Recumbent Cyclist
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The ReHog
by ReBike

Are you ReBorn to be Wild?
Find out in this issue!

Also inside:
- Tim Brummer and the Lightning P-38 design history
- How you can support the recumbent movement
- Summer recumbent events calendar.

DESIGNER FORUM:

THE LIGHTNING P-38 DESIGN HISTORY

LIGHTNING

I initially began design work on the Lightning P-38 over 10 years ago. At that time, recumbents were even more rare than they are today, so there was not much previous design information to go on. Thus I had to decide what the main objectives of this bike were going to be. This is necessary because in the design process of any piece of machinery, trade-offs normally have to be made. For example, with a recumbent, wind resistance can be decreased by lowering the rider, which results in higher speeds, but this also makes it harder to see and be seen in traffic. Thus it is best that you know what you want the bike to do before you design and build it.

DESIGN GOALS

At the time, I owned a Raleigh Grand Prix "ten speed" bike, and rode quite a bit with a friend of mine. He owned a really nice Italian sport-racing bike. Like me, he not only used his bike for day rides, but also for occasional commuting and lightly loaded tours. Thus I used this Italian bike as the starting point for my design, with the goal to improve on it in some areas. What I came up with is the following (as compared to the Italian bike):

1. Obviously, have a much more comfortable seat
2. Safer braking with a shorter stopping distance
3. Improved cruising speed
4. The same level of hill climbing, acceleration, and handling performance
5. About the same price range

Plus I felt the following was important:

6. Seat as high or higher than the average automobile seat, in order to safely ride in traffic
7. Ability to put a relatively compact, practical full fairing on the bike.

Steel was selected for the frame material for a couple of reasons. The best bikes were being made from steel at that time. Alternative material bike frames were just making their appearance, so their reliability was not yet certain. Also, steel was, and still is, the easiest material to modify, repair, and add "braze-ons" to.

REAR WHEEL SIZE

A 700C rear wheel size was chosen because of the gearing advantages it offered. For the unfaired P-38, a top gear of 110 inches was desired. For the F-40 model, a high gear of at least 130 inches was needed due to the faster speeds made possible by the fairing. For hill climbing, a low gear of 24 inches for both bikes was preferred. The only way to do this using available bicycle geartrain components was:

A) Use a 700c rear wheel, or

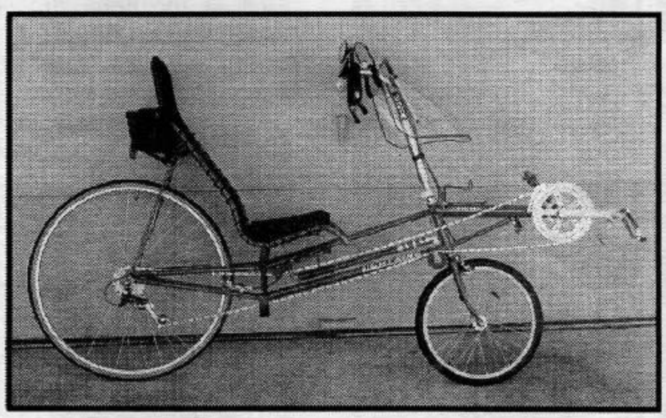
B) Use a smaller rear wheel with a pair of overdrive gears in place of the idler under the seat, similar to the ATP. It was not possible then, and is not possible today, to use a 20 inch rear wheel with a normal type of geartrain and obtain the gear range desired. If the low gear is kept the same at 24 inches (39x32 sprockets) the highest gear possible is 112 inches (64 x 11 sprockets). The gear range cannot be increased any more than this because available derailleurs are already at their limit with the 25 tooth front chainring difference and 32 tooth largest rear cog.

The drawback I discovered to overdrive gears are the extra weight, drivetrain, and aerodynamic losses. This type of gearset has four times the bearing loads as a simple idler. As a result, the bearings and support structure needs to be much heavier in order to ensure adequate longevity. Any weight saved by the smaller rear wheel would be more than offset by this extra weight. By my calculations, about 1/2 pound more. The double wraparound chain losses, while only about 2%, are still measurable. Another disadvantage is the rear derailleur is now down lower in the airstream, which increases frontal area and thus air drag, especially if a fairing is used.

