Bicycle Powered Generator

I skim a few Usenet newsgroups daily, among them misc.survivalism and alt.energy.homepower. Frequently posters on these two groups will inquire about generating electricity using a stationary bike coupled to some sort of generator. Most replies are to the effect that while it's possible to do this, the amount of power output by such a rig when pedaled by the average person wouldn't be worth the effort. I wasn't convinced that this idea was a lost cause. I decided to build one and see how well it worked.

Because bikes are made in a range of sizes to match their rider's stature I wanted to build the generator as an accessory which could be driven by any ordinary bicycle. I used to work in a bicycle shop when I was 13 and remember seeing the owner, Mr. Hank, ride his track bike on a set of rollers. While I was looking through bike accessory catalogs for rollers that I could adapt to my purposes I came across another similar device called a training stand. While rollers require a lot of skill to ride because there is nothing but the gyroscopic force of the spinning wheels and the rider's balance to hold you upright, a training stand clamps on the rear axle of the bike and keeps you vertical.

To make a long story short I bought the most versatile training stand I could find and then did extensive modifications to the roller assembly. Originally the ball bearings were pressed into the bore of the roller at the outer ends. The roller assembly spun on a stationary axle fixed to the frame. The end of the roller, opposite the integral three pound flywheel, drove the hub of a centrifugal clutch. The shoes of the clutch engaged a stationary drum which provided resistance increasing with speed. I had to make a new axle which is locked to the roller and move the bearings to machined aluminum plates outboard of the steel frame. The plates are made to a standard NEMA 42 size and provide the mounting surface for a permanent magnet DC motor that is driven as a generator through a flexible coupling. The other end of the axle exits from the bearing through an identical plate and is available for PTO use. You can see a black sprocket on that end of the axle in the pictures. I also had to weld in a brace to stiffen up the frame to allow carrying the extra weight of the generator. I'm pleased with the result. Even under heavy load it runs cool and relatively friction free. The part of the frame that clamps to the rear axle of the bike pivots with respect to the ground so that the rider's entire weight forces the tire into contact with the roller reducing slippage to a minimum. The black object under the front wheel is a contoured plastic block that levels the bike to avoid the feeling of riding downhill.

I have done quite a few tests to see how much output power could be produced and what practical applications there were. See the tables below for a list of those tests and the results. In summary I think the most practical application of the bicycle powered generator would be battery charging. This application presents a constant load to the rider which allows them to select a single gear ratio which lets them pedal at their optimal cadence. Another practical application is running small appliances and tools which use universal series wound motors or permanent magnet DC motors. All of the motorized items in the table below have universal series wound motors and would run on DC even though their nameplates all said "120 Volts AC Only". Induction type motors such as those found in washing machines and shaded pole motors which are used in clocks really are AC only and won't work at all. I couldn't get my variable speed drill to work, probably because the speed control electronics are incompatible with DC. Good candidates are appliances or tools that can perform their functions with 300 watts of input power or less and which present a narrow range of loads such as the mixer and electric drill. Although producing heat with electricity is usually a bad idea, I think that small soldering irons might also work well since they are almost all are under 100 watts and most are less than 50 watts. Since there is no voltage regulation at all, connecting the generator output directly to the power input jack of battery powered TVs, radios, and similar devices will probably destroy the sensitive electronics. Use the generator to charge the batteries, and power the electronics from the batteries. Since the generator is capable of outputting several amps it may be best to charge only batteries that can accept a charging rate in this range, and then building an efficient switchmode regulator to charge smaller cells and batteries off of the large battery. The final, and as yet unexplored, application is hitching mechanical loads such as a water pump or grain grinder to the PTO end of the axle using roller chain. I expect a lot more useful work out of this arrangement as it avoids the inefficient conversion of the rider's mechanical energy into electricity and then back to mechanical energy via electric motors. Using 27" tire diameter on the bike and a 10 MPH "road speed" the roller will turn at about 2600 RPM. The sprocket shown is the smallest I could find at 9 teeth for 1/2" pitch #41 chain, so you would need to figure from there what size sprocket you need on the load to give the desired load RPM. One suggestion that came up during testing was to drive a heavy flywheel to dampen out electrical load variations, but that was never tried.

