Listeroid 6/1 Engine & ST5 Generator System Photos

Legal* Disclaimer *and Warning: ***One should never startup and operate these EPA illegal and dangerous open flywheel engines as serious injury or death may result!!! Competent people use these engines for renewable fuel research and historical purposes. Additional information may be found here if one can wade through the endless regurgitation of facts and fiction as is often the case with social media frequented by easily brainwashed individuals lacking critical thinking skills for self-flagellation, for some sense of self-worth or for promoting their personal and often misguided degenerate agenda:***

Lister Engine Forum

Our 2005 self-constructed Listeroid 6/1 diesel "kit" engine (6 HP/1 Piston) and 5 kW ST5 generator system uses an auto/manual emergency engine shutdown system; an auto electrical disconnect system; an auto carbon-neutral vegetable oil fuel system; a Liquid Propane Gas (LPG) fumigation/power boost system that boosts our 6/1 diesel-fueled engine nominal continuous 6 HP of mechanical apparent power to 9.6 HP of continuous mechanical apparent power (and the heavy flywheels also enable 13.4HP of surge mechanical apparent power); an engine water cooling system; an exhaust carbon retention/silencer system and a resilient mount vibration isolation stand. Details on these systems may be found below.

From 1930 to 1987 the Lister company made diesel engines for pumps, generators, and general-purpose use, using a slow-speed, heavy flywheel design and using simple, easily self-repairable parts. Today there are many Indian and Chinese companies that produce Lister copies for export known as "Listeroids". These relatively quiet low 650 RPM workhorse engines were rated 100% duty cycle which means they could operate 24/7, with zero down time due to heat and lubrication needs. Fuel efficiency for our 6/1 engine is about 0.11 gallons per KWH and they operate using either diesel fuel or vegetable oil which can also be augmented with LPG to significantly boost power output. Their high fuel efficiency and 100% duty cycle rating makes them perfectly suited for electrical generation for long-term use versus the much higher RPM "emergency-only" generators which use a large amount of fuel and have a relatively short lifespan. Their simple design makes them easy to self-maintain and rebuild if ever needed. The 6/1 engine heavy flywheel kinetic energy design enables it to handle power loads significantly in excess of its diesel-fueled nominal rated 6 HP of mechanical apparent power and significantly in excess of our LPG boosted 9.6 HP of mechanical apparent power for very short durations (e.g., it can provide us LPG boosted 13.4 HP of surge mechanical apparent power or 7 kW of surge electrical working power).

The ST series of single-phase AC synchronous generators are a simple 4 pole, rotating field, self-excitation, and constant voltage design. These generators are very heavy and very rugged in construction and are very easy to self-maintain and self-repair. These generators can be coupled directly to diesel or gasoline engines or via belts to provide their required 1800 RPM for balanced 120VAC or unbalanced 240VAC 60 Hz power generation. These generators were often used for primary power for small towns, villages, ships, and mining 24/7 operations.

Our self-constructed Listeroid 6/1 "kit" engine and our ST5 generator, both inspired by ***George Breckenridge***, were originally built for about $600 in 2005. Our 5 kW ST5 generator uses an 8.4 inch diameter ***Randy Allmand*** eight vee groove SK bushing pulley and an eight vee rib Micro-V serpentine belt to drive it from the 23.5 inch diameter 6/1 flywheel. This eight vee rib Micro-V serpentine belt results in significantly less required belt tension and associated engine/generator bearing loads than can be achieved by using either a flat belt or simple vee belt thereby significantly increasing engine/generator bearing longevity. This arrangement converts the flywheel's 650 RPM and 48.5 foot pounds of torque (i.e., 6 HP times 5252 divided by 650 RPM) to 1800 RPM (i.e., 60 Hz times 30 for this 4 pole generator) and 17.5 foot pounds of torque (i.e., 6 HP times 5252 divided by 1800 RPM) at the 5 kW ST5 generator pulley. The center point distance between the 6/1 engine flywheel and the 5 kW ST5 generator pulley is 20 inches requiring a 92.8 inch length eight rib Micro-V serpentine belt (Gates Part Number K080922). The flywheel and ST5 generator pulley belt lap angles are 222

and 138 degrees respectively. Assuming a conservative 0.32 coefficient of friction between the belt and the ST5 generator steel pulley, the required predicted static belt tension to avoid any belt slippage during operation is 55 pounds. This predicted static belt tension results in a predicted dynamic belt tension that varies from this maximum 55 pounds of tension to a minimum of 6 pounds of tension (i.e., 50 pounds of cyclic belt tension variation). This results in a predicted static bearing load of 111 pounds and a predicted dynamic bearing load of 61 pounds. The operational belt velocity is 3999 FPM. Actual belt tension is even less and set manually at a point slightly above where actual belt slippage occurs. If interested, our calculator for designing a pulley drive system may be found here:

Pulley Drive System Calculator

Our auto/manual emergency engine shutdown system operates by injecting a canister of CO2 into the engine intake to suffocate the engine and shut it down. A solenoid valve is triggered and opened if the engine vibration becomes excessive, smoke or CO are detected, engine RPM gets high, coolant temp gets high, oil level gets low, diesel fuel tank level gets low, or the 12 VDC power supply used for this system fails...or if a big red lighted button is manually pushed. The engine was also painted with a special red paint formulated to identify any stress cracking. Safety should never be sacrificed for anything and having an auto emergency shutdown system that can operate immediately without needing human intervention was deemed a high priority.

Our auto electrical disconnect system operates by opening the generator power lines between it and the transfer switch whenever voltage or frequency exceeds the allowed tolerances. Our primary objective was to ensure that a ***Brownout*** situation would never be created if engine were to shut down while still powering our remote southern Oregon homestead. This electrical disconnect system just uses a voltage/frequency switch with settable thresholds and solid state power relays.

Our auto carbon-neutral vegetable oil fuel system just heats the vegetable oil to required temp and then switches from diesel to vegetable oil when this occurs. It also switches feeding the engine from the vegetable oil back to the diesel tank when the vegetable oil tank gets low. The system uses a vegetable oil temp sensor and a tank level sensor to open/close a diesel/vegetable oil solenoid valve.

Our LPG fumigation/power boost system is a manual system. Just a LPG tank, pressure regulator and manual LPG needle valve to inject the required LPG quantity and pressure into the 6/1 engine intake to perform carbon removal maintenance or to boost the 6/1 diesel-fueled engine nominal 3.1 kW continuous electrical working power to the full 5 kW continuous electrical working power capability of the ST5 generator when needed via ***Air Fuel Ratio Lambda Curve*** migration from maximum efficiency to maximum power and ***Turbocharger*** effect. A diesel-fueled 6/1 engine is rated for 6 HP at the flywheel which translates to 4.5 kVA (6 HP times 0.747 kVA/HP) of mechanical apparent power. A well-loaded and diesel-fueled 6/1 engine driving a ST5 generator has been accurately measured to produce 3.1 kW of electrical working power from the ST5 generator while using 0.34 gallons/hour of fuel. Power Factor (PF) is the ratio of electrical working power measured in kilowatts (kW) to electrical apparent power measured in kilovolt amperes (kVA). So 3.1 kW of electrical working power divided by 4.5 kVA of electrical apparent power equals 0.7 PF which can also be thought of as a 70% ST5 efficiency. And LPG boosted 5 kW of working power divided by 0.7 PF translates to achieving 7.1 kVA of electrical apparent power or 9.6 HP of mechanical apparent power while still only operating at 650 RPM. It should also be noted that the 6/1 engine heavy flywheel kinetic energy design and the robust ST5 generator design further enables handling even larger electrical power loads (about 7 KW of surge electrical working power capability) for very short durations such as to start large well pumps. And LPG boosted 7 kW of surge electrical working power divided by 0.7 PF translates to achieving 10 kVA of surge electrical apparent power or 13.4 HP of surge mechanical apparent power while still only operating at 650 RPM.

