The Personal Electric Monowheel (or P.E.M)

A ELECTRIC MONO-WHEEL WITH GYROSCOPIC STABILITY.

December 2019

Aditya Advani
Bombay International School, Mumbai, India
www.adityaadvani.com | aditya2advani@gmail.com

Concept:

The idea came from the Segway, but what if one could sit instead of stand? Does one need 2 wheels then? I saw a video by Professor Walter Lewin (see link #1) on Wheel Momentum and how once a wheel is spun beyond a certain angular velocity it will stay upright and wondered: what if this could be used to keep a single wheeled vehicle upright. Professor Lewin also talked about mounting the spinning wheel **inside** a 3 axis gimbal gyro (see 49:00 at link 2). What is we could mount the gyro inside a spinning wheel instead? How much angular velocity would be required to maintain equilibrium? How much off center can the center of gravity be to still ensure the wheel can "return to centre"?

Link 1: https://www.youtube.com/watch?v=NeXlV-wMVUk

Link 2: https://www.youtube.com/watch?v=N92FYHHT1qM&feature=youtu.be&t=2749

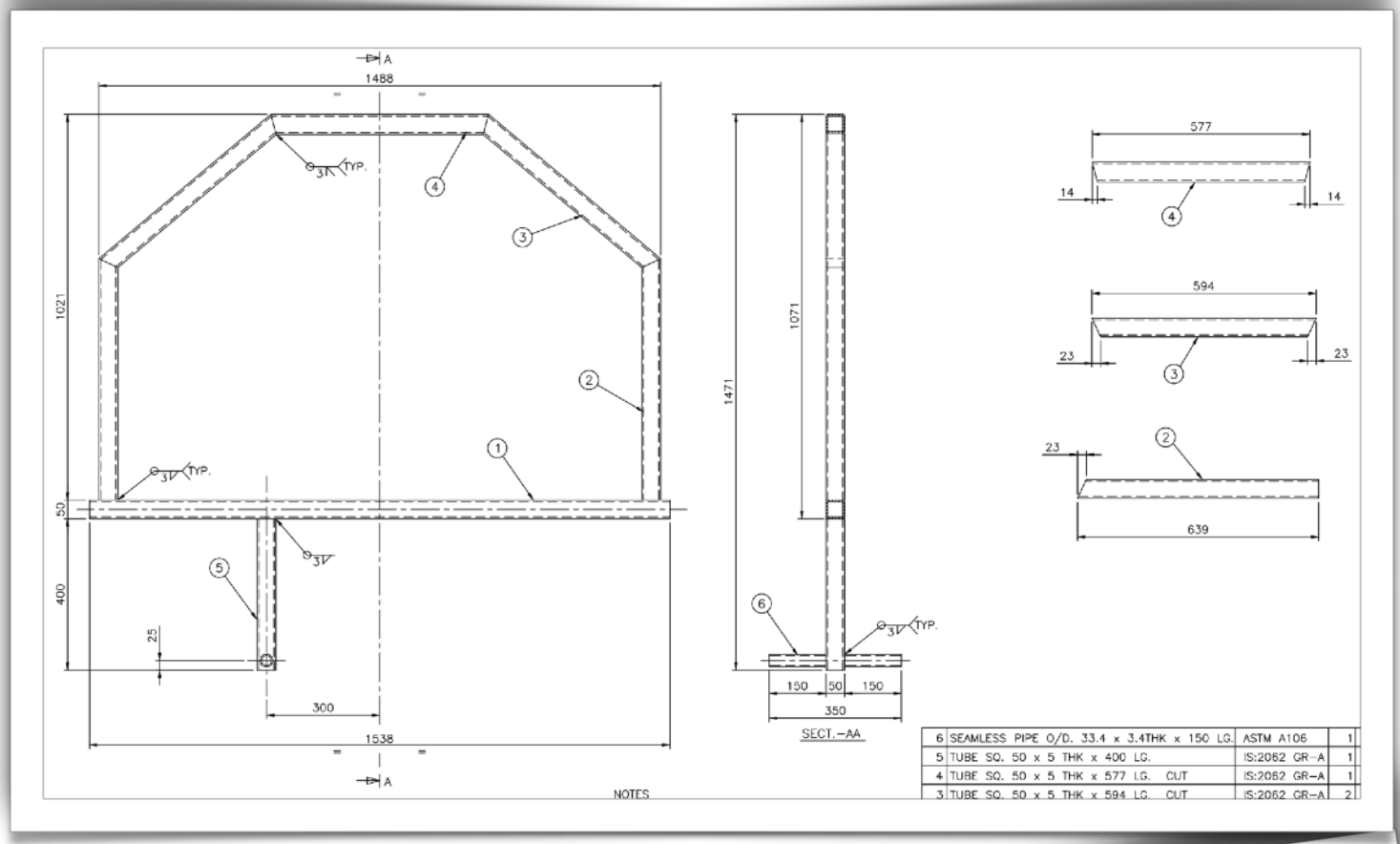
These are the questions I wanted to answer but for that I needed to first make a mono wheel, drive it with some motor (to develop the angular velocity) and then add a weighted gyroscope to ensure the wheel can return to center even if the center of gravity is temporarily shifted off center for turning. My first target was to build a vehicle that would have some degree of stability without a gyroscope and then add any weight balancing later as needed.

