Rough Draft, 10 pp. incl. sketches
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A SINGLE-STEP METHOD OF ALIGNING A BICYCLE FRAME SO NO HANDLEBAR TORQUE IS REQUIRED FOR STRAIGHT-LINE RIDING

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Bicycle misalignment which hinders straight-line riding is irritating, and can adversely affect consumer perception of product quality. However, many factors can contribute to misalignment, and controlling each to maintain a cumulative alignment tolerance may be expensive.

Here is sugested a way of making a single 'final' adjustment of a misaligned frame, which should compensate for construction imperfections and permit straight-line riding without a steering torque.

Steer Torque Produced by Misalignment

In a standard bicycle, where the weight of fork, handlebars, and front wheel is much less than that of the rider, the most important steering-related effect of misalignment is that the vertical ground force of the front contact does not pass <u>through</u> the steering axis*, but exerts a turning moment <u>about</u> it. When this occurs, the rider must exert a compensating torque on the handlebars in order to travel in a straight line. Such a situation may exist because the frame is not straight, or because (for example) the seat is off to one side, so that the frame is not quite vertical when the rider is balanced over the support points.

To understand this better, imagine a perfect bicycle (fig.1a) to which is added a variety of misalignments (fig.1b):

— wheels arbitrarily offset and angled from frame mid-plane
— steer axis arbitrarily offset and tilted from frame mid-plane

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* By this I mean that a vertical line extended upwards from the front contact does not intersect a line representing the (extended) axis of the steering bearings.

— rider mass offset from frame plane.

How much steering torque will be needed when riding straight? To answer this question, two steps are needed:

(a) Turn the steering so that the ground traces of the two wheels (the lines in which their mid-planes intersect the ground) are *parallel* (fig.2a). This condition is necessary for the bicycle to travel straight (if tire side-slip phenomena can be ignored).

(b) Now tip the bicycle so that the rider is balanced — i.e., his mass center is vertically over his base of support (the dashed line joining the two wheel–contacts; fig.2b). For convenience, assume that the top of the seat post represents this mass center.

A bicycle can travel straight and balanced this way, but the steering axis probably does not pass directly over the front contact (i.e., it probably does not intersect a line drawn vertically from the front contact, but is offset by a distance O), so the force of the ground tends to steer the front wheel (fig.3a). If we let W_f be the weight of the front wheel on the ground, and θ be the head angle (normally around 70-75 degrees), then $W_f cos\theta$ is the component of the vertical ground force perpendicular to the steering axis, and

$$\text{Torque} = W_f \times cos\theta \times O$$

Even if the bicycle is made to "track" according to conventional thinking (i.e. with no offset of the wheel traces when travelling straight) the steering axis may still not pass directly over the front contact (fig.3b).

Detecting and Correcting Misalignment — One Approach

How can the torque for straight-line riding be evaluated without actually riding the bicycle, and how should it be corrected? These questions can be answered properly only with experience and a thorough knowledge of the production sequence. What follows is just a suggestion to start the thought process.

The suggested procedure involves three components:

(1) Orient the steering so the wheels have parallel ground traces.

(2) Hold the bicycle so the steering axis passes directly over the front contact.

(3) Note whether the seat lug or seat clamp is in the vertical plane through the front and rear contacts (measurement phase). If it is not, re-align the bicycle until it is (correction phase).

Possible Design

If it can be assumed that all wheels are accurately dished, measurements and adjustments may be made to the frame and forks alone, which will be clamped to a pivoting jig in place of the wheels. (See fig.6 for an assembled view.)

The framework for the proposed device involves a base with two strong machined studs (both accurately vertical), and a strong vertical backing plate, which would be used as a reference plane and also as a support for straightening operations. (See fig.4a.)

The two studs will rotatably support the bases for two 'wheel' jigs, connected by a tie-rod keeping them parallel. (See fig.4b.)

The jig bases carry 'wheel plates', hinged at their bottom edges, and spring-supported to be vertical. (See fig.5a.) The wheel plates carry dummy axles and frame-clamping hardware. A strong, straight forked rod (fig.5b) is meant to fit snugly through the fork steerer, and its forked end fits over the front stud.