Our engine water cooling system uses ***Thermosiphon*** negating the need or use of a water pump. For engine efficiency, there is a thermostat that only opens after the engine cooling water reaches 190 degrees F and then allows it to flow through a ***Geo Metro Car*** radiator which uses a 12VDC fan controlled by a water temperature

switch. By the way, the Geo Metro was a 1990s gasoline car that would get nearly 50 MPG! There is also a 120VAC shop building exhaust fan adjacent to the radiator to enable either removing all the 3,700 BTU/H of heat produced from the engine, exhaust pipe and radiator or using this heat for supplemental living space heating of our shop building as desired. For some reason, some people get very excited about this and call it ***Cogeneration***. We just call it old-fashioned common sense which has increasingly become far less common.

Our exhaust carbon retention/silencer system consists of a self-constructed cylindrical concrete underground tank constructed using two different diameter ***Sonotube Concrete Forms*** that our 6/1 engine exhaust is piped to via combination of rigid and flexible stainless steel pipe/hose and self-constructed wall thimble. This underground concrete tank allows the engine exhaust to then expand and cool without creating any sound energy that can be heard above ground. The cooled engine exhaust is then routed through flexible and perforated plastic drainage pipe that was trenched in about 3 feet below ground and runs about 100 feet before it is allowed to surface via a screened outlet. This perforated plastic drainage line exits the concrete tank at the bottom so the large amount of water generated from exhaust condensation is continuously drained from the tank and this heated water drainage also performs a self-cleaning function of both the concrete tank and the perforated plastic drainage pipe that prevents any carbon buildup within them over time. In this way all the engine exhaust carbon and water is retained in the soil and the engine exhaust noise is completely silenced.

Our 2005 original resilient mount vibration isolation stand eliminated 96% of the vibrational energy transmission (please see our ***Design Example***). If interested, our calculator for designing a resilient mount vibration isolation stand may be found here:

Isolation Stand Design Calculator

In addition to eliminating vibrational energy transmission into the building, converting this destructive vibrational energy into resilient mount heat energy instead of trapping it within the engine significantly increases engine longevity…which is why all modern engines, even very large engines, all now use resilient mounts. Our 2005 original resilient mount vibration isolation stand sat directly on and unattached to our 4 inch thick concrete slab garage floor in our suburban Seattle area home, adjacent and close to our daily weight lifting exercise equipment, and only a couple feet away from our living room with young children present…making safety a primary concern. When moved to its final location in 2016 to our remote southern Oregon retirement homestead, it was placed on a self-constructed 6 foot long x 4 foot wide x 8 inch thick pre-tensioned and highly reinforced concrete slab base resting on a 1.5 inch thick dense rubber isolation pad in corner of our shop floor to eliminate the last 4% of vibrational energy and to raise the engine and generator height to facilitate easier maintenance and starting. Please see the below photos for construction details of this new concrete base and the final location of our engine/generator which is now contained within a shop storage shelf area and directly adjacent to our chicken hen nesting area which has a stainless sheet sliding floor compartment for easy cleaning and is exhaust vented with a 3 watt muffin fan to maintain a slightly negative air pressure relative to our shop area to keep any smells out. Our hydronic radiant heated shop floor is 6 inch thick highly reinforced 5000 PSI concrete with 4 inch thick high density EPS under-slab insulation resting on 12 inches of self-compacting pea gravel. If interested, construction photos of our remote southern Oregon homestead garage/shop/guest quarters, residence and water filtration system that we largely self-constructed ourselves may be found here:

Construction of Our Garage/Shop/Guest Quarters

Construction of Our Residence

Construction of Our Creek & Well Water Filtration System

While a ST5 generator can be wired to produce either balanced 120VAC or unbalanced 240VAC 60 Hz power, any electrical load unbalance when wired to produce 240VAC will cause large ST5 vibration and noise (unless

first re-balanced using additional transformers) so we wired our ST5 generator for balanced 120VAC electrical power, but we can still obtain and use 240VAC as will now be further explained. Our 6/1 diesel engine and ST5 generator raw 120VAC output produces acceptable electrical power quality that can be directly used for most applications except for sensitive electronics and incandescent light bulbs which will flicker badly. This is a consequence of the low RPM engine 10.83 Hz (650 RPM divided by 60 sec/min) fundamental power stroke "noise" being much less than the 60 Hz AC power specification that some electronics applications require. To remedy this less than desirable power quality situation when needed, our ST5 generator output is handled the same way as the wild AC output from our self-constructed hydro power Cross Flow Turbine and Permanent Magnet Generator (PMG) to create clean 120/240VAC power that is suitable for ALL electronics applications. If interested, our calculator for designing a cross flow turbine may be found here:

