Potential Quantum Well Thermoelectric Applications

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Areas Of Particular Interest For Quantum Wells

- Cooler Applications
- Power Production Applications

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Quantum Well Cooler Applications

- Potential Quantum Well Cooler Materials
  - Bismuth Telluride Alloys
  - Si/SiGe
- Potential Quantum Well Materials for Power Production
  - B_4C/B_9C
  - SiC/Si
- Early Applications To Require Only Small Amount of Material Because Of Production Restraints

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Quantum Well Coolers

- Quantum Coolers Can Be High Voltage Low Current Devices
- Micro-Coolers For I.C. Chips
  - Mounted Or Made On The Die Using Mems Technology
  - 25% Of Current Power Requirements
  - Cool Die Below Ambient
  - Heat Removal From Case By Normal Methods
    - Air Cooling
    - Liquid Cooling
    - Thermal Electric Cooling
  - Allow Increased Circuit Packing Density
  - Permit Higher Speeds (Moore's Law Continues)

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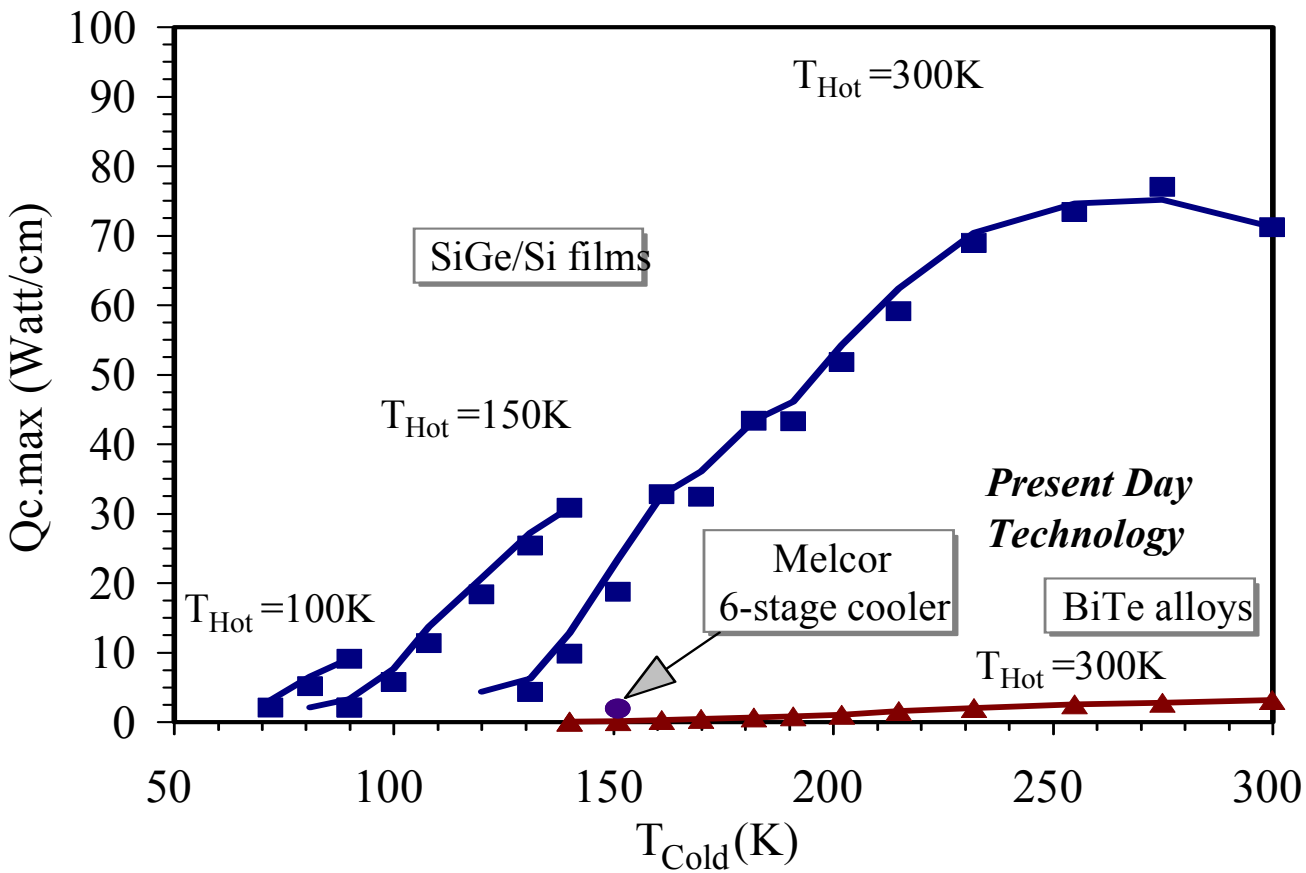
Maximum Heat Pumping Rate



