# *Introduction to the G4 Bicycle*

*To finish this talk in a reasonable time, I had to limit the message, and focus…*

- Who am I?
- The Five G4 Bikes
- What is a G4 Bike?
- Why is it different?
- How does it work?
- More on the 5 Prototypes
- 25,000 Miles of Riding, Touring and Racing
- Where to from Here?
- Does History Repeat Itself?
- Summary, Q & A

## *Potential Follow-on Topics*

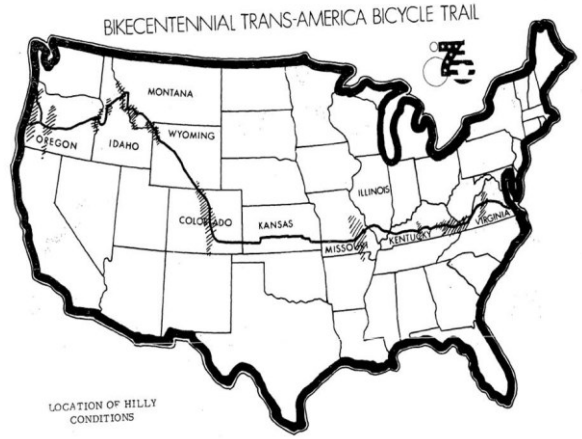
*(Too much for today…)*

- Build Process and the Shop
- G4 Fairings, Aerodynamics and Sailing
- System Engineering and Patent Processes
- G4 in Mixed Group Rides
- G4 “Road Racer” (vice current “Sport Tour”)
- G4 Travel Bike
- G4 Delta Trikes
- G4 vice Upright vice Recumbent

***The G4 Uses a New Principle of Operation, Based on Standing to Pedal an Upright, To Better Integrate and Engage the Rider, Result is a New Type of Bicycle.***

# *Who Am I?*


- Retired in 2014 to develop bikes!
  - Professional Engineer and Systems Analyst
  - DoD Career:  System Development, Test and Evaluation
- Conventional Bike History
  - Biked to work
  - Peggy (wife), kids, friends and vacation rides
  - Harford Velo Club - Founding Member
  - Tandem
  - Trans-Am in 2011
- Building – My shops have been a lifelong passion
  - My “Dream Shop” built in 2009
  - Started with Wood, added Machine, Welding, Composites
- Recumbent Research – I needed to understand…
  - Wanted to Buy Current *<u>and</u>* Build New
  - Studied, Traveled, Shopped, Tested, Documented
  - First ride in 2014
  - I did not buy…
  - ***Peggy fell and was kinda done with recumbents…***





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# *The Five G4 Bikes*

P-1

P-2

***P3 was the first to allow effective and substantial hand power input!***

- Started building Bikes in 2014
- Wanted comfort, speed, & safety for "Road Touring". Also wanted fairings for speed, protection and cargo.

***Had no thought of hand power input…***

- "Developmental Prototypes" P1 to P5
- P1 - Spring 2015 – ***Manage PFF!***
- P2 - Spring 2016 – ***Manage PFF??***
- P3 - Spring 2018 – ***Hand Power!***
- P4 - Spring 2019 - *Refinements*
- P5 - Spring 2020 – *Peggy's Bike*

***Have kept quiet about the bikes, until now.***

P-3


P-4


P-5

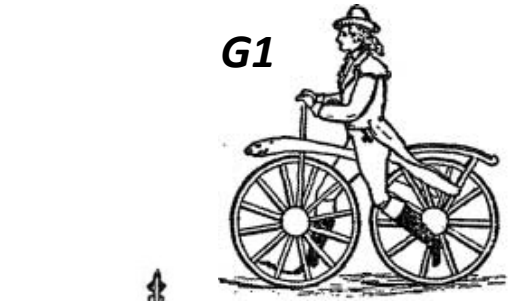
# *What is a G4 Bike?*

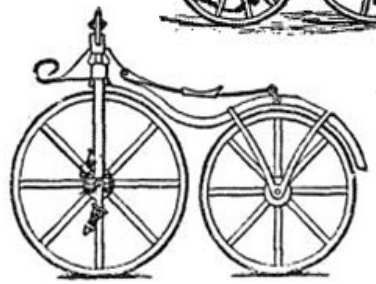
***Defined by ~Three Prior Generations of Bicycle Function***

- Generation 1 - Draisene - 1818
  - Two wheels can be balanced by steering the front!
  - "Scooter" propulsion

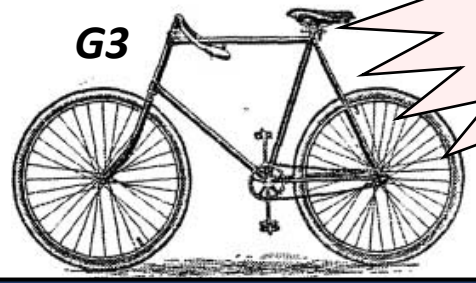
- Generation 2 - Boneshakers and High Wheelers - Circa 1860
  - Pedal-Crank front wheel propulsion
  - Pedal force input is ~ *<u>parallel</u>* to the steering axis

- Generation 3
  - "Safety Bike" which is the current "Upright" - Circa 1885
    - Drive to rear wheel separated steering and propulsion
    - ***Can stand, pedal and provide hand power!****
  - Recumbents – Circa 1896
    - Bents Are a subset of G3, because they are concurrent (arguably, could be G4, and then G4 is G5…)
    - Pedal force input is ~ *<u>perpendicular</u>* to the steering axis
    - ***Reclined rider, for aerodynamics, comfort and safety***