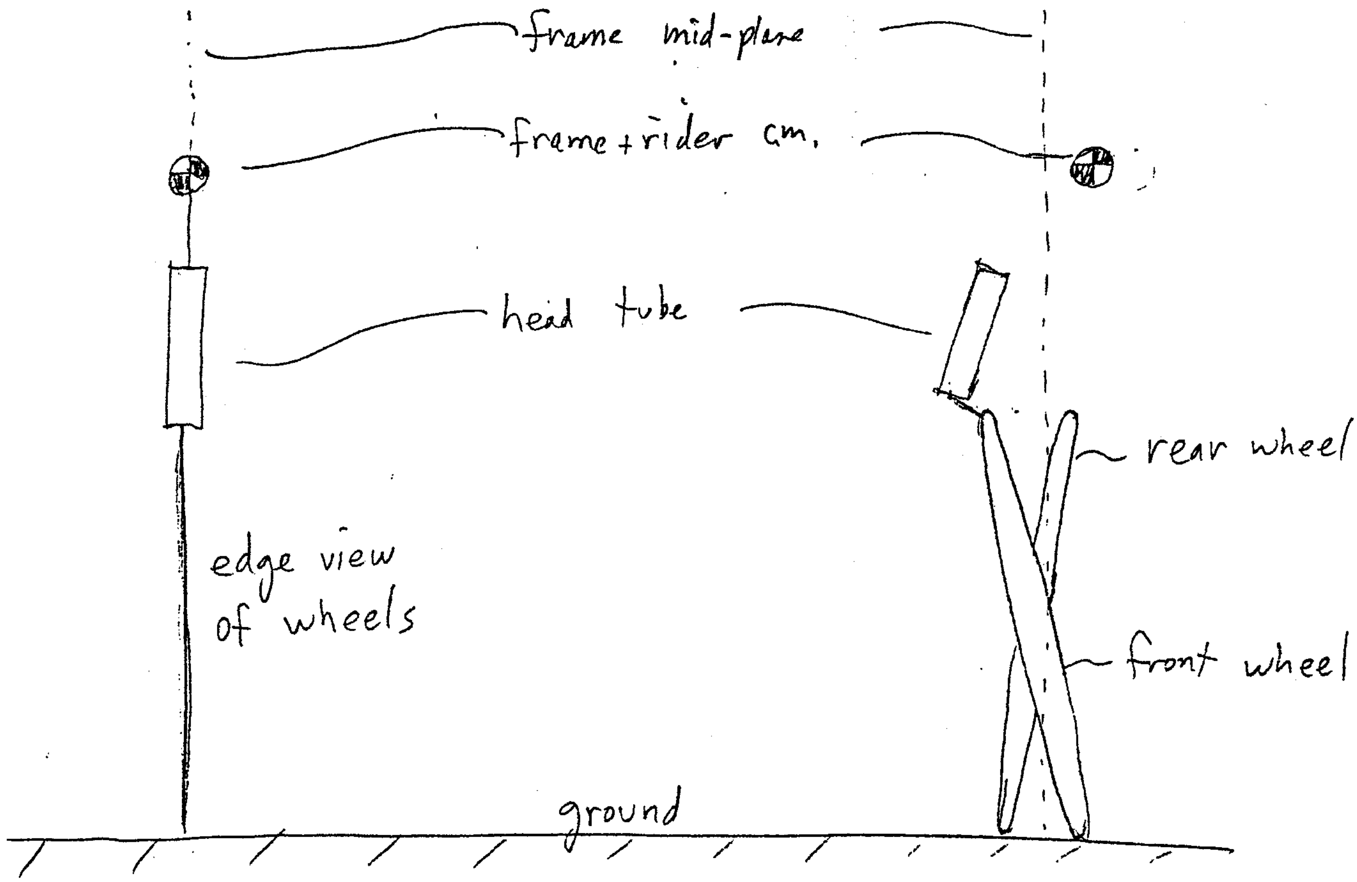
To use the device, the "rear wheel" is centered between the chainstays and clamped, and the "front wheel" is centered between the fork blades and clamped. When the forked rod is installed (fig.6), we have parallel wheels and the steering axis passing through a vertical from the front contact. The only question is whether the bicycle is balanced in this configuration — is the seat clamp S <u>in the vertical plane</u> which is defined by the two studs? Measure its distance from the backing plate, and push it until it is!

Cautions

This procedure has not been tested in practice. It is based on the assumption that the weight of the front fork/ wheel/ handlebar is unimportant, that the weight of rider and luggage is symmetric with respect to the seat, and that there are no tire effects. It is assumed further that the wheels to be used are correctly dished and centered when installed.

The suggested jig is just a starting idea — there may be some practical reasons why it won't work.

