A New Electric Generator for Powering Remote Facilities

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ABSTRACT

This paper introduces a new, emerging electric generator technology, significant to electric, gas, water and related utilities. Solid state, no moving parts except fan, this generator makes no noise in operation. Burning propane, natural gas, or liquid fuels, applications include remote communications facility support, pipeline protection, primary power in remote locations, and back-up for grid-connected facility. Selling into third world countries at this time for primary power, and as grid backup, this 5-kW, one cubic foot generator can be carried with one hand, weighing only 27 lbs. Series connected, semiconductor crystals produce 5 volts at 100C differentials. Arranged as a 9 inch ring, highly doped crystals have a ring conductivity of 2.5 E-3 Ohms. The five Volt drive produces a 2,000 Amp current circulation when the ring is shorted (Ohm's Law). Thermally induced energy amounts to 10-kW (V x I, or 5V x 2,000A). Using classical thermoelectric output methods to drive an 8 Ohm load with 5 Volts directly [(5V/8Ohm) x 5V], the output is a mere 3 Watts. This new generator uses switching power supply output methodology, i.e., a one-turn primary, operated push-pull at 200-kHz, a ferrite core with a multi-turn secondary. This provides a high voltage (120/240vac), 5-kW and up to ten generators can be connected for higher output performance. A future 220vac, 3f variant will drive motors more aggressively. Simple as the "Model-T", this generator may usher in an age of distributed generation for industry as well as the home. Largest of applications may be the home where any fuel can be converted cleanly into electricity.

INTRODUCTION

Have you noticed that a lot of the ideas that seemed laughable not so long ago are now a reality? An example: ion-beam propulsion systems for spaceships. Remember when that was unbelievable even in science fiction? NASA's Deep Space I flew by the asteroid Braille on July 28 using an ion-beam engine. Or how about those personal communicators Captain Kirk and Mr. Spock used on Star Trek 30 years ago? See any similarity between them and modern cellular phones? They even flip open the same way.

Thirty years ago, computers filled rooms. Now you use them sitting on your lap as you fly between cities. No doubt about it: We're zooming down a superhighway to the future at speeds most of us are unaware of, or prepared for. I bring to you today the notion that we can have the equivalent of a power station's grid anywhere we go, anytime we want it — a way to produce the electrons we need to power the portable and stationary appliances for remote and stranded facilities.

Technology is scary when it outpaces our ability to comprehend, but think how quickly computers change our lives, nearly everyone on the face of the planet — before we even had a chance to comprehend what was happening. Think about what the internet is doing to us today. Worse yet, we don’t even know what it’s doing to us. Under the hood of your car, the engine is sealed — no tinkering please.

All of which brings us to the subject of today’s discussion: A new Electric Generator for Powering Remote Facility. As if we didn’t have enough trouble with the old put-put generators, and what’s wrong with just plugging your application into the tried and proven, nationwide electric grid? Well, as you know, there are many places on this earth where there is no grid. There are many places in the U.S. where power lines will never be run because of low utilization, maintenance costs, or because of environmental concerns, scaring the land for right away. Portable generators, except fuel-cells, belch smoke and make considerable noise. The generator described today is silent, burns fuel cleanly, is totally portable and can operate unattended for years. It may be the perfect solution for that mountain top communications repeater, to provide the power needed to protect a pipeline through the swamp. No utility vehicle should be without one of these handy devices to power exhaust fans, provide emergency lighting, to illuminate signs for highway safety. This generator can provide backup power when the grid fails. This generator sounds a lot like one of those ion-propulsion engines, working by mysterious forces, but be assured that once you see it work, understand how it works, you’ll understand, then forget the details and begin to consider the possibilities and applications for this product.