Theoretical Qc.max (Maximum Heat Pumping Rate from the cold side/unit length) of SiGe/Si film vs. Bulk BiTe alloys.

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Quantum Coolers (Continued)

- CCD And IR Laser Diode
  - Improve Signal/Noise
  - Stable Signal
- Refrigeration And HVAC Systems
  - COP's Similar To Mechanical Systems
    - No Freons Or Other Refrigerants
    - No Moving Parts Except Air Moving Devices
    - Can be Placed Where Required
  - Can Be Used In Autos And Trucks Instead Of Engine Driven Systems

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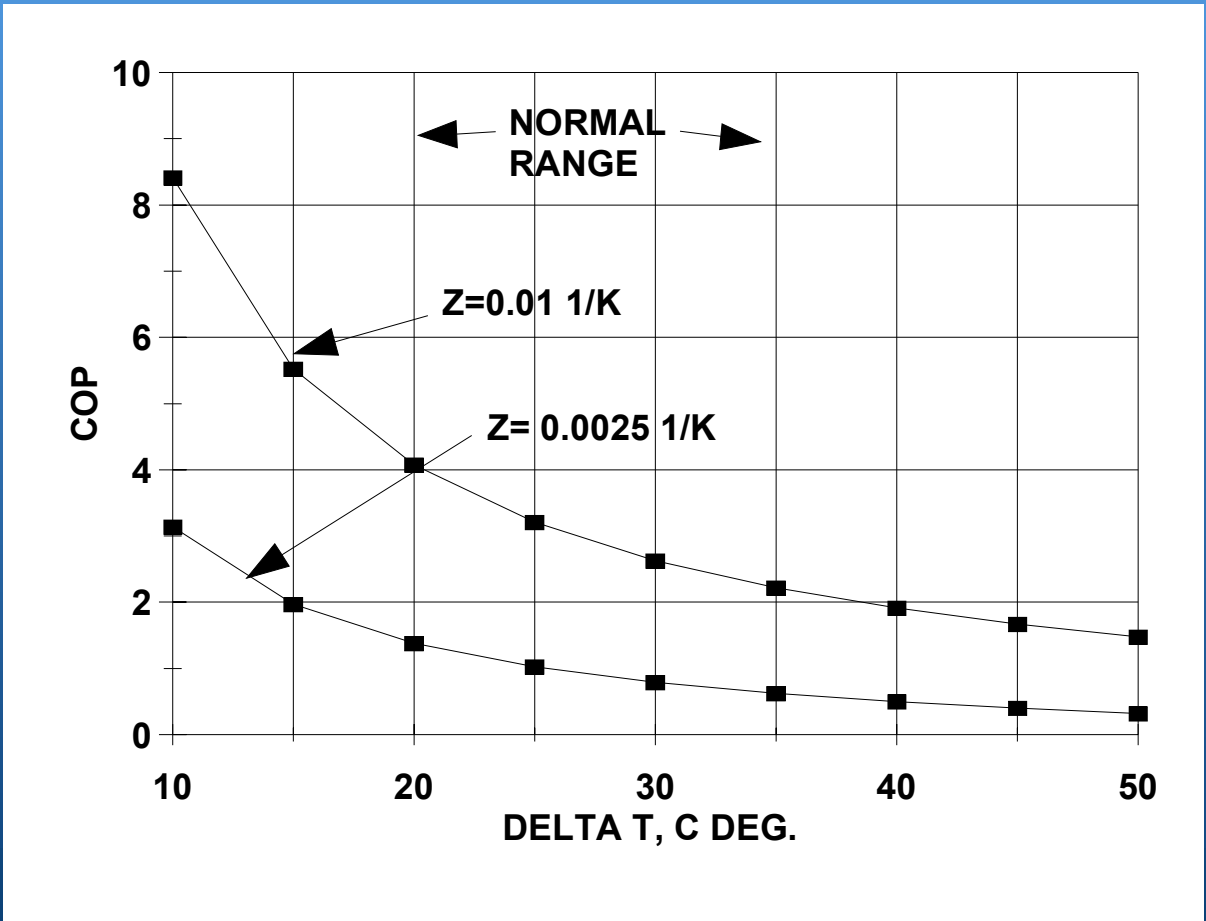
COP vs ΔT For Two Z Values

