HUMAN POWER

THE TECHNICAL JOURNAL OF THE IHPVA ISSUE NO 22

Vol. 7 No. 1 $4.00 Spring/Summer, 1988

DESIGN CRITERIA FOR AN ENERGY-SAVING LIGHTWEIGHT VEHICLE FOR COMMUTING: First Experiences with a Prototype for Experimental Use

by Falk Riess and Rainer Pivit

INTRODUCTION

Since 1982, a small research group in the physics department of Oldenburg University, West Germany, has been working on the scientific and technological basics of the bicycle, or more precisely of energy conservation in general human-powered lightweight vehicles. The group is part of a research program on renewable energy sources that deals with the production and use of solar, wind and hydrogen power within small decentralized energy systems. One of the main subjects of the bicycle research group is the development of a commuter vehicle for city use that combines the advantages of the bicycle (energy economy, ecological soundness, technical simplicity, and costs) with those of the automobile (comfort, weather protection, load-carrying capacity).

REFLECTIONS ON CITY TRAFFIC AND ECOLOGY

In West Germany, motorized street traffic has caused 450,000 deaths and 4 million severe injuries during the last 30 years (1953 to 1983). In the last few years, 40 percent of the fatal accidents occurred in inner-city traffic, and more than 50 percent of these were pedestrians and bicyclists. It is an important and valuable goal to reduce these figures by a considerable amount; the appropriate means are political, e.g., by changing the traffic laws, and technical, e.g., by reducing speed and mass, representing the kinetic energy of the parties concerned.

A physician from West Berlin analyzed the relationship between vehicle speed and the risk of pedestrians being injured (Fig. 1). The conclusion is simple: by reducing the speed limit to 30 kph (19 mph) compared with the present limit of 50 kph (31 mph), which is often exceeded, the number of pedestrian fatalities can be reduced by nearly 70 percent.

Moreover, there is another important effect of a stringent speed limit. The total stopping distance diminishes according to the function

$$S = V^* (T_{reaction} + T_{threshold}) + V^2 / (2 * D_{brake}),$$

where V is the initial velocity, T is the time, (constant for all velocities) and D is the deceleration of the vehicle. Stopping distance is enormously reduced by shortening the unbraked forward motion during the time when brakes are not yet in operation (Fig. 2, see p. 12).

Further positive effects of a speed reduction can be expected on the total fuel consumption of vehicles, emission of toxic exhaust gas, and on noise emissions.

Under the conditions of a low city speed limit and other measures for calming down traffic, the use of automobiles for short-range transportation will become obsolete, for it will be too expensive, too slow, and too annoying. Based on these presumptions, the neces-

(continued on page 12)

NEWS FLASH!
Daedalus photographs and drawings on pages 19-20.

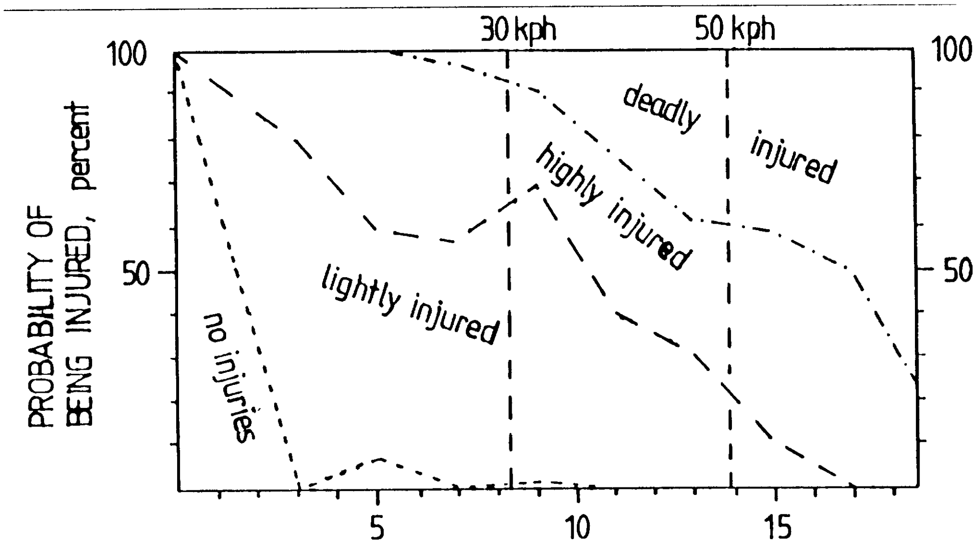

Figure 1. The relationship between vehicle speed and the risk of pedestrians being injured.

The typesetting and layout of this issue was done by The Professional Edge, 8204 South Bettina Lane, Sandy, Utah 84093, 801-942-1181.

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Human Power is published quarterly by the International Human-Powered Vehicle Association, Inc., a non-profit organization devoted to the study and application of human muscular potential to propel craft through the air, in the water and on land. Membership information is available by sending a self-addressed, stamped business-sized envelope to:
IHPVA
P.O. Box 51255
Indianapolis, IN 46251-0255 USA
Members may purchase additional copies of *Human Power* for $2.50 each. Nonmembers may purchase issues for $4.00 per copy.

Special thanks to the authors, Sabina Rataj, Marti Daily, and The Professional Edge, without whom this issue would not have been possible.
ISSN 0898-6908

In This Issue—

Editorials

Daedalus Triumphs!

This is being typed just after the news came of the successful Daedalus flight from Crete. There is universal celebration. The world seems young again. There are no losers. This wasn't a race. No appeals will be heard against a transgression of the rules. The team set its own rules. There will be no complaints of a well-financed US enterprise imposing itself on another culture. John Langford's sensitive approach involved the Greek government and people from the start. Scholars were recruited to re-examine Greek mythology. The recruiting of pilot-athletes included citizens of Greece. The final team included one Greek and three US pilots whose training regimen brought them to peak in succession. Luck favored Kanellos Kanellopoulos, Greek Olympic cyclist, who operated the fragile plane superbly. The three US pilots for whom the Mediterranean weather did not shine at the right time will not grudge him and Greece the victory: they shared in it. We all shared in it. Human power as a clean, healthy, exciting and wonderfully liberating activity will gain new converts around the world. Congratulations and thank you from us all!

A Personal Note

There is no doubt now that people read the editorials. Among mine in HP 6/3 was what I thought was a mild complaint of too many people asking authors and IHPVA officers for responses to technical questions and for copies of literature without them sending even stamped envelopes. It must be partly a coincidence that the flow of such letters coming to me has totally ceased, because most formerly came from non-IHPVA members. An unintended result has been that people sending material for publication have included SASEs. No need! All of us depend on and are very grateful for information that so many of you send to us. (Let me recognize and pay tribute to the most prolific and generous of correspondents: Peter Ernst, Theo Schmidt, and Phil Thiel.) If you take the trouble to do so, we can certainly afford the stamps to return material and to thank you. And all of us welcome letters for publication. (Sometimes I am not sure if a letter is meant for me personally or for publication—I often publish parts of these if I think that readers will be interested and if the writers will not be embarrassed. I hope that my judgment has not been faulty.)

I hope that another unintended result of my suggestion has not been a drying-up of major articles. We've had some significant contributions recently. For some of these we asked individual authors, but many have arrived unsolicited. That the authors have chosen *Human Power* over other possible publications for their research is a compliment. I had thought that we were on our way to greatness. Then the articles stopped coming. Marti Daily and Mike Eliasohn stepped in with an expanded HPV builder's guide as the last issue. We need material for the next issue within a month of your receiving this. There is no guarantee of publication, but there is a guarantee of a response. Please write for an author's guide if you don't have it already produced.

When you write, please use, for the moment, my office address listed on this page. My old Cambridge address is no longer valid. I've simultaneously entered my sixties and a period of uncertainty, but I will try not to allow either to affect the quality of HP, except favorably.

—Dave Wilson ❑

LETTERS TO THE EDITOR

Would all you bicycle researchers please develop something sensible for the senior citizen! Those unable to manage the standard two wheels are relegated to a modified tricycle not even as stylish as are designed for the adolescent.

How about a bike with:

1– Gears
2– Sidecar outrigger with strap-type hangers for groceries or extra rider
3– A flywheel for traffic or lift on uneven areas, and
4– Possible moped operation adaptability.

In short, something (like the moon car) that would give exercise and could be operated by a LOL. Thank you.

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Letters. . .

In Steve Bussolari's response to Ramondo Spinnetti, he talks about research he has done comparing power outputs from different pedalling positions. The Gossamer Condor/Albatross team apparently also did similar research. How about seeing some of this research published in *Human Power*?

I found Spinnetti and Antonson's articles very interesting and would like to see more articles like these.

John Riley
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[Steve Bussolari has promised an article when the Daedalus team returns from Greece.—Ed.]

A lot of us build HPVs for use on the street. Is there any possibility of forming a "Road" or "Practical Vehicle" class for racing HPVs? This would be roughly analogous to the present "partially faired" class; the restrictions would be those required in the real world to build a successful road vehicle. As an example:

- Eye height no less than 1 meter (39") from the ground
- Can be entered and exited single-handed in less than two minutes
- Windshield of a fully-faired vehicle not to exceed $0.4m^2$ ($4 ft^2$) to reduce solar heating
- Non-leaning tricycles and multi-track vehicles would have a minimum track width of some ratio x center of gravity height above ground
- No prones—too dangerous
- No rear-steered vehicles.

Any input?

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Unfortunately, my latest attempt to cross the English Channel has failed again. We had some good weather suitable for my solar/human-powered boat, but it took so long to get a support boat organized and to get permission from the French that by the time I went, I had a day that was too cloudy and slightly too windy (it was sunny everywhere else in Britain!). I got about one-quarter of the way but progress was too slow and we turned back before getting into the shipping lanes. Then the weather really turned windy until recently, but it is now too late in the year to justify another attempt. Well, maybe next year!

. . . (T)he Tour de Sol Race Committee have decided to incorporate solar-powered boats in the event! For 1988, this will probably be an ad-hoc gathering of whatever people care to bring, with serious competition in 1989. It is still very open; we are trying to think of some sensible rules. No doubt Alec (Brooks) will come up with a solar-powered hydrofoil before long!

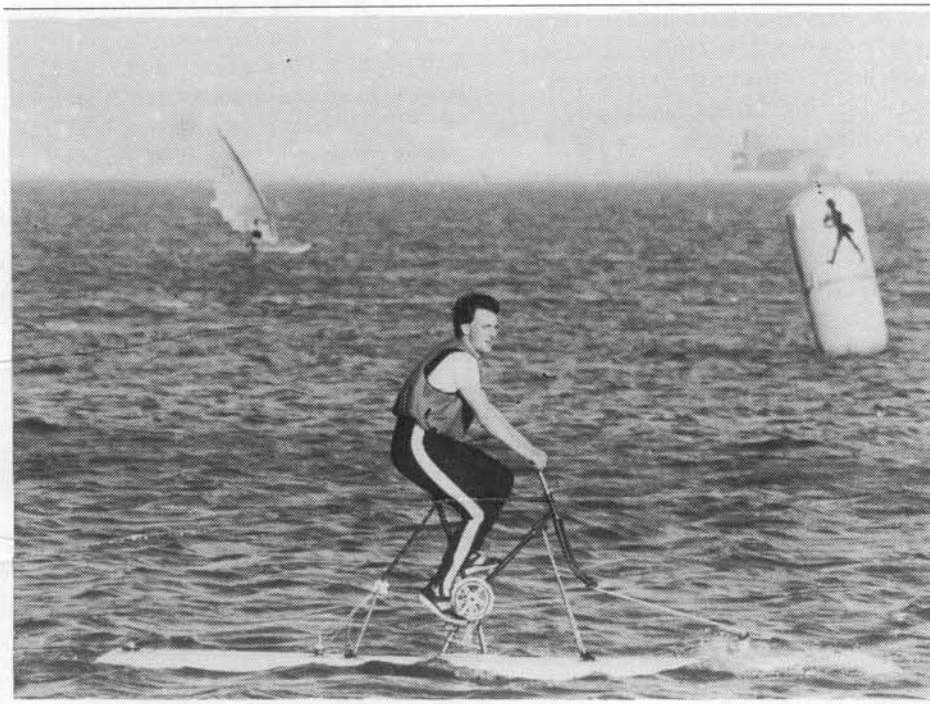
I'm presently trying to make some high-pressure inflatable catamaran hulls out of Kevlar (about 1 kg each) and making a propulsive hydrofoil that can be used as a rudder and "shark-tail" vertically or as a "whale-tail" horizontally, in which case it would also utilise wave power. By keeping the angle-of-attack control universal (either springs or linkage) it should be usable for my racing craft and for heavier boats and yachts as well. It should be especially compatible with linear pedals.