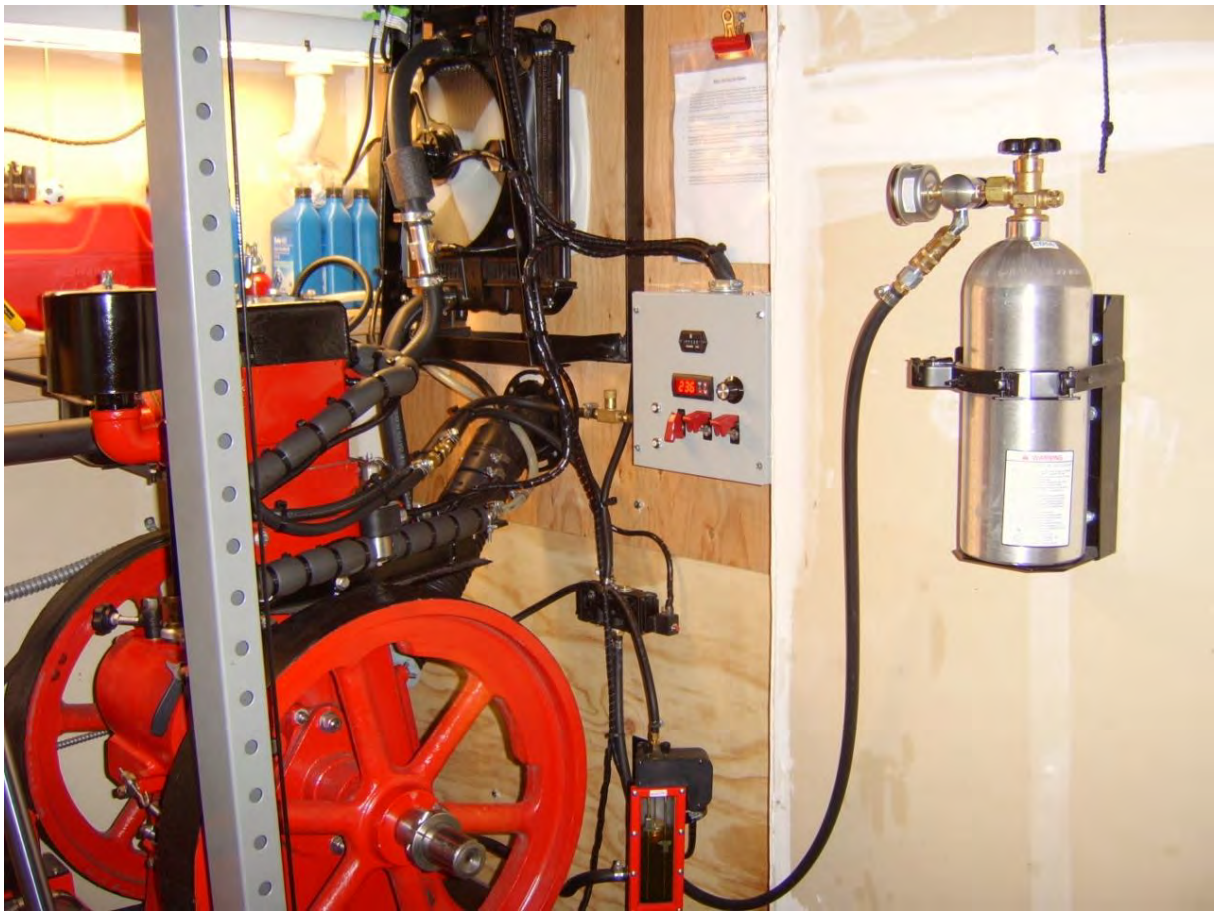
Cross Flow Turbine Design Calculator

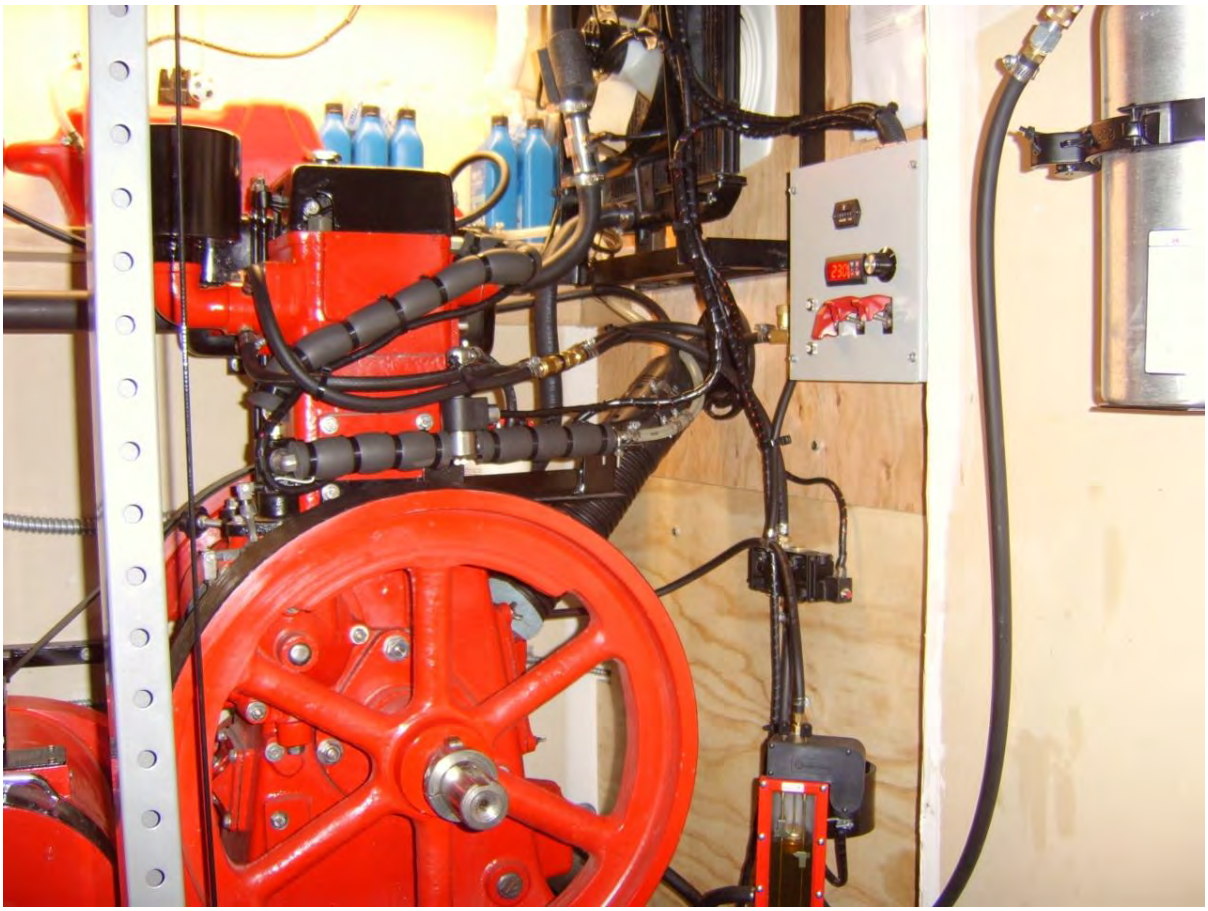
Namely, we use a self-constructed full wave bridge rectifier with a capacitor filter to first convert the raw ST5 generator balanced 5 kW 120VAC 60 Hz power to low ripple 48VDC power that can be used to charge 48VDC Lithium-Ion (LiFePO4) batteries or can be used to feed an efficient single-phase 48 VDC input pure sine wave power inverter to produce clean single-phase 5 kW 120/240VAC power. For more power, the batteries can also be used to feed an efficient three-phase 48VDC input pure sine wave power inverter to produce clean three-phase 36 kW 120/208VAC power which can then be used directly in the shop or which can then undergo inefficient secondary power conversion to produce clean single-phase 24kW 120/240VAC power for residential power needs using a ***Scott T Transformer***.

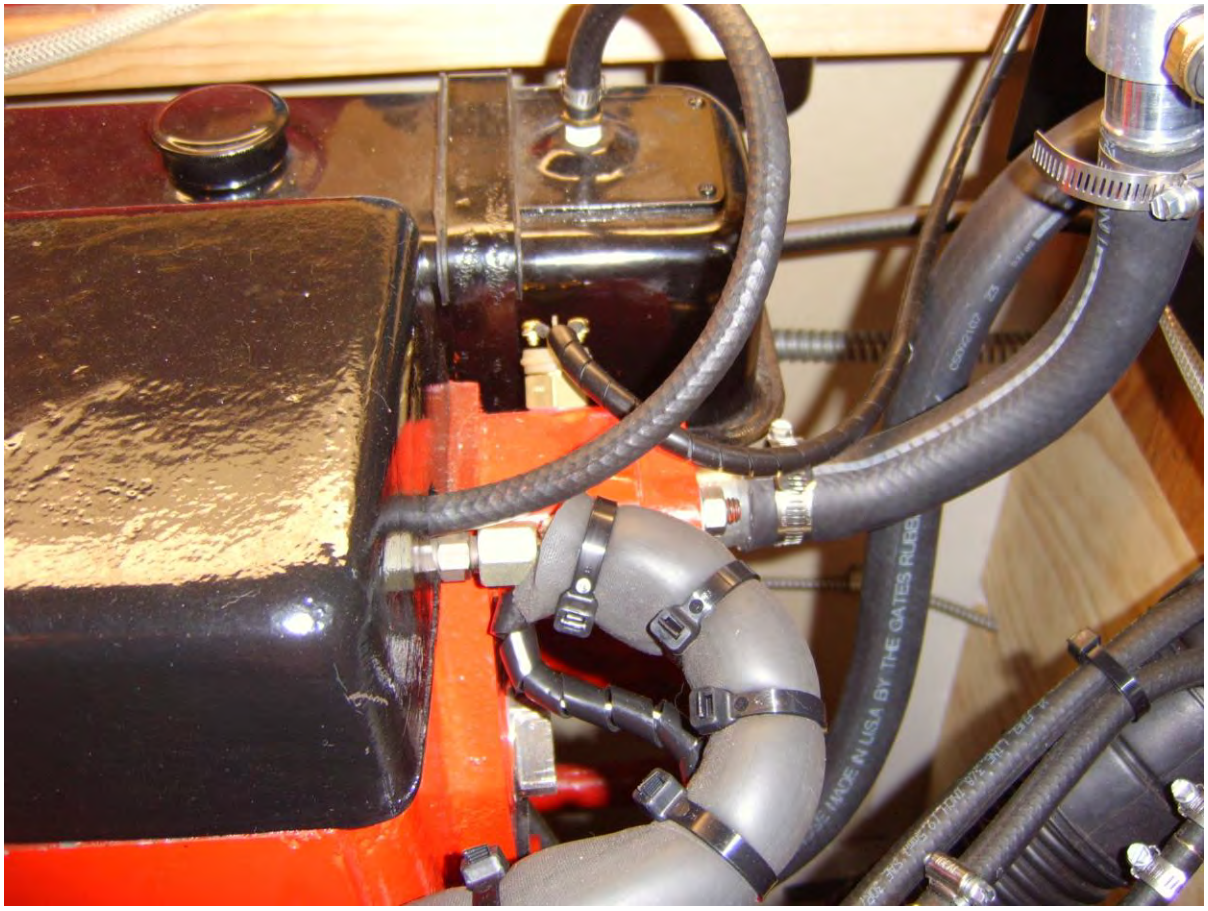
This inefficient secondary power conversion from three-phase to single-phase is deemed acceptable to us given our primary hydro power source availability (we are fortunate to have three mountain creeks on our property) which may also be supplemented with photovoltaic solar panels in the future. The 5 kW power options (i.e., the raw ST5 generator balanced 120VAC power or the clean single-phase pure sine wave power inverter 120/240VAC power) avoids us needing any batteries at all or allows us to by-pass the batteries if needed or desired. The three-phase 36kW power option allows us to efficiently operate our three-phase shop equipment. The single-phase 24 kW power option allows us to operate our more conventional power hungry residential appliances such as our clothes dryer, hydronic radiant heated floor boilers, kitchen oven, etc. including our three ***Stiebel Eltron Tempra Plus 24*** tankless water heaters that EACH can require 24 kW (240VAC @ 100A) as governed by our self-constructed tankless water heater power load shed system (please see below photos for more details) such that only one water heater is allowed to operate at any one time so as to ensure never tripping our 200A residence main service circuit breaker. We also have single-phase 48 kW grid power in our residence and single-phase 96 kW grid power in our garage/shop/guest quarters. Self-sufficiency and redundancy were critical design elements of our remote southern Oregon retirement homestead. We used this very same philosophy for our **"*Los Gatos Casita*"** RV too.