Tc = 0°C



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Quantum Well Power Applications

- Initial Applications Small Because Of Early Limited Production
- Materials PB_4C/B_9C And N SiC/Si

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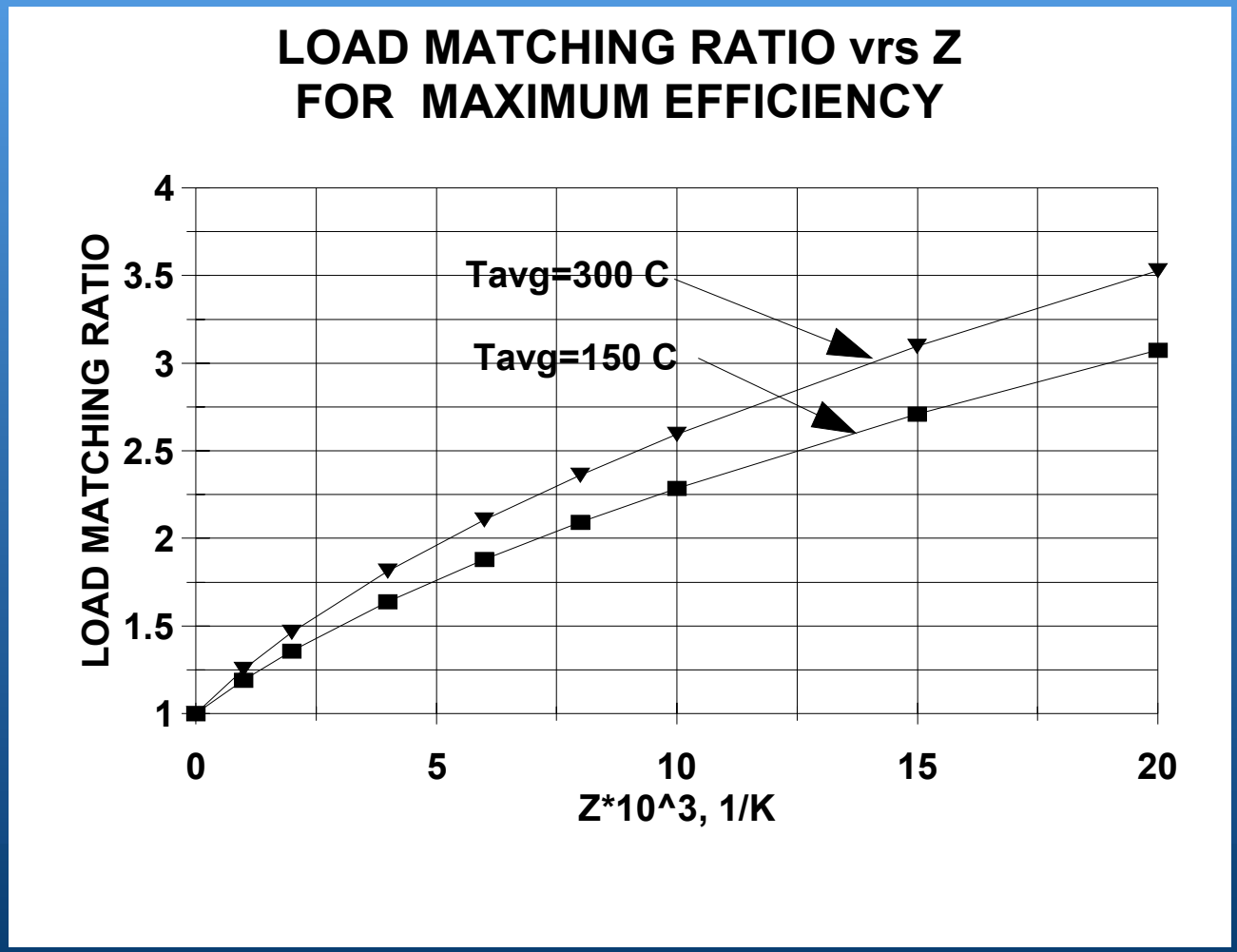
Load Matching Ratio Versus Z For Maximum Efficiency