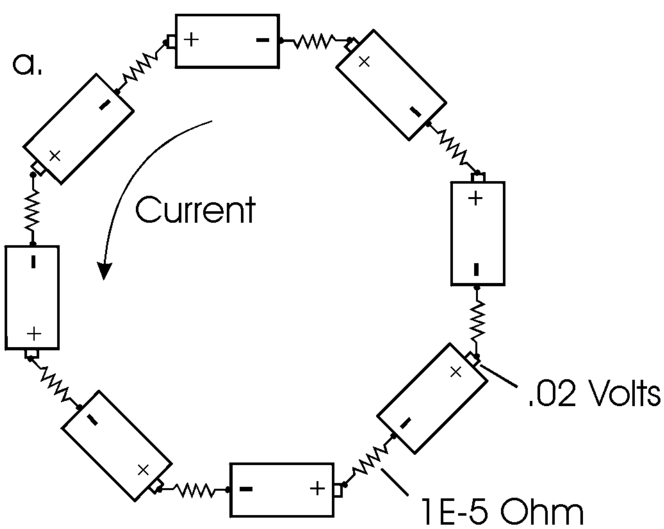
HISTORY OF THE TECHNOLOGY

Thermoelectric technology has been around for a long time. Actually it competed head-to-head with James Watt’s steam engine. Seebeck discovered the thermocouple effect about the same time Watt invented his steam engine. Seebeck discovered a way to produce voltage between non-similar metals, causing current to flow in a loop of wire. His was also a heat engine, maintained by differential temperatures. Ironically, both systems were about one percent efficient. Watt made use of expanding gas to move a piston doing mechanical work and Seebeck used his heat to emit and collect electrons in metals or crystal. He caused an electrical current to flow in a wire. The modern steam turbine in this age produces electricity with an efficiency approaching 50%. NASA’s Cassini probe, launched recently, had an isotope-powered, thermoelectric generator onboard with a thermal-to-electric efficiency of about 6%. Both systems have been with us for almost 200 years. What’s new is a way to squeeze energy, more energy from a thermoelectric system. Recognizing the fact that there were no personal computers in Seebeck's day, no switching power supplies to copy, no electric motors to drive, he was working at great disadvantage. He could however, have developed the special thermoelectric ring needed to produce the high current with modest voltage for our new generator. The energy up-converter, needed for a high voltage output, became available only recently. The opportunity was his to usher in the age of solid state electronics and electron generation in 1822, rather than now. Think about how electric-powered ships, electric airplanes developed then would have changed the history of the Civil War. For the next, great solid state invention, we had to wait for Bell Laboratories to invent the transistor in 1947. Solid state technology, at least as it applies to electron generation, was running a little behind Watt's steam engine, but catch-up can be very fast. The microchip is an example. Can it be that we've at last found a practical way to supply the electrical energy we need, produce all the electrons we need to power remote facilities without reliance on Watt's steam-powered electric grid or the internal-combustion engine — for truly portable supplies of electrical energy?