You asked about the linear pedal drive mechanism of the winning vehicle in the assisted class in the Tour de Sol 87 (built by the Gesamthochschule Kassel, W. Germany). This was the usual string, spring, and ratchet mechanism and thus not very efficient. They used this in order to save weight and get a small aerodynamic frontal section. I used a similar system on my solar/ human-powered boat, except that the sliding pedals were arranged to pull each other back, thus giving a more normal feel to it and not requiring springs. Two pulleys with one-way ball bearings on the prop shaft constitute the mechanical analog of a full-wave rectifier. I found this system neat, light, cheap, and completely silent. It is adequate for low power and speed but unsatisfactory if the legs have to push fast or hard.

I have just come back from the Johnnie Walker Speed Sailing Week at Portland Harbour in Dorset, UK, held from October 13-20th. This caters to unusual sailing craft (mostly with hydrofoils) but more recently for sailboards, which routinely go over 30 knots in enough wind. This year, the organisers were persuaded to include human-powered racing over the 500-meter course on days when the wind is light. Seven craft came but managed to race only once, as it was an uncharacteristically windy week (with much storm damage).

The most innovative craft were the two brought by David Whitt, a lecturer at Oxford University, and a group of students. One was a sailboard with an upright cycling position and an inclined-

(continued on page 15)



Craft (not "Daring") brought to Johnny Walker Speed Sailing Week by David Whitt, Oxford University, developed by Johnathan May and David Whitt. Conventional sailboard as hull. Note position of front rudder. Photo courtesy of Johnnie Walker.

Development of the Breeze-Cheater™ Fairing (patent pending)

by John Nobile

ABSTRACT

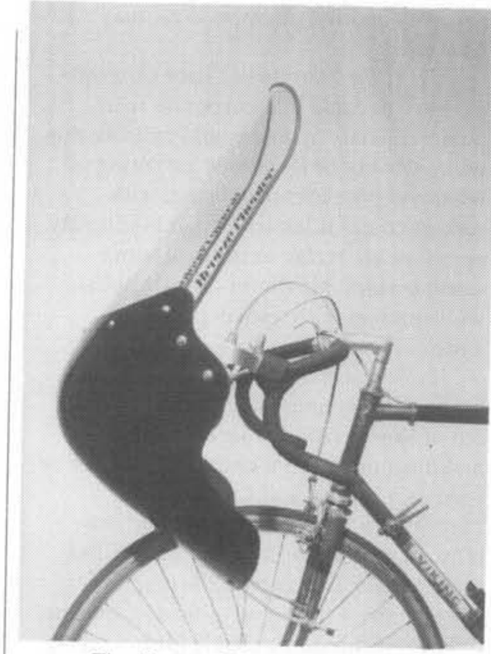
Anyone who has ever tried to design a human-powered vehicle knows what a challenge it is to exceed the practicality of the standard bicycle. An even greater challenge lies in gaining public acceptance of these high-efficiency machines. As a mechanical engineer and cyclist, it seemed very strange to me that fairings for standard bicycles have not been well accepted, since it is such a simple and straight-forward (and the only) way of substantially improving performance. One rarely sees a large truck or a touring-type motorcycle without some sort of fairing, and cyclists have more to gain than either of them (weather protection and increased efficiency). I discussed this with many bicycle-shop owners and fellow riders, and purchased all available fairings. I resolved to try to bring about a further degree of development of fairings, and to discover if this would lead to widespread acceptance.

INTRODUCTION

All of my prototype fairings were constructed of fiberglass using rigid closed-cell-foam plugs for rough male molds. Surface finish was not considered important for initial shape evaluation in order to save time. A smooth surface mold was not constructed until the shape was fully defined. Many different sizes, shapes, and constructions were investigated using wind-tunnel data, coast-down testing, and hundreds of miles of actual use to measure and compare them to existing designs and to each other. The following are the results of my research.

DESIGN GOALS

In order for a fairing to be considered truly practical, it must do much more than just give an improvement in aerodynamic efficiency. It must be large enough to give substantial weather protection, yet be stable in sidewinds. The device must be light in weight but rigid enough not to move around or make annoying noises. Ease of mounting, removal, and adjustment are important, along with adaptability to fit a variety of bicycle sizes and geometries. The difficulty is in combining all of these features into one design that also has aesthetic appeal, a factor that is critical if widespread acceptance is a goal.



The Breeze Cheater™ Fairing

EFFICIENCY

The fairing must give a noticeable increase in speed, since this is one of the primary motivations for purchasing one. For a partial front fairing, 22% is about the limit for aerodynamic drag reduction, which will cause a 7-10% gain in speed. This requires a frontal area of around 0.29 sq.m. (450 square inches). A larger area would be slightly more effective, but size and weight start to cause stability and mounting problems. Wide variations in the bluntness of the shape do not substantially affect drag because a front fairing reduces only frictional (viscous) aerodynamic drag and does nothing to reduce pressure drag. Thus, it is important that the fairing be placed so that it blocks the airflow to as much of the rider and bicycle as is practical while increasing the total frontal area as little as possible.

STABILITY

Although not a critical factor when considering efficiency, the shape or bluntness of the fairing is most important when thought of in terms of cross-wind stability. A slightly less "complete" aerodynamic shape will produce much less side force and a larger lifting moment to counteract this force (see Fig. 1). Although the coefficient of drag of this shape is higher, it produces a larger wake near the trailing edge. Thus, a smaller fairing can be used with an equivalent overall drag reduction and better stability. A ratio of frontal area to side area of about 3:1 has been experimentally proven to work well. Because the fairing side area is relatively small, the net side force experienced will be only slightly greater while the adverse steering input due to sidewinds can almost be eliminated. By varying the shape of the fairing (thus, the lifting moment and side drag) and its distance from the steering

Shape B has a slightly higher coefficient of drag than that of shape A, but produces the equivalent wake with reduced frontal area, thus giving similar performance in terms of speed.

M ≡ moment due to lift
D ≡ drag force
L ≡ perpendicular distance of drag vector from steering pivot
If D • L = M, the fairing will be stable. Although this condition cannot be perfectly satisfied, it gives a good indication of which direction to go to approach the stable condition

Figure 1. The aerodynamics of the Breeze Cheater™.

axis (the moment arm of the side drag), the optimum condition for stability can be approached.

WEATHER PROTECTION

After road testing a variety of different fairings, I found that the most valuable design feature is the ability of the device to keep the airflow off the rider. When in a normal riding position, the air must be guided around the cyclist as completely as possible. This requires a relatively high clear windshield, enough width to go around the handlebars, and an area low enough to prevent air from curling up in front of the rider from underneath. If it does not extend up high enough, the person will be forced to either duck down behind it in an uncomfortable position, or to ride with his/her head in the high-velocity flow near the edge. Both conditions are unacceptable, so a high enough windshield is an important design requirement. The use of a windshield of this size, however, will interfere with the rider when in a sprinting position unless it is placed extremely far forward. This placement causes reduced effectiveness and makes for an awkwardly shaped fairing. An easily retractable windshield was developed instead. It is optimum in size and location when up, and completely out of the way when down. This also aids greatly in cooling off during long hill climbs.

MOUNTING

The rigidity with which the fairing is attached to the bicycle is important in terms of safety, stability, and noise. It must be readily adaptable to fit as wide a range of bicycle and rider variations as possible without interfering with the rider or compromising the control of the bike in any way. After trying a number of different mounting systems, most of which were either not stiff enough, too heavy, or too complex, a simple but very rigid four-point aluminum attachment system was devised. Mounting the fairing onto the frame, rather than to the handlebars and fork, was not attempted because the long distances involved would require a relatively heavy support system to provide the needed stiffness.

The fairing should be at least as durable as the bicycle, which means it should withstand repeated 6g vertical shock loads without excessive deflection or deformation. Because of these design constraints, the mounts required the use of a high-strength heat-treated aluminum alloy (2024-T3).

The elimination of all mechanical noises involved the fine tuning of mounting-hole locations along with the use of redundant mounting points. A gasket was needed to isolate the windshield from the shell to eliminate the small relative motions due to road shocks that were responsible for an occasional squeak. The sound of the air flowing around the windshield does not become audible until about 30 mph, and is still relatively quiet at 45 mph.

MATERIALS

Although weight is not as significant as is aerodynamics for performance, it is still a very relevant factor from a marketing point of view. It is also important that the device be as stiff and light as possible to minimize movements, vibrations, and noise. Keeping the mass low will also aid in reducing the amount of steering damping caused by the added inertia in the steering system.

The use of a composite material is essential for a maximum stiffness-to-weight ratio. Since the upper area has to be clear for visibility, polycarbonate is the best choice because of its toughness. The lower part is made of a Kevlar composite for the best possible combination of strength, stiffness, weight, and vibration-damping properties. The windshield is a cylindrical section that is held rigid by the Kevlar shell. It is very stiff in this configuration, but when the windshield is folded down, it is buckled forming a straight section at the bend line, thus making it fold very easily. The exact properties of the shell were optimized through experimentation, and a varying wall thickness turned out to be the most effective way of getting the most out of the structure.

APPEARANCE

One of the major questions at the start of this project was: would all of the requirements that needed to go into a truly practical design be able to fit into an aesthetically pleasing package? Without physical appeal, no amount of functionality would be enough to initiate widespread social acceptance. There were some tradeoffs in other areas in order to help achieve this goal, but the basic use of streamlining, symmetry, and a high-quality surface finish certainly contribute to this area.

SUMMARY

The product that is the result of this research costs four to five times more to produce than competing products, and sells for about double. It is my observation that the high end of the cycling market is oriented much more to quality and performance than to cost. This fairing could be potentially helpful in bridging the gap between dedicated conventional cyclists and the innovated, open-minded members of the IHPVA. Gaining public acceptance of improved methods of human-powered transportation is a gradual process, and improving the efficiency and practicality of the standard bicycle is a natural first step.

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❑

Friction Damping as a Simple and Effective Cure for Bicycle Shimmy

by John S. Derr

ABSTRACT

A simple friction steering damper which can be rapidly engaged and finely adjusted completely eliminates shimmy under even the most adverse conditions. This 0.1 kg (4 oz.) device is considerably lighter, safer, and more effective than dynamic damping, and has been used to extend the useful life of an old, lightweight frame.

INTRODUCTION

Recent contributions to *Human Power* by LeHénaff (1) and the subsequent discussion address the theory of designing for stability, and mention the consequences of poor design only in passing. Other articles in popular magazines (2) have discussed the techniques of getting down a long hill, and mentioned the problem some frames have with violent, high-speed oscillations. I've had that problem with my 27-year-old Peugeot racer for the last 8 years. Asking several pros and frame builders if they could solve my problem didn't get me very far: the pros said only that replacing the fork didn't help, and the frame builders said only that their frames never shimmied. The scientific literature on steering stability and dynamics shows that the subject is very complex but offers no solutions for shimmy problems. Being somewhat attached to what was, in its youth, a very fine machine, I had to either solve the problem myself, ride the brakes to keep speed under 11 m/s (25 mph), or give up descents. My favorite ride is an 11 km (7 mi) hill gaining 550 m (1800 ft) of elevation, so the only practical choice was to find a fix.