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Quantum Well Power Applications (Continued)

- 40 mW Generator
  - Upgrade Vacuum Multifoil Generator To 160 mW Outpout
  - Use Gas Insulation and Maintain 40 mW Output
    - Lower Fuel Capsule Re-Entry Temperatures
    - Lower Degradation Rate
    - Decrease Outgasing
- GPHS Based MHW RTG's
  - Decrease Fuel Loading For Same Power
  - Improve Specific Power by Decreasing Radiator Size
  - Decrease Cost

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Insulation Assembled On Generator

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Quantum Well Applications (Continued)

- Low Delta T Systems (>5°C)
  - Problems With Current Materials
    - Low Voltage
    - Large Heat Sink For Output Power
  - System Provides Power For Wireless Sensors
    - 1 mW
    - 3 Volts
    - Heat Sink 1 ft^2
  - Could Be Used To Harvest Power In Cold Areas
  - Quantum Well System Provides Higher Efficiency
    - Decrease Heat Sink By 4
    - Can Provide Higher Output Voltages

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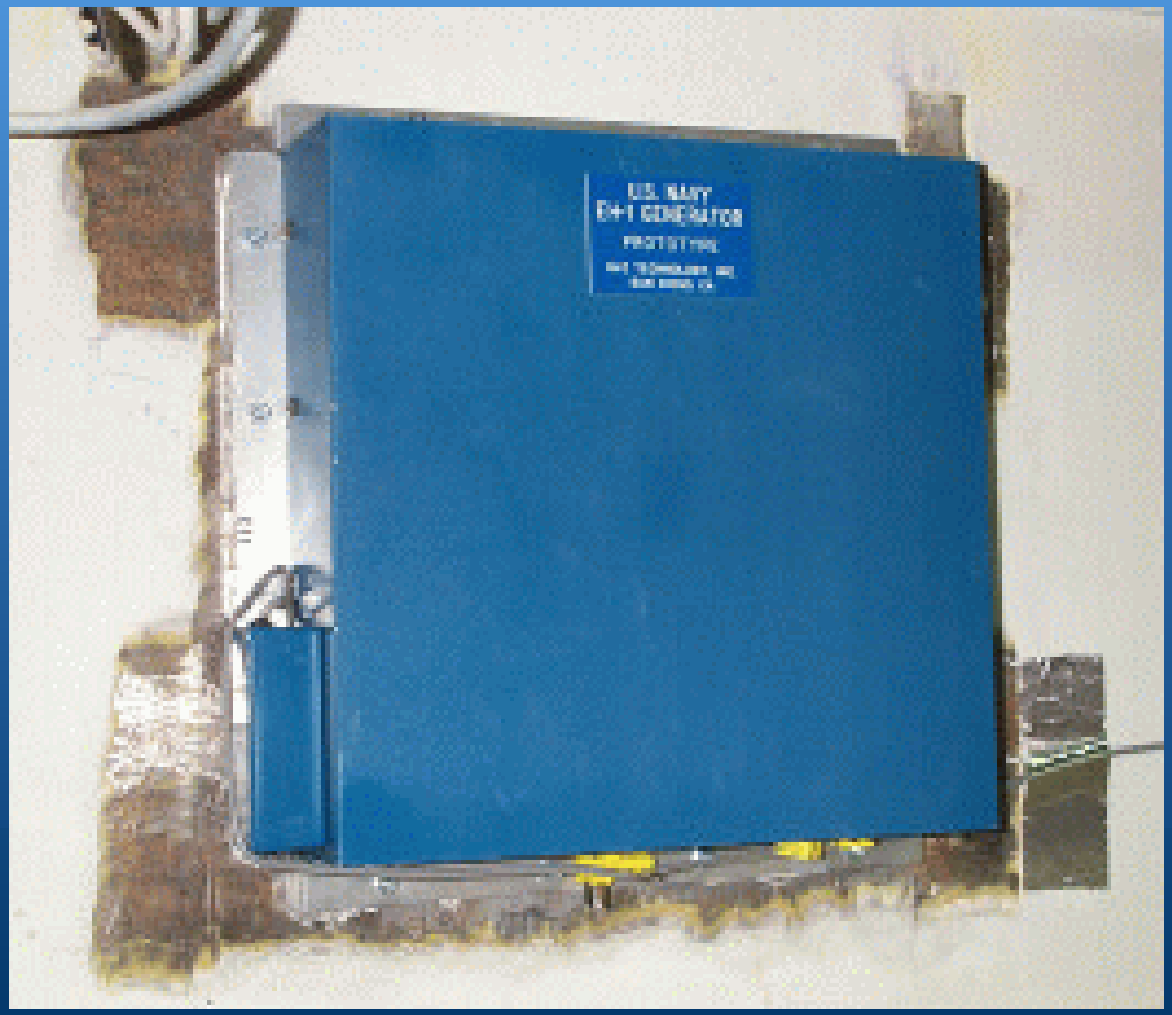
EH-1 Generator

