francesco Conconi showed curves of heart rate correlated against some measure of power output, such as running speed. The relationships were linear for all types of effort up to some limit, at which the heart rate leveled off. He maintained that this limit of proportionality was also the limit of aerobic power, and that blood lactate increased after this point. His thesis provoked a lively debate, including the following speaker, Peter van Handel, whose talk was on the measurement and interpretation of physiological parameters associated with cycling performance. This discussion, which I will not try to summarize, and the discussion at the end of the day, which included Arthur

Campbell from the Union Cycliste Internationale, showed me that US and world bicycling is far from the static condition that I used to assume. The debate between those who wanted to clamp down on bicycle-design changes because of the cost to people in small countries, and those who wanted the rules relaxed at a greater rate (Arthur Campbell said that the last few years had been a "nightmare" because of disk wheels and streamlined components) was heated. (Paul MacCreedy's talk had been on just this topic).

CLOTHING, CHET KYLE AND HANG-GLIDING.

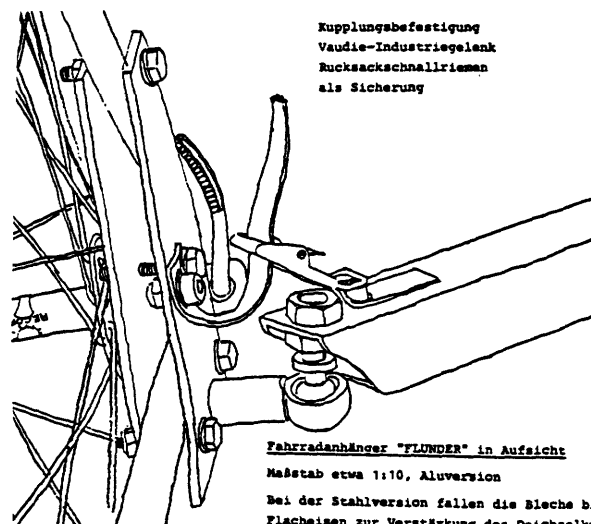
"Athletic clothing" is the title of another of Chet Kyle's delightful articles, in a recent SCIENTIFIC AMERICAN. (Don't ask me why I don't write the date on articles I tear from magazines). A more-popular article on the relationship between aerodynamics and clothing is in Schweizer Illustrierte no. 2, January 6, 1986. One of the magazines with which we exchange issues is HANG GLIDING: the modern harness is combined with an aerodynamic body suit or bag for improved comfort and performance.

HPUVs IN LATIN AMERICA AND GERMANY.

A large and very thorough paperback on the use of bicycles and tricycles in Latin America ("La Bicicleta y los triciclos", Ricardo A. Navarro et al, 1985) has a wealth of photographs, tables, diagrams and drawings of various present and projected uses of cycles and pedal power there. It is published by a coalition of intermediate-technology groups, the principal apparently being SKAT, Varnbuelstrasse 14, CH-9000 St.Gallen, Switzerland.

There is a great deal of activity on HPUVs in Germany, if "utility" includes commuting, in addition to the UHPVs (for "ultimate") sponsored largely by Wolfgang Gronen. Since 1982, a small research group led by Falk Riess and Rainer Pivit (who travelled to the 12th International Speed Trials at EXPO-86) in the physics department of Oldenburg University, West Germany, have been working on general human-powered lightweight vehicles. Their especial emphasis has been on a commuter vehicle for city use. They also have a strong interest in improved safety, following a substantial increase in bicycling injuries and deaths in West Germany in the last decade. (This is partly the result of increased bicycle use).

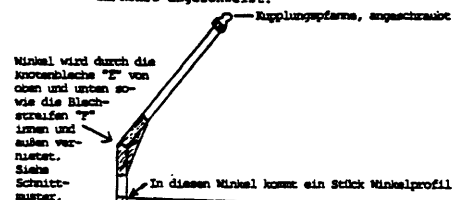
One recent practical development was of a bicycle trailer. It was shown on TV, and resulted in such a huge number of inquiries that Norddeutscher Rundfunk, the TV company, sent out the group's instruction booklet, free, on how to construct the trailer. We will try to give just some of the diagrams here, without attempting a translation. Dimensions will be in mm; "stahl" is steel, and "alu" can be guessed.