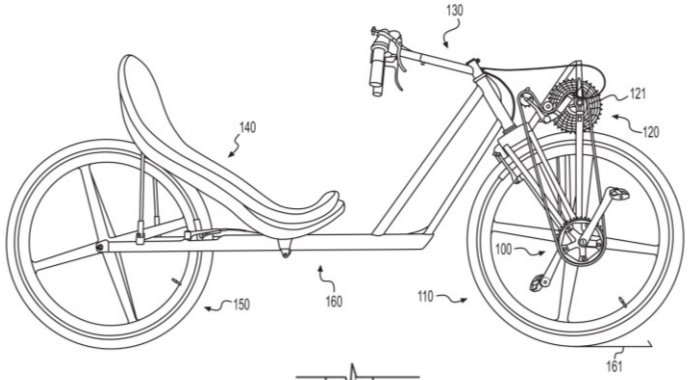



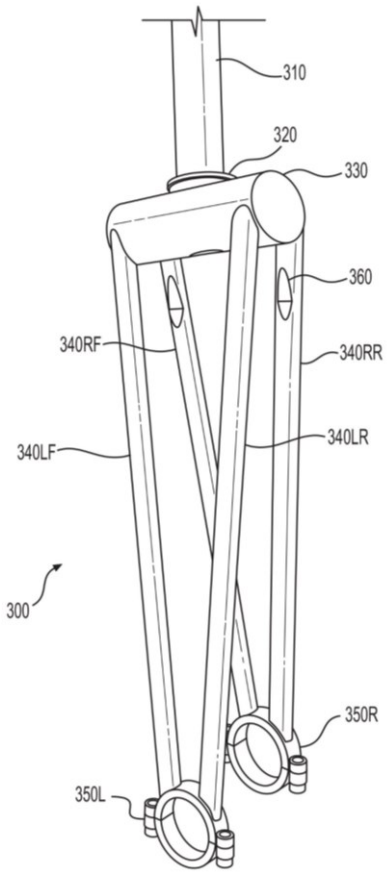

**** Safety Bike ~inventor said the big advantage was being able to stand and pedal!***




***The "Generation Four Bicycle"***
***Provides the Best of the G3 Upright and Recumbents.***

# *The Generation Four Bicycle*



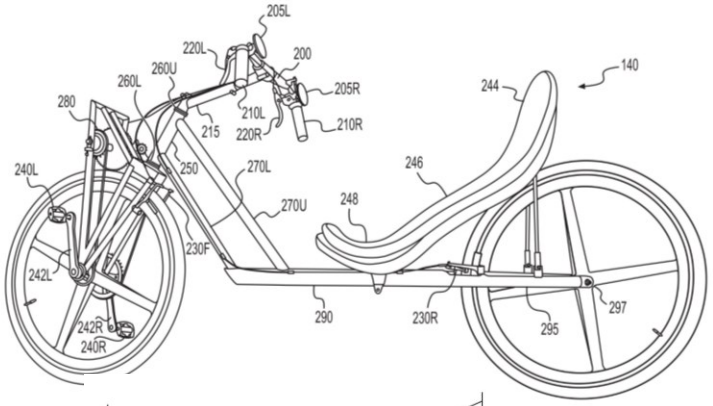



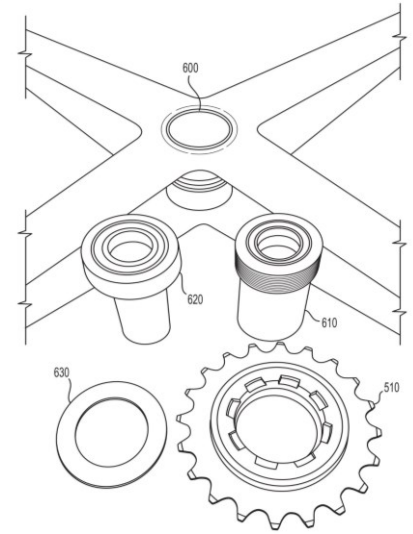

- Front wheel driven and steered
- Crankset is on the fork near the steering axis
- Hand leverage controls foot forces
- Fork is rigid in torsion to hand and foot forces, applied in opposition, about the steering axis
- Uses extended steering trail
- Dual chain derailleur transmission
- Low step over, feet easily reach ground
- Natural head up position
- Intermediate length wheelbase, and
- Rider seating is ~centered on the wheelbase for balanced handling and a smooth ride.

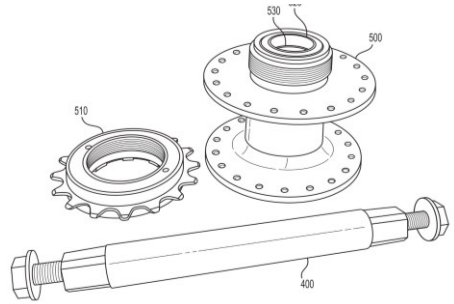
***Hand power application is by rhythmically pulling the crankset into the pedal thrust.***