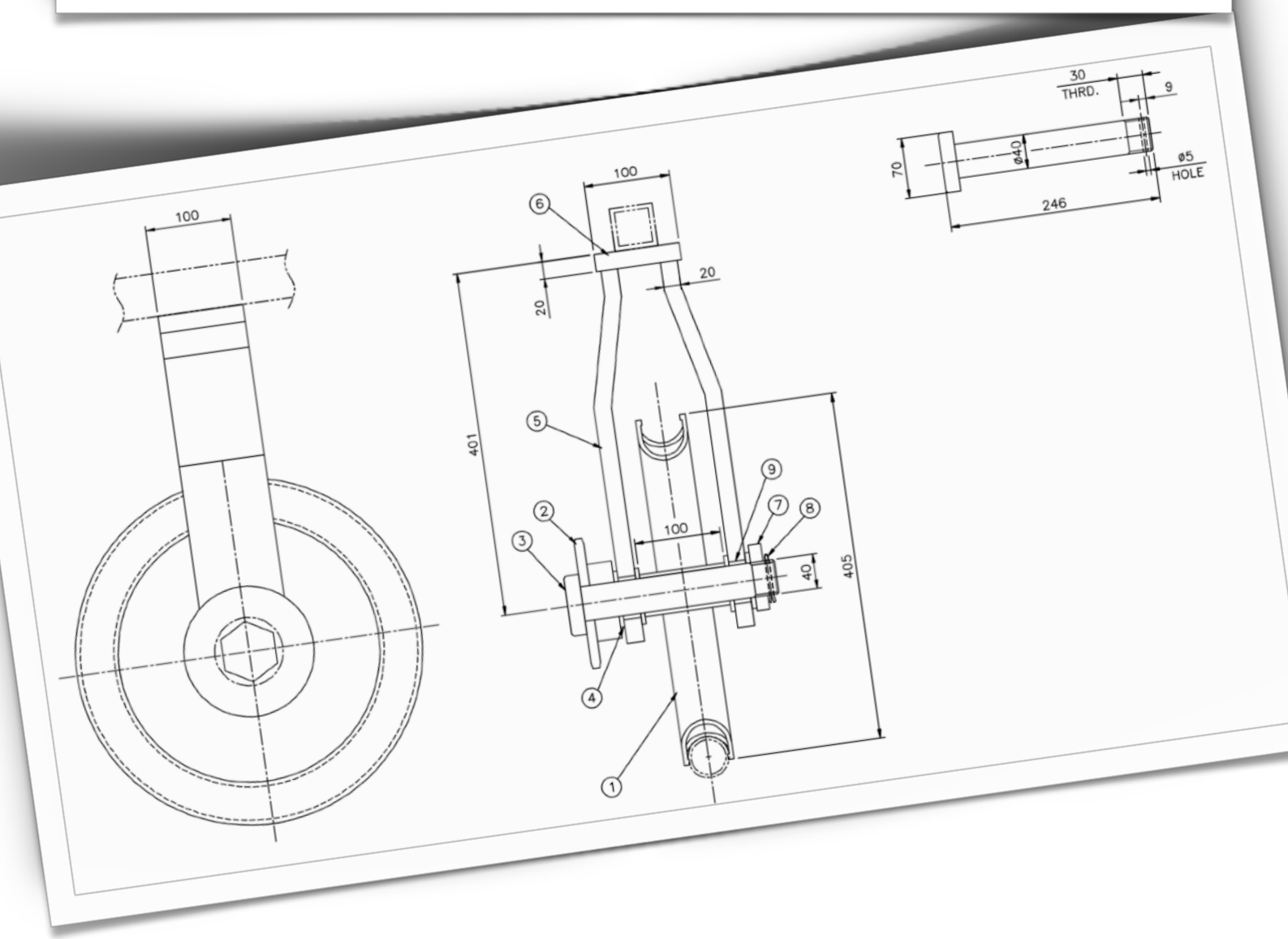
The vehicle would also need assistance to remain in vertical equilibrium when not in motion and this would be provided via two small side wheels. Hence the first prototype I have started building has two small wheels. I hope that the design eventually evolves so that these side wheels can be eliminated.