Produces 1 mW At 5°C Differential



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Quantum Well Applications (Continued)

- Thermal Gradient Generators
  - Use Available Thermal Gradients
    - Wireless Sensor
    - Internal To Engine
      - I.C. Engines
      - Aviation Engines
      - Eliminate Sliprings Or Grasshoppers
      - Low Mass For Use In Dynamic Situations
- Use Change In Ambient Temperature With Thermal Storage
  - Instrusion Sensors
  - Remote Power Source For Planetary Probes

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Quantum Well Applications (Continued)

- Convert Energy in Truck and Auto Exhaust
  - 1 kW System Being Developed With Bulk Materials
  - Provide More Electric Power
    - Drive By Wire
      - Electric Water Pump
      - Electric Oil Pump
      - Electric Steering Assist
      - Cooling Fan
    - Computer Power Demand Increasing
    - Thermoelectric A/C Systems
  - Increase Power Output Power By Four or More
  - Provide Wider Operating Temperature Range

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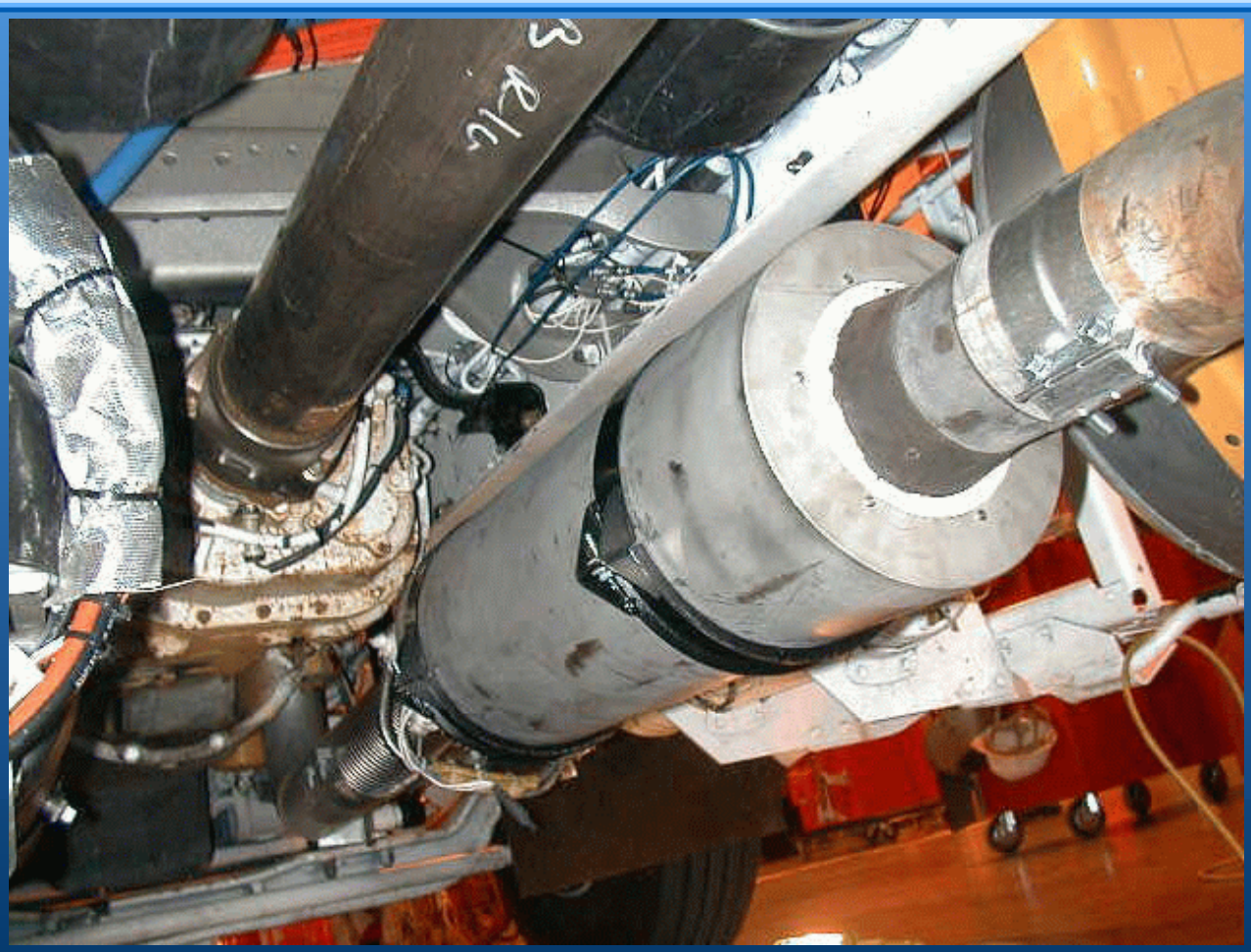
Under View Of The Thermoelectric Generator Mounted On The Truck Showing Shock Absorption Brackets