THE PROBLEM

Shimmy is a forced resonant torsional oscillation of the front wheel, fork, and handlebars, and whatever part of you is holding onto them. At 13 m/s (30 mph) it's just frightening, but at 22 m/s (50 mph), it's absolutely terrifying, and in all cases it's potentially lethal if you lose control. My first encounter with the problem occurred when making a sudden sharp turn while descending around a corner at 13 m/s (30 mph). That kind of sudden lateral force can easily move you into the region of instability. Hitting a rock has the same result. The head set starts a rotational oscillation that is simply impossible to stop without slowing down to about 2 m/s (5 mph). Another encounter happened one fall day at an elevation of 2800 m (9000 ft) on a long, straight stretch with a gentle slope and ferocious wind behind me. I accelerated much more than I realized until a gust hit me from the side. The front end was instantly out of control, with the sound of rubber scuffing on the road louder than anything else as the tire scraped from side to side. When I had stopped the bicycle—and stopped shaking myself!—I noted the maximum speed on my cyclometer: 22 m/s (49 mph).

WHAT TO DO WHEN IT HAPPENS TO YOU

After that, I knew I had to do something. With each new encounter, I experimented and gradually found some solutions.

1. Above all, no matter what the problem, steer the bicycle and stay on the road and in your lane. This can be an exceedingly dangerous condition. On any hill where you can go fast enough to induce a shimmy, you may have a cliff on the right and oncoming traffic on the left. To put it simply, mistakes can be deadly.

2. Lower or decrease the weight in front. If you have a handlebar pack, put it on the back. Others would suggest replacing it with low-mounted panniers.

3. More generally, move the center of gravity of the bicycle back as far as possible. For example, slide back on the seat. You can prove to yourself that this is correct by taking the most stable mountain bike and leaning forward until even it will shimmy. I've done it, with near-disastrous results.

4. Stiffen the front end. As you slide back in the seat, push forward on the handlebars so that you stiffen your arms and shoulders and bring your elbows in to your body. This will slow down the shimmy a little and help you stay in control.

5. If feasible, slow down as much as possible by using the rear brake only. Some cases of minor instability can be transformed instantly into the maximum shimmy just by applying the front brake. Once you have the maximum problem, however, use both brakes as hard as you would under normal conditions to stop as quickly as possible and still stay in control.

6. Increase the handlebar stem length so your hands are farther forward. This by itself increases stability, and also has a secondary beneficial effect of lowering the body's center of gravity.

THE IDEAL SOLUTION

Idea no. 4 leads to what a mechanical engineer might think would be the ultimate solution. As a geophysicist and light-plane pilot, I knew that airplane nose wheels needed shimmy dampers, and I had often flown with a dynamic damper functionally equivalent to the steering damper on my ancient Porsche. As the builder of an experimental aircraft, I knew that simple frictional dampers were also used. Ideally, the dynamic damper would be the way to go, because its resistance is proportional to the velocity of the oscillation. So, I took an old steering damper from my car junk box, some clamps from the bike junk box, and put together the system in Fig. 1. It looked horrible, it weighed one kg (2 lb), and it only almost worked. When I provoked a shimmy, it responded with one that was mild by comparison, and much easier to stop, but it wasn't worth carrying that much weight around all the time. Besides, it made the steering much too stiff. The problem was that I couldn't eliminate all the free play in the bolts that attached the damper to the pivot points. This let the handlebars move undamped just enough to induce an oscillation. By the way, all my testing was done on a clear stretch of road with no traffic.

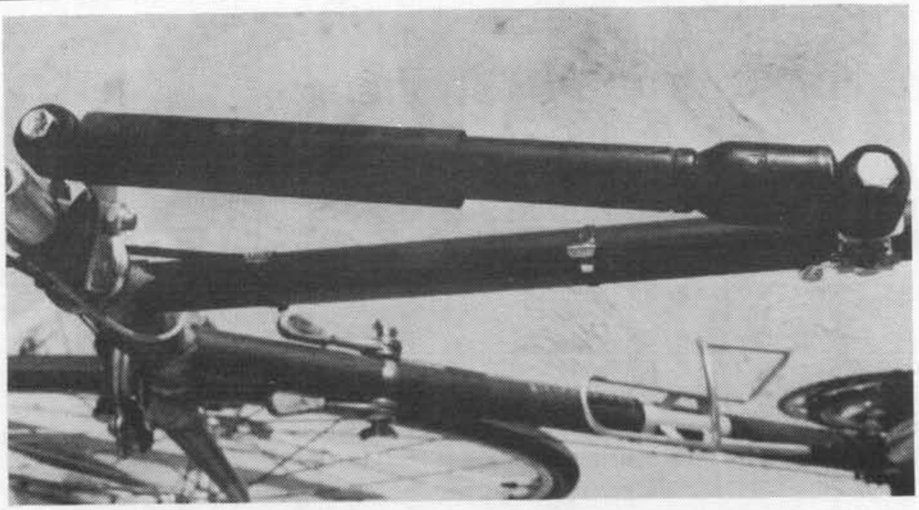

Figure 1. Dynamic steering damper

THE PRACTICAL SOLUTION

The next device I tried was a simple friction damper. (See Fig. 2.) This weighs only 0.1 kg (4 oz), is almost completely out of the way, can be turned on and off with the flick of a quick release, is infinitely adjustable, and best of all, it works! And the reason it works is that there is absolutely no free play in the brackets that attach it. The clamp around the stem was an Ideale seat-post clamp from the Peugeot's original seat. The quick release is a Campagnolo, but anything would have worked as long as it is finely adjustable. In practice, I started out clamping it too tight and having trouble staying in my lane—not much safer than the original problem, but I was determined to stop the shimmy. As I gained confidence, I loosened it enough so that the steering was just a little bit stiff. With the damper engaged, it takes 8 N (1.8 lb) of lateral force to start to move the handlebars, or 1.7 N-m (15 in-lb of torque). This stiffness is slight but noticeable, requiring that I compensate for it and stay alert, but I really have no trouble staying in my lane. I have used this damper now for three years, and it does work! I haven't had a shimmy since I added it to my bike. In practice, it's as easy to use as the gear shift, and I flick it on or off as my hand moves to shift gears. Certainly it's one more thing to do, but it beats the alternatives of living in fear of shimmy or buying a new bike.

WHY?

From my point of view, shimmy is an underdamped torsional oscillation pumped by an external force. Its closest relative in common experience is a person on a swing: every child learns how to pump. As a professional seismologist, I have encountered a closely related problem in the end-on forces acting on a horizontal pendulum seismometer. In at least this latter case, the motion is described by Mathieu's equation, whose multiple solutions consist of closely spaced regions of stability and instability. If the same equation applies, this would explain why you can be descending rapidly one moment and in sheer terror the next.

Why some bicycles and not others? Clearly, the heavier the front wheel, the greater its angular momentum and resistance to torsional oscillation. Likewise, the more friction in the headset or the tighter its bearings, the less likely it is to shimmy. Front-end geometry and frame height are clearly involved in a complex way, but the elasticity of the whole frame is also a factor. As the front end rotates, the frame and rider will move sideways but lag behind the motion a little bit. As the wheel reaches its extreme deflection, road friction takes over and forces it back toward the center. The frame and rider will also reverse their sideways motion and follow back toward the center, but their momentum will keep pushing the wheel past center and to the opposite extreme. This motion will continue until the driving force is eliminated. I suspect that this driving force is road friction, pushing the front wheel back toward center at each extreme of its deflection. The motion is in resonance because it is pumped by the weight of the rider and the elasticity of the frame—just like the person on the swing.

Among bikes with similar light wheels and frame geometries, why do only some shimmy? And why is it sometimes a problem as a bicycle gets older? For aging frames, I suspect that the culprit is the down tube. It may be too weak to begin with, or it may fatigue or rust from the inside. Finite-element

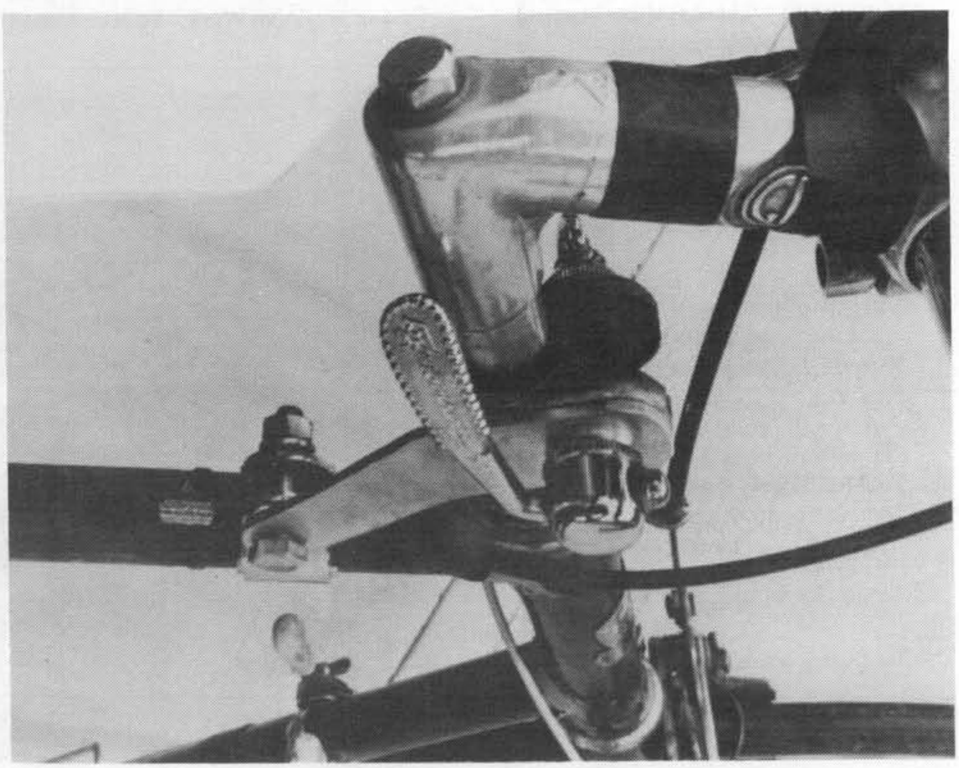

Figure 2. Friction Steering Damper

analyses of frame motion show that this tube both rotates and moves out of plane (3), motions which will store energy to sustain the oscillation. The top tube may also contribute to the problem, as well as all other elements of the frame, but I think to a lesser extent. I don't have the computer tools to prove this, but when I finish building my airplane, I intend to take some of the leftover fiberglass and stiffen the down tube. If that eliminates the tendency to shimmy, that will be my proof.

CAUTIONS

The device shown here of necessity reduces the responsiveness of the steering. If anyone else decides to try this, I suggest starting with just a little friction and working up to just enough to solve the problem. It does affect steering precision somewhat, so for a serious racer with shimmy, the only practical solution is a longer stem, new frame, or possibly stiffening the down tube and top tube. I have found that the damper is a totally acceptable solution to my tired-frame syndrome, but it is still a compromise that has to be approached with care. Whatever its drawbacks, though, it's infinitely safer than an uncontrolled shimmy at 22 m/s (50 mph)! I would never willingly have embarked on this series of experiments: it's simply too dangerous. Having been "forced" into it, I hope that my analysis and solutions will help others to avoid getting into trouble.

ACKNOWLEDGEMENT

I thank Frank Berto for reviewing the manuscript and offering some useful suggestions and criticisms.

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Previously Published Articles—Comments and Responses

BACKWARD VS. FORWARD PEDALLING (6/3)

by Ramondo Spinnetti

I tried backward pedaling for two days during the Tour de Sol in my machine, which seemed especially sensible, as my crank-set was considerably higher than the seat and pedaling backwards along the line of the power stroke was about as if pedaling forward on a lowered crankset. Unfortunately, I had to revert to forward pedaling after two days as it was difficult to control my foot angle sufficiently to avoid hitting my heels, and my ankles and knees started to hurt. However, with more space and practice, I could well imagine backward-pedaling being useful with extreme recumbents, at least.