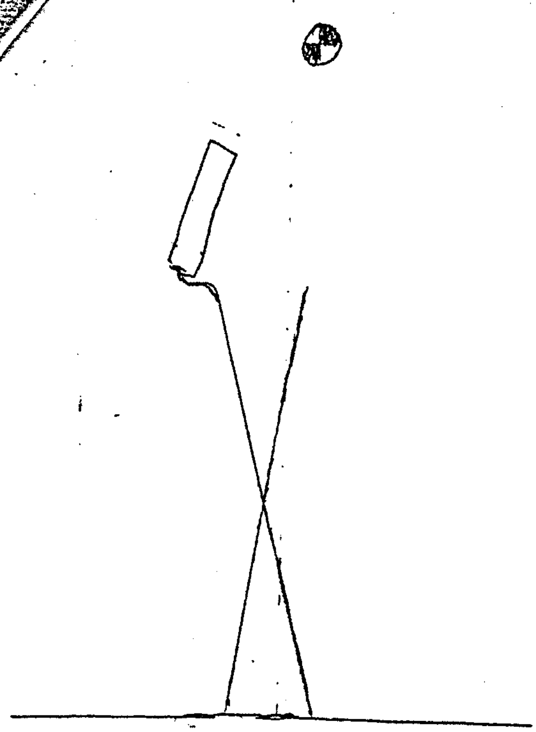
A bicycle 'aligned' in this fashion will not necessarily give torque-free riding if the rider moves very far forwards or backwards — however as this usually involves standing up, any steering torques may be barely noticeable.



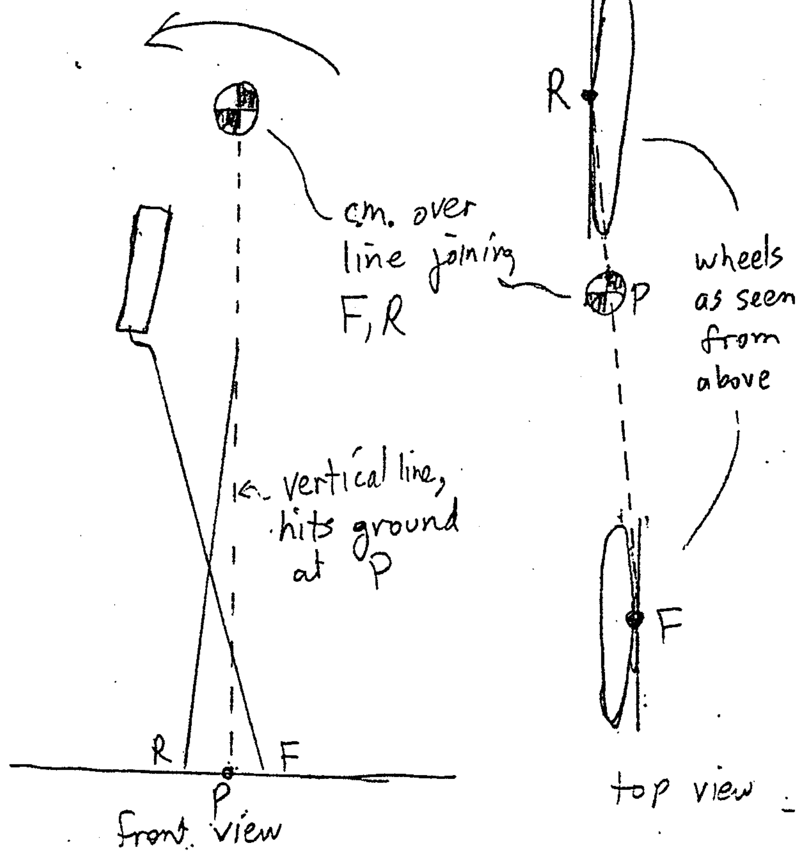
(a) Perfect bicycle: wheels, head tube, rider c.m. all in frame mid-plane

(b) Misaligned bike — offsets + tilts, viewed from frame mid-plane.

Fig. 1. Front view of aligned bike and misaligned bike. (Frame mid-plane may be defined by bottom-bracket shell, i.e. mounting for pedal-crank bearings.)



(a) Front view when steered to travel straight — i.e. front wheel turned so both wheels have parallel ground traces (Note that bicycle doesn't travel // to frame plane)



(b) Bicycle tilted to bring c.m. over base of support (i.e. dashed line joining rear contact R and front contact F)

Fig. 2 For bicycle to travel straight, front wheel must be turned so its ground trace is parallel to trace of rear wheel, and bicycle must be tilted to bring c.m. over "line of support" between wheels.

(Front views — from plane of rear wheel.)