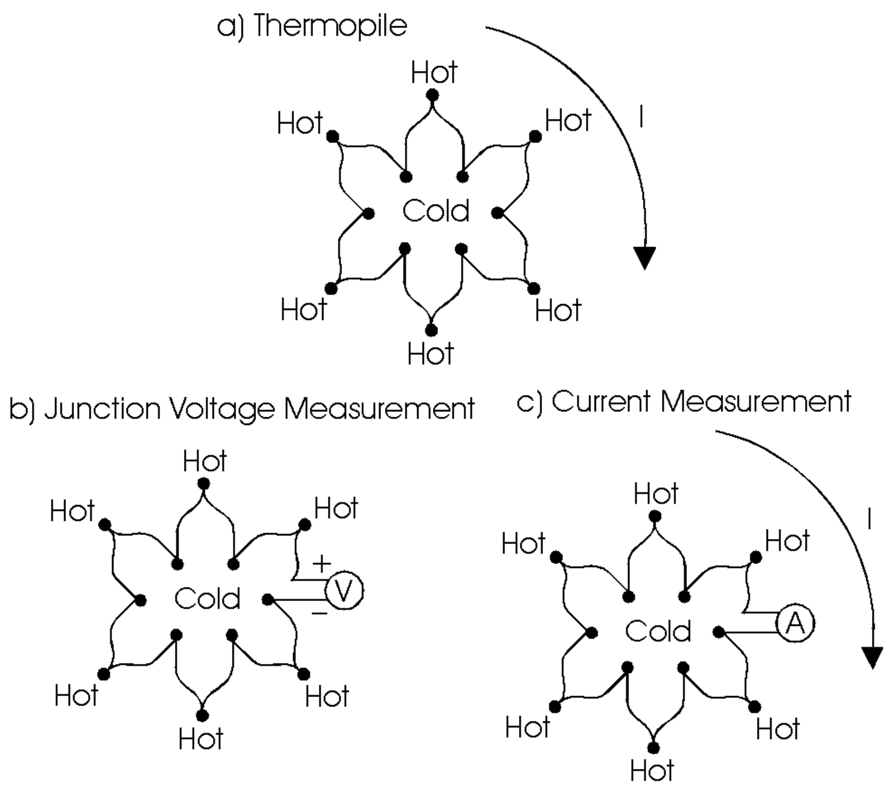
HOW THIS GENERATOR WORKS

This generator works just like batteries in a flashlight, only these batteries operate by heat flowing through crystals to cause voltage as shown in Figure 1.

Figure 1 Closed Circuit Current Generator

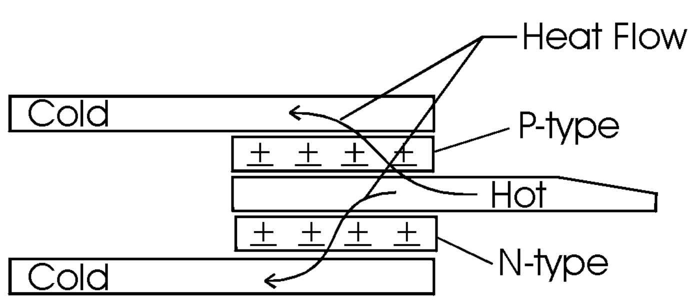


b.



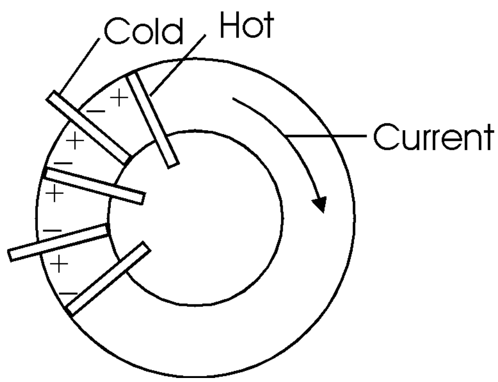
Arranged so the voltages add with each thermal battery, single crystal materials, placed between heated and cooled paddles produce a combined voltage of 4 to 6 Volts. Heat flows from each heated fin, through the crystals and into the cold fins. The heat is finally expelled to ambient air, as in Figure 2. Notice how heat naturally flows in the opposite direction through half of the crystals with this arrangement.

Figure 2 Heat Flow and Voltage Polarity



The voltage caused by opposite heat flow would oppose if the same type material were used on both sides of the hot fins. Using alternate p-type and n-type crystals, on opposite sides of the hot fins, sinking heat to the cold fins, voltages in all crystals add around the ring, even though heat flow is in the opposite direction through half of the crystals. With all voltage-producing crystals oriented so they add around the ring, this forces current to flow in the ring, shorted on itself as in Figure 3.

