DOUBLETALK

BULLETIN OF THE

TANDEM CLUB OF AMERICA

VOLUME 3, NO. 4

SEPTEMBER -OCTOBER
1978

DESIGN OF THE MAT 2 TANDEM

BY ZEKE MATAGA GLENDALE, CA.

Greta and I became interested in tandems in early 1976. Even at that time I had some thoughts of building my own tandem. However, being a reasonably prudent person, I quickly dismissed the thought and ordered a Jack Taylor touring tandem (double diamond configuration) through Bud's Bike Shop in Claremont, California. The tandem arrived in January 1977 and we became avid tandem enthusiasts.

In looking back at the events that culminated in the finished tandem, the start of the project occured during our tour in England in May of 1977. While in Stratford, England, we had the fortunate luck of meeting Andrew Hague, a manufacturer of quality bicycle components who was attending a conference there. I had concludedthat it wouldn't be very satisfying to build a tandem without incorporating the nice braze-on features. As a result of this fortuitous meeting, Andrew promised to send us brochures on his products. Sure enough, on our return from England the brouchures had already arrived and the project was begun in earnest.

I can't think of anything more crushing to an enthusiast than to build something and find that nobody is interested. Well, this certainly doesn't happen with the Los Angeles Wheelmen when the object is a tandem. In fact, things may be going too far. As a studious advocate of the low profile approach to everything, I must report that your editor has obtained possession of my photographs of the Human Powered Championships and refuses to return them until an article for Double Talk is received.

In thinking about a theme for this article, I was struck by the fact that when explaining how the tandem was built, the inevitable question is, what is your profession? When you say you are an engineer,the immediate reaction is "Ah, so that's it". Protesting that this has nothing to do with building a tandem does not seem to convince otherwise.

In looking back, there is a facet of the tandem design that drew on my experience as an engineer. Considering the practical aspects of the problem at hand it became quite clear that a good understanding of the factors affecting tandem

stability was mandatory. First, it made little sense to copy the Jack Taylor design and own two tandems that rode essentially the same, regardless of the merits of the design. Secondly, I sensed a strong reluctance of the stoker member of the team to tolerate a design failure in something as expensive as a tandem.

It had become my practice to write notes that summarize results at some point in an analysis. In reviewing my notes on bicycle stability it was concluded that these notes seem appropriate for an informal format such as Double Talk, and therefore will be shared with the reader. Hopefully this may spark some dialogue between enthusiasts interested in the theoretical aspects of bicycles.

The following comments on the notes are in order:

1. First a warning. One should be extremely cautious of anyone who claims to have solved the equations of motion of anything as complicated as a bicycle with rider.

2. These notes are really intended only for my own personal use. I have found in the past that being the originator of notes is no gaurantee that they can be understood at a later date. I therefore try to make them as easy for me to understand as possible.

3. These notes were the basis for the front end design of the custom tandem and do have computer back up data.

4. Ther finished tandem seems to ride essentially as I thought it would.

BICYCLE STABILITY NOTES (12/5/77)

Minimizing the trail distance (or caster) on a tandem has the desirable effect of minimizing the disturbance caused by pedaling action and riders shifting weight. It is basically possible to reduce trail on a tandem to a much greater degree than on a single bicycle because the tandem has a more reliable source of weight on the front wheel. A single bicycle with either a "no hands" rider or one with light pressure on the handlebar has little front wheel weight.

To put the subject of trail distance on bicycle stability in proper perspective, it is important to note that bicycle speed has a overriding effect on bicycle stability. In fact, a bicycle at very slow speeds is controlled quite differently than one at very high speeds. At low speeds, the rider senses lean rate and controls through a proportional steering angle. In control system terminology, the former is a rate servo and the latter is a proportional servo.