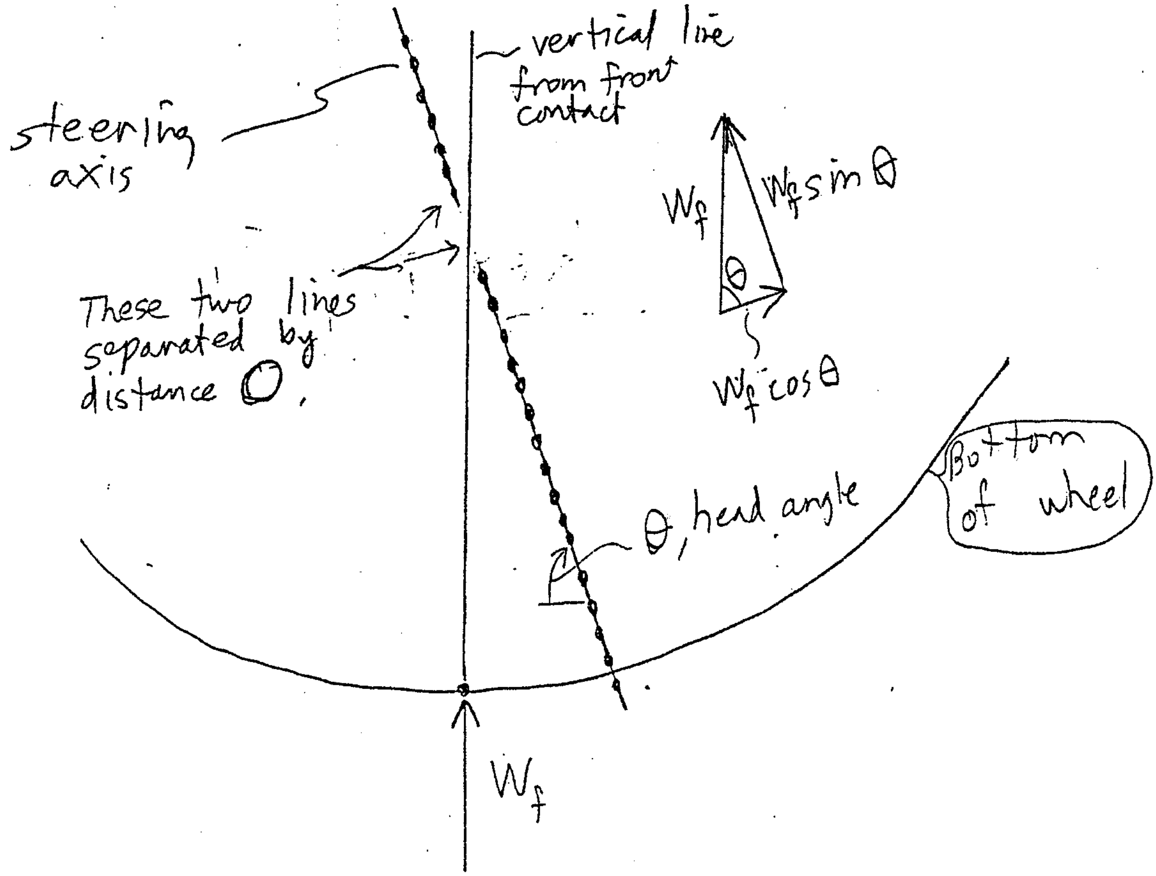
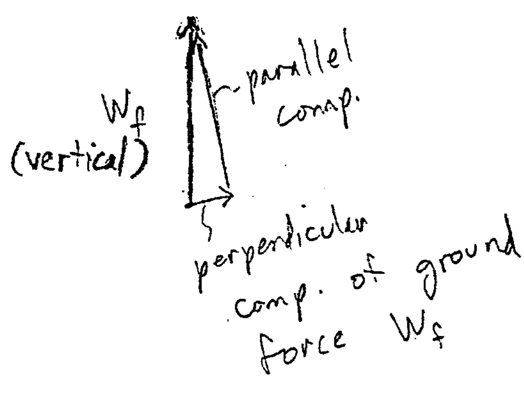


Fig. 3a

Side* view of front wheel — the line of action of the vertical ground force W_f is shown passing the steering axis (dotted line) without intersecting it. — in fact missing it by distance O.

The vertical force W_f has a component $W_f \cos\theta$ perpendicular to the steering axis, so it exerts a moment of $(W_f \cos\theta) \times O$ about the axis.



* To be precise, view is along the line of least separation of ground force and steering axis — i.e. both lines are parallel to page.