Figure 3 Current Flow in Shorted Ring

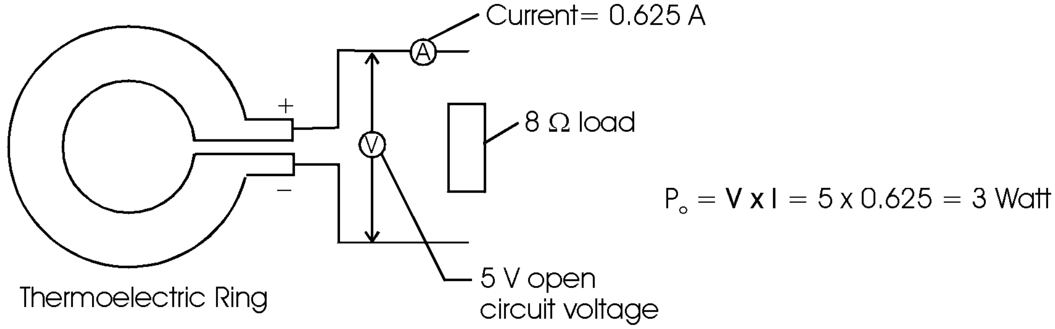


With proper heat flow, the open-circuit ring voltage measures between 4 and 6 Volts for a typical generator. Voltage depends on the temperature differential maintained across each of the crystal junctions. When the ring is shorted, it circulates a current of 2,000 Amp in the ring. The current reaches this level because the internal resistance of the ring is very low. The magnitude of the current depends on voltage, caused by temperature differential across the crystals, but it is also dependent on resistance of the ring, the bulk resistance of the crystals and the ring interconnection system. Visualize how electrical energy circulates in the ring, driven by voltage, caused by heat flow. The current circulation store amounts to 12 kW, 4 to 6 volts driving a shorted ring with a resistance of 0.0014 Ohms [(4/0.0014)(4)] = 12-kW. Electrical energy circulates in the ring as if it were a flywheel. Actually, the part moving is current. This is totally useless as a generator, with current in circulation — or is it?

USES PAST AND PRESENT

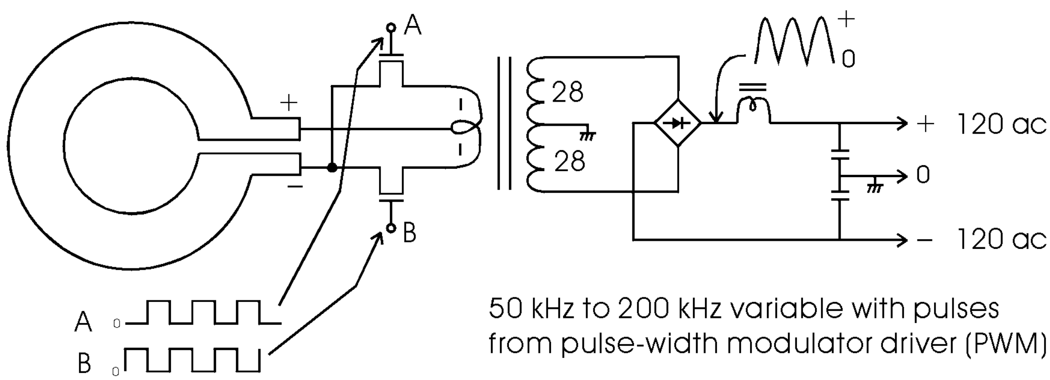
To demonstrate how thermoelectric systems were used in the past — why they will not operate efficiently today, simply open up the ring circuit and test for voltage. Use the 5 volts to drive a typical, useful load of 8 Ohm directly, as in Figure 4. Current through the 8 Ohm load would be about half an ampere (0.625) with 5 Volts. Electrical output would be only 3 Watts and the Cassini probe was launched with this output configuration.

Figure 4 Classic Thermoelectric Power Supply



There is another way to make use of the 5 Volts. It can be used to drive current around a magnetic core, through a one-turn primary as in Figure 5.

Figure 5 New Generator Circuit Diagram



Before current in the ring has a chance to saturate the magnetic core, the direction of the current can be reversed. By reverse-switching the current back and forth around a magnetic core, a high voltage output can be picked off a multi-turn secondary winding. This is the basic idea behind “Switching Power Supply Design” described by A.I. Pressman. The new generator makes use of “push-pull” switching technology. A small, lightweight magnetic core is fed 2,000 Amps through a center-tap. Current can either go clockwise or counter-clock around the core, depending on the opening and closing of switches. The circuit is operated push-pull at 50-kHz to 200-kHz. Fast switching prevents the core from ever becoming magnetically saturated. A 28-turn secondary winding, wrapped tightly around the magnetic core stem, provides a practical way to provide a high voltage output and high voltage is needed to drive everyday loads. The transfer efficiency of switch-mode can be as high as 80 to 90%. The disadvantage is; with high voltage comes high output frequency. Frequency is 10 to 3,000 times higher than conventional 50/60 Hz ac. The solution is to rectify the high frequency output into high voltage dc. This energy can then be processed into 50/60 Hz ac with single, split or 3f power using a bridge circuit, shown in Figure 6. The result is a 6-step sine-like waveform that can be further smoothed to a perfect sine wave with inductance and capacitance conditioning before final output.