Theodor Schmidt
Rebackerweg 19
CH-4402 Frenkendorf
SWITZERLAND

I read with interest Mr. Spinnetti's article on backward pedalling. I thought that your readers might be interested in some other research, "The Physiological Cost of Negative Work," by B.C. Abbott, Brenda Bigland and J.M. Ritchie, *J. Physiol.* (1952), 117, 380-390.

Steve Nimocks
2347 Floral Hill
Eugene, OR 97403
USA

["Negative work" is what the physiologists call what we do when we walk downstairs, or try to brake a fixed-gear bike by "backpedalling." It is discussed on pp. 212-3 of Bicycling Science, *with material given by Sharp in 1896 quoted. It is different from pedalling backwards to produce positive or useful work. On Ramondo Spinnetti's bicycle, one would "backpedal" or do negative work by pedalling forwards.—Ed.]*

Response by Ramondo Spinnetti—

I can understand the difficulty Theodor Schmidt describes about hitting his heels. With the power stroke at the bottom of the cranking circle, the heels naturally tend to sweep lower when backpedaling. I took this into account in designing my own extreme-recumbent prototype. My longest ride, in one day, was 100 kilometers, with no strain or pain.

Ramondo Spinnetti's Contretti prototype

I have also back-pedaled prototypes in five other configurations. Of these, only the conventional racing configuration was uncomfortable. A more forward location of the cranks is necessary for backpedaling comfort and performance.

Steve Nimock's letter provided me with an interesting, but unrelated article on positive and negative work. My research is concerned with backpedaling positive work and its application to vehicle design.

Seeing my article in *Human Power* 6/3 and knowing that members around the world can share my findings, turns my many hours of hard work into pure joy! I'll soon be building a new backpedaling prototype and making more comparison tests.

TABLE I. POWER OUTPUT, WATTS

	Recumbent 51.5	Recumbent 154.5	Conventional 51.5	Conventional 154.5
R	.4843	.4809	.4839	.5003
C	.4966	.5064	.5190	.5308
N	.4508	.4341	.4742	.4553
	PERCENT CALCULATIONS COMPARISONS			
R	-.07461%?		4.040%	
C	4.5127%		4.8284%	
N	5.1878%		4.9544%	

AUTHOR'S NOTE: Percent comparisons are probably close together because these persons were proficient at both types of bicycles.

OXYGEN COST OF SUBMAXIMAL EXERCISE IN RECUMBENT AND CONVENTIONAL CYCLING POSITIONS (6/3)

by Ingrid E. Antonson

The conclusions drawn in this study seem to be on incomplete data calculations. According to my calculations of VO_2/V_e there is a significant difference of VO_2 needed to sustain the same output (i.e., 51.5 W and 154.5 W). This difference is between 4% to 5% more VO_2 to sustain an equal amount of work on a conventional bicycle compared to recumbent. In the human body, 4%-5% is not an insignificant amount. Also according to my calculations, at an even higher output (313W), this percentage increases to 6.5%. With these calculations, a conclusion can be drawn as follows: a 4%-5% increase in VO_2 relates directly with a 4%-5% increase in energy burned to maintain a conventional bicycle at the same level as a recumbent. Which leads to support the study (8) of a lower VO_2, therefore less energy used to create the same amount of work.

I would appreciate your comments on my calculations and conclusions drawn. I am new to the HPVA and am excited about the great things I have heard.

NOTE: This test table is not really a fair test, because you could be looking at the low mark of one person in one section against the low mark of another person. There needs to be a list comparing one person against himself, recumbent and conventional, and a graphing of these comparisons. Then a graph VO_2/V_e comparison of each person and a graph of all persons combined to get a true overall picture. What you get in Table I is an average of comparisons but not even a true average comparison because of the high of one person against the low of another person, but it still shows an increase of 4%-5% of energy use for the conventional bicycle.

Ken Schuman
2514 17th S.E.
Auburn, WA 98002
USA

Response by Ingrid Antonson—

The calculations on which conclusions were drawn in my study were based on a statistical analysis of the individual subjects' data, specifically, a three-way (subject-group by workload by position) ANOVA (analysis of variance).

For each individual, minute-by-minute values for oxygen consumption (VO_2), minute ventilation (V_e), and heart rate (HR) were recorded during exercise. The mean values for the last three minutes of exercise, at each workload, for each subject, were used in the statistical analysis. The first three minutes of exercise were excluded in order to allow the subject to approach a steady-state.

An ANOVA is appropriate for analyzing the effects on a variable; e.g., VO_2, V_e, and HR, of multiple factors; e.g. subject-group, position, and workload, acting simultaneously to determine both if any of the factors significantly affects a variable and whether the interaction of factors significantly affects a variable. An ANOVA indicates more than the magnitude of any difference that may have occurred between subject-groups and between positions for each individual. Based on the variance of the observed data, the sample size, and the expected variance if no true difference exists in the general population, the probability that any observed difference is due to a true difference existing in the general population or due to random chance in subject selection is analyzed. The meaning of statistical significance is derived from probability. For a more complete discussion of statistical significance, please refer to a text on statistics.

The mean values for each group were reported in the table accompanying the article rather than individual subjects' values because the results of the analysis completed on the data are more revealing than the raw data. It is not, therefore, appropriate to dedicate the space that would be required to publish the raw data. I have, however, included a copy of the individual subjects' data for your perusal. *[This copy went to Ken Schuman.—Ed.]*

Ingrid E. Antonson
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USA ❑

Vehicles for the Homeless

by Dennis L. Dollens

Krzysztof Wodiczko's vehicle for the homeless.

A recent exhibition entitled "Homeless Vehicles", sponsored by the Institute of Art and Urban Resource at the Clocktower, presented the response of Krzysztof Wodiczko with Rudolph Luria and Craig Buamhofer to the plight of the homeless.

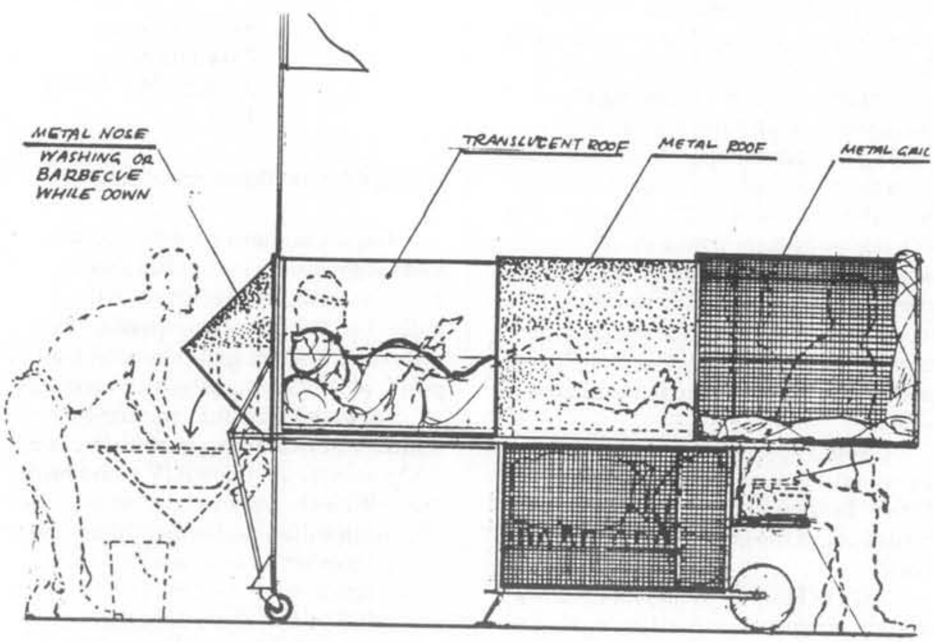
Wodiczko's pragmatic approach has led to the development of a mobile, shelter-storage vehicle based on the needs of the wandering homeless.

Neither to be romanticized as an RV or Recreational Vehicle for the downtrodden (it's much more related to traditional Gypsy wagons), nor as "an ideal shelter," it should be viewed, according to its designers, "as a vehicle designed with attention to the specific limitations and compromises imposed by urban nomadic existence. . . . It is conceived as a starting point for further collaborations between skilled designers and potential users." In fact, the design and the prototypical vehicle have been modified at different stages after potential users gave comments and advice.

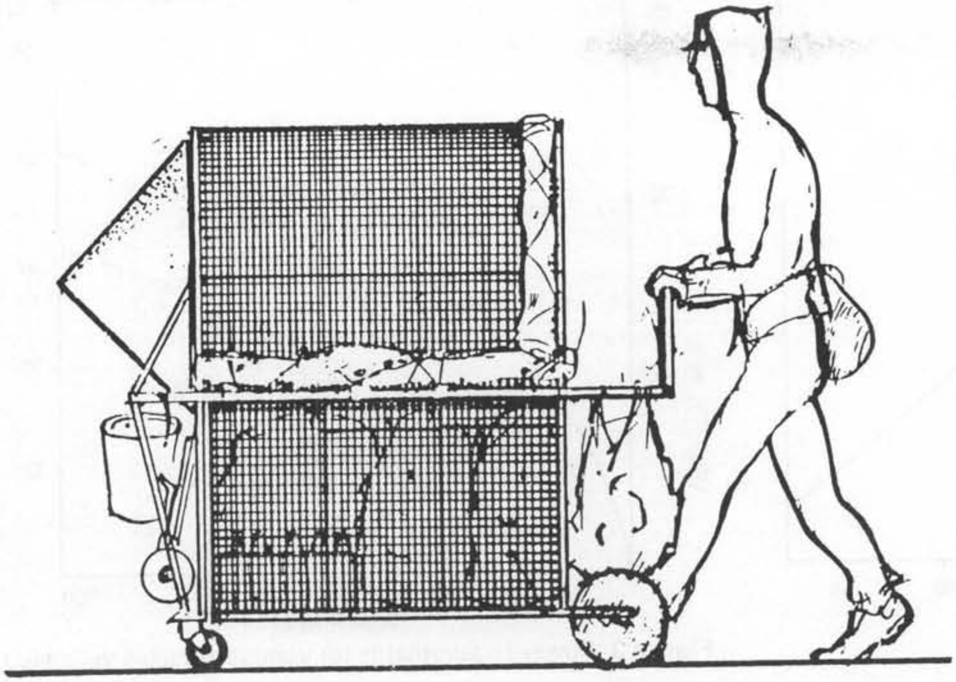
The vehicle/shelter bears only a slight resemblance to metal shopping carts; nevertheless, those carts, along with postal carts, are its precursors. Appropriated by segments of the homeless population for mobility, storage capacity, and strength, those standardized carts have been adapted as collection vehicles and have become the main capital resource for the survival-industry of the homeless—recycling. Wodiczko guided the transformation of the generic cart, retaining its storage capacity and mobility, into a multipurpose vehicle providing a covered sleeping and resting area. He thereby made the much-modified design of the cart responsive not only to the task of gathering paper, plastic, and aluminum for recycling, but also, to a certain degree, environmentally responsive as a protective shelter, something currently unavailable or undesirable to those citizens who either choose a nomadic existence or have no alternative to one.

Constructed of aluminum, steel mesh, sheet metal, acrylic and off-the-shelf wheels, the prototype vehicle proved remarkably easy to steer over the streets of Manhattan where it was road-tested.

Introducing the vehicle/shelter onto the streets will also require some degree of official recognition and perhaps even some monitoring agency to ensure that



Washing/Sleeping/Resting Position (Day)
Metal nose operates as emergency exit, storage for basin and other objects and tools, when open as base for basin while washing and barbecue kitchen.