Fahrradanhänger "FLUNDER" in Aufsicht

Maßstab etwa 1:10, Aluversion

Bei der Stahlversion fallen die Bleche bis auf ein Flacheisen zur Verstärkung des Deichselknicks weg, und die Ausfallenden werden nur an die Innenseite der Nabe angeschweißt.



Would anyone willing to translate these plans please let me know?
Dave Wilson

We hope to have a formal article from Oldenburg in a future issue. It is obvious that we do not keep as up to date on international work as we should. See the next item.

BIBLIOGRAPHY ON BICYCLE LITERATURE.

This is another publication from Oldenburg University, in the production of which Rainer Pivit was joined by Heinrich Allers and Wolfgang Bohle. They review 357 publications, mainly from Germany, Britain and the US, in 67 pages, and then they produce several breakdowns by categories. It is impressive how much of the English-language literature is covered, whereas I know of nothing in English that attempts to cover world HPV publications (an idea for a bachelor's thesis?). The price is not given, but I will guess that \$7.50 would cover it and postage, and that this address would be good:

Rainer Pivit
Bicycle Research Group
University of Oldenburg, Physics Dept.
PO Box 2503
D-2900 OLDENBURG, WEST GERMANY

HPV SOURCE GUIDE.

Michael Eliasohn

The following is an update of the source directory on human-powered vehicles that appeared in the fall 1985, issue of HUMAN POWER.

The only sources listed in that directory that appear in this update are those which I have been told have either added a new product during the past year or have a new or corrected address. I did not contact everyone listed a year ago to determine if he/she had new products or were still in business.

Most of the firms and individuals listed here were sent to me in response to the request for new sources published in HPV NEWS. My thanks to everyone who responded.

As was stated in the introduction to the original directory, in your search for items don't forget the Yellow Pages. Local bike shops may be able to order parts they don't stock. Thin plastic for windshields can be found at plastics-supply and some hardware and discount stores. Heat-shrink plastic can be obtained at hobby shops (for model airplanes) and at hardware and discount stores (for covering windows in winter). Thin foam panels may be found at art-supply stores and corrugated-plastic panels at graphic-arts stores and box suppliers. Both can be used for simple HPV fairings without compound curves. Spandex stretch cloth, also used for fairings, is stocked by many fabric-supply stores.

Some of the firms listed in this directory update will handle mail orders, but some may deal only with walk-in customers. If no mention is made of literature, I suggest phoning or sending a self-addressed stamped envelope with inquiries.

Next year I am tentatively planning a complete update, that is, to contact all firms and individuals listed this year and last. To make that effort easier, I would appreciate anyone finding any sources listed that have gone out of business or who won't handle small orders from individuals to let me know. Also, please send me any new listings or give me a call.

If anyone with a computer would like to help me with the 1987 revised directory, please let me know.

Michael Eliasohn
2708 Lake Shore Drive, apt. 307
St. Joseph, MI 49085
616 982 4058

1. READY-TO-RIDE HPVs AND FRAMESETS.

1. Alternative Bikestyles previously listed
P. O. Box 1344
Bonita, CA 92002

New: plans, kits to convert BMX bikes into recumbents, called Beam-X.
Literature available.
2. Angle Lake Cyclery
Corrected address:
20840 Pacific Hwy. South
Seattle, WA 98188 (206) 878-7457

Alex Moulton bicycles, accessories, parts
(17 x 1 1/4 wheels, tires).
3. D. C. Custom Enterprises
9480 Cambie Road
Richmond, BC V6X 1K4
Canada

Short, long and tandem recumbent bicycles.
Brochure \$2.
4. DeFelice Recumbent Bicycle Corp. previously listed
P. O. Box 321
New Palestine, IN 46163 (317) 861-6045

Lower-cost model now available in 4 frame sizes. Literature available.
5. Fendt Co. (US distributor)
2512 Crystal Spring Road West
Tacoma, WA 98466

Fendt Cardano Comfort upright bicycle with suspension, shaft drive (made in West Germany).
6. Kann Mfg. Corp. previously listed
P. O. Box D
Guttenberg, IA 52052

Recumbent bicycle now in production.
7. Hammacher Schlemmer
147 E. 57th Street
New York, NY 10022

Sculling-action cycle.
8. Lewis Cycles (Peter Lewis)
8615 Regent Road
Milwaukee, WI 53217 414-351-2453

Tour-Easy and Roulandt dealer.