***Application is directly to the hand grips. There is no need for supplemental mechanism.***

***I think this new principle of operation, makes the G4 a new type of bicycle.***



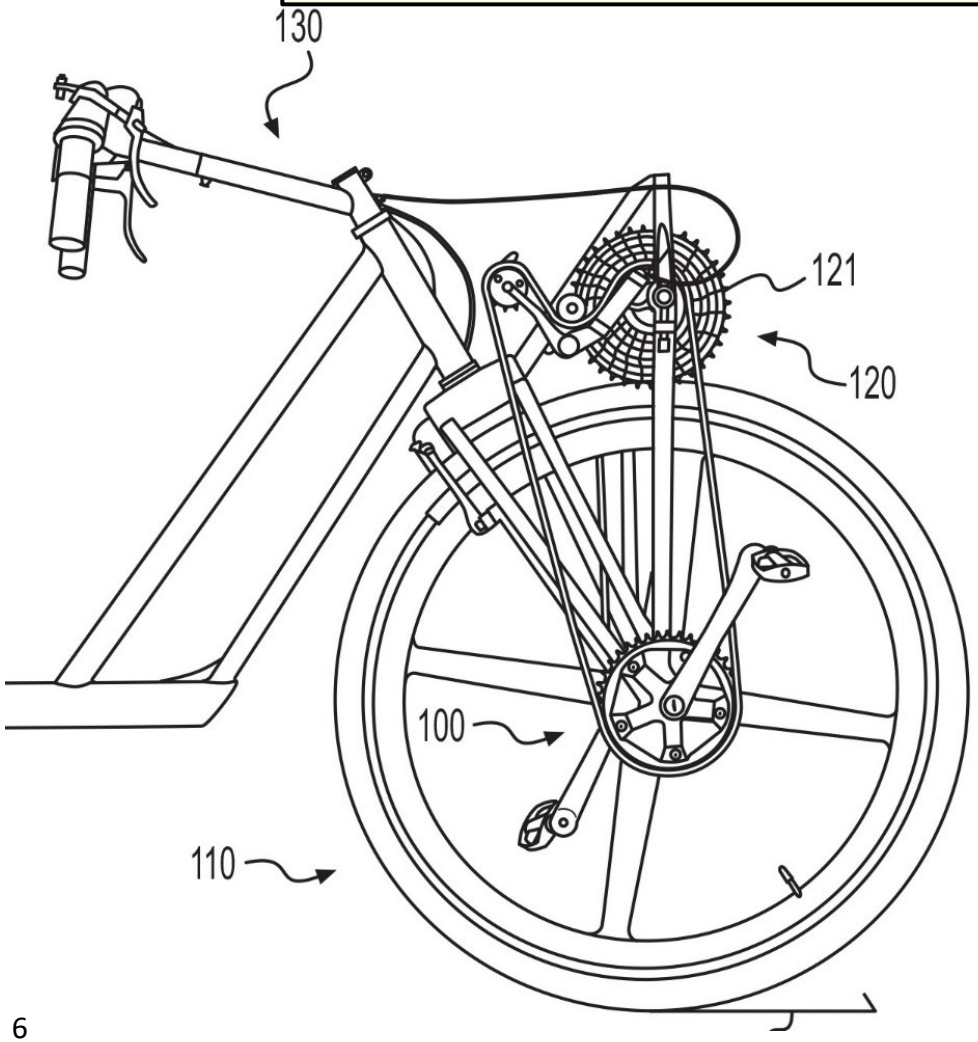


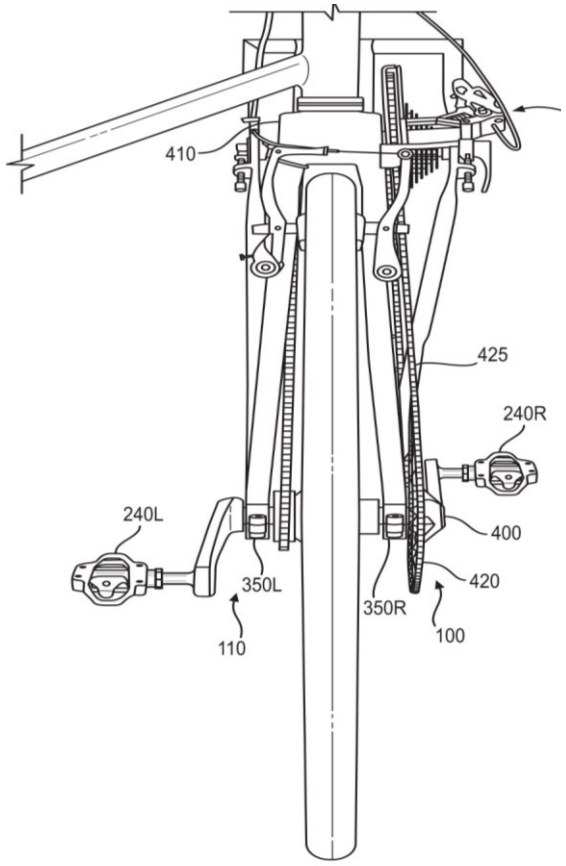

***"Recumbent Bicycle and Methods of Riding Employing Supplemental Upper Body Power, Enhanced Aerodynamics, Stability and Control" Utility Patent Publication is Expected in Fall 2021.***