Locking

According to Pressman, power out (P) of a push-pull circuit can be determined by substituting values for the generator into the following equation:

P = 0.129 [VA/ND] x 1E+6 Watts (1)

Typical values for this generator are:

V = 5volts
N = 1 turn
A = 6 in (the surface area of the center stem of the E70,magnetic E-core)
D = 500 cma (circular mils, the cross sectional area of the primary winding)

P = 0.129 [5 x 6 / 1 x 500] x 1E+6 = ~8-kW (2)

Pressman refers to the term Dcma as the current density factor. It is actually the reciprocal of current density. Current density units would be written amperes per circular mil, written acm, not cma. Either way, whether one specifies the voltage or the current, the resulting output power would be the same. Notice the output power is dependent on primary wire size and the skin of the E-core stem. This assumes the E-core never saturates. The 5-kW generator uses an E70, E-core.

The maximum available output power for half or full-bridge topology, based on operating frequency for this core is shown in Chart 1, where the output power is stated in kilowatts. This chart serves to illustrate the possibilities for generator output stage when operated at frequencies up to and beyond 200-kHz. This assumes the thermoelectric ring can process the heat necessary to support greater than 2,000 Amp current needed to drive the core.

Chart 1. Max. Power-Out for E70 Magnetic Core vs. Operating Frequency

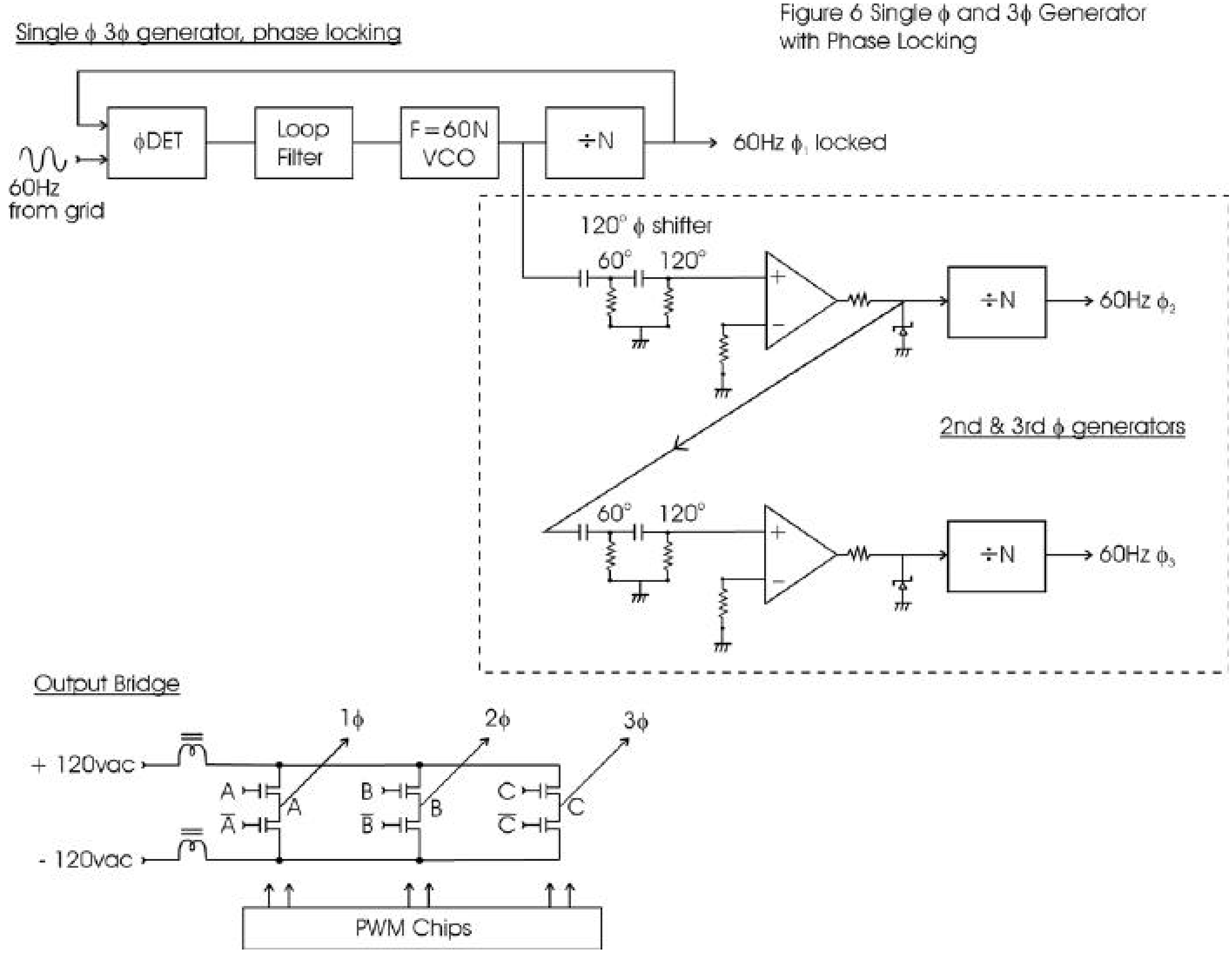
Frequency (kHz)	**20**	**48**	**96**	**200**	**300**
P (kW)	**1.2**	**1.4**	**5.7**	**11.9**	**17.9**