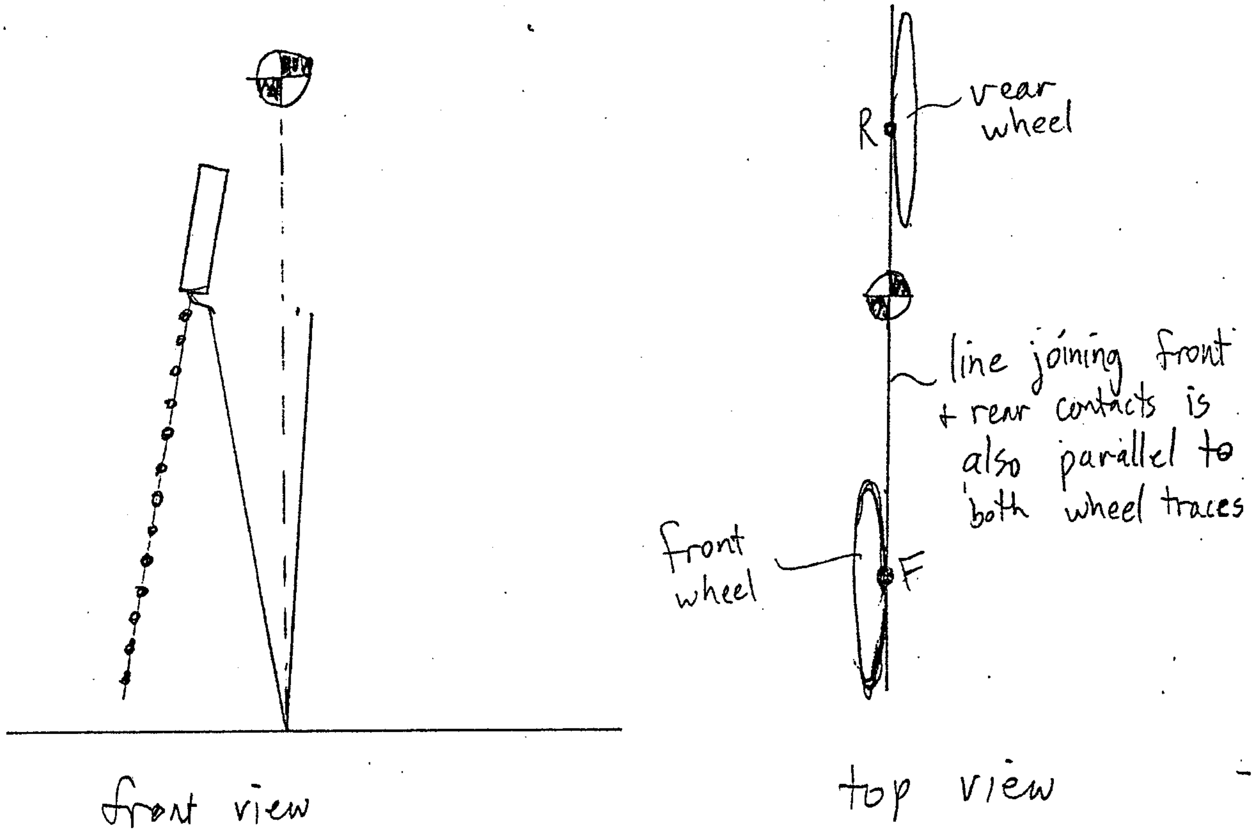


Fig. 3b A conventionally "tracked" bicycle:

wheel traces form a single line with no offset, but vertical front contact force still needn't intersect steering axis.