Traveling Position. The bottom section is a container for collected bottles and other resalable objects.

the vehicles do not become either health hazards or portable slums. Moreover, its implementation will need to be accompanied by the recognition that the user is a legal, working member of society (consider the labor and civic worth of recycling 500 soda cans with a return of $25) and is contributing to the wholesomeness of the city.

The "Homeless Vehicle Project" is intended as a starting point; it is neither a comprehensive proposal for the homeless in general, nor even a final vehicle for a segment of that population. In the end, it may pose as many questions about the rights of homeless individuals versus the rights of society as it answers. Yet the project also establishes a possible forum for design and public policy, based on the requirements of a nomadic sub-group of homeless society. The partially isolated and outlined requirements identified by this project may now be addressed, accounted for in design, and eventually reflected in law.

Dennis L. Dollens
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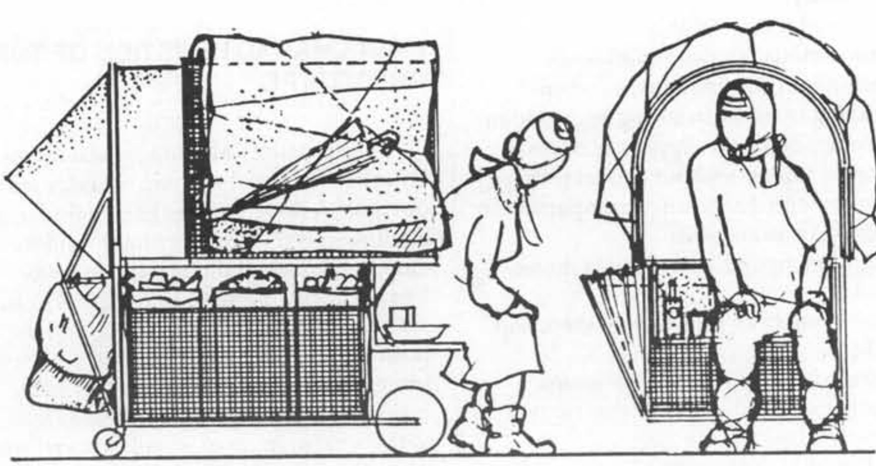

Resting Position (while traveling and collecting)

REVIEWS

Computing Across America

by Steven K. Roberts
(Learned Information, Inc., Medford, NJ, ISBN 0-938734-18-0)
(See HPV News, Jan/Feb 1988 on how to get an autographed copy.)

Keen IHPVA members will have heard Steve Roberts talk about his way of life, for instance at the 1987 IHPSC symposium in Washington, DC and College Park, MD, and will have read his piece in the January/February, 1988 issue of *HPV News*. As he bikes around the country on his special long-wheelbase recumbent replete with several computers and a myriad of other electronic devices he gives talks to local groups, communicates through GEnie ("WORDY") with bulletin boards and friends, and sends articles off to his publisher(s).

This 347-page book is one of the results of his travels. It could well be called "communicating across America." He establishes a rapport with (almost) everyone he encounters. He makes friends for himself and for the human-power movement. He has an easy self-deprecating style close to poetry when he philosophizes, and always makes one want to keep on reading. He has a keen interest in the opposite sex, an interest about which he writes frankly. It has resulted in some of his recent journeys not being so lonely, we learned from his talk at the IHPSC. Despite all the technology Steve employs, he brings it in very little. This is a book celebrating humanity. I think you would enjoy it.

Dave Wilson

Baidarka

by George Dyson
(Published by Alaska Northwest Publishing Co., Edmonds, WA, 1986, 200 pages paperback, $19.95, ISBN 0-88240-315-X.)

This is a mainly historical account about Aleut/Alaskan/Russian baidarkas, or kayaks. George Dyson builds these craft in modern materials (eg., synthetic canvas and aluminum tubing). A large section of the book describes his methods and boats, culminating in the magnificent "Mount Fairweather," an enormous six-hatch baidarka. There are many extremely good color photographs in this

(continued on page 18)

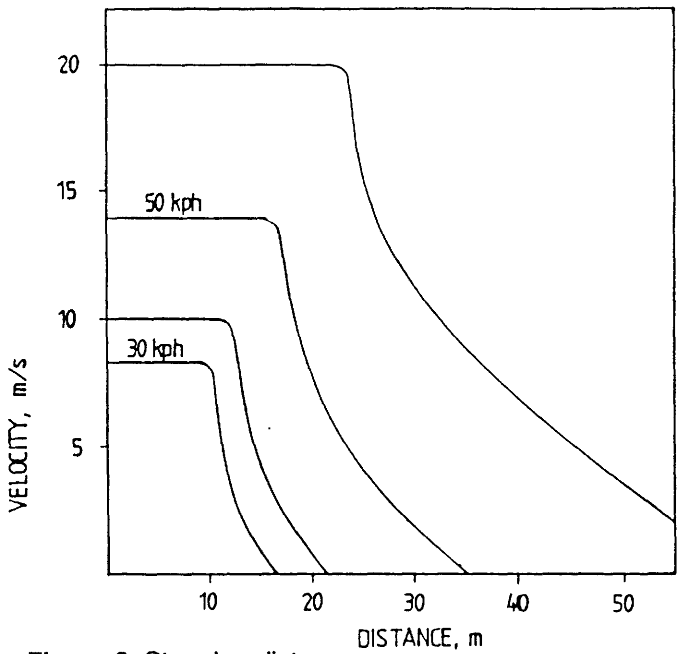

Figure 2. Stopping distance

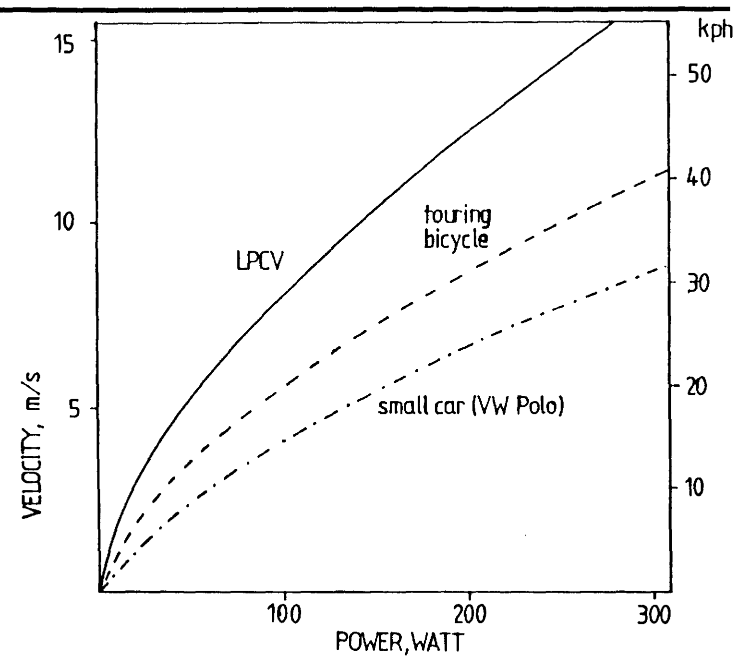

Figure 3. Power requirements for various vehicles vs. speed

DESIGN CRITERIA FOR AN ENERGY-SAVING LIGHTWEIGHT VEHICLE FOR COMMUTING

(continued from page 1)

sity for a new kind of commuter vehicle arises. First of all it has to avoid the specific disadvantages of the automobile, and then it has to maintain the characteristics of bicycle technology, such as low weight, low rolling resistance (high-pressure tires) and a highly efficient drive train with wide-range gearing. The design of such a vehicle must add some attributes such as comfort, weather protection, high transport capacity, and security. Because its most important properties are low weight and low speed, it doesn't need much power: human muscles or a very-low-power motor (less than one hp) will be sufficient (Fig. 3).

To prove the feasibility of replacing most of the city automobile traffic by a low-power commuter vehicle (LPCV), some 1982 statistical data from West Germany are given.

27% of the city trips are no longer than 1 km
52% of the city trips are no longer than 3 km
66% of the city trips are no longer than 5 km
80% of the city trips are no longer than 10 km
38.6 percent of all car trips are no longer than 3 km (under 2 miles)

(As the distances covered in North America generally are longer than in Europe, the data might differ there.)

The expected positive effects of the introduction of numerous LPCVs accompanied by an appropriate speed limit can be summarized as follows:

- a reduction of the number of pedestrian fatalities in urban traffic by more than 80 percent;
- a reduction of the total kinetic energy in accidents by a factor up to 100 (reduction of the masses by 10, and a reduction of the velocities by 3);
- a reduction of the total energy consumption for inner-city traffic by 50 percent, if only every second car ride is replaced;
- a reduction of toxic exhaust gases by up to 50 percent (estimated); and
- a reduction of average street noise by more than 6 dB.

So what must the LPCV look like?

MOST DESIRABLE QUALITIES OF A LOW-POWER COMMUTER VEHICLE (COMPARED TO A BICYCLE)

- Reduced risk of falling
- Less serious injuries in accidents
- Stability in all situations, as when braking in turns, in strong and sudden side winds, or on slippery surfaces
- Can be ridden without special training
- Brakes with deceleration comparable to that of an automobile
- Lights comparable to those of motorcycles
- Protection from rain, snow, wind, and cold
- Good visibility without the screen getting covered with moisture in wet weather from inside
- Adjustable ventilation
- Comfort by spring suspension comparable to that of automobiles
- Drag (CD*A) between 0.1 m^2 (twice the value of the Vector) and 0.3 m^2 (value of a racing bicycle), i.e. between 1.1 ft^2 and 3.2 ft^2
- Coefficient of rolling resistance comparable to a good touring bicycle (.004)
- Weight under 20 kg (44 lbs) including fairing
- Wide-range gearing for slopes up to 18%
- Adequate theft protection
- Lockable fairing or luggage compartment
- Adjustable to the anatomy of almost all people
- Cargo: one child and a few shopping goods, or a lot of shopping goods
- Possibility to fasten an aerodynamically shaped trailer
- Nearly free of maintenance

MAIN CHARACTERISTICS OF THE PROTOTYPE

The practical advantages of a three-wheeler compared to a two-wheeler are obvious. A three wheeler can be ridden at any low speed (especially important for elderly people), and there are no problems of balancing with heavy loads or in side winds. Calculations concerning the position of the center of gravity, the maximum deceleration, and the risk of overturning under favorable conditions lead to the arrangement of wheels: two wheels in front, one in the rear, and the position of the seat: close behind the front axle; track width: .85 m, wheel-base 1.4 m

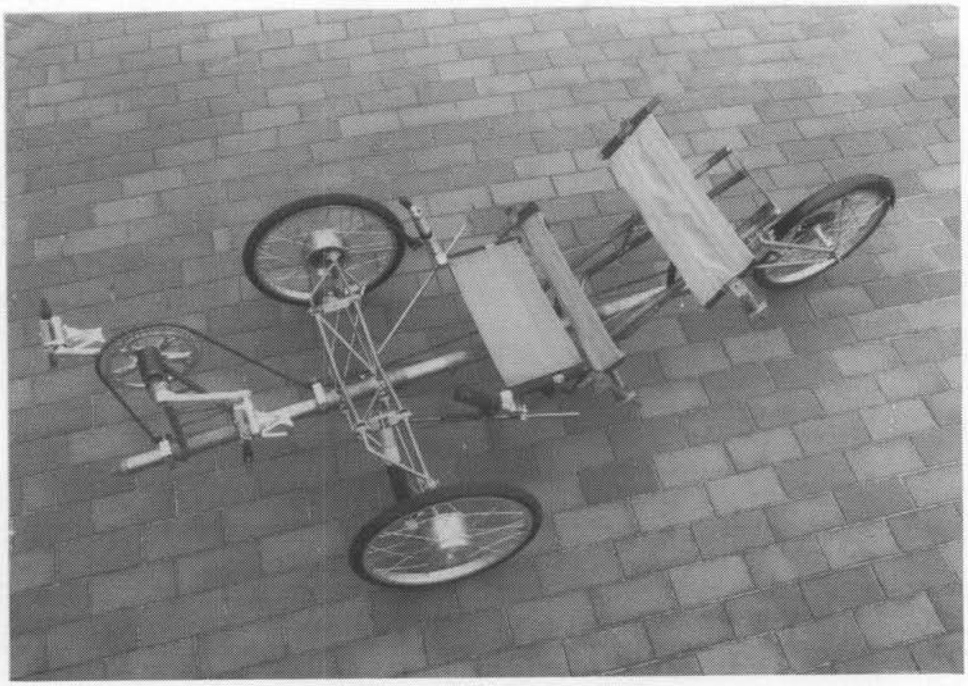

Figure 4. Lightweight commuter prototype

(adjustable). The drive train is conventional bicycle technology (Fig. 4). A front-wheel drive would have required not only a differential but also drive shafts which seemed too complex and too heavy. Besides, rear-wheel steering is not a standard technique at present.