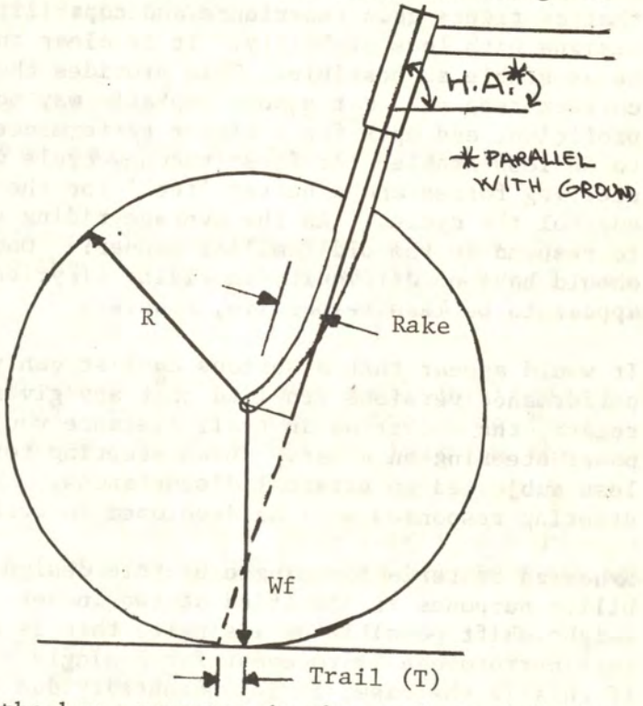
In view of this wide range of adaptive performance exercised by a typical rider, what is meant by the oft used term "bicycle stability"? In discussing this subject the first thing to realize is that the term is not meaningful in an absolute sense. It is probably true that regardless of design, the riding of the cycle can be mastered with sufficient practice. However, the terms relative ease in

riding and relative experience of the rider are considered meaningful to the subject of bicycle stability.

The design of a bicycle front end affects the handling qualities of a bicycle to a greater degree than any other design parameter. The front end design is controlled by the following:

H.A.= Head Angle
RAKE
R = Front Wheel Radius

FIGURE 1 AT RIGHT



$$\text{TRAIL} \triangleq T = \frac{R\cos(\text{H.A.}) - \text{Rake}}{\sin(\text{H.A.})}$$

Wf ≜ Total Force on Front Wheel

From a bicycle dynamics standpoint, the key parameter is the product of Trail (T) and Total Front Wheel Force (Wf)or (TWf) Generally similar handling characteristics can be achieved by similar TWf products. A bicycle with a large TWf product is considered more stable than one with a small TWf product.

The factors that produce this judgement are relatively simple to explain. Suppose a bicycle is progressing with moderate forward speed and a lean angle develops. The reaction to the front wheel force (Wf), acting through the trail distance, produces a steering torque in the direction of the lean. The resulting steering angle produces a centrifugal force that prevents the bicycle from an ever growing lean angle and resulting fall. In fact, when the centrifugal force balances the force of gravity the steering torque goes to zero. The foregoing effects are the ones that allow no hands operation of the bicycle.

It is of interest to note that with negative trail distance, the steering torque is away from the lean angle and tends to accelerate the lean angle. Obviously "no hands" operation is clearly impossible. This, however, does not mean that the bicycle is impossible to ride. With sufficient practice even this so called

unstable configuration can be eventually mastered. This configuration is particularly undesirable because any experience learned in riding stable configureations must be"unlearned" before eventual success is possible.

At this point in the discussion it is tempting to conclude that maximum stability is always desired. From knowledge of bicycle dynamics, it can be deduced that as riders gain experience and capability, they tend to gravitate toward designs with less stability. It is clear that a bicycle for a beginner should be as stable as possible. This provides the learner with a feel for the correct resp nse i t e most emphatic way possible. As the rider becomes more proficient and opts for a higher performance version, the new bicycle will tend to be less stable. At first the new cycle will seem strange, requiring less steering forces and a better 'feel' for the steering mechanism to proficiently control the cycle. As the average riding speed increases, the cycle will tend to respend in the old familiar manner. Once proficiency is achieved, the rider should have no difficulty in riding bicycles that are more stable. They will appear to be less responsive, however.

It would appear that a serious cyclist can progress through a series of improved performance versions provided that any given change is not too drastic. In this regard, the reduction in trail distance would seem somewhat analogous to putting power steering on a car. Less steering forces are required. The steering is l less subjected to external disturbances. However, a greater sensitivity to the steering responses must be developed to proficiently control the vehicle.

So design criteria for single bicycle design exists where minimum trail for stability purposes is specified at two inches. Considering the large front wheel weight shift possible on a single, this is a good guide. It is also possible th that performance improvement for a single bicycle becomes marginal at this point. If this is the case, it is undoubtedly due to the fact that a single reder had complete knowledge of the forces applied by the rider himself. Such is not the case with tandems.