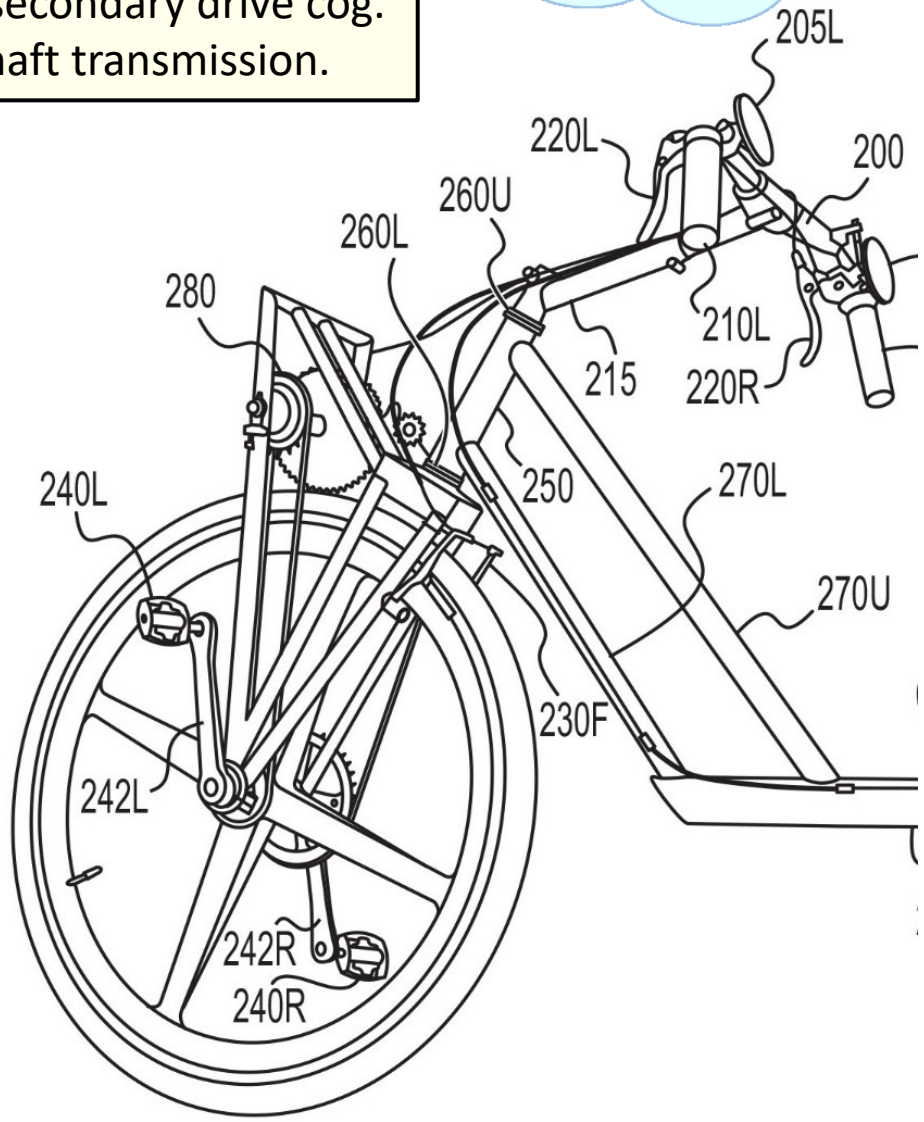
# *G4 Bike Dual-Chain Drive*

- The coaxial crankshaft and front wheel rotate independently.
- Chain 1 provides pedal input to the secondary shaft.
- Secondary shaft has a derailleur & cassette, or gear hub, and secondary drive cog.
- Chain 2 drives the front wheel at the speed from secondary shaft transmission.

***No special coaxial hub gear is needed.***



# *Why is the G4 Bike Different?*

***Many patented mechanisms show the need for recumbent hand power. They are not used, because bicycles also need to be simple.***

## *Hand Power Input*

- G4 is a Moving Bottom Bracket (MBB) bike.
- Prior MBB, from Boneshakers and High-Wheelers to Kervelo and Cruzbike, are designed to limit Pedal Force Feedback (PFF).
- PFF is controlled by:
  - Aligning foot force input with the steering axis, or
  - Offsetting the crankset far forward of the steering axis

***The G4 bike uses this "Pedal Steering Interaction" as the mechanism for hand power input!***

## *Trail Dynamic Effects*

- Trail increasingly controls PFF with groundspeed.
- Hand power input is most important at lower speeds for acceleration and climbing.
- Cruise at speed is relaxed because trail controls PFF.

## *Aerodynamic Stability and Control*

- Hand and foot forces about the steering axis provide powerful stability and control.
- Allows routine use of a full disk front wheel.
- Even in blustery wind conditions.

***Serendipity***

***Hand Power Engagement Creates a Better Ride Experience!***

# G4 Bike – How Hand Power Input Works

- Standing to pedal is familiar, but often not well understood. David Gordon Wilson explains:

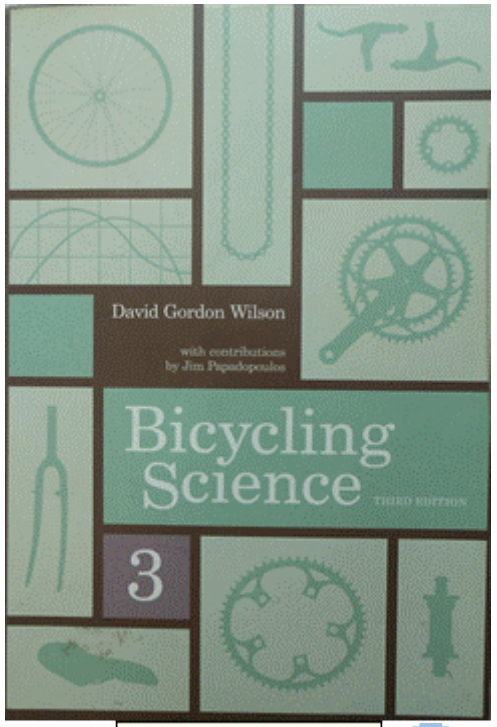
***"in conventional upright bicycles … substantial arm work is easily performed by tilting the bicycle away from the descending pedal … the legs can then push harder or move faster for an overall increase in power output. Recumbents … do not permit the rider to use additional muscles in this way."***

***Is this a reason recumbents have never achieved upright bike popularity?***

***The G4 solves this problem - The rider forces the crankset into the foot pedal thrust!***

- I was not convinced this really worked until Prototype 3!
- G4 hand power input is a result of complex geometry, in three dimensions, with rotation in two directions. *I am certain that I can not do that math…*
- Also, *I believe* G4 hand power input mechanisms are *more* effective than on an upright! *I need to work this…*