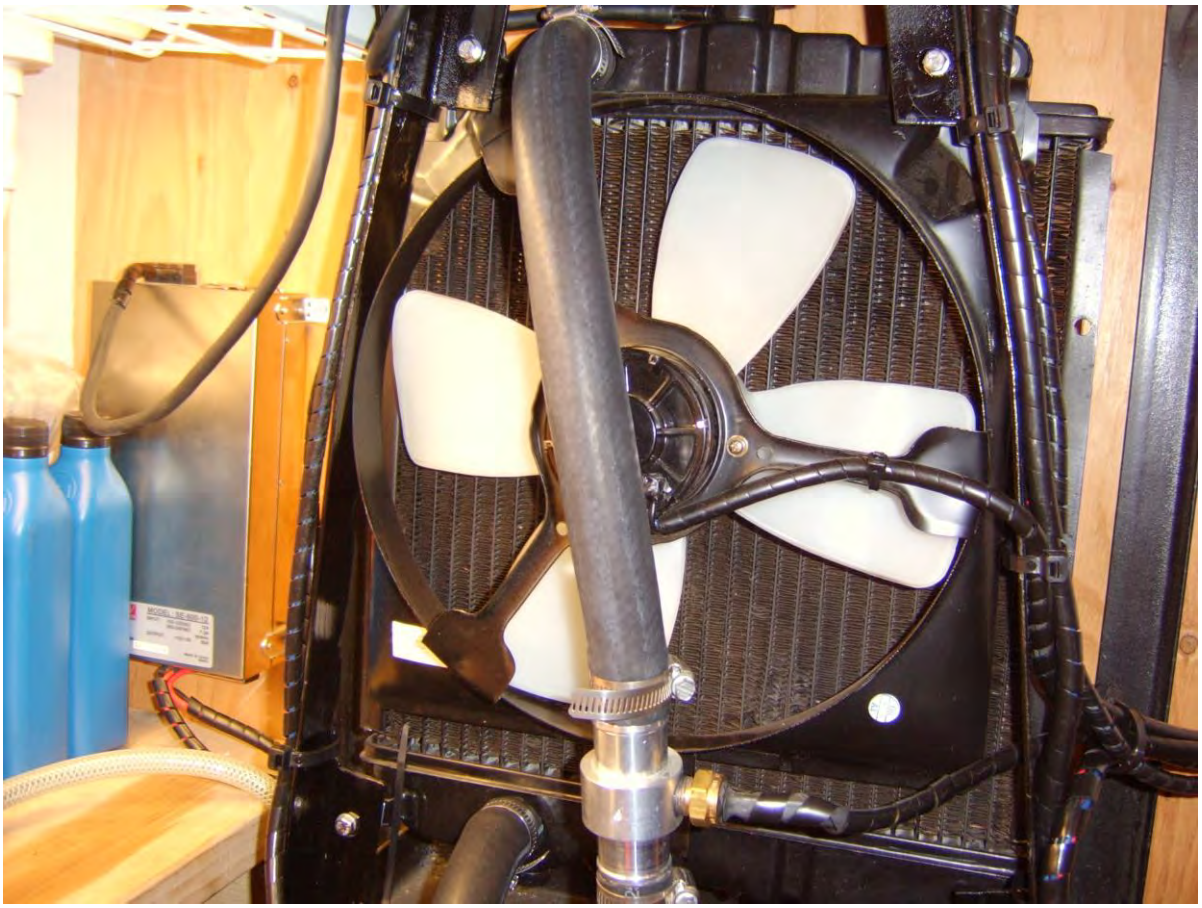
However, these days we can't in good conscience recommend wasting any precious time and money using internal combustion engines to generate electrical power. Fossil-fueled internal combustion engines are grossly inefficient (typically only about 15% efficient) from a fuel energy conversion to working power perspective and are detrimental to adverse man-made climate change. So why use costly fossil-fuels and complicated approaches at all when free renewable energy and simple approaches are now readily available? So these days we recommend using micro hydro power and solar power given rapidly improving battery technology and associated capability and low cost power inverters. Still, being a licensed professional mechanical engineer in multiple States and having been a "gear head" since about 10 years old, I personally find these early engine designs very interesting, enjoyable to work on, amenable to experimentation & refinement, and nostalgic & reminiscent of a quickly disappearing past.

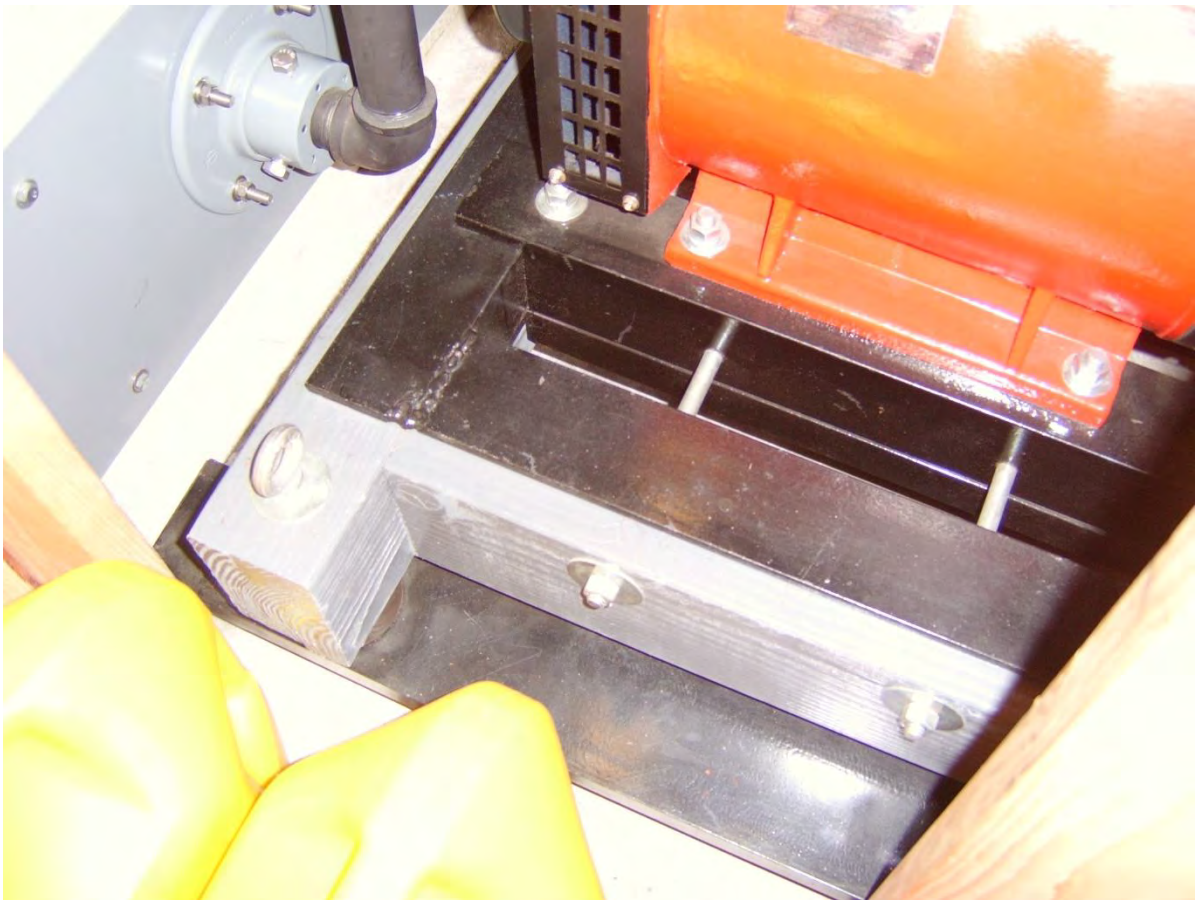
Bob Borst
CEO & Principal Engineer
Borst Engineering & Construction LLC