9. Rans Co. previously listed
1104 E. Hwy 40 Bypass
Hays, KS 67601 (913) 625-6346

2 recumbent models (complete bikes or framesets) now available in different frame sizes.

Lower-cost bike/frameset now available - brochure available.

New model under development.

10. Roulandt Recumbent Distributors
Southeast: Trailmate
2151 Trailmate Drive
Sarasota, FL 34243 (813) 755-5511
Northeast: Tekton Corp.
Conway, MA 01341 (413) 369-4367
West: Roulandt California
1045 N. Azusa Ave., No. 236
Covina, CA 91722 (818) 969-1616

Literature available.

11. Swingbike American Imports Inc.
25743 Adams Road
Los Gatos, CA 95030 (408) 353-3341

Rowing-action bicycle.

12. Ultimate Vehicles previously listed
Saginaw, MI

No longer in business.

13. Via Cycles USA
P. O. Box 223
Pearland, TX 77588 (713) 489-0814

Long- and short-wheelbase recumbents.

2. PLANS.

1. D. C. Custom Enterprises
9480 Cambie Road
Richmond, BC V6X 1K4

Plans for long-wheelbase (\$25), short-wheelbase (\$30), and tandem (\$45) recumbent bicycles. Brochure \$2.
2. L. M. Hendricks
1350 E. Main Street
Houma, LA 70363 (504) 872-0590

Recumbent bicycle, plans \$10.

3. Lyons Gifts
Dept. PS 2
1124 Molvey Ave.
Winnipeg, Manitoba R3M 1J5
Canada

Side-by-side tandem 4-wheel recumbent plans, \$7.95.

3. COMPONENTS.

1. Cyclo-Pedia Inc.
P. O. Box 884
Adrian, MI 49221-0884
(517) 263-5803 (hours M-Th 1-8 PM, Tues 1-11 PM)

Mail-order bicycle parts, including some small wheels and tires, big chainrings - price list available.

2. John Howard Performance Bicycles and Accessories
1705 Old Mill Road
Encinitas, CA 92024 (619) 753-5894

Flexten Mylar wheel spoke covers.

3. HUDYN Vehicles (Tom McGriff) previously listed
P. O. Box 22444
Indianapolis, IN 46222

New products:

20 x 1 1/4 skinwall tires, drum-brake hubs, drum brakes w/internal 3- and 5-speed transmissions, form-fitted fiberglass seats - free information.

4. Mountain Safety Research
1212 First Ave. S.
Seattle, ? WA (206) 624-8573

Manufacturer, quick disk wheel spoke covers for 27 inch, 700C, 26 inch, 20 x 2 1/8, 17 x 1 1/4 wheels - other sizes under development.

5. Douglas Milliken
245 Brompton Road
Williamsville, NY 14221 (716) 632-6710

Wheel disks (spoke covers) for Alex Moulton 17 x 1 1/4 wheels - send SASE.

6. Pesznecker Brothers Inc.
P. O. Box 375
Clackamas, OR 97015 (503) 655-5128

Large, custom chainrings.

- | | |
|---|---|
| <p>7. <u>Portable Bicycle Design</u> previously listed
 Gary Crooks
 New address:
 198 W. Harcourt Street
 Long Beach, CA 90805</p> | <p>2. <u>Aircraft Steel</u>
 P. O. Box 307
 Lafayette, CO 80026 (303) 665-5817

 Steel and aluminum tubing.
 Catalog available.</p> |
| <p>8. <u>Ken G. Rogers</u>
 71 Berkley Ave.
 Cranford, Hounslow
 Middlesex TW4 GLF
 Englanu 01-897-9109

 New product: tricycle hubs
 dual-wheel-drive tricycle axle.</p> | <p>3. <u>Allied Chemical Corp. - Fibers Div.</u>
 Technical Center
 P. O. Box 31
 Petersburg, VA (804) 520-3265

 Spectra fiber (supposedly lighter than
 Kevlar).</p> |
| <p>9. <u>Stick em Up</u>
 1642 Holmes Street
 Livermore, CA 94550 (800) 227-2924
 CA only: (800) 524-5102

 Olympic wheel spoke covers for 20, 26, 27
 inch wheels - available at dealers.</p> | <p>4. <u>Alternative Engineering</u>
 8 Goldsmith Street
 Heavitree, Exeter
 England phone: Exeter 51137