***I can tell you that it works. And how to work it. But maybe not exactly why it works…***




*See Pgs. 98-99*

***Innovation often precedes theory…***

***Airplanes before aerodynamics…***

***Steam engines before thermodynamics…***

# *G4 Bike – How it Works*

- Hands control foot forces about the steering axis using leverage
  - Hand ***reaction*** balances foot pedal input.
  - Hand ***force*** adds crankshaft torque. Crankshaft lateral force is applied to the crankarm. ***"push harder"***
  - Hand ***motion*** adds both torque and "work". Foot perimeter distance traveled is reduced. ***"move faster"***

***Empirically, hand power input may be ~50% of foot power input.***

***Hand power input is limited by rider cardiovascular capacity***.

## *Hand Torque Input to Crankshaft*

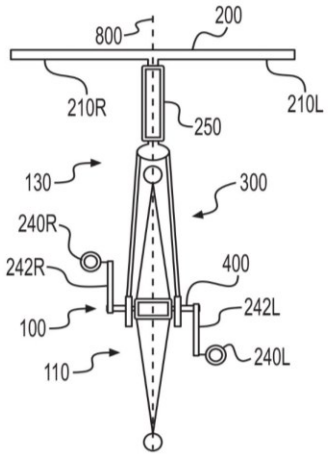



FIG. 8A

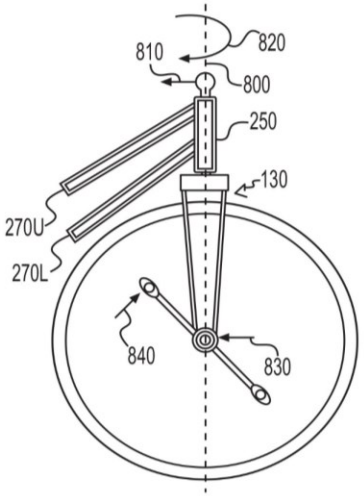



FIG. 8B

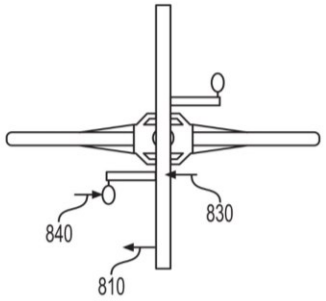



FIG. 8C

## *Hand Torque and "Work" Input*

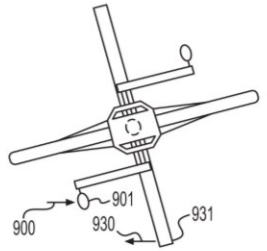



FIG. 9A

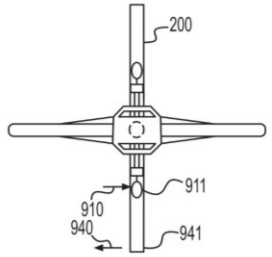



FIG. 9B

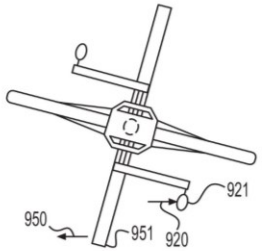



FIG. 9C

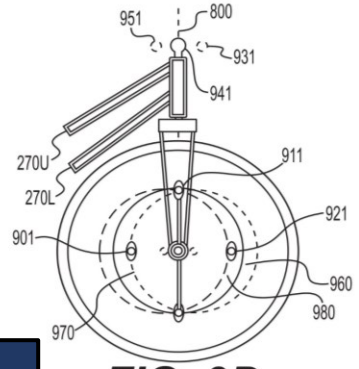



FIG. 9D

**Play Video Demonstrations 1 and 2**


VID_01 hand input

VID_03 hand power

# How G4 Hand Power Input Works

*Its complicated. And hard to explain. If it needs to be studied, this write up is available.*

## G4 Hand Power Input As Supplemental Torque and Work

**Supplemental Torque Input**

The G4 Bike structure is configured to apply rider hand force on the handgrips as supplemental propulsive hand power in the form of additional torque applied to the foot pedal crankshaft when;

A. hand force applied to the right and left handgrip creates a torque about the steering axis which is transmitted by the handlebar, fork and crankset to the attached crankshaft, and results in lateral force at the crankshaft endpoints,
B. the crankshaft lateral force is applied to the crankarm at the crankshaft-to-crankarm connection point, which is at the opposite end of the crankarm from which rider foot force is applied to the pedal to cause rotation of the crankshaft,
C. the hand and foot induced forces on the crankarm are at opposite ends of the crankarm length and, as coordinated by the rider's timing of forces input to the handgrip, are directed in opposition to one another,
D. the hand and foot induced forces on the crankarm result in a rotational torque applied by the crankarm to the crankshaft that is greater than that due to the foot pedal input by an amount that is proportional to hand force input, so that hand force input is converted, transmitted and applied at the foot pedal crankshaft as increased propulsive rotational torque.

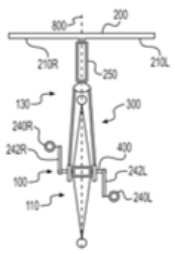



FIG. 8A

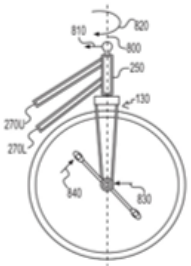



FIG. 8B


FIG. 8C

**Supplemental Work Input**

The G4 Bike structure is configured to apply rider hand force and displacement of the handgrips as supplemental propulsive power in the form of hand induced torque and hand induced work when;