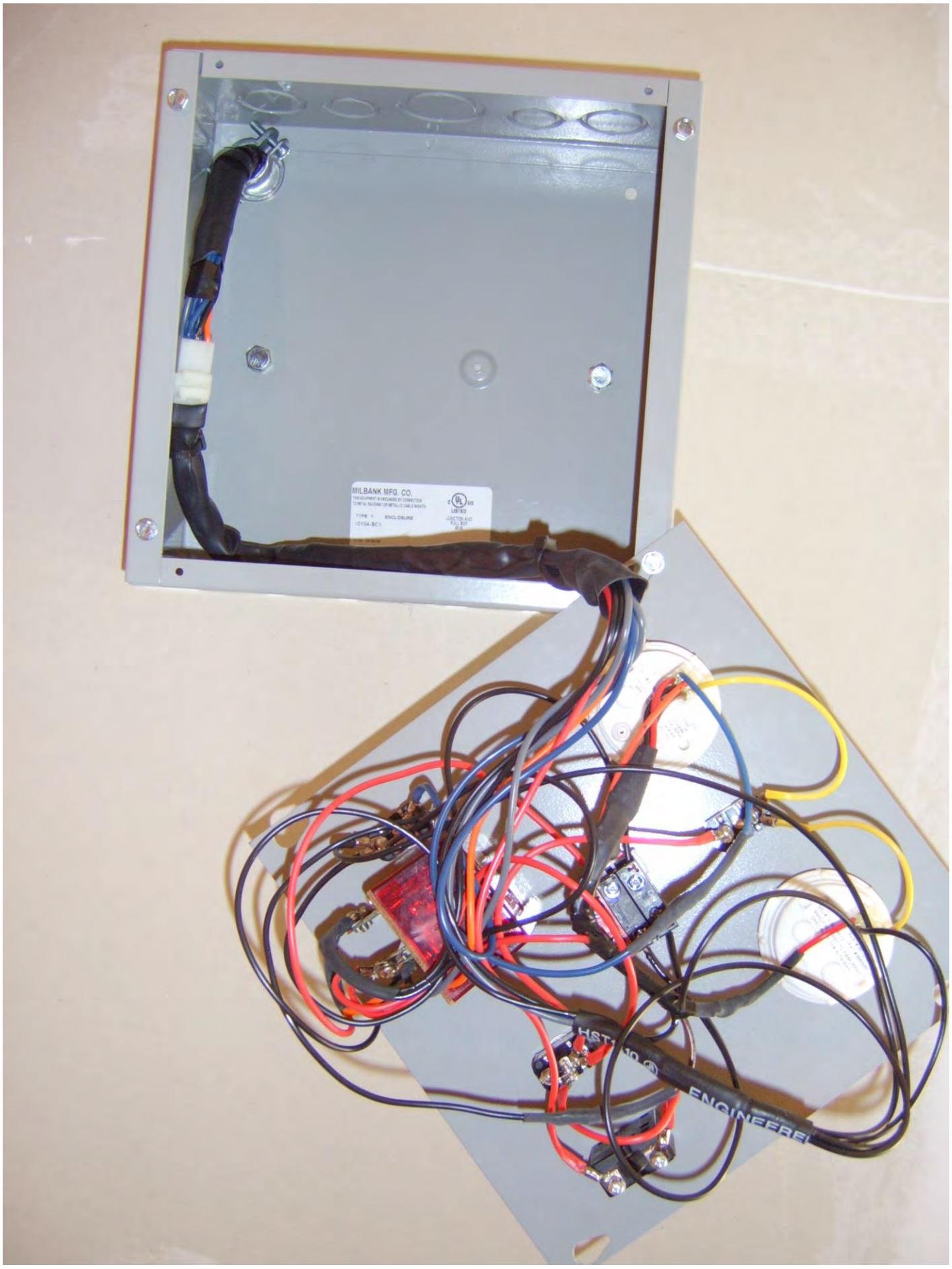

MADE IN USA BY THE GATES RUBBER

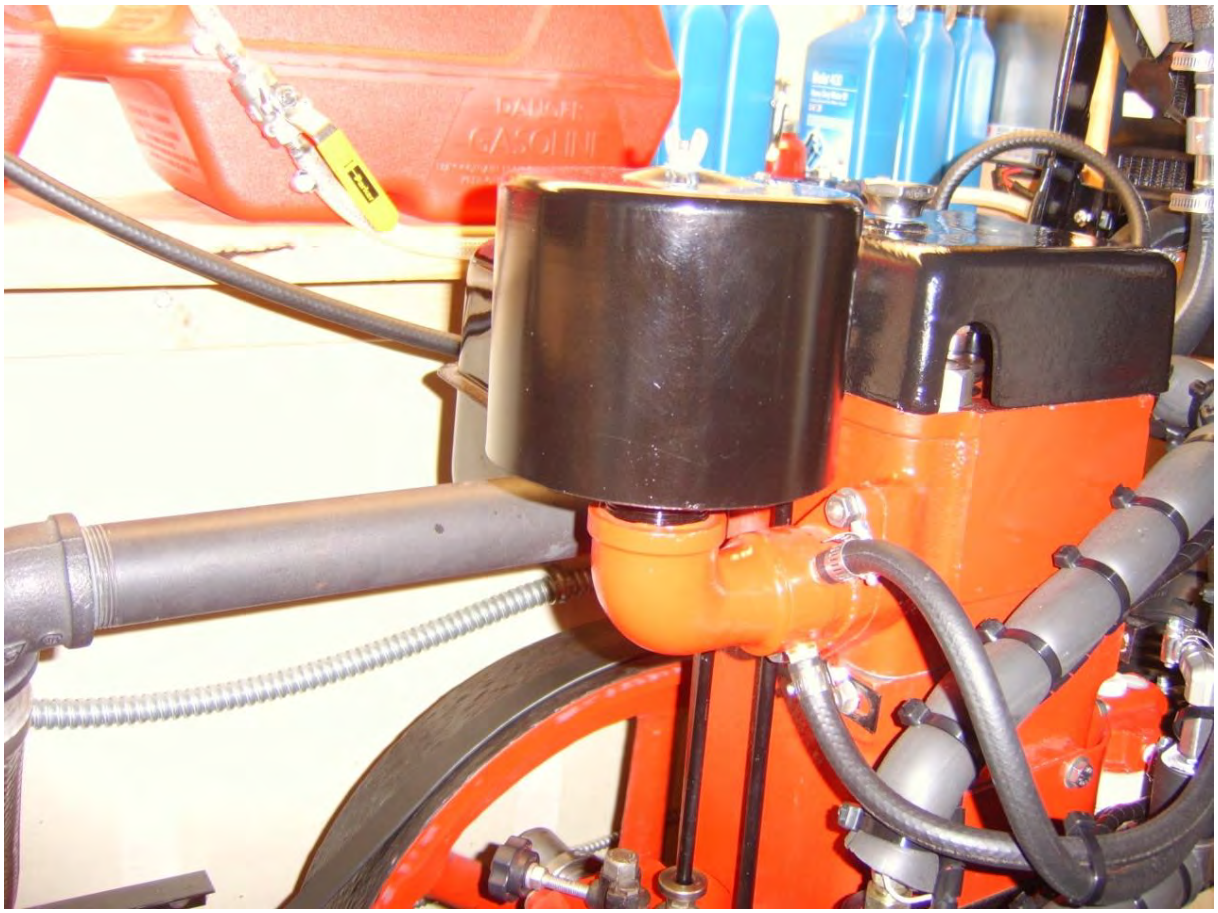