Notice, as the operating frequency of the pulse-width modulator in Figure 5, driving the E-core in push-pull increases, the output capacity (P) of the core, (Chart 1), also increases dramatically. The E-70 core has a volume of 40 cm, and weighs a mere 12 ounces. This is much smaller than the barrel-sized, 300lb, 60 Hz transformer, mounted on the power pole outside the home, office or factory. For this reason, the 5-kW thermoelectric generator is smaller, lighter in weight and completely portable, yet it is capable of producing the power needed to do the big jobs.

So there we have it; using the same thermoelectric generator, it can be either a 3-Watt, low voltage, dc system — or it can be a 5-kW, standard voltage system for today's power needs. Ironically, both systems use the same amount of fuel to provide heat flow. The difference is in output methodology. We should thank the IBM Corporation for specifying a switching-type power supply for our personal computers (PCs). We must also thank Mr. Seebeck for giving us a practical, solid-state current source that makes this new generator possible.

One other detail; the thermoelectric crystals, that produce voltage when heated, must be configured to conduct electricity as if they were made of copper. Romania and the Ukraine should be thanked for helping us through these issues. High electrical conductivity is necessary to achieve high ring current. Normal thermoelectric materials conduct electricity as if made of carbon, as in carbon resistors. Further operational economy for the generator is realized by recirculating the burner's heat, to achieve higher, overall operating efficiency.

Figure 6 Single ϕ and 3ϕ Generator with Phase Locking



EFFICIENCY

Carnot efficiency for the thermal portion of the generator can be calculated using the equation:

h = (T - T)/T (3)

Substituting operating temperature values for the generator, expressed in Kelvin:

h = (922K-353K)/922K = 62% (4)

Taking into consideration the output efficiency of the Switch-Mode Section, which is about 90% efficient at best, the maximum P we could expect from the generator would be about 56%. A more valuable number is the actual cost of operation. This generator operates for about 3 to 5 cents per kW-hr, based on today's fuel prices. In some locations, it can be more economical to produce your own electrical power with this generator than purchase it from the grid.

The generator is a combination of various developments integrated into a simple machine. It can provide standard electric power, just as with the grid, but now, we can take it anywhere it's needed. Again, this lightweight, fully portable, electric generator has no moving parts except the fan. It makes no noise, produces 120/240 vac, 50/60 Hz. This generator can be picked up and moved around using only one hand! Operation is based on simple principles, easy to understand taken one step at a time, once you've seen one operate.