A. hand force induced movement of the right and left handgrips about the steering axis results in a lateral force and displacement at the crankshaft endpoints,
B. the crankshaft lateral force and displacement is applied to the crankarm at the crankshaft-to-crankarm connection point,
C. rider foot force is applied to the pedal connected at the opposite end of the crankarm causing rotation of the crankshaft,
D. the hand induced crankshaft displacement and the foot force input is applied in coordinated opposition, typically such that the rider simultaneously pulls the handgrip while pushing the foot pedal located on the same side of the bicycle,
E. the lateral motion of the crankshaft endpoint moves the axis about which the crankarm rotates during rotation of the foot pedal,
F. when the axis of rotation is shifted in a coordinated way by rider handgrip inputs during foot pedal rotation, the perimeter distance traveled by the rider's foot during rotation of the pedal is reduced because of the hand work input,
G. supplemental hand power is thereby input both as hand force induced increased torque and as hand work; hand work input is proportional to the reduction in perimeter distance traveled by the riders foot during rotation of the pedal about the crankshaft as compared to the perimeter distance that would have been traveled if the crankshaft endpoint and pedal center of rotation had not been displaced by hand work,

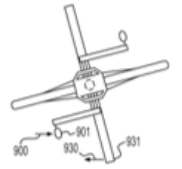



FIG. 9A

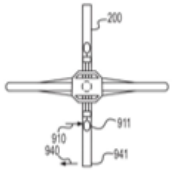



FIG. 9B

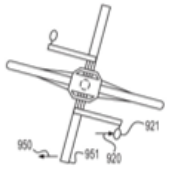



FIG. 9C

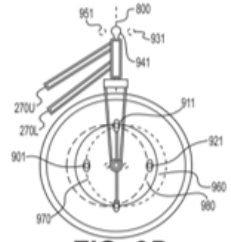



FIG. 9D

Empirically, hand induced pivot of the front fork assembly about the steering axis of plus and minus about 15 degrees is practical, the effective range of angular displacement decreases with increasing ground speed, total torque and work based hand power input may approach 50 percent of foot power input, hand power input can routinely be applied over many successive right and left foot pedal strokes, the number of which is often limited by rider's cardiovascular capacity.

***Gary has a link to this file in the video description below.***

# *More on the 5 Prototypes - P1*

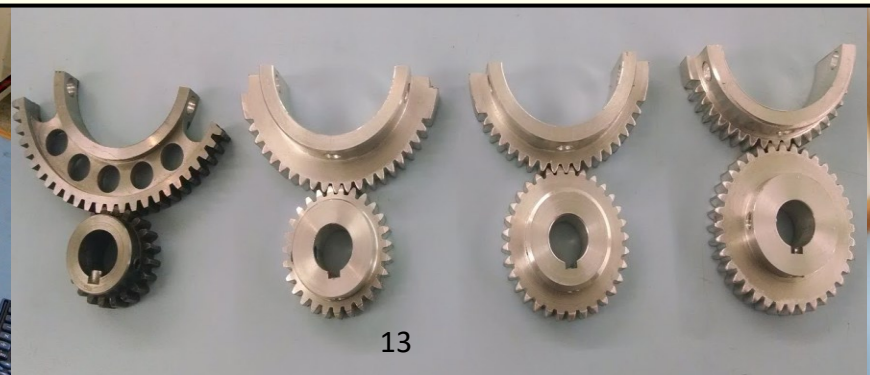
- A better commuting bike?
- Designed to control PFF.
- Did not work very well.
- I only rode it ~200 miles.
- Was fun. I learned a lot. But P1 was not a good bicycle.
- ***Peggy could ride it!***