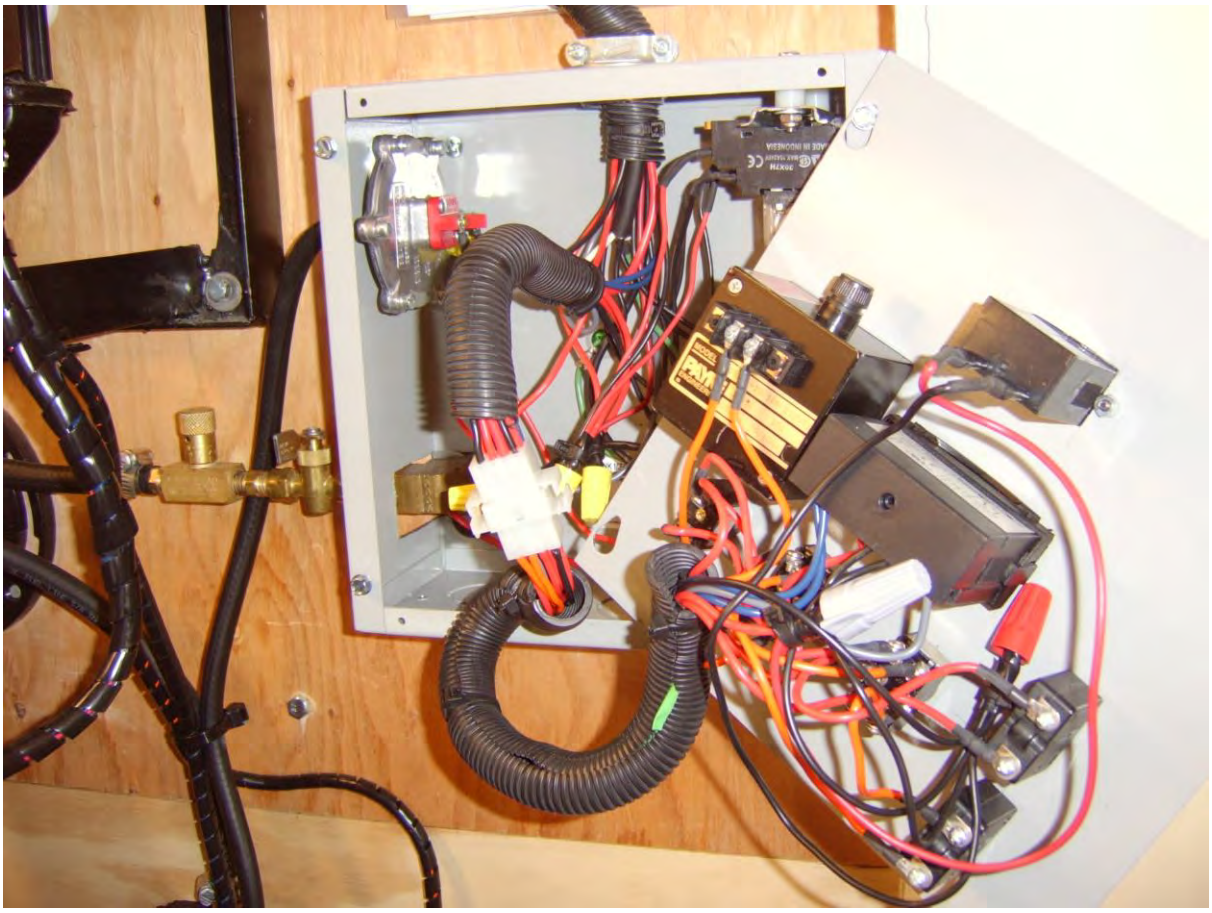

MURPHY

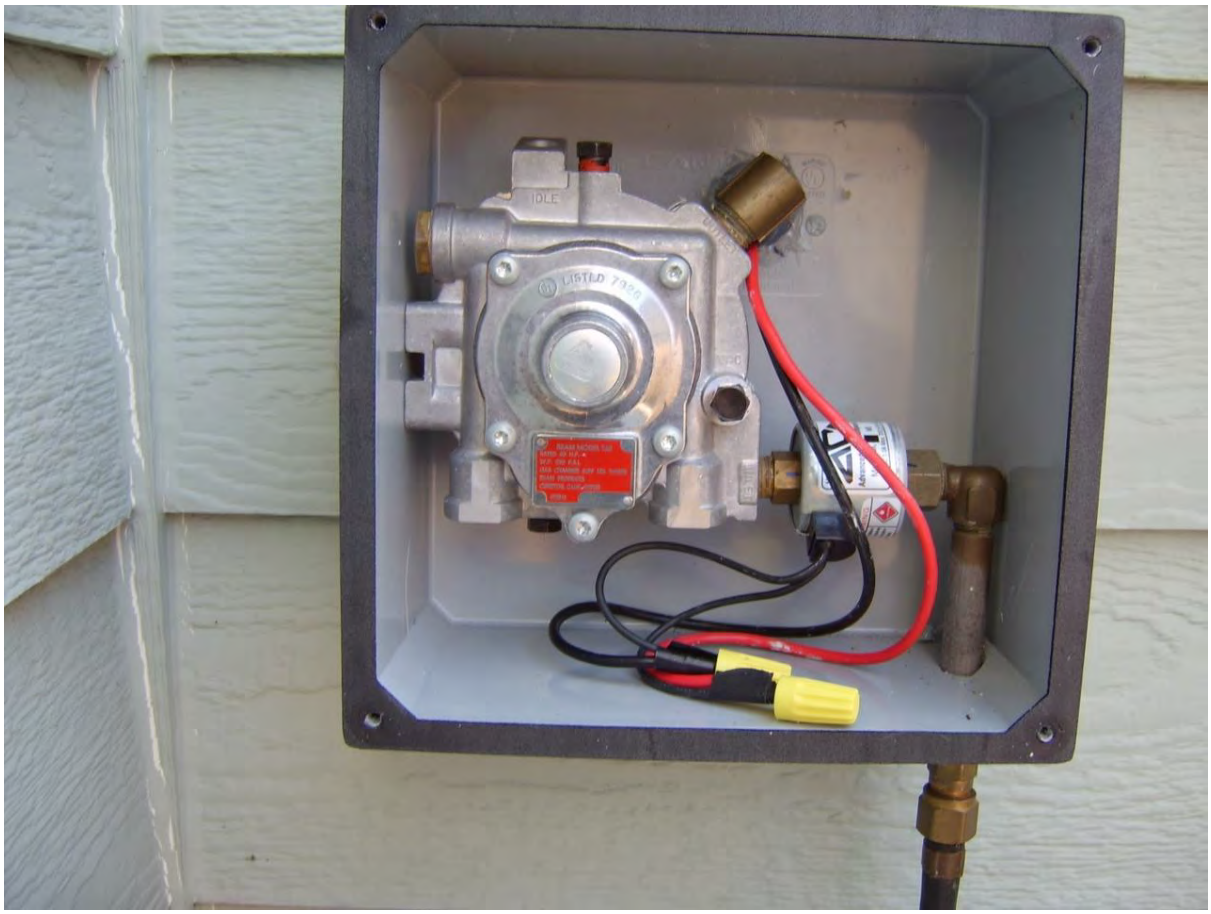

VOLTS


MILBANK MFG. CO.