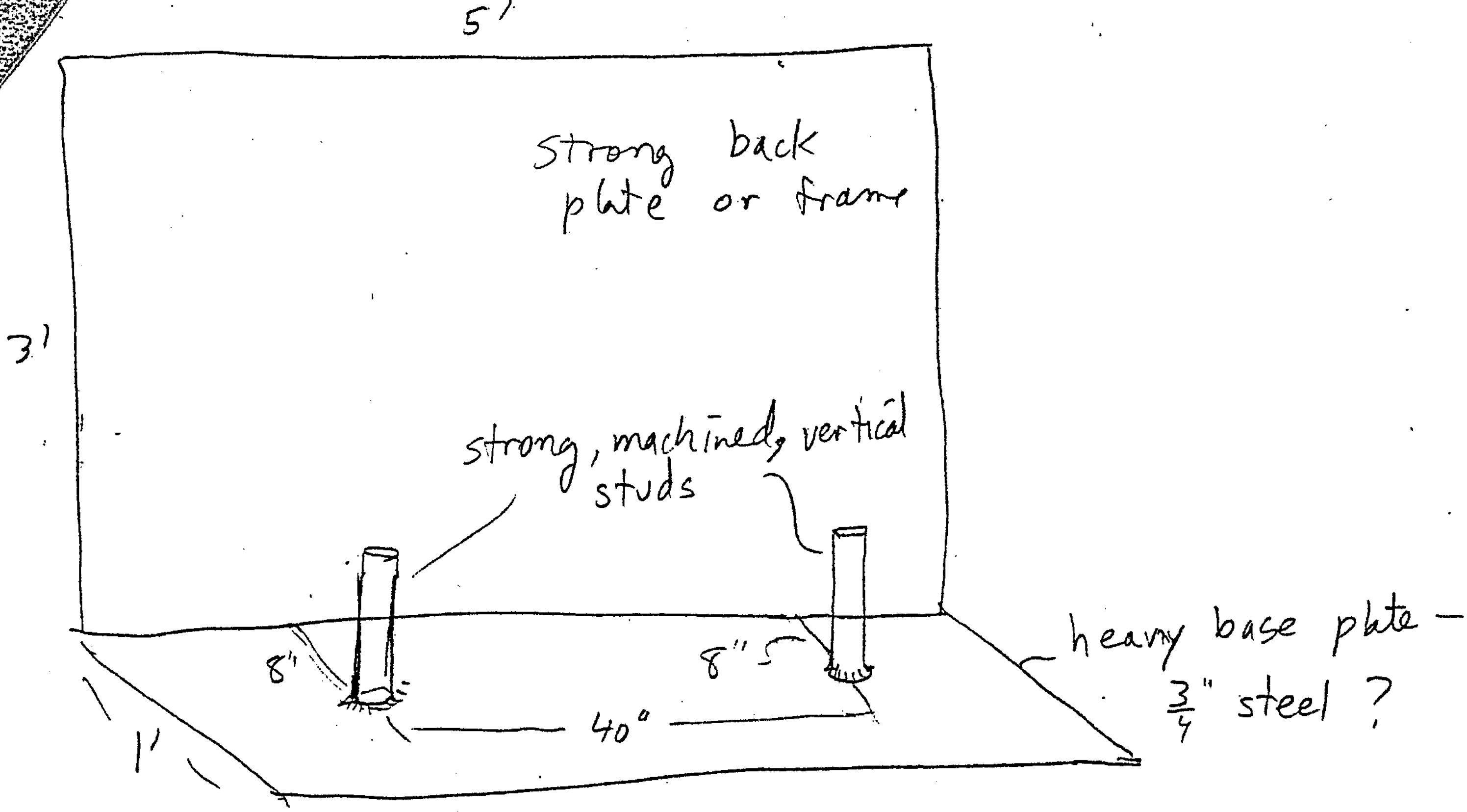


Fig. 4a Framework with studs

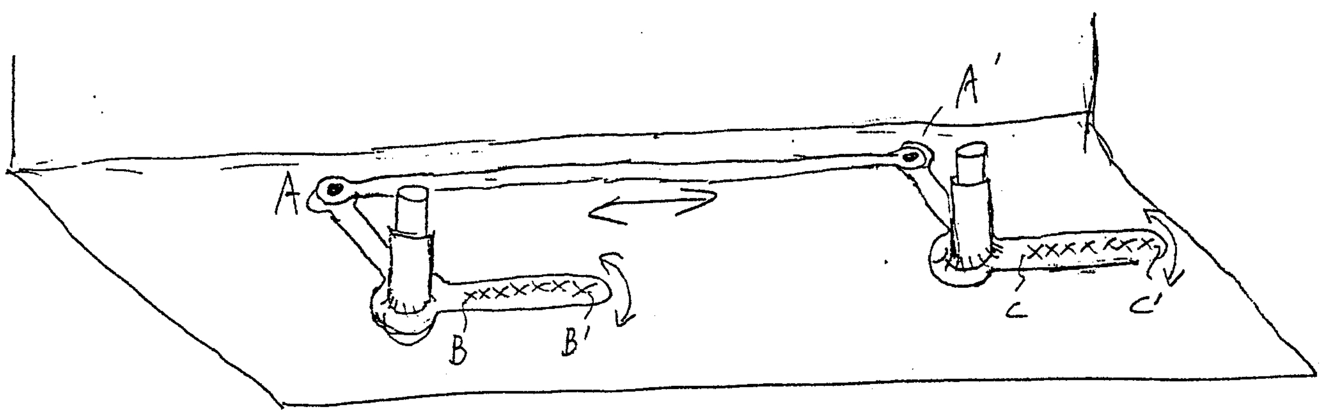


Fig. 4b On studs (which represent wheel contacts) are two close-fitting pivoting "wheel supports", connected by tie-rod AA', which keeps BB' and CC' parallel. BB' and CC' each have a hinge (represented by xxxxxx) which will support a "wheel plate".

Precision machining may be needed.