DETAILS

Wheels

In order to reduce room required for front-wheel turning and to minimize the turn radius, small wheels were used. Moreover small wheels are more stable from sharp-turn lateral forces. The increase in rolling resistance with the small diameter was compensated for by equipping the vehicle with high-pressure tires (17" Moulton rims and tires). In order to meet the demand for comfort this decision requires the installation of a spring suspension.

Suspension, springing

The front wheels are suspended by means of a double-wishbone single-wheel suspension system borrowed from automobile engineering. The rear wheel is suspended in a cantilever construction by a transverse axis and is not influenced by the varying chain tension. The springs consist of rods made of polyurethane foam which shows considerable vibration damping (Fig. 5). The spring suspension was designed for a natural frequency which resembles that of an automobile (1 to 1.5 Hz, for the vehicle plus driver). The main problem with spring suspensions of lightweight vehicles is the big difference between minimum and maximum total weight which is approximately 1 : 2 (whereas for the automobile it is 2 : 3).

Steering, brakes

The design of the steering is also derived from the automobile construction: the steering axle is located inside the hub, and therefore it always points at the spot where the tire touches the ground (centre-axle steering). Roll radius is approximately zero, and there is no influence of the street surface on the steering forces. The steering is operated by hand levers (see Fig. 6 on page 14). The front brakes are integrated in the hub construction (see Fig. 7, page 14). A normal caliper brake is attached to the rear wheel.

Seat

The position of the rider is similar to that on a recumbent. The angle between the shoulder, hip joint and bottom bracket is 120°; it, as well as the height of the bottom bracket, is adjustable. To provide a good ventilation of the rider's body, only the seating, the pelvis, and the shoulder blades are supported by cloth belts. The seat can be adjusted to body heights between 1725 mm (5 ft 8 in) and 2000 mm (6 ft 7 in).

Fairing

It is planned to provide two different kinds of fairing. A relatively simple construction made from glass-fiber rods and a light fabric will give protection against wet weather. An aerodynamic fairing made of plastic will not only protect rider and cargo against the weather but will also reduce drag by a considerable amount. Three main problems arise with the construction of a fairing for an LPCV: despite a low drag coefficient, the fairing should not hinder the rider in comfort-

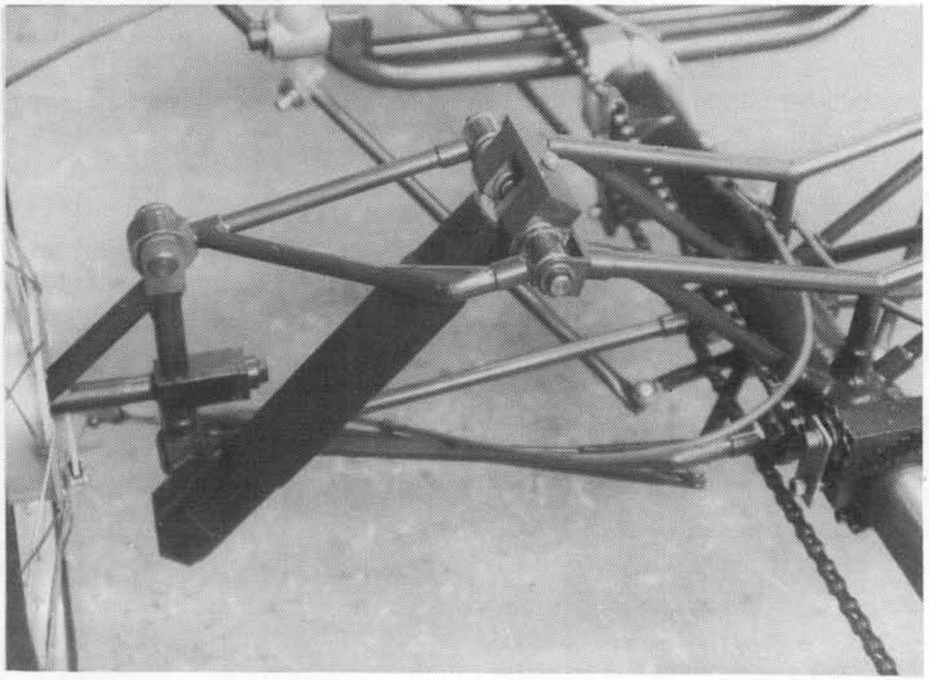

Figure 5. Spring detail

ably getting in and out of the vehicle; it also should give good visibility to the rider; and it should be lightweight in order not to increase the necessary power too much for accelerating and going up slopes.

FUTURE MEASUREMENTS AND IMPROVEMENTS

First experiences with the prototype have shown in general the practicability of the concept. Predictions and expectations concerning a very good comfort and secure driving qualities have been fulfilled so far. The upcoming research programme consists of:

- optimizing driving qualities by variation of the geometry of the vehicle;
- precise measurement and optimizing of drag forces;
- building and testing of fairings;
- measurement of dynamic forces on the most important components; and
- supplying the vehicle with an additional low-power source (e.g. an electric motor).

TECHNICAL DATA OF THE OLDENBURG LPCV:

wheel-base: 1.0 m to 1.4 m (adjustable)
track width: 0.85 m
overall length: 1.84 m to 2.24 m
overall width: 0.95 m
radius of turn: approx. 2.9 m (diameter: 5.8m)
mass: 28.5 kg (63 lbs)
overall height incl. rider : 0.95 m
springs: rods made of Cellasto (polyurethane foam), density .65 g/cm³; diameter (front): 34 mm, length (without load): 173 mm, diameter (rear): 41 mm, length (without load): 80 mm
wheels: diameter 17" (32-369), aluminum rims (Moulton), 36 spokes, undisked, high-pressure clinchers with 100 psi (Moulton)
brakes: two drum brakes in front, integrated in the hub construction, rear caliper brake (Shimano)
drive train: Shimano 600 crankset 53/48 teeth, Shimano freehub, cassette type, 11/32 teeth
adjustable:
- wheel-base/overall length
- height of bottom bracket, distance between bottom bracket, and seat
- distance between front axle and seat, i.e. center of gravity
- inclination of the seat
- height and inclination of the support for pelvis and shoulder

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Figure 6. Steering detail

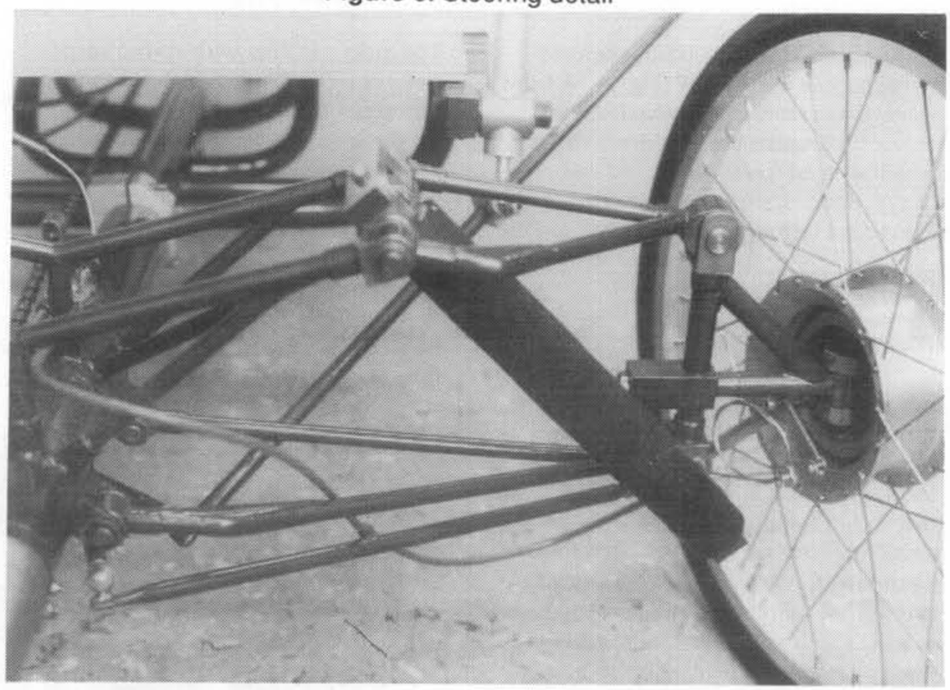


Figure 7. Front brake detail

Figure 8a. Front view

Figure 8b. Side vew

Letters. . .

(continued from page 3)

shaft propeller. It had a large front rudder used to give the craft dynamic stability. The other one, called "Daring," had a very narrow destroyer-shaped hull with almost no static stability and hence sported a retractable single outrigger float. The drive and steering was similar to the first craft.

The standard of construction of most HPBs in Europe is not as high as many American craft, reflecting the low level of interest. However, the opportunity to race will again be given next year in October. Interested persons are encouraged to contact Michael Ellison, Amateur Yacht Research Society, 10 Boringdon Terrace, Turnchapel, Plymouth PL9 9QT, England.

The rules for our solar-powered boat race (July 2nd in Switzerland) will soon be out. They allow human power in the racing category but require a minimum of 120 installed solar watts and allow a maximum of 480 W solar batteries (and pedals) disconnected for the solar water speed record. Practical boats will have a drag test instead and race for 4-1/2 hours. They are constrained to less power but can have more batteries. I will send the rules directly to Jean [Seay, ed. *HP News*] when they officially come out.

Flexifit Limited two-seater rowing machine.

If anyone has information on how to convert a 50-cc four-stroke engine to use hydrogen, please let me know.

Theodor Schmidt
Rebackerweg 19
CH-4402 Frenkendorf
SWITZERLAND

I am already in the process of designing a two-seater rowing machine. We are not designing this to break any speed records but are hoping to rent them out in a holiday situation where they would be used as a fun-fitness-tourer or racing machine. So it is absolutely necessary that the machines are reliable, robust, safe and reasonably light.

The present model is made of mild steel and polypropylene: far too heavy and difficult to get a good finish on. I intend to use braided-tube structures and resin in the future. I enclose some information on this material. This should reduce the weight by about 35 percent and allow us more flexibility in design. The present machine is capable of up to 40 mph on the level; however, one needs to be very fit and strong to achieve these speeds.

I would appreciate your comments or that of your readers on the following assumptions.

- More power is produced by the use of arms, back and legs in the rowing motion than in pedalling alone, particularly for inexperienced people.
- Recumbent machines propelled by pedalling are uncomfortable and difficult for beginners to control.
- Rowing as an all-around exercise is superior to cycling, particularly so because it is easy to get one's breathing correct when using a rowing motion.