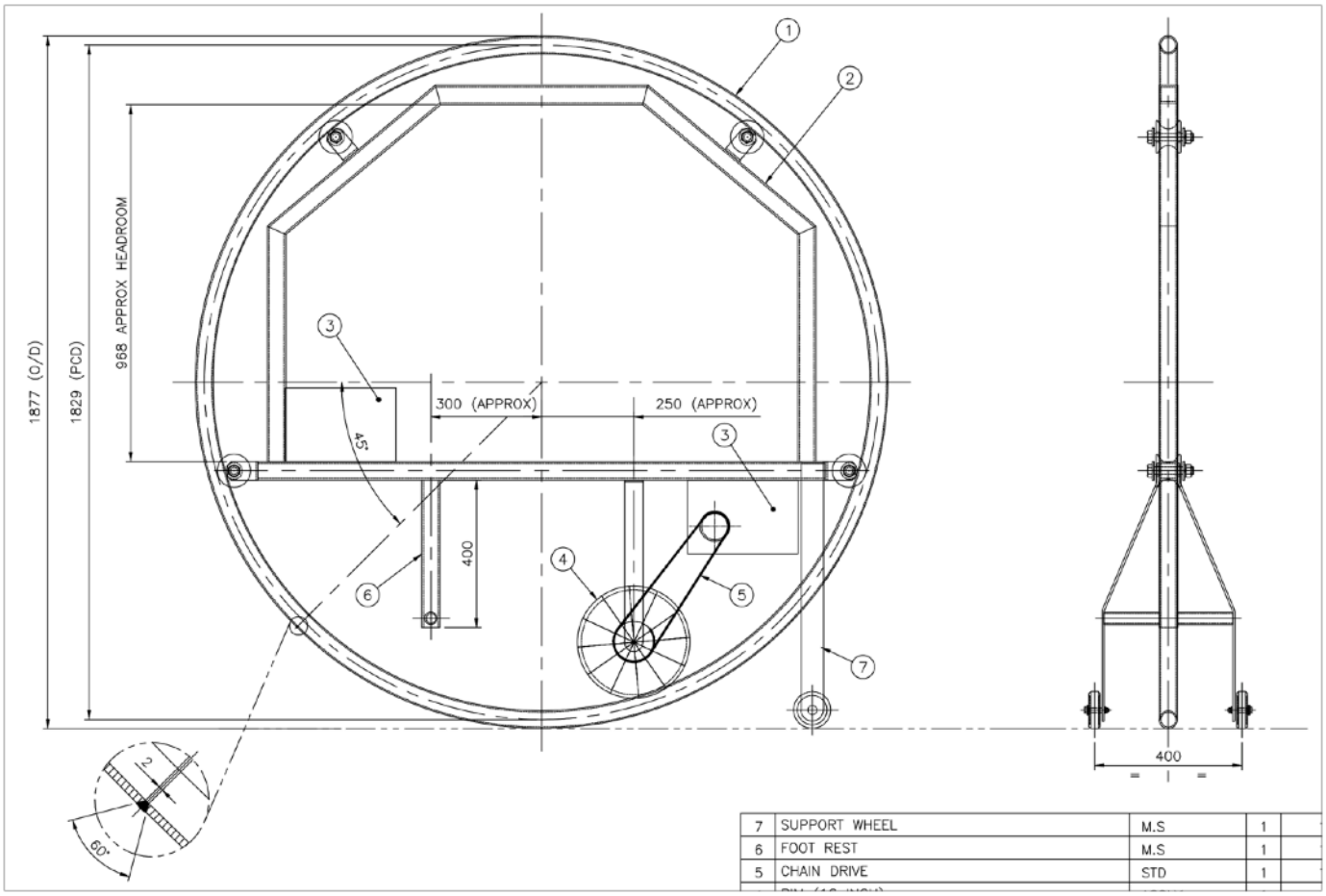
The Design

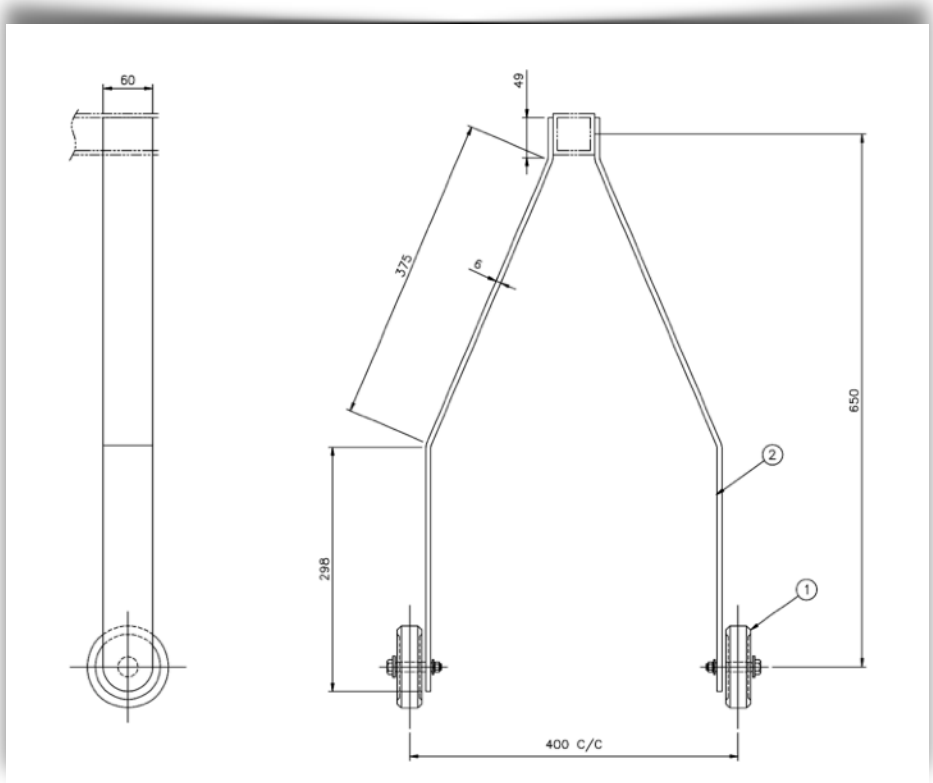
For this first stage I decided to use a small 250W / 24V DC motor that is easily available. The motor would drive a small wheel via a chain and the small wheel would drive the mono-wheel using friction. The ratio of diameter between the small driving wheel and the driven mono-wheel is approximately 4.5:1. This is in effect the "gear ratio" of the mono-wheel.