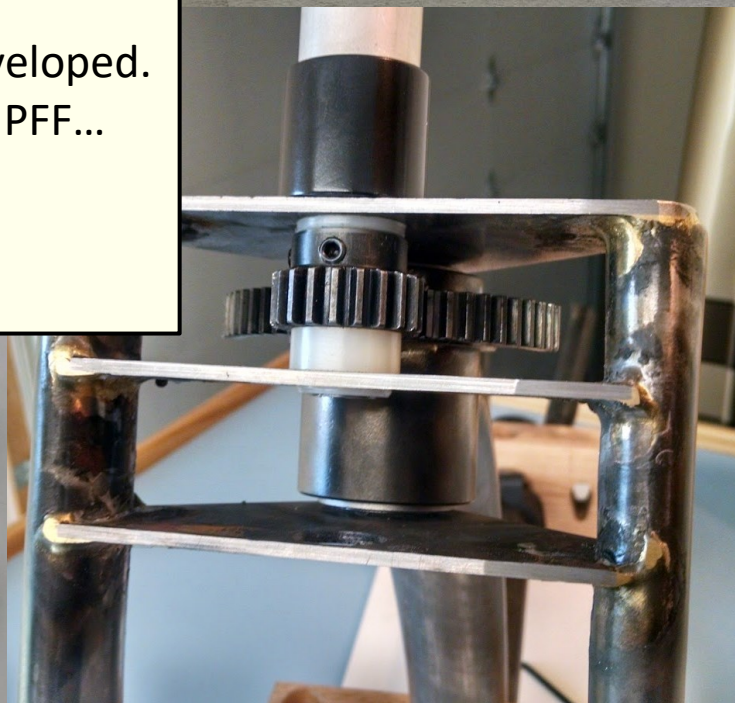
## *Prototype 2 - P2*

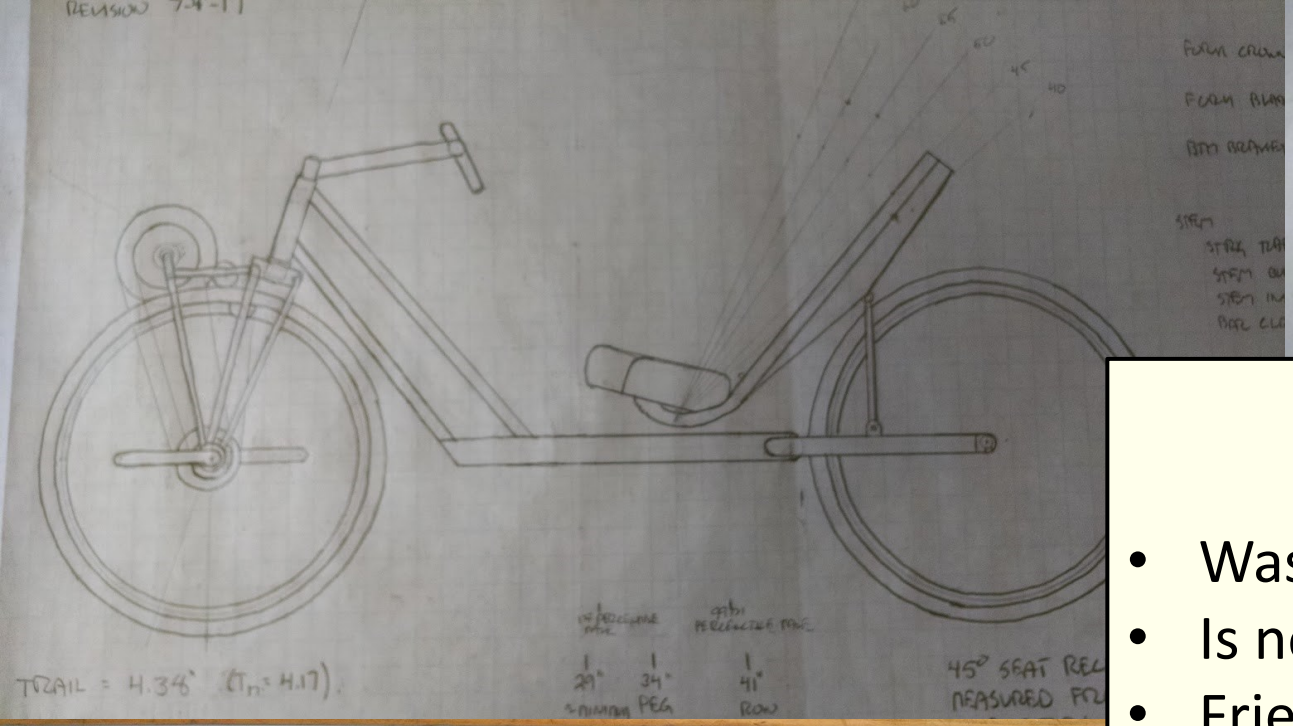
- Based on P1 lessons. Extensively modified and developed.
- Started with geared steering to completely control PFF…

***Before I understood!***

- Rode it ~8-10K miles over 2+ years.
- *Indicated effective hand power input was possible!*