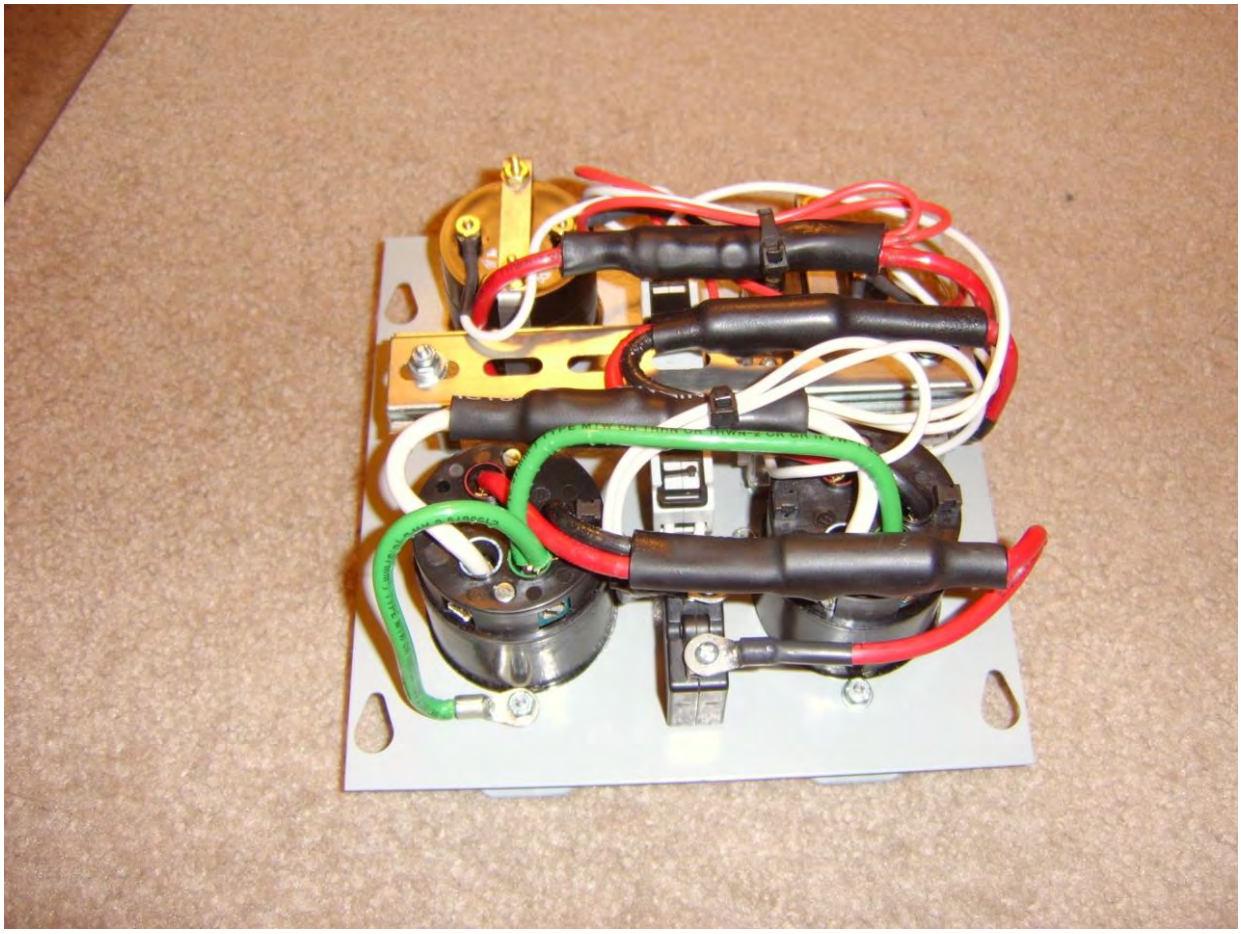


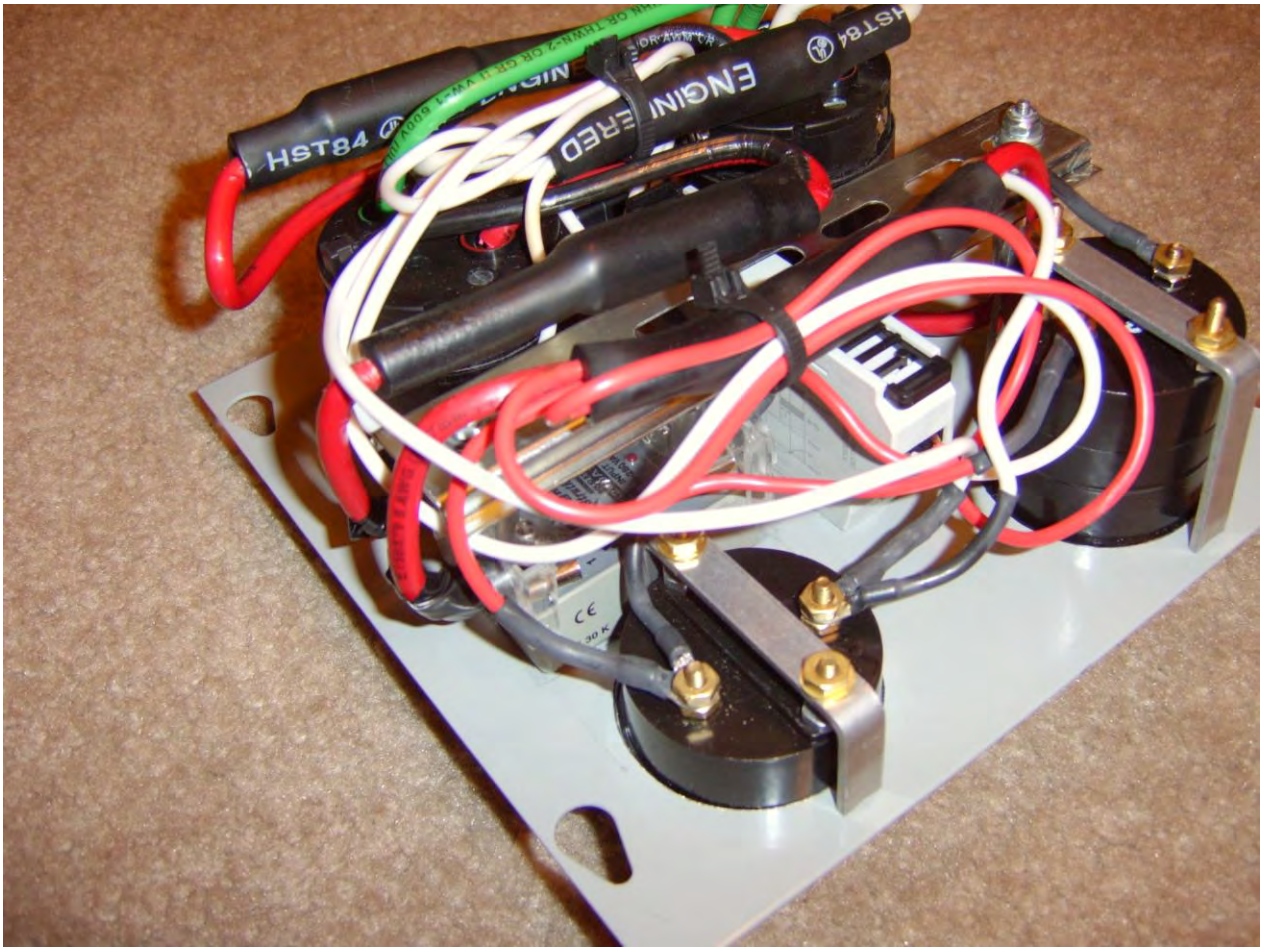

00114
HOURS 1/10
230
°F
set
5
10

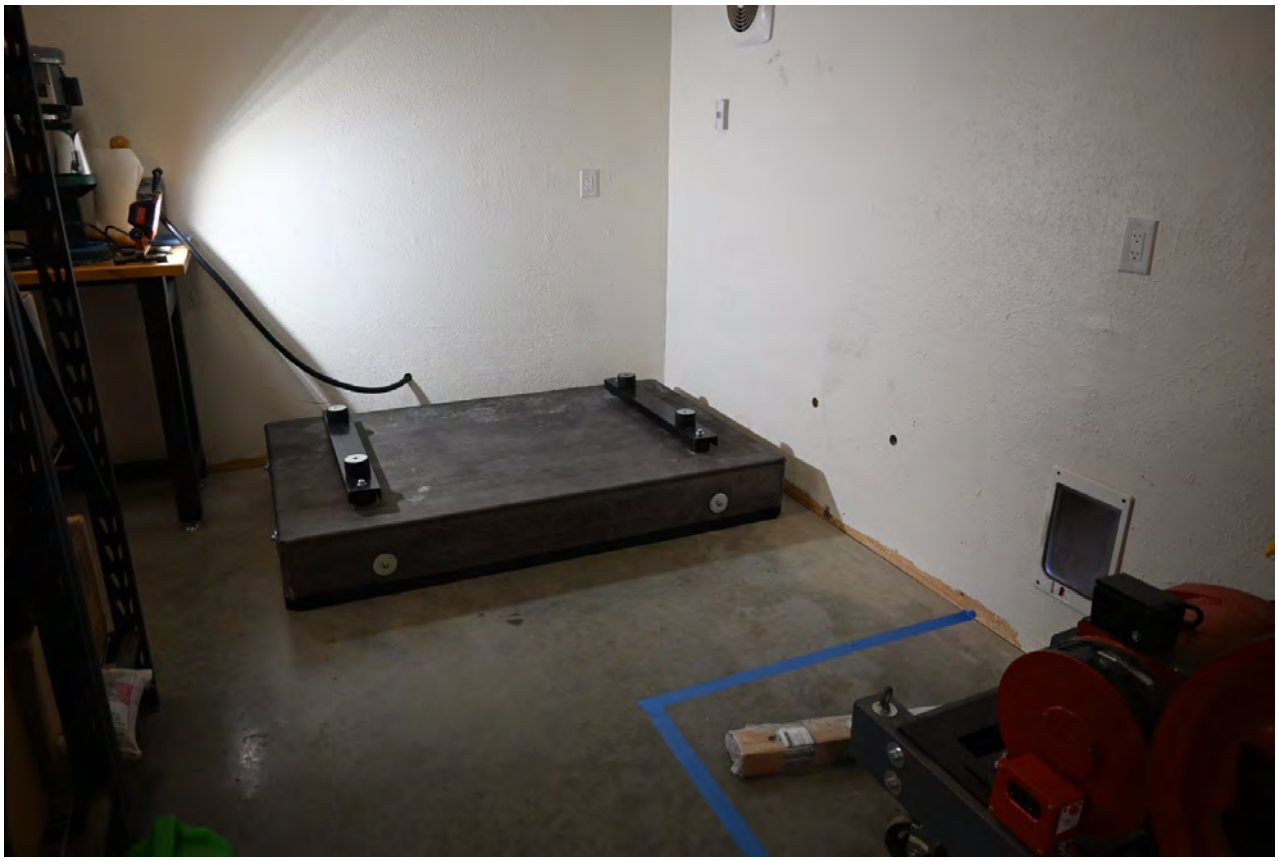