 531 tubing, cycle-frame parts, miscellaneous
 parts. Also brazing, welding, "will construct
 anything to order".</p> |
| <p>10. <u>True Wheels</u>
 South Milwaukee, WI

 Apparently no longer in business.</p> | <p>5. <u>Bradson Supply Inc.</u>
 4001 35th St. N.
 St. Petersburg, FL 33714 (813) 526-6465

 Epoxy supplier.</p> |
| <p>11. <u>UNI-USA</u>
 3815 S. W. Murray
 Beaverton, OR 97005

 Nylon wheel spoke covers
 20, 24, 26, 700c, 27 inch wheels.
 Write for name of dealer.</p> | <p>6. <u>Cadillac Plastic and Chemical Co.</u>
 Branches in South Bend, Detroit, Cleveland
 and probably other cities - plastics supplier.</p> |
| <p>12. <u>Wag-Aero Inc.</u> previously listed
 P. O. Box 181 (not 81)
 Lyons, WI 53148
 (414) 763-9586

 Rod end bearings, etc.
 Free catalog.</p> | <p>7. <u>Chem-Tech</u>
 4669 Lander Road
 Chagrin Falls, OH 44022

 Epoxy supplier.</p> |
| <p><u>4. CONSTRUCTION MATERIALS.</u></p> | |
| <p>1. <u>Advanced Composite Technologies</u> previously listed
 P. O. Box 24722
 Baltimore, MD 21220 (301) 882-6051

 Revised product lineup:
 composite materials - Kevlar, graphite foam,
 resin, book. Catalog \$4, includes graphite,
 Kevlar samples, refundable with \$35 purchase.</p> | <p>8. <u>Clark Associates Inc.</u>
 Sugarloaf Star Route
 Boulder, CO 80302 (303) 444-1890

 Kevlar and fiberglass cloth.</p> |
| | <p>9. <u>Clark Craft Boat Co., Inc.</u>
 16-834 Aqualane
 Tonawanda, NY 14150 (716) 873-2640

 Epoxy supplier.</p> |

(Paul and Lois Des Jardins have published the original Guide as a separate booklet. I don't believe that the price is fixed, but if you send \$1.75 to the IHPVA it should be enough - Ed).

10. Commercial Plastics Supply
1642 Woodhaven Dr.
Cornwells Heights, PA 19020 (215) 638-0800
11. Fibre Glass-Evercote Co.
6600 Cornell Road
Cincinnati, OH 45242 (513) 489-7600

Epoxy supplier.
12. Fomebords Co.
2211 N. Elston (home office)
Chicago, IL 60614 (800) 362-6267
IL only: (800) 462-6267

Other sales offices in Los Angeles, St. Louis,
Greensboro, NC, North Kansas City, MO.

Lightweight foam and plastic panels suitable
for HPV fairings including Fome-Cor, Sintra,
Cor-X.
13. Glassteel Tennessee Inc.
P. O. Drawer 521
Collierville, TN 38017 (800) 238-5548
(except TN)

Manufacturer of corrugated and other
plastic panels suitable for HPV fairings.
14. Glen-L Marine Designs
9152 Rosecrans
Bellflower, CA 90706 (213) 630-6258

Epoxy supplier.
15. Headland International
2020 124th Ave. NE
Bellevue, WA 98005 (206) 855-0622

Epoxy supplier.
16. INAV Ltd.
P. O. Box 2984
Oshkosh, WI 54903 (414) 426-1212

Aluminum bonding epoxy cures at room
temperatures. Catalog \$3.
17. Industrial Titanium
310 Pflingston Rd.
Northbrook IL, 60062 (312) 272-2730
18. Koppers Co., Inc.
1850 Koppers Bldg.
Pittsburgh, PA 15219 (412) 227-2310

Epoxy supplier.
19. Kristal Kraft, Inc.
1507 17th St., E
Palmetto, FL 33561 (813) 722-3206

Epoxy supplier.
20. LBI, Inc.
973 North Rd., Route 117
Groton, CT 06430 (203) 446-8058

Epoxy supplier.
21. Loctite Loc-Weld
Check at auto supply stores.

New 2-part epoxy suitable for binding aluminum
supposedly doesn't require as much surface
preparation as some epoxies.
22. Lonza Inc.
22-10 Route 208
Fairlawn, NJ 07410 (201) 791-7500

Airex foam (easy-to-form expanded PVC foam
compatible with polyester resins).