So my solution was to use a 700C rear wheel. Besides the other reasons cited, I also thought a larger rear wheel made the overall design look better.

FRONT WHEEL SIZE

This was a harder decision than the rear wheel. The options were between the 20" and 17" sizes. The 20" size was initially preferred because it is much more available here in the United States. When building my prototypes, however, this size caused a lot of problems. For the best handling and braking characteristics, I found that the front axle needed to be within 4 to 10 inches of the bottom bracket, depending on frame size. This was also the best place for good stability at high speeds, especially when using a fairing. But on the other hand, the front tire had to be far enough away from the bottom bracket so that the crank arms would not hit it when the front wheel was turned. When a 20" front wheel was used, these



The Lightning P-38
(Photo courtesy of David Yust)

conflicting requirements led to a high bottom bracket, and consequently a high seat. This not only increased the air drag, but also made it very hard to put your feet on the ground.

I also found out that while 20" BMX tires for dirt riding were readily available, 20" high performance road tires were not. In the town where I live (population 40,000), all three bike stores did not stock them, but told me they could order them....., in other words, availability was the same as a 17" tire.

Thus I decided on the 17" size, with the 16x1-3/8 size as a less expensive alternative for touring or commuting on bad roads.

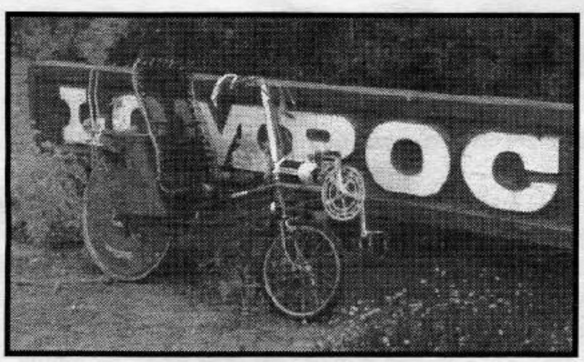
SEAT DESIGN

During development of the P-38, I built and tested numerous different seat designs. Of the various designs, the seat currently used on the Lightning was the most comfortable, coolest, lightest, and had the smallest power loss. I tried suspending the seat, similar to the current Presto and ATP, on one of my first prototypes. I found that there were significant power losses when accelerating and climbing hills. This was because (as every recumbent rider knows) when I pushed hard against the pedals, I was also pushing hard against the seat. Part of my power was compressing the elastomer suspension bushings, but when they rebounded, I did not get any of that power back.

I found that a better solution was to lean forward in the seat when you hit big bumps, and a little later on, also leave some room between the forward seat cross tube and main frame top tubes, so that the seat bottom acted as a springboard. These two items result in a seat that is actually more comfortable than the elastomer suspended seat frame was, and there is almost no power loss when cranking hard.

FRAME DESIGN

During my initial design process, I mathematically calculated the differences between various frame designs. There were three different "space" frame designs, and one monotube design. During this process, each frame was designed to have the same amount of stiffness to resist deflections under pedaling loads. I then determined the weight, and the current P-38 frame design had the lowest weight of the four options. The monotube design was the heaviest, weighing at least 3 pounds more. I later confirmed this by building a monotube design.



(Staff Photo)

HANDLEBAR DESIGN

This was an easy decision to make. I built one bike that had two handlebars, one below the seat and the other shoulder high. You could ride around and steer using either handlebar. The high handlebars were lighter, simpler, faster, gave much better handling, and provided a mounting point for speedometers and fairings. The low handlebars had the one advantage of being more relaxing, but not by much, since I could steer with one hand on the high handlebars, and let my other arm relax. I could also drape both of my forearms over the high handlebars when riding - this was another relaxed position.

CONCLUSION

Some of the aspects of the P-38 design mentioned above may make you think that I made certain decisions in order to gain a relatively small increase in performance, like I was splitting hairs. This may be somewhat true, but you have to remember that many of these decisions have to be made in the design of a bicycle, and they all add up. Thus it is important to look at every little detail during the design process, in order to ensure the initial goals are met. In the P-38 design, I have even emulated some of the Italian bikes' frame details by using custom pointed lugs, sloping fork crown, and forged dropouts with adjusting screws.