TANDEM CONSIDERATIONS

The fact that a tandem has not only a greater front wheel weight but also a more dependable source for this weight is sufficient to reduce trail by ½ to 3/4 inches for a tandem to obtain equivalent stability to a single. This would put minimum trail distance in the 1½ to 1¼ inch range. Reasons for choosing the minimum trail are as follows:

1. "No hands" operation of the tandem should not be considered. Even with a highly stable configuration, this stunt would be foolhardy.

2. Tandems can achieve considerable downhill speeds. Reduced trail decreases the chances of steering oscillations.

3. Unpredictable rider disturbances are prevalent on a tandem. Minimizing trail minimizes the disturbing effects.

4. Minimizing trail will tend to minimize induced oscillations in the frame.

The overring consideration is of course the ability of the tandem captain to accommodate the reduced stability. In this regard, note that top of the line tandems (eg. Jack Taylor) are designed with 1½ inches trail distance. A 1¼ inch trail experimental tandem for someone who already owns a Taylor is too intriguing to pass up.

A Tandem to Sunrise . . . Almost

by Rudy and Kay Van Renterghem, Tucson, Az.

We are recent transplants in Tucson from Michigan, and now that we have been Arizonans for three months and got to know the lay of the land a bit, we decided to take our Assenmacher tandem and ride our first western tour.

The White Mountain Bicycle Tour (Aug. 12-13) was well publicized locally and after making some cautious inquiries about the ride from local bikies who had ridden in that area, we decided to join in the fun.

The first day's ride was to be 65 miles from Show Low via Springerville to the Sunrise Ski Lodge. The second day was about 38 miles from Sunrise via Pinetop back to Show Low.

That sounded like a rather short and easy tour according to our midwest cycling standards, but there was only one hitch: the first day's ride started at 6,330 ft. elevation and ended at the 9,200 feet level at Sunrise, a climb of almost 3,000 ft.

Having just gotten used to Tucson's 2,500 ft. altitude, compared to Michigan's 900 ft. elevation, we expected some problems at the higher altitude, as we had never exerted outselves in such a rarified atmosphere. However, after being assured by many riders that it was not all that much of a problem, we felt we could cope with the situation.

Cyclists from all over Arizona gathered at Show Low this fine August morning. The ride started at 10 a.m. under the usually sunny western skies and 108 bicyclists were ready to start the trek up to Sunrise.

The many uphills were followed by some nice downhills and all was going well. The first two refreshment stops were brief interludes before the scheduled lunch stop at Springerville.

However, Mother Nature had a surprise in store for us before we reached our awaiting lunch and it came in the form of two rain squalls. The first shower was of the mild variety but the second one was a real downpour that dropped the pleasant temperatures into the cooler zones.

Without a place to wait out the driving rain we continued pedaling and got thoroughly soaked. Our shoes felt like puddles rotating around and around.

We reached the long downhill before Springerville and we were getting quite chilled while spinning out in our 106-inch gear while the rain continued in torrents.

The rain ceased suddenly and we were glad to reach the town three hours after we started from Show Low. We followed the well-marked route into the city park where we joined other riders for a quick lunch while watching some Tucson cyclists wring the water from their socks. We donned our windbreakers to preserve our body heat and soon started the climb to higher elevations. The 45-mile ride to Springerville had passed without experiencing any breathing problems although we already were at the 7,500 ft. level.

After lunch we were faced with a rather strong headwind and the road continued to climb.

Sagwagons went by carrying several cyclists and their metal steeds as the climbing and thining air started to take its toll.

More dark clouds wreathed the nearby mountain tops and somewhere ahead a terrific hailstorm broke loose; fortunately we only saw the evidence -- hailstones four inches deep alongside the roadway -- and did not have to take the pelting like some riders did.

Our breathing now started to become more labored and we had to take our first unscheduled break. After a brief rest we remounted our twicer but lo and behold a mile later we had to dismount again. Our 29-inch gear was getting a real workout but to no avail. We had to dismount again and again until finally we had to walk up the long hill before the Greer refreshment stop.

By now the sagwagons were working overtime hauling tired bodies and dirty bikes up to the ski lodge.

But we persevered; we finally were advancing only a hundred feet at the time astride the tandem before we were forced to dismount and walk. But soon even our walking became a big effort. Our minds urged us to continue on, but our oxygen-starved lungs and muscles refused to obey any longer.