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Quantum Well Applications (Continued)

- Self-Powered Truck And Car Heaters
  - Eliminate Need To Idle In Cold Weather
  - Current System Can Supply Some Excess Power
- Quantum Well Would Increase Electric Power Output
  - Power For Sleeper
  - Use In Conjunction With Quantum Well A/C System For Summer Operation

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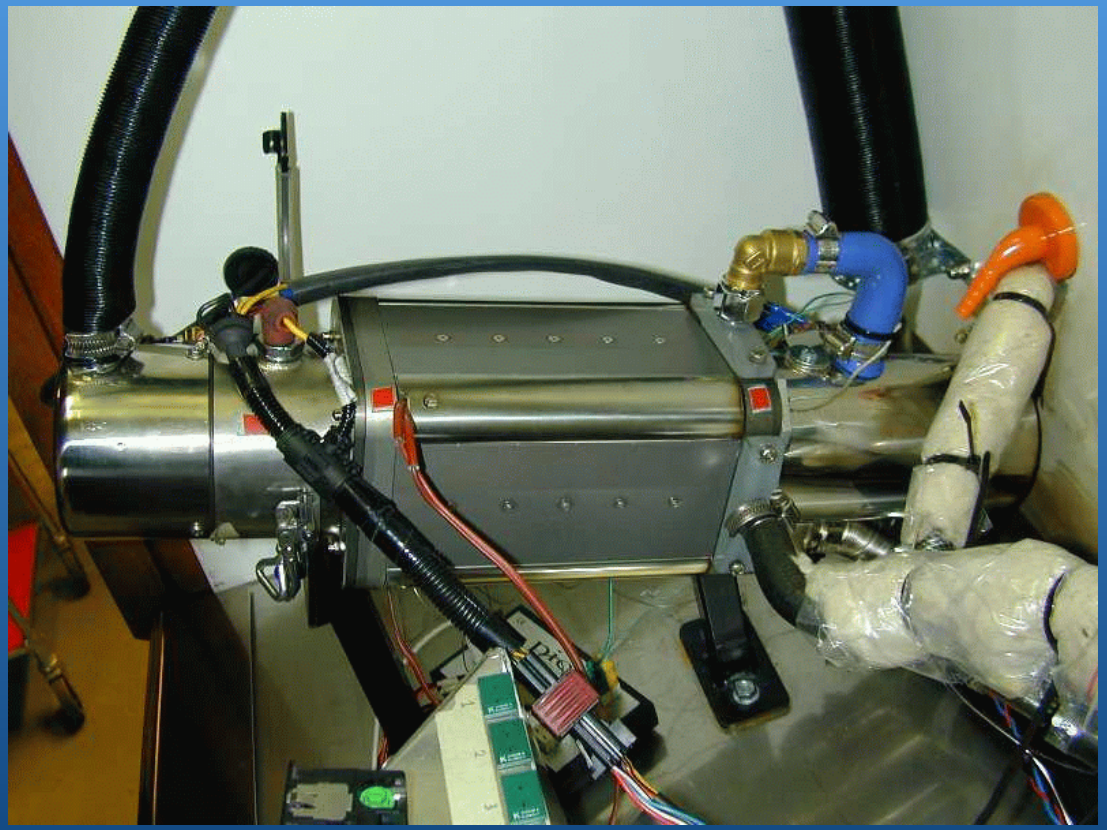
OmniNove Self Powered Preheater