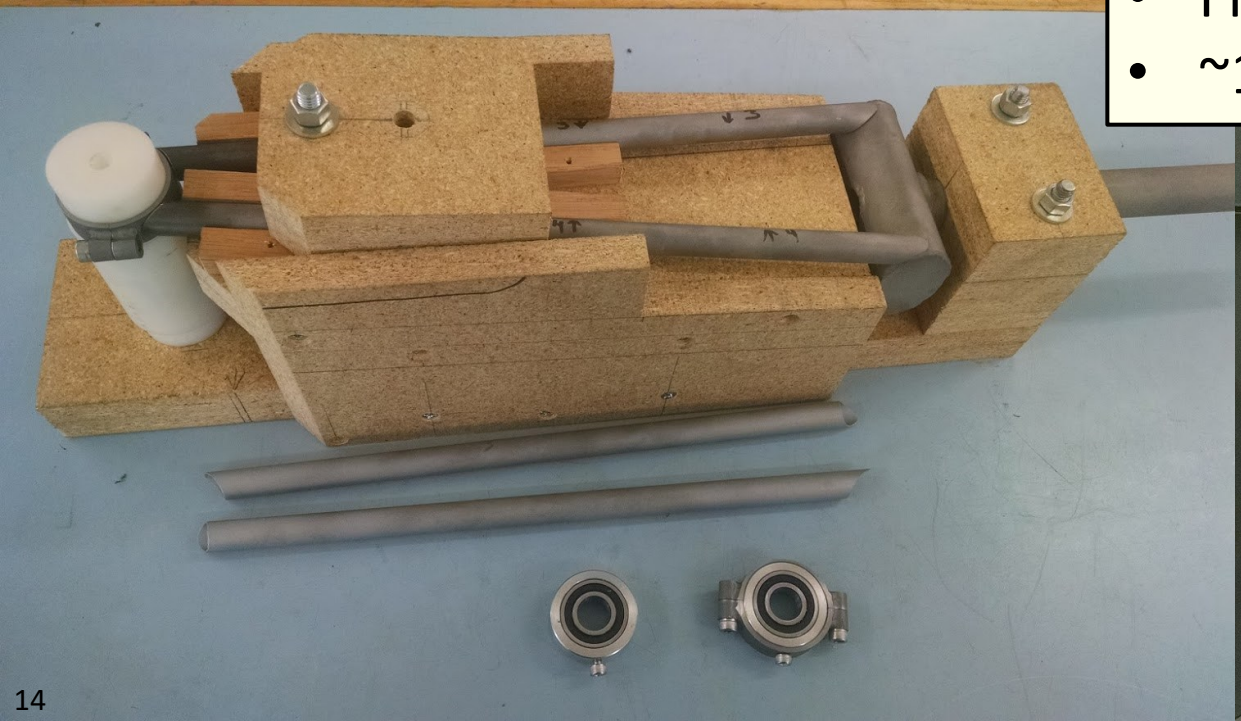





## *Prototype 3 - P3*

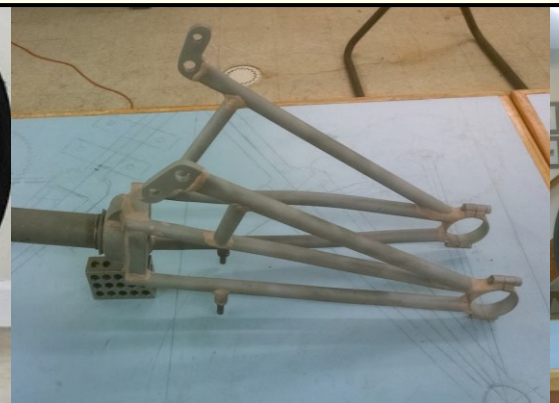
## *Hand power works!*

- Was also extensively modified and developed.
- Is now my, “Big Tire Gravel Bike”.
- Friends in the club call it the “Do Anything Bike”.
- ~10k miles and going strong.




## *Prototype 4 - P4*

- Simplified secondary drive support, 1.5” steerer, new crown, secondary chain tension idler
- My current racer, club bike and cruiser.
- Routine use of disk front and rear wheels.



# *Prototype 5 - P5*

- Peggy's bike
- Easily adjustable for rider size
- Close reach down tubes
- ~ 5k miles so far
- ***Peggy quit riding her upright bikes!***

# ~ 25K Miles of Riding, Touring and Racing

***In 2 videos and 2 pages of photos***

- It is all about the magic of riding a bike.
- Rider is fully engaged, feet, hands, seat, head and heart, as an integrated part of a high-performance machine.
- Performance and efficiency with comfort and safety.
- A joy to ride. It moves well. People smile seeing it pass.

Building P5 Peg First Ride

Peg Close at Beach


HIGHEST POINT
ON DRIVE
ELEVATION 3680


CONTINENTAL
DIVIDE
ELEVATION 8391
NATIONAL PARK SERVICE


OLD FAITHFUL
GEYSER




HARFORD VELO CYCLING CLUB

# *What's Next?*
# *Can the G4 become the next mainstream bicycle?*

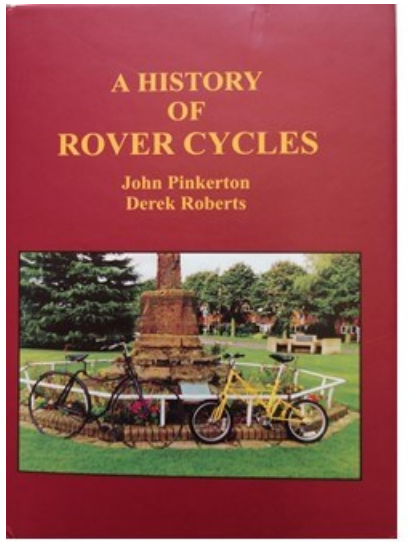
- Riding the G4 is great fun.  People see that it is.  They ask to buy one.
- Easily the best Bicycle I've ever ridden.
- I think the G4 could ultimately sell in upright bike quantities.
- Making it available will take a team.
- My objectives:
  1. Be happy!  Enjoy the prototype bikes.
  2. Continue my "G4 System" development.
     - A long list of projects I want to do…
     - Race, Travel and Trike prototypes; Aerodynamics, Sailing, Protective and Cargo Fairings, Composites, and more…
  3. Be part of the team to make the G4 available.
  4. Recover my investment and fund future work.
  5. Help build a G4 Bike Community.

***I do want the G4 to be commercially available.***
***Please contact me if you can help make that happen!***

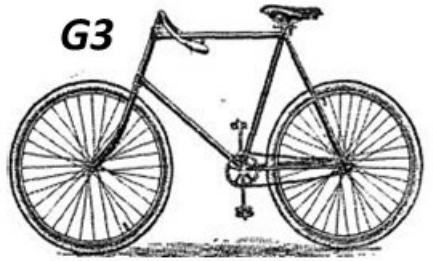

# *Will History Repeat Itself?*

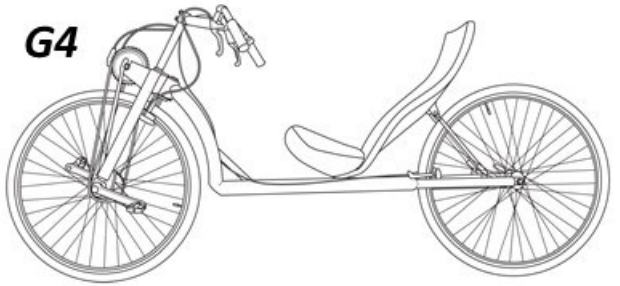
*J.K. Starley Letter Circa 1885, on the Rover "G3-Safety Bicycle" vs. "G2-High Wheeler"*

*"The Rover is absolutely the outcome of a determination to obtain advantage previously unknown in a bicycle. We felt confident that a large percentage of unused power could be utilized if the rider were properly placed, particularly with regard to hill climbing. In this we were not mistaken, as the enormous success of the Rover undoubtedly proves."*








***G4 has the same, "advantage previously unknown"***
***and***
***"a large percentage of unused power could be utilized"***

***Could G4 have the same "enormous success"?***

# *Summary & Questions?*

Current bikes are not the right machines for what I want to do.

Upright bike development has been constrained by professional racing, which has kept bikes the same, to compare riders and keep competition fair.

Important and worth doing. But not what I want...


I want full engagement, integrated as part of an efficient, high-performance machine, with comfort and safety.

I want the best machine for Sport Touring. Even if it is different. Sometimes different is better.

The G4 is a better bicycle for people like me.

And, in this respect, I don't think I'm unusual.

***The world is better when more people ride bikes.***

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