We had covered 15 miles in three-and-a-half hours! Five miles to go to Sunrise . . . it may just as well have been 5,000 miles. As the last sagwagon came by we loaded our tandem and exhausted bodies aboard and rode up to the ski lodge. The high altitude claimed two more victims.

This was the first time ever on countless bicycle tours we participated in that we had to resort to the sagwagon . . . our egos and bodies were suffering.

Upon arriving at the lodge we learned that only about 10 percent of the riders who started out that sunny morning managed to go the full distance; and that 10 per cent was equally divided between male and female riders.

After a much needed overnight stay at the lodge and an early morning ride on the skilift to the 10,700 ft. crest, (what a magnificent view from atop of the world!), we were ready and eager to tackle the second part of the ride. Facing a 3,000 ft. drop in elevation in the next 38 miles, we took off with high hopes.

The weather and scenery were great and we just loved to get more and more oxygen in our lungs as the road continued to spiral down. We arrived at Show Low just two hours later.

In retrospect it was a good tour and very well organized . . . it was also the roughest tour we've ever been on; rougher than TOSRV, rougher than the Canadian Mileater, rougher than a double century.

Now, about our next tour . . .

A Four Chainring Tandem Transmission

by Cliff Coffey, Brea, CA.

In setting up the gears on my Gitane tandem, I wanted a low gear (33") for climbing and a high gear (112") for those fast downhills or tailwinds. With a triple plateau set up on the TA crankset, this range requirement was met, but there were some large blank places in the gear chart. Under some conditions I couldn't find a comfortable gear. Hence, I elected to try for a quadruple plateau. This seemed the most practical method since I already had the fourth chainring and the necessary bolts. Here is the way I modified my tandem.

First, assemble the three smaller chainring (34-45-52T) as if building a triple plateau. Then with the bolt kit for 2 double plateau, assemble the triple cluster to the single chainring (58T) with the crank spider as the spacer. (See fig. 1)

Now, since there are no front changers that will satisfactorily shift four chainrings, a front changer must be modified. I used a Huret Jubilee, because it is steel and therefore easier to modify. The two vertical arms of the Huret must be lengthened at least 1/2 inch in order to provide the throw necessary to reach the outer chainring. I found that the parallel arms of the Campagnolo Gran Sport rear derailleur were the correct length and width. They are also made of a hard enough steel that they will not bend easily. A new hole was drilled near the center of the Campagnolo arms to accomodate the screws to hold these arms to the original Huret arms. (See fig. 2). After this modification, the Huret changer was reassembled and installed on the front seat tube.

The bottom brackets I used were a Phil Wood #3 in the front bottom bracket and a Phil Wood #5 in the rear. The longer crank axle in the rear is necessary to allow the rear crank arm to clear the chain. The drive is from the front crankset because of the clearances involved and the distance allows the chain line to be acceptable. Combined with a 14-17-20-24-28T freewheel, I have found that this set-up shifts very nicely and I can always find a comfortable gear.

A "Town and Country" Saga

by Harvey M. Sachs, Princeton, NJ

In answer to Dale Brown's DoubleTalk question about his "...older Schwinn tandem..." and to offer some guidelines for cost-effective equipment changes on other tandems, we offer a few notes on our Schwinn.

The Bike:

This model was billed the "Town and Country" in contemporary Paramount catalogues. We bought ours in Rhode Island in 1972 for less than $100. At the time, we felt that (a) it was the only way we could afford a tandem and (b) whatever its flaws, we should be able to fix them. The first point was true...Before purchasing it, we weighed it: at 50 pounds or so, it was lighter than the only handy reputable tandem - a new Citane.

That summer, we learned a lot. The bike had belonged originally to Bill and Edith Lovely. Their son told us that the Veeder cyclometer got a new paint stripe after each 10,000 mi. circuit: we had bought it with over 30,000 mi.! Unfortunately, a year later the rust of later neglect caught up and ate through the frame. Schwinn extended the warranty and sent us a replacement - from stock! Mr. Fred Sikora of Schwinn also sent us pictures of the Lovelys. In addition to about 100 centuries - many on singles - they completed a double century in 15 hr. 37 min. on the tandem. At the time, he was 61 and she was 59, and they did the hilly ride with a 3-speed derailleur.