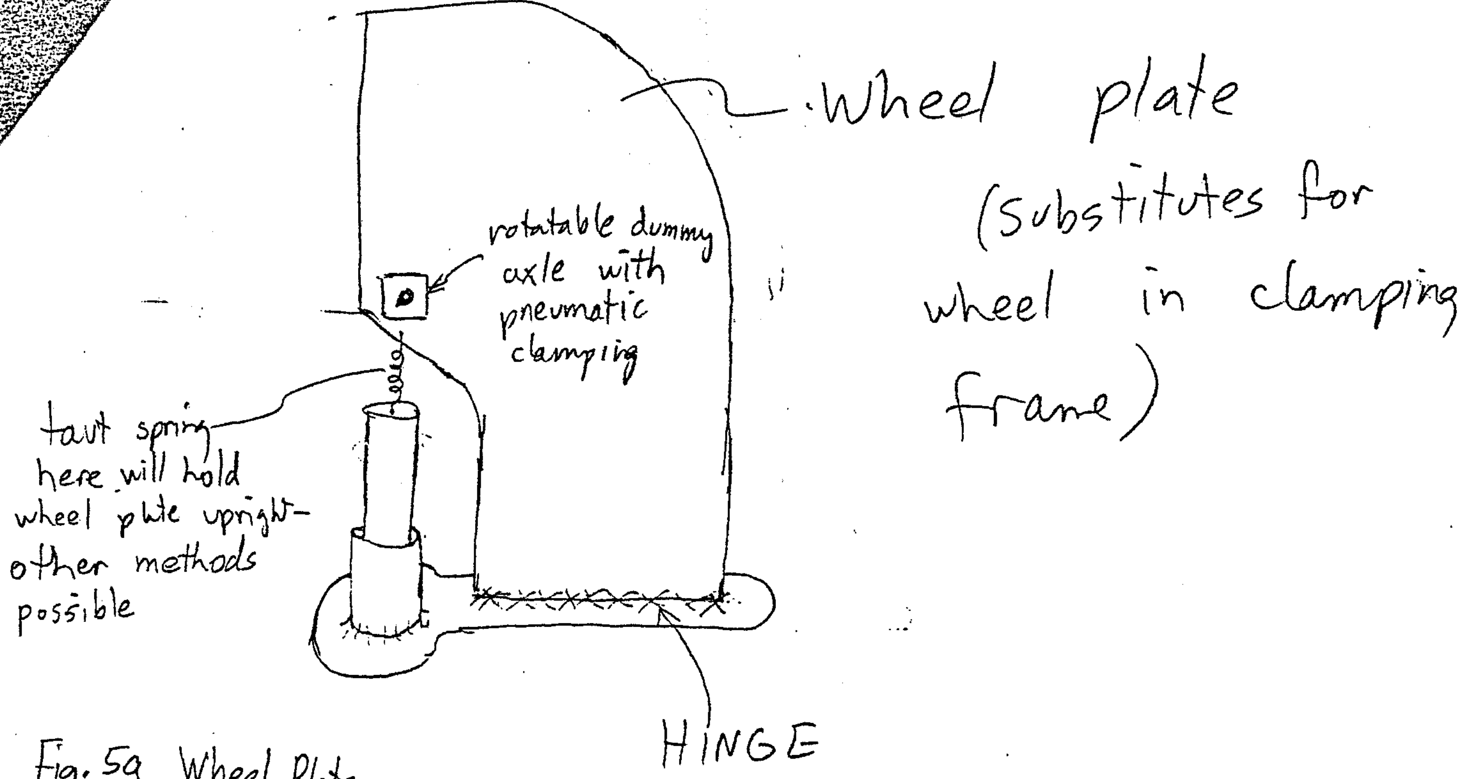
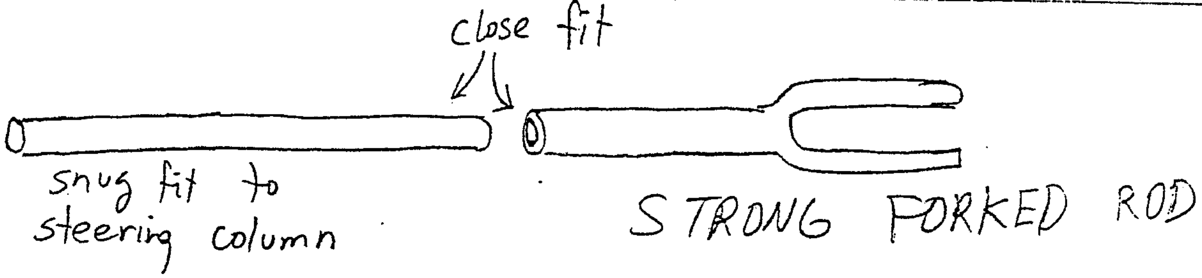
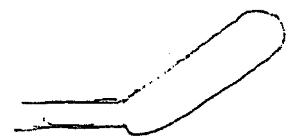