Ken Lynch
Flexifit Limited
46 Ballinteer Park
Dublin 16, IRELAND

[Ken Lynch sent a copy of a brochure about composite "braided" tubes of various shapes

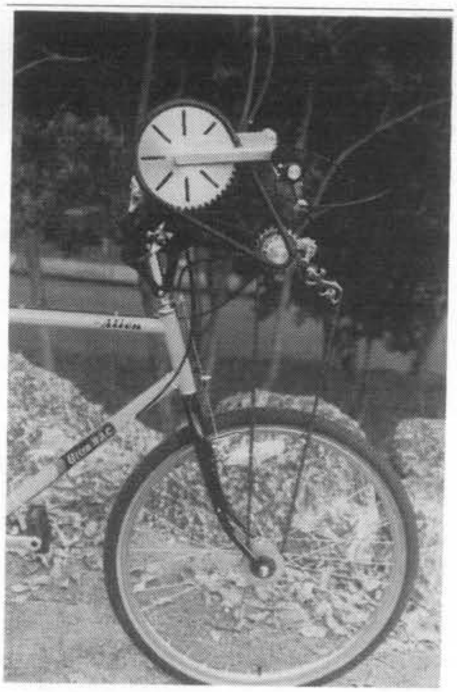
RESULTS OF JOHNNIE WALKER SPEED SAILING WEEK (10/13-20/87)
as reported by Theodor Schmidt

Single rowing shell	James Grogono	7.18 kts (3.73 m/s)
Single rowed catamaran	David Cartright	6.38 kts (3.32 m/s)
"Daring"	David Whitt	5.47 kts (2.84 m/s)
Upright pedalled sailboard	David Whitt	4.63 kts (2.41 m/s)
Linear drive inflatable cat	Theodor Schmidt	4.12 kts (2.14 m/s)
Recumbent pedalled sailboard	Alan Griffin	3.32 kts (1.73 m/s)
Recumbent pedalled shell	David Cartright	3.60 kts (1.87 m/2)

Winning craft sculled by James Grogono. Photo courtesy of Johnnie Walker.

produced by Courtaulds, a British company producing, inter alia, plastics. Write for information to Funsho Ajibade, Courtaulds Research, P. O. Box 111, Coventry CV6 5RS, ENGLAND.—Ed.]

ULTRA MAC Corporation would like to join your organization and receive whatever monthly publication you send out. We are a new Florida-based corporation with a product that should interest your staff *[Ha!—Ed.]* very much... a front-wheel-drive five-speed conversion kit. We have found that it adds considerable power and speed to the bicycle.... Utilizing co-extensive handles imparts more power to the bicycle (than do normal out-of-phase hand cranks). The whole upper body is involved in pulling and pushing during rotation of the sprocket....



Front-wheel drive, five-speed conversion kit by ULTRA MAC Corp.

Ken Haan, President
ULTRA MAC Corp.
2127-B NE 161st St.
North Miami Beach, FL 33181
USA

I have been thinking about your comments about Clive Buckler's polo bikes and their high center of gravity. Have you ridden a Roulandt? My impression is that it offers some of the advantages of a higher center of gravity. The seat is about five inches higher than the Avatar seat. Also, this bike has the bottom bracket relatively lower compared to the seat, than on most other commercial recumbents. All of this also makes the bike a bit shorter, simplifying transport and storage problems.

Having the bottom bracket so much lower than the seat runs counter to the intuitive notion that more power can be developed by pushing into the seat with a higher bottom bracket. I've been riding a DeFelice lately, which has a stout underseat steering setup. I've been experimenting on some of San Francisco's over-18-percent grades and find that my maximum power seems to come from pulling on the bars, thus firmly anchoring my hips in the seat. If this is correct, a low bottom bracket, as on the Roulandt, may not be a problem.

The high, upright seat of the Roulandt also makes it possible to see over most cars. Of course this setup reduces aerodynamic efficiency, but my impression is that the buyers of most commercial recumbents are mostly looking for comfort. For at least some applications, this semi-recumbent position may be worth considering.... Unfortunately, the construction quality of the Roulandt... is more typical of European utility cycles than American-market sport bicycles.

John Riley
554 Sixth Avenue, #102
San Francisco, CA 94118-3856
USA

I am interested in pedal-powered boats. In the 1960s I was an ordinary seaman during summer vacation. During a boat drill I saw a mechanism for propelling our lifeboat.... I am hoping you can help locate more information on the device I have described....

Dustin Miller
Star Route, Box 2275
Bradley, CA 93426

[Dustin Miller described and sketched something I saw on one of the lifeboats on a Vancouver ferry during the 1986 IHPSC. It had shoulder-high vertical levers in front of some of the seats. The levers were connected to the propeller shaft. I wrote to many people trying to locate the origin of the mechanisms. The successors to the builders of the ferry stated that they were imported from Britain originally, but even the Royal National Lifeboat Institution in London couldn't lead me to any articles about them. Years ago I was told of another lifeboat mechanism in which the passengers pedalled the prop, rather than using hand power as here. If anyone can lead us to more information, please write.—Ed.]

As you may see [by the cartoon below], in Switzerland politicians are also getting ready for elections. Over the past ten years the "green movement" has slowly but steadily made inroads and gained many seats, even on federal levels. Today every party carries a green programme.

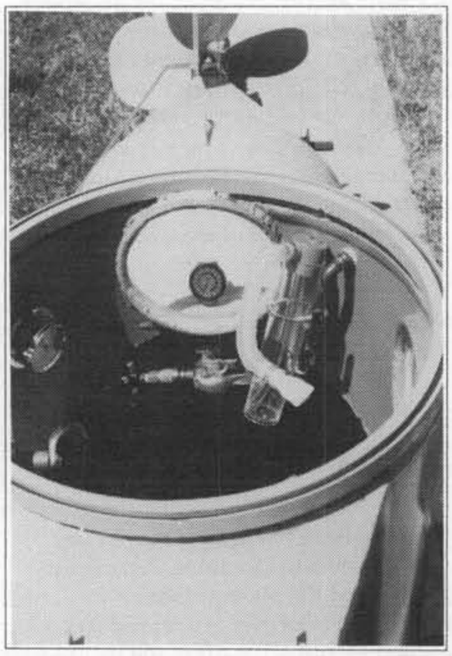
I wonder how much that is also the case on Mayor Ed Koch's or Ronald Reagan's level? From what I read, EPA is

Translation: *Bundeshaus* = Parliamenthouse; *N. Wahlen Velos* = well-known name but also National Elections; Balloon contents = "They are all scared of the greens."

still fighting an uphill battle and so far no news has emerged on breakthroughs in US light vehicles for commuting (though it seems a foregone conclusion that the USA will also have their annual solar-mobile race in the future). James Worden and some of your graduating students will certainly become future catalysts in a nationwide benign-vehicle-demonstration movement.

A Swiss TV team was recently in Davis CA and it is hoped that they will return with lots of good shots of road and cycle-path concepts for the benefit of our own city planners. We need positive action badly, since the car density in our cities has reached catastrophic dimensions.

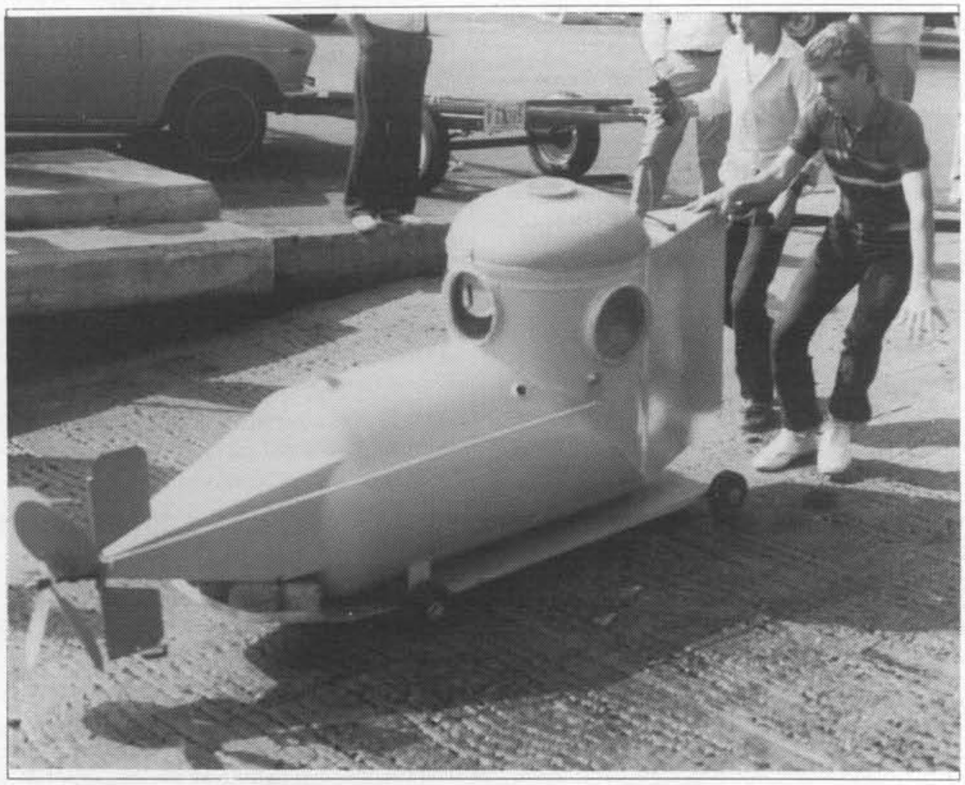
Peter Ernst
Verein Future-Bike Schweiz
Moserstr. 15,
2503 Biel, SWITZERLAND



Interior mechanism—dry submarine

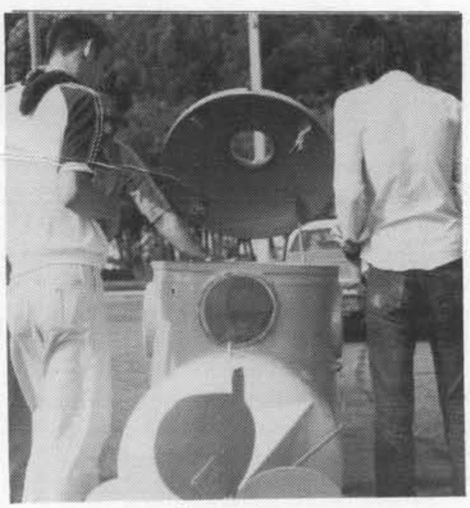
HUMAN-POWERED "DRY" SUBMARINE

The photographs are of Dave O'Neil's submarine. It would be ineligible for the submarine races sponsored by the H.A. Perry Foundation and Florida Atlantic University because in these the vessels must be "wet"—that is, flooded, with the occupants in full SCUBA gear. Phil Thiel, who will be taking a large part in organizing the NWHPVA's "Pedal-powered Potlatch" again this year, followed up a letter he saw in Small-Boat Journal about the sub and sent me this reply.—Ed.



Exterior view of Dave O'Neil's dry submarine

"(It) is a one-man atmospheric dry model that carries about a half-hour of air in the hull. The ballast gas is (liquid) carbon dioxide from a 2-kg (5-lb) fire-extinguisher tank. The gas is shot into or released from the wedge in the back and the pyramid behind the prop. The hull is 4.7-mm (3/16") steel that was a propane tank. The ports are 32-mm (1.25") Plexiglas. The prop (an air fan) pulls as in an airplane, not pushing as in a boat. The rudder is behind the prop. There is no trim ballast tank. This function is served by lead weights before descending. And the main weight is shifted for pitch control. The hull is good to 75 m (250 feet). It is 610-mm (2-ft) in diameter. There is a flood valve so that the operator could exit at depth. The bottom plate is steel and can be dropped in an emergency. The sub weighs 590 kg (1300 lb). The pedals and cranks are normal bike parts. The control shafts are O-ring sealed. The prop shaft has a pump seal. The hatch has a molded-Durathene gasket. The tiny wheels stay on the sub at all times and aid handling.



Front view

"A new electric-drive model is in the works that will have much less volume and therefore can be lighter. It will be a mummy-case type with domed faceplate and much better control and speed. The operator can put his/her face right up to anything a diver could. . . ."