Notes regarding thin foam and plastic panels:

in addition to those materials listed in references 14 and 15, there are other potential materials. I was unable to verify the names and sources of two of them, which are apparently Tuffak Twin-Wall made by Rohm and Haas Co., Philadelphia, and General Electric Lexan Thermoclear.

Artcor plastic-sided foam panels are no longer being manufactured by Amoco, but are worth hunting for because of their light weight (a 3/16ths-inch-thick 4x8-foot panel weighs 4 pounds). Rumor is another company may start manufacturing Artcor.

As mentioned in the introduction, various kinds of thin foam or plastic panels may be found at art-supply and graphic-arts-supply stores and possibly box suppliers.

And there's always corrugated cardboard and aluminum. Very thin aluminum sheets can be purchased cheap from many printers if you don't mind having printing on one side. They're used as offset printing plates.

M. R. E.

(We acknowledge the SMALL BOAT JOURNAL for the listings of many of the epoxy suppliers given here.)

23. Norbrook Industries Ltd.
 172 Madison Ave.
 New York, NY 10016 (212) 889-2708
 Spandex fabric - different weights, colors,
 no minimum order.

24. Permalite Plastics Corp.
 1537 Monrovia Ave.
 Newport Beach, CA 92663 (714) 548-1137
 Epoxy supplier.

25. Polygal USA
 P. O. Box 272
 Edgerton, WI 53534 (414) 639-6770
 Clear polycarbonate structured sheet
 ("8 times impact strength of acrylic").

26. Polymer Corp.
 Reading, PA 19603 (215) 929-5858
 Plastics supply.

27. Precision Plastics
 1401 N. Clovis Ave.
 Fresno, CA 93727
 Plastics supplies.

28. Quality Composites
 4083 West 14036 South
 Bluffdale, UT 84065 (801) 254-7315
 Carbon fiber, carbon-fiber hybrid tubing -
 free advice.

29. Schupan Aluminum Sales
 2040 Olmstead
 Kalamazoo, MI (616) 382-3434
 Aluminum tubing, sheet, angles, etc.

30. SP Systems, Inc.
 14932 Kercheval
 Grosse Pointe, MI 48230 (313) 774-7370
 Epoxy supplier.

31. System Three Resins, Inc.
 5965 Fourth Ave. S.
 Seattle, WA 98108 (206) 762-5313
 Epoxy supplier.

32. Travaco Laboratories
 345 Eastern Ave.
 Chelsea, MA 02150 (617) 884-7740
 Epoxy supplier.

33. United Resin Corp.
 2730 F South Harbor Blvd.
 Santa Ana, CA 92704 (714) 662-2404
 "Tooling Foam" putty, good for fillet and
 metal/plastic attachments.

34. US Plastics Corp.
 1550 Elida Place
 Lima, OH 45805 (419) 228-2242
 Plastics supplier.

35. Wooden Boat Center
 13000 Culver Blvd.
 Marina Del Ray, CA 90292 (213) 306-2770
 Epoxy supplier.

5. SERVICES.

1. Ron Hale
 632 N. California Ave.
 La Puente, CA 91744

Machine work for HPVs.

2. Pegasus Research Co.
 3055 Plymouth Road
 Ann Arbor, MI 48105 (313) 996-3923

Engineering, design and fabrication
 of prototypes.

3. Jim Kunkle Mechanics
 4 Chester Road
 Enola, PA 17025 (717) 732-0354

Prototype designing and/or building;
 precision machine work, brazing;
 personal service; reasonable rates.

6. ODDBALL TRANSMISSIONS.

1. Sachs-Huret Inc. Sachs Motor Corp. Ltd.
 14 Connor Lane 9615 Cote de Liesse Road
 Deer Park, NY 11729-7287 Dorval, Quebec H9P 1A3
 (800) 524-2764 outside NY Canada
 (516) 586-5303 in NY state (514) 636-9180

Wholesale distributors
 Sachs-Commander 2-speed rear hub combined with
 six derailleur gears (useful for HPVs with no
 place to mount front derailleur), hub front
 and rear brakes.

7. ADD-ON FAIRINGS.

1. National Cycle Inc. previously listed
2200 Maywood Drive
Box 158
Maywood, IL 60153 (312) 343-0400

New model fairing for regular bikes.