We understand that the Town and Country was only made 21"/19", with a mixte back and curved rear seat tube. The wheelbase is tight - about 61", with 15½ rear stays (adequate for the 26" wheels). The front bracket (with eccentric) is 74 mm; the rear 73. On the other hand, after some 10,000 mi. on this one and lots of comparison rides on others, we still love her: the bike is stiffer by far than most we have used (long rides are numbing). Only the heavy steering and the shallow head angle make the bike feel old - not bad for a model discontinued about 1953. If you find one, buy it and enjoy, or call me. We - and Schwinn - didn't feel that it had museum value, so we decided to try to make it a modern bike.

The Modifications:

With the benefit of 20-20 hindsight, I have tried to suggest a rational sequence of changes. Most are applicable to other tandems. Throughout, I assume that you will do most of the work yourself. If not, a nearly new modern bike is probably cheaper: these changes are very labor-intensive.

First, a couple of minor frame modifications will make a lot of difference. I sliced off the bottom half of each rear dropout and replaced it with a vertical "half-dropout" (Figure 1). This has several good effects: Verticial drops eliminate wheel slippage; you can hang a rear derailleur without sacrificing wheel clearance to mounting plate; and you can mount 700 c or 27" wheels without deflating the tires. As important, this allows you to make the other frame modification: adding a brake bridge to the intermediate stays, as I suggested in the previous DoubleTalk. These steps will ruin your paint but give you great freedom. While you are at it, don't forget a small cable stop brazed on for the rear brake - I used a Weinmann cam assembly mounted under the mixte tube. Also, you will want to grind away almost 1/2 of the inside of the right intermediate stay for about 4-5 cm. to clear the chain, then dress it with bronze. Assuming that you do the rough work of shaping the new dropouts (made with hacksaw and file from 1/4" plate) but get help with the brazing, I would guess the cost at $20 - $50.

Having arranged for good braking and holding the wheel in place, the next change is gearing. Initially, we used the drum hub sold for Schwinn 5-speed tandems, but we are much happier now with the Shimano E disc: it stops better and removing the wheel is much simpler since no cables have to be disconnected. This should be about $26, including $5 for their grotesque steel hub (which we discarded for a proper Phil). At this point, get out the scissors jack and some lumber to cold set the rear triangle to 125, 130, or 135 mm, according to taste and hub choice. Be certain drop-out inner faces are parallel and that the rear triangle is centered.

We are happy with Suntour Tandem freewheels - they are probably the cheapest ones which are strong enough, and they have good interchangability, using Suntour cogs. The Pro-Compe will not withstand in-phase cranks.

Ah, how are you going to use your new freewheel setup with those nasty old 1/8" chainrings? One solution is to find a 3 mm chain, an intermediate size which rides properly over freewheels but clears 1/8" chainrings. At this point, the new rear hub, freewheel, brake, and derailleur have cost you about $50 - $80. A better solution (if you live in relatively flat country and don't haul concrete blocks or children) is to leave it as a five-speed, but substitute an appropriate 5-pin or 3-arm steel crank for the right rear. The former allows fitting aluminum chainrings from TA, Nervar, or Stronglight, and saves some weight. The bit-more-complex solution is to scrounge an old, high-quality, no-gearcase clearance right crank and discover that the existing rear spindle will just allow you to mount a double chainring. We used a Stronglight Competition. If you can't find such, you may have to have a custom spindle ground -- R E W Reynolds or DoubleTalk advertiser Sumner White may be a good source of help.

TRADE: 56 Tooth Campagnolo chainring, 3/32" chain, never used, for a 48 to 52 Tooth chainring. This chainring is for older cranks with 7½ cm. radius bolt circle, and will not fit new Campagnolo cranks.
Ben Furst 22 Pleasant St. Potsdam, New York 13676

If you do go this route, you will have to mount a chainwheel shifter. There are two problems: the 73 mm bracket means that the chainwheel offset is too great for many shifters, and the curved seat post leaves the back of the derailleur quite far from the rings - cutting down the chainwheel range considerably. We had best luck with the old Huret Allvit (cage angle is adjustable), but the Huret Success used on modern curved-tube Paramounts should work as an alternative. We are now using a Shimano Titlist whose cage has been reworked by adding a spacer between body and cage and rebrazing at the proper angle. It's robust, but needs a helper spring. Having installed and used a triple on ourrs, I don't recommend it. With reasonable luck scrounging, the 10-speed set-up will cost $20 - $30 more than the 5-speed; we feel that the expenditure is well justified.