Electrical Tests:

Load	**Output**	**Comments**
Open Circuit	230 Volts DC	Spinning it as fast as possible in the highest gear that the test bike had and measuring the output with a DMM.
Short Circuit	4 to 5 Amps DC	Generator output shorted by the DMM on the 20A DC scale. This measurement doesn't mean much because it took a lot of torque to turn the generator against a short circuit. It was hard to get consistent readings due to the speed fluctuations from the low rate of pedaling that could be achieved.
2 Ohm Wirewound Resistor	5.5 to 6 Volts DC (15 to 18 Watts)	This test had the same problem as the short circuit current test, the load impedance was too low to allow the rider to pedal effectively.
65 Ohm Wirewound Resistor	100 Volts DC (150 Watts) Continuous, 130 Volts DC (260 Watts) Peak	The continuous figure is what the rider felt he could keep up for 15 to 30 minutes. The peak value was a few second burst of speed.
100 Ohm Wirewound Resistor	100 Volts DC (100 Watts) Continuous, 150 Volts DC (225 Watts) Peak	The difference between this test and the previous one could be variability of effort on the part of the rider, perhaps as a result of fatigue. Another possibility is impedance mismatch between the source (generator) and load. The generator has a very low output impedance and the ideal load would be the lowest resistance that will still allow the rider to pedal at an effective rate.

Practical tests:

Load (Nameplate Data)	**Results**	**Comments**
Battery Charging	Great	Able to push a continuous 4 to 6 amps into a 12 Volt automobile battery. The best setup was to put a rectifier diode in series with the generator output. This stopped the battery current from driving the generator backwards and enabled the rider to start pedaling without any initial resistance. It was then possible to take up the charging current load gradually as the generator output exceeded the battery voltage plus the forward voltage drop across the diode.
Waring Multispeed Handmixer	Good	Moderate pedaling effort was required to run this appliance up to operating speed. I loaded the motor by trying to slow the rotation of the beaters by hand. There was plenty of available torque to use the mixer in its typical applications. I'm certain that similar appliances such as blenders and food processors would work just as well.
Black & Decker 3/8" Drill Model 7104 Type 1 (2.9 Amps 1200 RPM)	Fair	Lots of 1/4" holes were drilled through a 2" thick piece of framing lumber with a standard high speed twist drill and I'm sure that larger holes would be possible. The only special consideration was to ensure a steady feed rate while drilling to avoid load fluctuations.
Black & Decker 7-1/4" Circular Saw Model 7308 Type 5(1-1/2 HP 9 Amps 1200 RPM)	Poor	Considerable pedaling effort was required to get the saw up to operating speed and it bogged down to a standstill when a cut through a 2 x 4 was tried. We might have been able to cut 1/4" plywood or luan. I think the problem is that the motor in this tool is designed for maximum power output regardless of conversion efficiency. I'm sure a person has enough power to saw a board, after all, I can do it with a hand saw using only the muscles in one arm! I would like to try this test with a saw designed to run efficiently on DC such as the battery operated ones made by DeWalt.
McCulloch ElectraMac Chainsaw Model EM14ES (2 HP 11Amps)	Useless	This tool's motor has the same characteristics as the circular saw. It was impossible to get it up to full speed, and the blade merely bounced off the surface of the log and stalled when any meaningful cutting force was applied. The nameplate claimed 2 horsepower and the motor's size was perhaps 3" in diameter and 6" long.

Acknowledgements:

During my "what if" phase of research on the internet I was directed to David Butcher's Pedal Generator page which provided me with the proof of concept I needed to justify building my own

version of a bicycle powered generator. I think my results correlate well with his.

I would also like to thank my long time friend Mike who spent several hours with his Paramount mountain bike clamped in my contraption pedaling diligently while I measured and fiddled around. For reference he is in his mid 50's, in good physical health, a non-smoker and semi-regular recreational cyclist, so you can scale your own expectations accordingly.