8. BOATS.

1. American Marine International
4803 Northwest Hwy.
Crystal Lake, IL 60014 (815) 455-6380

Man-U-Motor human-powered outboard motor (tiller pumped up and down for propulsion).

2. Monfort Associates
RFD 2, Box 1490
Wiscasset, ME 04578 (207) 882-5504

Plans for boats as light as 13 pounds using wood framework, Kevlar strands, covered with heat-shrink Dacron - construction method could be used for HPV fairings - information, \$1.

9. BOOKS, VIDEOTAPES, ETC.

1. Aircraft Designs Inc.
11082 Bel Aire Ct.
Cupertino, CA 95014

Books include "Composite Aircraft Design".

2. Ronald Steven Blair previously listed
New address:
281 Castle Hill Ranch Road
Walnut Creek, CA 94595 (415) 934-5844

"Decade: The First 10 Years of HPV Racing"
"Simplified Fairing Construction Techniques"
"HPV Gearing"

3. Jerry Holcomb
1010 N. E. 122nd Ave.
Vancouver, WA 98664

Handbook on paper-composite aircraft constructions \$2.

4. Marshall Consulting Inc. previously listed
720 Appaloosa Drive
Walnut Creek, CA 94596 (415) 945-6051

"Composite Basics", 212-page book.

5. Seair Dynamics
P. O. Box 43
Boyne City, MI 49712

Videotape of 1985 International Human-Powered Speed Championships.

6. TAB Books Inc. previously listed
Corrected address:
P. O. Box 40
Blue Ridge Summit, PA 17214

Free catalog.

7. Tangerine Productions
Harvey McPhail
7908 E. Jefferson Ave.
Denver, CO 80237

Videotapes of recent IHPVA championships.

8. T/C Publications
P. O. Box 842
El Segundo, CA 90245 (213) 938-6923

Books on plastics, foams, adhesives.

9. Transportation Research Associates Inc.
731 Pacific St., Suite 50
San Luis Obispo, CA 93401 (805) 541-6044

TRA is preparing pamphlet/notebook on composite plastics and HPVs - not yet available.

10. Greg Trayling
3381 E. 29th Ave.
Vancouver, BC V5R 1W7
Canada

Index of HPV articles, Nomex and honeycomb sample with outline on HPV applications.



KLAUS SCHMID, PRESIDENT
CANADIAN HPV ASSOCIATION

RICKSHAWS IN BANGLADESH.

H. Frederick Willkie II

(Fred Willkie wrote about his plans to build new rickshaws in Bangladesh in the fall, 1985, issue of HUMAN POWER. He spent eight months there. I asked him to give us something about his work when he returned. He writes about human power and lack of power. The view is not so much technical as philosophical, political and from the heart. It deserves a place in our journal).

* * *

There are too many landless people in Bangladesh. After all, it is a country of agriculture. No land in your family means no food for you to eat. No income either: income comes from sales of surplus crops. Poor families sell their little rice to someone rich enough to have silos to store it. They all sell all they can at harvest, so they have to sell cheap. Very likely, they are also in debt to the buyers, and when the land's growing season passes, and rice gets short, they have to buy some back at much higher prices than they sold for. This process, repeated year after year, eventually forces too many people to give up their little plots of land as payment of long-running debts. The family now joins tens of millions of other people who can't read or write, can't do basic arithmetic, and have no proven skills other than farming, which they can't count on doing because their land is gone.

Men who are strong enough leave the villages, walking barefoot, hunkering on the roofs of trains, taking any way that goes to the big cities, looking for something to do for money to send back home to feed the family. There are very many of them.

Material and manufactures are very expensive in Bangladesh. An old woman in a dirty sari uses a bundle of stalks to sweep the piles of metal chips off the floor of little machine shops. She separates the shiny brass from the curly steel and sandy iron. She ties the piles up in rags and goes to sell them for some rice. In the streets of the capital, Dhaka, there are middle-class people with jobs and homes to go to, errands to go on, and hundreds of thousands of rickshaws to carry them. Rickshaws don't burn expensive petrol; they carry more passengers and freight than all other forms of transport combined: air, rail, trucks, cars and boats.