We have not yet mentioned wheel changes, because we have mixed feelings. For thousands of miles, we made do with the original 26" wheels, using marvelous Michelin Sport tires which withstood 80 psi and cornered like nothing else we have ridden. Honestly. In a fit of affluence, last year we replaced these wheels with 700c high pressure ones. We like having S.C. aluminum rims (and the 48 rear, although spoke breakage was never a severe problem with 12/14 spokes), but I doubt that a tire will ever last 1000 mi. Costs for the wheel conversion are widely variable, of course, so we won't estimate them. If you plan to tour with gear, or carry a child, we heartily recommend extra spokes, at least in back. Not only does the dead weight impose strains, but the hub brake also pulls mightily.

Having selected your wheels, you can set up rim brakes, as discussed in an earlier DoubleTalk article. To recapitulate, (1) We love our Matthauser shoes. (2) For an intermediate stay-mounted brake, only a center pull will clear stoker ankles. (3) We have been very pleased with Universal 61's front and rear; have little against Mafac "H" cantilevers in front, but dislike side-pulls.

At this point, there is one slightly unesthetic point: your pedals have two spindle sizes: 9/16" for the right rear, and 1/2" at the other three corners. We found the cost-effective solution to be the Schwinn-supplied French alloy pedals which come either way and last at least two years. I've seen the steel cranks reamed and tapped, but it is a chore.

Of course, if you decide to convert to cotterless cranks, you can choose among pedals - indeed, that will be the least of your worries. We did mount cotterless cranks, using a triple, and should outline the grief required for a saving of less than 3 pounds (exactly 1256 grams): First, I never did find standard axles which would do the trick. It may be that standard or extended Phils will do the job - I wound up making my own Phil types. The bearings alone cost almost $30, and the project takes several days for an amateur machinist. Unless you have access to a machine shop, and inherit a bunch of cranks (ours came from an auction), forget it. Retail, the time and expense (several hundred dollars) aren't warranted. Instead, use an allow double on the right, install Nervar cottered steel 5-pin arms on the left, and buy TA crossover chainrings with an even number of teeth for the connector chainrings: the eccentric will not take up enough slack to use an odd number.

Finally, there are a number of comfort and convenience items we should mention. The rear saddle is particularly critical since the frame is so stiff and the stoker is so far over the rear wheel. Splurge. For economy, we kept the steel seat posts, but added Ideale micro-adjusting clips ($3.50 ea.). We have been happiest with handlebar end controls on the stoker's flat bars. We get away with standard cables, have great cable runs (upside-down for the front shifter) and either of us can shift. We insist on a third brake, and it is controlled from the stoker's bars.

Conclusions

To summarize, our first step would be the minor frame changes, followed by the interrelated hub brake -- freewheel/derailleur -- wheels -- rim brakes set of changes. Get the stoker a real saddle. Then worry about the 10-speed changeover. With care, patience, and adequate supplies of used parts, the cash outlay for doing the above should be much less than $200 if you keep 26" rims, somewhat more if you go to 700c or 27" wheels (note that these virtually require the vertical dropouts). To that you have to add the purchase price of the bike, and you must consider the conversion effort to be recreation and fun -- I have not included the cost of your labor!

TREASURER'S REPORT 1977-78 From Glenn Zeichner (October)

Assets	Cash	483.16	Liabilities	Unearned membership revenue for 1978-79	180
	Merchandise	423.61			
Revenue	Membership 77-78			1269.00	
	Merchandise Sales 115 Patches 28tee shirts			411.25	
	Advertising			141.00	
	Interest Earned			26.83	
	Donations			13.90	
				1861.98	
Expenses	Supplies			127.27	
	Postage			236.21	
	Printing			574.79	
	Telephone			51.62	
	LAW Fees			10.00	
	Cost of goods sold			311.79	
				1311.68	
Net Income	1977-78			550.30	

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ALSO,

THE TANDEM CLUB INVITES LETERS AND ARTICLES FROM ITS READERS CONCERNING TANDEMS & TANDEM CYCLING. MAIL TO THE EDITOR.