Fig. 5a Wheel Plate



(Some offset of forked end may be needed



for clearance purposes - but then strength, friction, and dimensioning will be more important)

Fig. 5b Forked Rod

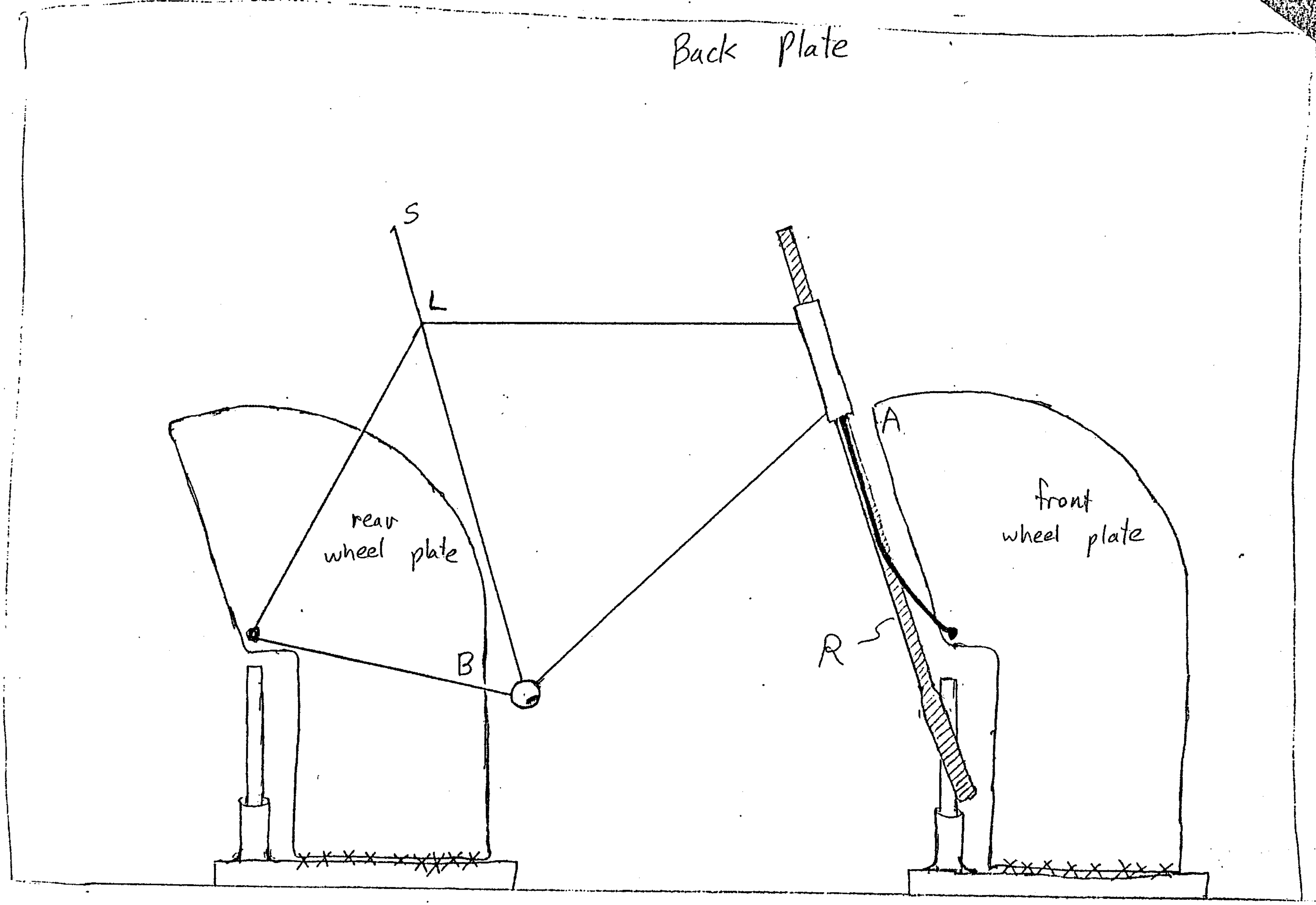


Fig. 6 Frame + Fork clamped to wheel plates (which are centered like wheels at A, B). Forked rod R fits over front stud. Seat clamp S or seat lug L is forced sideways until it is correct distance from back plate.