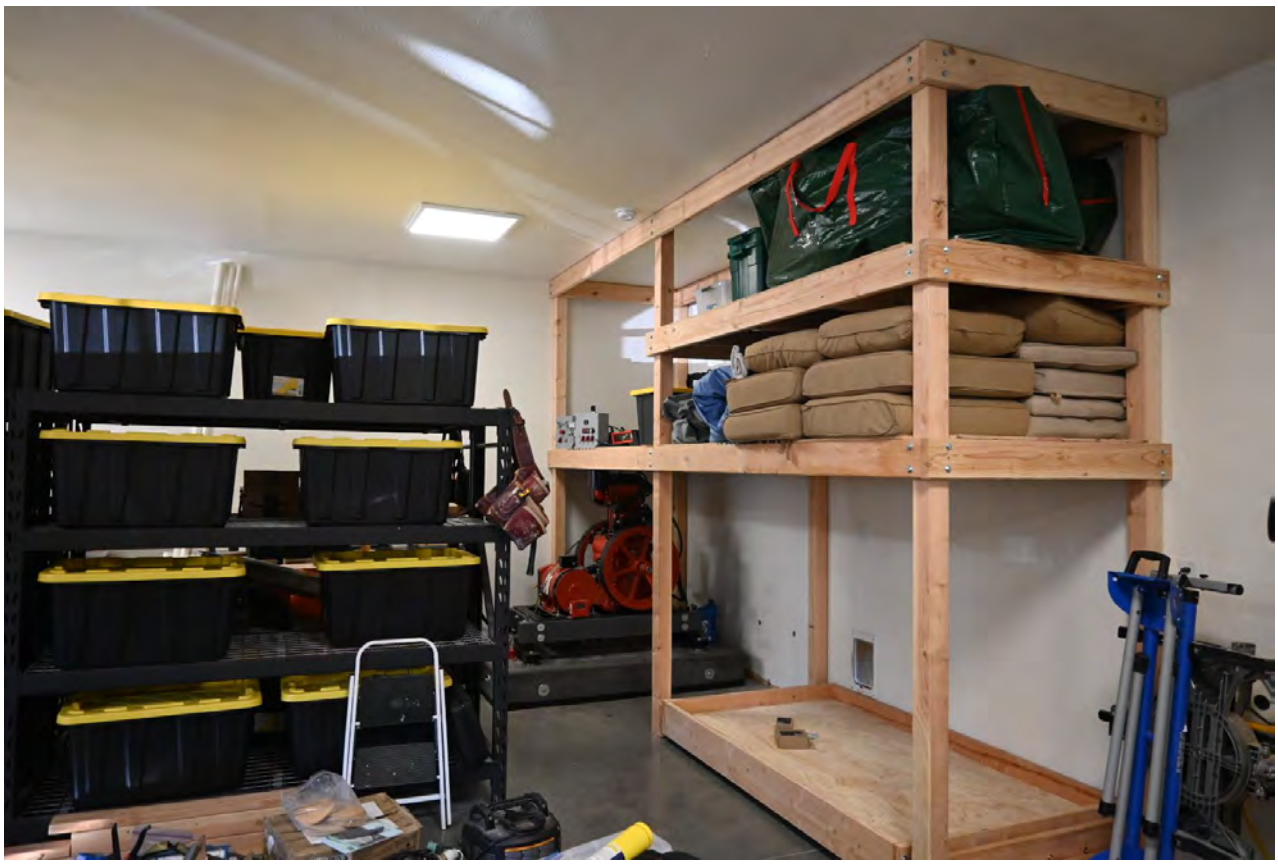

IDLE


H
I
J
20 A
MAX.
20 A
MAX.
20 A
MAX.
A.C. VOLTS
95
108
120
132
140
HERTZ
56
58
60
62
64
RELIANCE
RELIANCE
30




HST84






crydom
HA48125
EATON
EC5NCASC