- Fuel - Diesel
- Modules - 8 HZ-20
- Fuel Input - 0.8 ℓ/hr
- Thermal Output - 6.3 kW
- Electric Output - 100 W
- Power Consumption - 35 W
- Surplus Power - 65 W



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Quantum Well Applications (Continued)

- Self-Powered Appliances
  - Boilers For Home Heaters
  - Wireless Elecric Power For Water Heaters
    - Being Developed In Europe
  - Self-Powered Gas Furnace
    - Requires Quantum Well To Provide Enough Power
  - Pellet Stoves
  - Fireplace Inserts
- Quantum Well Would Lower Cost

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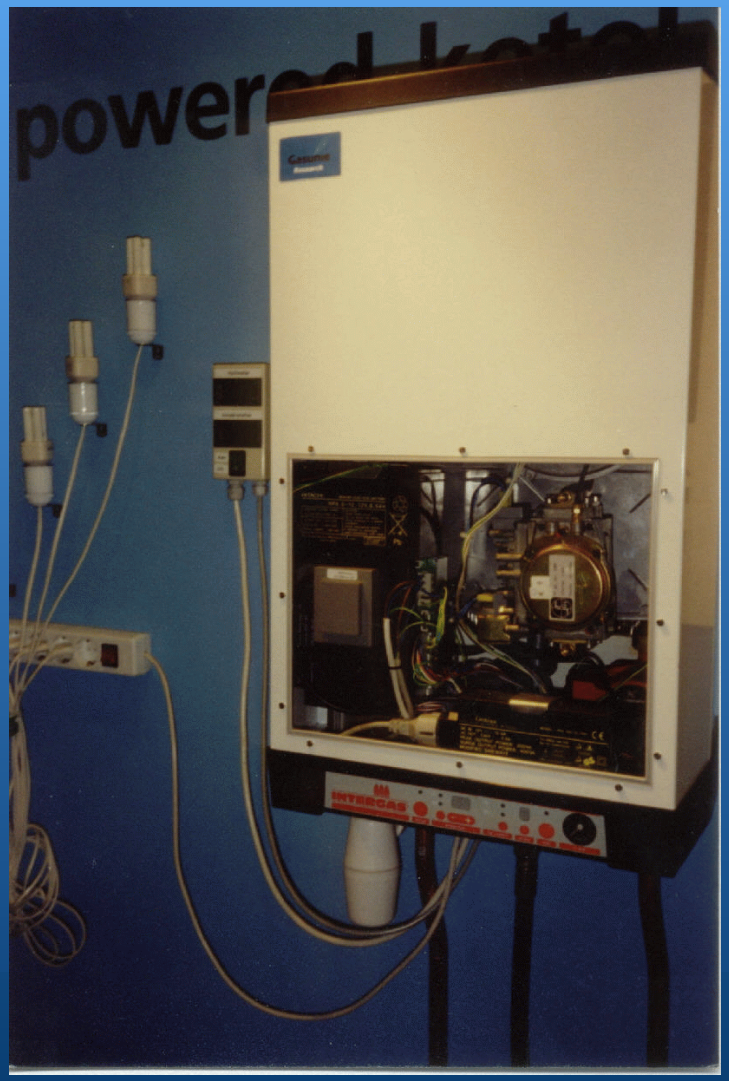
Self-Powered Boiler



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Thelin Stove

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Summary

- Many Quantum Well Applications
  - Cooling
  - Power Production
- Implementation Of Quantum Wells
  - Improve Conversion Efficiency
    - Low Cost Of Heat Transfer Equipment
    - Provide Higher Voltage If Necessary
  - Will Be Used In Small Applications First
    - Current Limited Material Production Capability
    - More Equipment In Near Future

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