Dave O'Neil
4241 Centurian Cir.
Greenacres, FL 33463
USA

. . . I'm intrigued by the claim that (the new THEBIS tricycle) has 21 speeds, and that you can change gears while standing still. I've always thought that the standard ten-speed is inadequate in that respect. . . . *[Robert Perkins has brought early versions of his Thebis tricycle to past IHPSC practical-vehicle competitions, and has continued development.—Ed.]*. . . Also enclosed is a clipping (from Der Spiegel) about a symposium on "The Future of the

Bicycle", convened by the German Bicycle Club in Berlin recently. The reporter's remarks betray his deep dislike of anything new. *[Otto quotes some snide and cynical comments, similar to those we used to see more frequently here in the US a few years ago.]* . . . I've bought another recumbent—one with a long wheelbase. I find, however, that I like my short-wheelbase one better.

Otto Brodtrick
440 Gloucester 1903
Ottawa, CANADA K1R 7T8

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Reviews. . .

(continued from page 11)

excellent book, which will fascinate anyone with an interest in small boats or the north Pacific.

Theo Schmidt

Bike Tech

"Titanium Lives!" is the headline of the December 1987 issue in which Jim Redcay, in his last major article as editor (Bruce Feldman took over for the February 1988 issue), waxes enthusiastic about the metal's properties and characteristics, and gives good comparative data. An article by Randy Ice called "Is Ultramarathon Cycling Harmful to your Health?" is especially relevant as we contemplate coast-to-coast HPV races. His answer, in this well-documented paper, was that it wasn't. Another short interesting article by Redcay also asks a question: "Two disks, or not two disks?" giving the results of some tests showing a small speed advantage to having both wheels equipped with disks on a regular bicycle but leading to crosswind instabilities with some front-wheel geometries. (There's also a letter from our Doug Milliken putting in some good words for the IHPVA.)

The lead article (by your editor—but don't blame me for the typo in the subhead) in the February 1988 issue is on the IHPSC: "Washington Power Struggles" with Gardner Martin, Freddie Markham and Gold Rush the cover photo. Danny Pavish gives equations, graphs and test methods on human-power output in "Unsaddling Horsepower", and John Olsen discusses "MountainBike Geometry." Bill Elam gives "A Paper Computer—The Cadence/Gear/Speed Nomograph."

Dave Wilson

Icarus, The Boat That Flies

by James Grogono

(Adlard Coles, Ltd., London, UK, 1987; 120 pages, hardback, L 12.95, ISBN 0-229-11803-8.)

This is a personal account of hydrofoil sailboat racing describing the author's "Icarus" projects: converted Tornado catamarans with surface-piercing hydrofoils, and other similar craft. There is also a section on human-powered hydrofoils describing the author's experiments with a hydrofoil sculling boat.

This book is very readable with nice photos and drawings. It has little technical data but interesting accounts of the early speed sailing at Weymouth, UK.

Theo Schmidt

The Technology of Winning: The Ski Jump, Flying Without Wings

(By Chester R. Kyle in a supplement to, I believe, *Scientific American.*)

Chet applies his HPV aerodynamics to those of ski-jumpers in this interesting short article. I look at ski-jumpers the way many motorists seem to look at bicyclists when we're having a great time battling a blizzard—they can't understand why we should do it and we can't understand why they don't realize what a thrill they are missing. The following statement, having only some relationship to aerodynamics, grabbed my attention: "A bad landing can send a skier tumbling down the slope in a frightening tangle. How could anyone have the nerve or skill to try such a potentially dangerous sport?... The commonly held impression that ski jumping is dangerous is misleading, according to Tom Daggett, technical director of the US Ski-Jump team. Daggett points out that a University of Missouri study found ski jumping at the elite level to be safer than cross-country skiing, and eight times safer than downhill skiing." (Maybe the definition of "elite level" is "able to land safely"?).

Dave Wilson

A Walk with the Maasai

by Allan and Colony Abbott

(*The Walking Magazine,* August/September, 1987)

This is a short article illustrated with superb color photos about the three-month sojourn of our first president, physician Allan Abbott, and Colony Abbott, a registered nurse. "The Maasai live on a high-fat, high-cholesterol diet consisting almost exclusively of milk and meat. Yet they have the lowest documented incidence of heart disease in the world. . . . We wanted to learn their secret. . . . We began to suspect that the Maasai's resistance to coronary problems is not entirely biophysical. It can also be attributed to avoiding stress, eating less, and exercising more.

"Accustomed to walking as the sole means of transportation, the tribe is not infected by psychological, time-oriented tensions. Their time sense is focused on the present. They do not have names for the days of the week or for the months. Another factor is the amount of food eaten in relation to physical activity, and the strictness and narrowness of the diet itself. When sufficient milk is available, the average Maasai consumes 3 to 5 quarts daily. Beyond that, food is limited to an evening meal of meat or meat soup.

"Perhaps the most important factors in the Maasai's ability to resist heart attacks, however, are exercise and superb fitness. . . ."

Dave Wilson ❑

DAEDALUS TRIUMPHS!

This issue of *Human Power* closes with a tribute to Daedalus. Peter Ernst contributed the photographs on the facing page. The back cover is a reproduction of a stunning three-viewdrawing by Mark Drela which was first published in May 4, 1986 issue of*Tech Talk,* a newspaper published at MIT. Mark is an assistant professor at MIT and was the senior engineer responsible for the aerodynamic design of Daedalus. He was a member of the Chrysalis and Monarch human-powered aircraft projects at MIT and teaches in the Department of Aeronautics and Astronautics. His research specialty is computational fluid dynamics.

We thank both of these gentlement for preserving the Daedalus achievement in art so we may all participate in the celebration of this ground-breaking ...nt.

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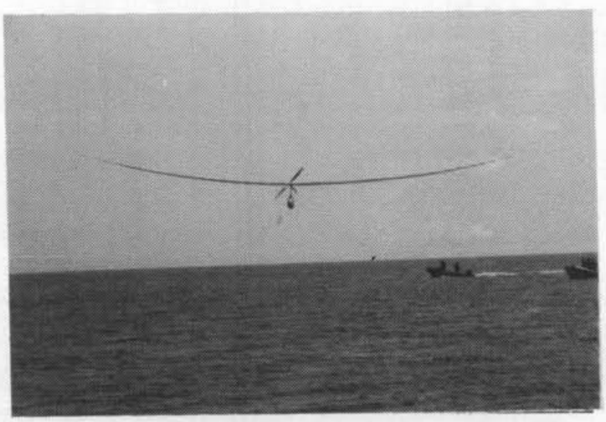
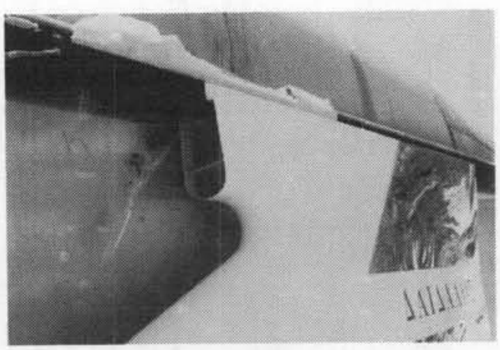
Daedalus

The *Daedalus* human-powered aircraft being prepared for flight at Edwards Air Force Base in California. Prof. Mark Drela (left), chief aerodynamic engineer for the project, makes final check on the aircraft's drivetrain. Director of flight operations Prof. Steve Bussolari (kneeling) reviews the flight plan with pilot Glenn Tremml. (Photo by Cathy Cummings; provided by David Gordon Wilson.)



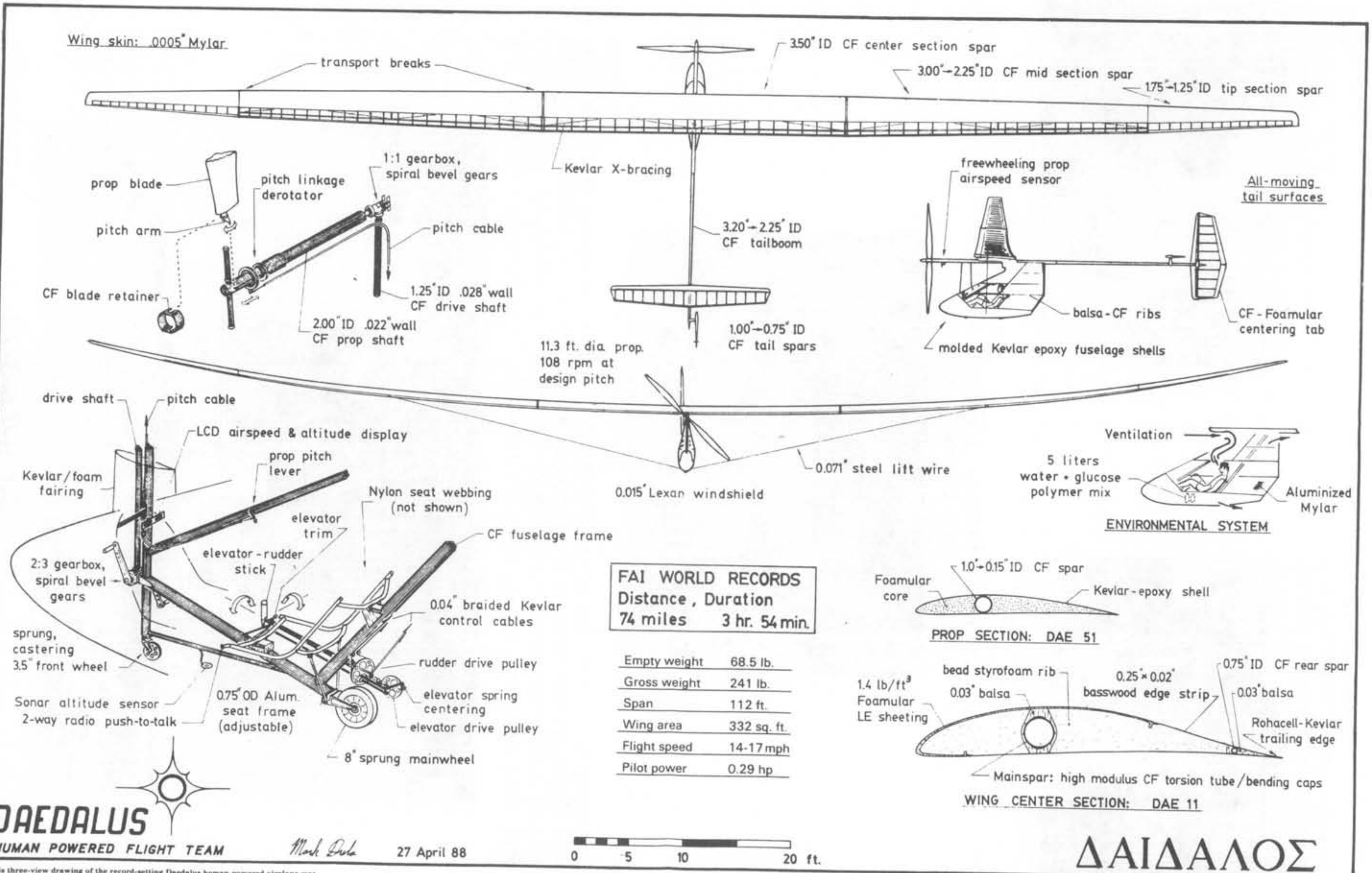
April 23, 1988: Daedalus taken from Thira (Santorini) beachfront. Photo by Peter Ernst.



Daedalus airscoop (normally under wing). Photo by Peter Ernst.

Daedalus tidying up in front of Thira-Santorini H.Q. hotel (the chute, also called the boat) Photo by Peter Ernst.

DAEDALUS FROM AN ENGINEER'S PERSPECTIVE



This three-view drawing of the record-setting Daedalus human-powered airplane was drawn by Assistant Professor Mark Drela '85, the senior engineer responsible for the aerodynamic design of the craft. He was a member of the Chrysalis and Monarch human-powered aircraft efforts at MIT. He teaches in the Department of Aeronautics and Astronautics where his research specialty is computational fluid dynamics.