I know I do not know how to weld so I would need to get the wheel fabricated by someone who could. However the fabricator would need detailed drawings so he could make what I envisioned so I set to work on AutoCAD and made a set of sketches for the fabricator.


A
1488
3V TYP.
1021
50
400
25
300
1538
A
1471
1071
150
50
150
350
SECT.–AA
577
14
14
594
23
23
639
NOTES
6 SEAMLESS PIPE O/D. 33.4 x 3.4THK x 150 LG. ASTM A106 1
5 TUBE SQ. 50 x 5 THK x 400 LG. IS:2062 GR–A 1
4 TUBE SQ. 50 x 5 THK x 577 LG. CUT IS:2062 GR–A 1
3 TUBE SQ. 50 x 5 THK x 594 LG. CUT IS:2062 GR–A 2


100
100
20
20
401
100
40
405
30
THRD.
9
70
Ø40
Ø5
HOLE
246


1877 (O/D)
1829 (PCD)
968 APPROX HEADROOM
300 (APPROX)
250 (APPROX)
45°
400
60°
400
7 SUPPORT WHEEL M.S 1
6 FOOT REST M.S 1
5 CHAIN DRIVE STD 1


60
49
375
6
650
298
400 C/C

Fabrication

The next step was finding a fabricator who would be able to do this work. During my Internship at Animal Factory in Sewri, in Mumbai I had seen several small road side shops that were doing all sorts of metal fabrication. So I took my drawing and ideas to them. Unfortunately all of them said they would not be able to help.

Eventually my father had a friend, who had a friend with a fabrication workshop about 90 minutes from where I live. So I had to go to Mr. Inderpal Singh of DMech Engineers. I took my drawings with me and I got lucky. Mr. Singh was a mechanical engineer so he was able to read my drawings very easily. His workshop was strewn with a variety of steel plates, pipes, and sheets. He did not have a pipe bending machine but he knew another workshop that had one.

Mr. Singh also pointed out many small things I had missed in my drawings. For example my mounting of the motor was wrong and the rotation of the "driven" wheel was in the wrong direction. If the monowheel had been built exactly as I drew it the wheel would move backwards!

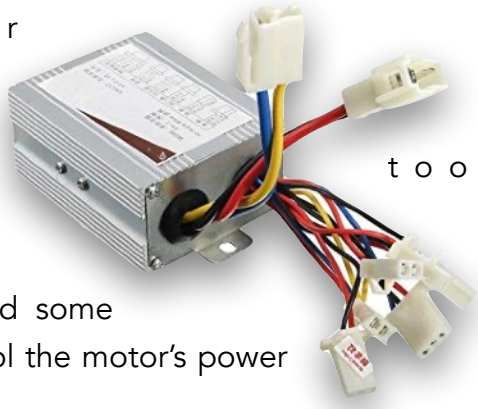
I was embarrassed but Mr. Singh told me not to worry, he understood clearly what I wanted and would do the needful. The work he did was even better than I expected.

Main Parts Used:

1. 24V 250W DC Geared Motor
2. Motor Controller 24V 250W
3. 24V 11000mAh Li-on battery
4. Lithium Ion Battery Charger
5. Throttle Control
6. Axle with coupling
7. Chain and Sprocket
8. Key switch

After I received the fabricated mono-wheel from Mr. Inderpal Singh I started working on the other components needed. Quite obviously

I would need a motor and a battery but which one? I finally settled on a 24 Volt DC, 250W geared motor and a 24V 11000mAh Li-ion battery. I could have gone for a bigger motor but that was turning out too expensive.