The end result is a bike lighter, faster, and more comfortable, in combination, than any other recumbent built. Plus, 95% of the other recumbents built do not have the quality, detailed frame construction and finish of the P-38. Other designs may have their attributes, but for a total performance package, the P-38 is the only way to go.

When you take a recumbent on Saturday training rides with the Santa Barbara Bicycle Club, like I do, you need to have the best one made in order to keep up with these guys. When you ride in a group like this, a fairing does not help your speed much, and on the negative side is viewed as antisocial. Interestingly, riding a recumbent is not, and I have had no problem being accepted.

I feel that if the recumbent is going to ever replace the upright UCI bicycle, then it has to do most everything that the UCI bike can now do, as well or better. This is the biggest advantage of the P-38. Additionally, it has the added flexibility so that I can ride it in a group unfaired, then easily put a fairing on it for solo rides or commuting.

Tim Brummer
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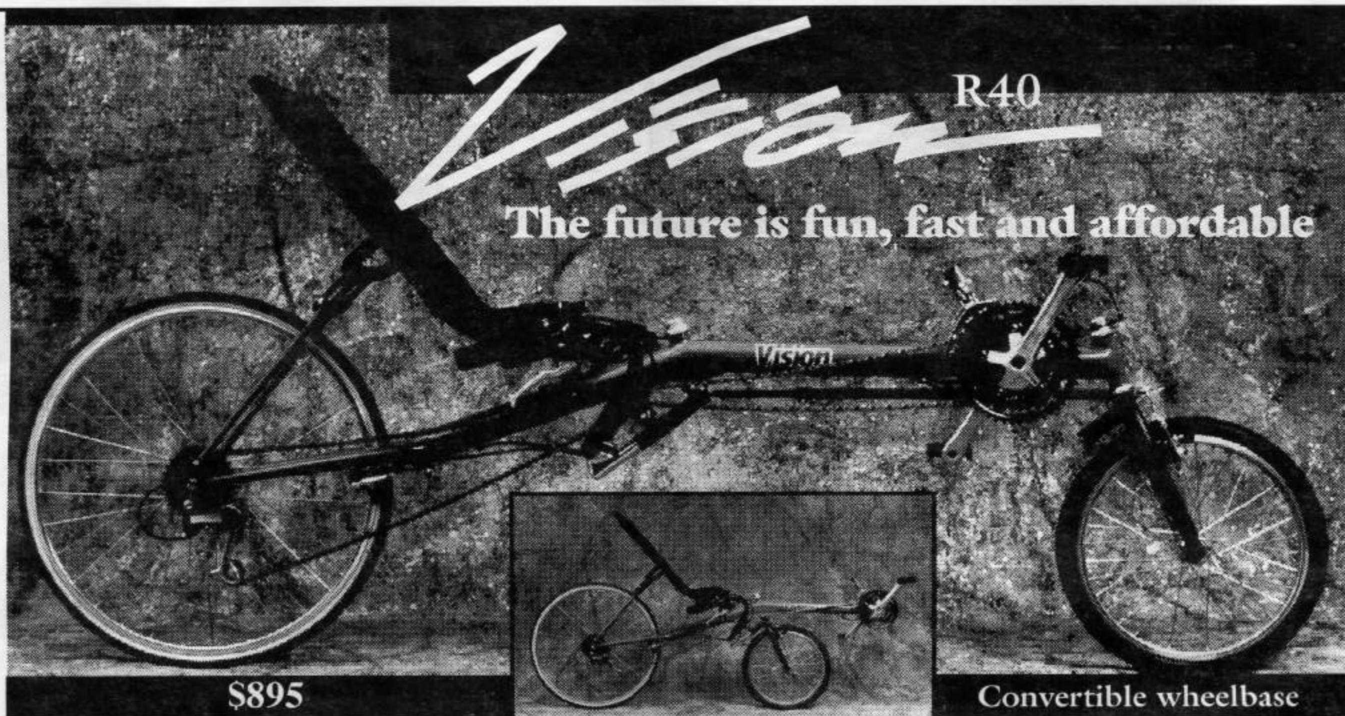
LIGHTNING



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