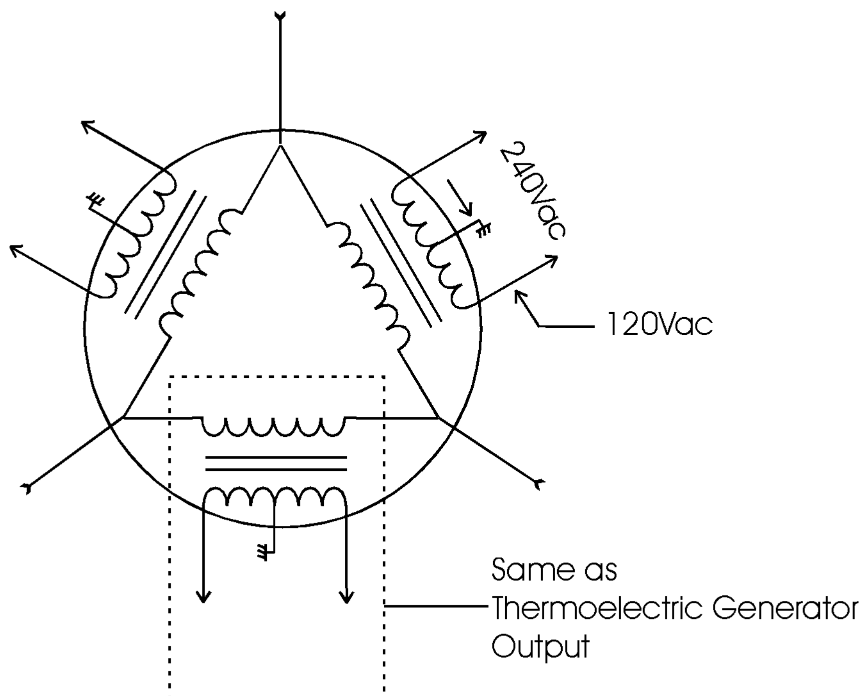
To make this generator available to the public, all that was needed was Seebeck's idea. We then had to wait about two hundred or so years for the switching power supply folks to get their act together, for others to develop some very cheap, high performance, solid- state switches and then choose the right microchips to control it effectively. So there, we now have something we can all use. This new generator, ion-thrusters and Spock's tricorder are each a part of today's technology.

POSSIBLE USES AND APPLICATIONS FOR REMOTE FACILITY

Consumer applications for this generator focus primarily on recreational usage, camping, electric power for the motor home, and even emergency power for the home. Industrial usage is believed to cover a much broader field. Regardless of end use, there is one common thread that binds all applications. Any machine that operates from the grid will also operate in a remote environment using this generator.

The generator's output is configured the same as the delta-connected transformer mounted on the pole, as in Figure 7. This generator's output emulates the single, split or three-phase, 120/240, 50/60Hz, for standard, high voltage power requirements. This generator makes the grid portable, able to travel to the job site. It can be operational with the flip of a switch. It can support remote facility, even power mobile applications. It can be used anywhere the grid is needed. Remote communication relay sites require a dependable source of electrical energy. In the energy sector, an obvious application would be to power the pumps used to gather and transport resources from the well-head. Electric motors are cheaper to operate and maintain than combustion engines. Visualize this generator as a three-phase generator, a motor-drive-package, operating on almost any fuel available. A package of this type would run for years, unattended. Remote applications for portable power are endless. When this new portable grid can be moved and installed anywhere, using one hand, this opens the book of possibilities very wide.

Figure 7 Line Pole User's Transformer Diagram



IN CLOSING

Consider, if you will, how this generator may also be the World's largest, heaviest, highest current, highest power integrated circuit chip. Essentially, it is a microchip electric generator with 140 semiconductor junctions. This eleven-pound, 2,000 Amp best is surely the largest semiconductor and it can supply all the electrical energy needed to power the average U.S. home, including the home's computer. It is a "connect and forget machine," a generator that will operate cleanly, efficiently, and without noise, for as long as there is a supply of fuel.

References:

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