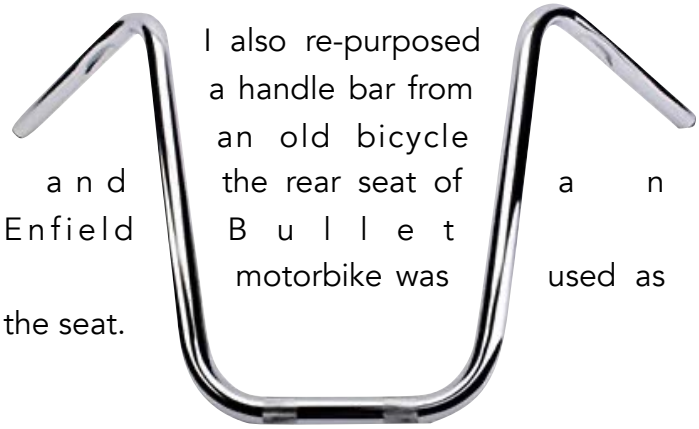


I also needed some way to control the motor's power and rpm so I could control my speed so I bought a Motor Controller compatible with 24V 250W motors. This came with a "throttle" control similar to the one regular gasoline powered motor-bikes have. Braking was provided simply by cutting power to the motor.

Next I had to find a way to connect the motor to the driving wheel. This was easily done via a sprocket and chain, similar to one found on bicycles.

In my hurry and inexperience making the drawings for Inderpal, I forgot that I would need a battery holder and some way to mount the motor to the frame. Now I had to make these at a local garage. The quality of workmanship of the local garage wasn't nearly as good as Inderpal's but I guess if you do not know how to weld, you take what you can get.

I also re-purposed a handle bar from an old bicycle and the rear seat of an Enfield Bullet motorbike was used as the seat.



Assembly

1. Lay the outer wheel on the ground.
2. Fit the square cross member with 2 rollers – one at each end. **This main cross member will hold the motor, driven wheel, battery, seat and handle bars**.
3. Weld a vertical beam to each end of the cross member.
4. Build 3 sides of an octagon using 3 smaller steel beams and weld this to the vertical beams.
5. Fit guide rollers to 2 of the sides of the above mentioned 3 sided octagon.
6. Rotate the 5-sided frame within the wheel to check for linearity of movement.
7. Weld 2 strips to one end of the square cross member. These strips will eventually be used to attach training wheels for support. Drill a hole in each strip for the training wheels.
8. Attach training wheels so the wheel stands.
9. Weld 2 more steel strips from the middle of the main cross member for the axle of the driving wheel and make a hole for the axle in each strip.
10. Attach a sprocket to the driven wheel.
11. Attach the axle and the driven wheel between the 2 steel strips.
12. Weld a plate for mounting the motor to the main cross member and make a long oval hole for the motor mounting.
13. Mount motor with its sprocket and chain to the plate and adjust the motors distance to the driven wheel so that the chain is tight.
14. Test the movement of the 5-sided frame again as all this work can distort the frame.
15. Weld a 'T' to the bottom of the main cross member. This will provide a foot rest and also space to install the battery and key switch.
16. Fit a cover over the chain for safety.
17. Fit the handle to main cross member.
18. Fit the accelerator and brake levers on the handle.
19. Thread the electrical wires for the accelerator and brake along the handle.
20. Fit the seat the main cross member.
21. Fit the box for the battery to the 'T' and complete full wiring.
22. Test the motor movement by turning it on and operating it slowly.
23. Remove the training wheels, seat, handle, motor, battery and all wiring and then paint.
24. Stick rubber strips from cut up bicycle tyres to the outer wheel to provide traction.


94


94