An illiterate, innumerate person can drive a cycle-rickshaw. The vehicles are owned by proprietors called maliks, middle-class office workers or merchants, employees or entrepreneurs who have accumulated a little surplus money, bought rickshaws and licenses

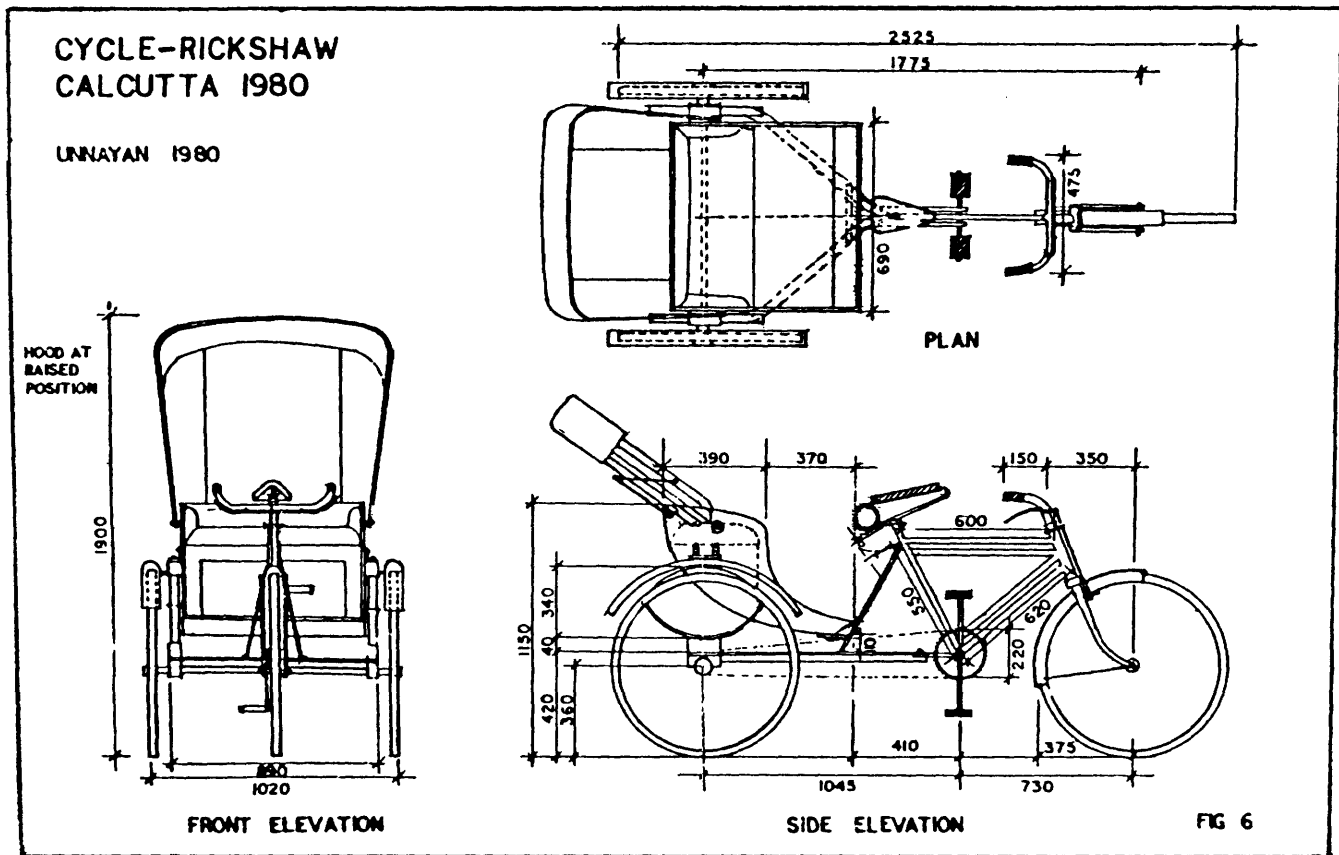
and then rent their vehicles to the drivers, called wallahs. This is the arrangement: there are two shifts, from early morning to two in the afternoon, and from then on into the night as late as frequent curfews allow. The wallah pays a daily fee according to the condition of the rickshaw. This comes out of his earnings when he returns the vehicle. Since he often can't do arithmetic, the rendering of accounts can resemble a shakedown. It is common to demand over half the money the wallah has gathered in the teeming streets.

For the malik, rickshaws are profitable: an owner can recoup the cost of a new rickshaw every six months. Still, many people decline to become maliks and to make this profit because the collection procedure can be too ruthless. Maliks have to be tough. Soft ones don't get paid.

For the wallah, rickshaw pulling is often the only job that can pay enough. Head-porters and handcart pullers make even less. Millions of dollars every year are sent from Dhaka for the maintenance of wallahs' families in the villages. Wallahs may sleep on a board laid across the passenger seat and saddle. They may pool food money in little groups, eating rice with their hands from leaves spread open on their palms while squatting by the side of the fire on bricks. They live with minimum expenditure on themselves. They are usually very thin.

The rickshaws they drive haven't changed significantly since they first appeared in the city around 1938. Someone brought in the idea of taking the scoop-like sun-shaded passenger compartment, the chaise, from a pedestrian rickshaw, and fastening it over an axle carried in a wishbone frame of angle-iron, bolting on to it the front of a roadster bicycle of the rod-brake "sit-up-and-beg" type in common use in Britain in 1900 (and still the standard all over the Indian sub-continent).

The standard rickshaw is heavy, from 90-110 kg empty. It has only one gear, the one the original bicycle came with: 61 inches. In the time of the jute harvest, the gross vehicle weight may reach 700 kg. The vehicle is grossly over-g geared. It wears down the synovial tissue in the wallah's joints, and strains his heart and back. The frame is so flexible that it consumes much of the wallah's propulsive effort in twisting up. There is only one rod brake on the front wheel, so the wallah has to depend on evasive actions in traffic. If the brake is applied too hard, it can stop the front wheel only, and the moving payload snaps the front fork off, right above the crown. A tricycle rickshaw is not a bicycle: a bicycle is built so that the front fork will turn in the direction the bicycle leans. This means that whenever the rickshaw's rear wheels go over an uneven surface, its bicycle fork turns out of the line of travel and has to be muscled back. Wallahs may



do a hundred miles a day; fighting the steering for so long eats up their energies for nothing.

Bengalis are smaller in general than Westerners. So the standard roadster-bike's frame dimensions don't fit. The seat tubes are too sloped for short Bengali femurs. The top tubes and seat tubes are both too long; they cause much useless daily straining. Still, the vehicles are profitable to their owners, give work to their wallahs, feed families, and are made and serviced in tens of thousands of tiny shops all over the country. Small-shop owners stock only proven-to-sell items. They can't afford much change of stock. Owners have too little incentive to investigate improved designs. As for the wallahs, they have no technical training and all their time and energy goes into the endless grind of their work.

The dynamic situation of the rickshaw puller is like that of any rider: he makes his way by applying power against resistance. His situation can be improved by increasing power and/or by decreasing resistance. Increasing power is a political job. It can come only from improved nutrition and living conditions, and those are tied to the production and distribution of income. Decreasing resistance is a designer's job, and a designer has to understand a wallah's work. In our own countries, Mexican field workers and bootblacks suffer damage to their lower backs that could be avoided by more ergonomically sound

design of the equipment they work with, but who cares about braceros and bootblacks? In China, rickshaw tricycles appear to be more highly developed, with two or three speeds and axle brakes (see "Simple Vehicles for Developing Countries", from Intermediate Technology Transport Ltd., Home Farm, Ardington, Oxfordshire OX12 8PN, UK 1977). This may be because the dominant political ideology of China has considered rickshaw wallahs as comrades, men and brothers who mattered. In Bangladesh and India, rickshaw wallahs are, like braceros, native people, and bootblacks among us, beneath most educated people's notice.

The actual state of a hard-working rickshaw driver is an integration of so many factors that actual trial of the work is the best way to learn about it. People laugh at a Westerner driving a rickshaw. So what? A designer needs a feel for the problems. Few wallahs can speak English, and few interpreters know what the wallahs are really talking about. It's important to learn the wallahs' language, to ask and hear about the work you are trying out yourself, so that you have the right questions before you start offering answers. For instance, the much smaller sunhoods on Thai rickshaws give them far lower air resistance in windward travel than Bengali rickshaws have, but if one of those skimpy hoods goes on a rickshaw in Bangladesh, the wallah loses a lot of fares: women won't ride unless they are protected from the eyes of strangers.

Fred Willkie's article will be concluded in the next HUMAN POWER