

Welcome to NASA Power Systems: Research in New Energy Technology

Network of Educator Astronaut Teachers
(NEAT)

Education Outreach
Glenn Research Center Region



NASA Glenn Research Center

Research Areas

- Power Systems Research
 - Solar Voltaics
 - Nuclear Power
 - Wind Energy
 - Electric Propulsion
 - Fuel Cells
 - Stirling Engine
 - Battery Technology
- Microgravity Research
 - Drop Towers
- Exercise Countermeasures
- Return to Flight Impact Risk Research
- Vacuum Research

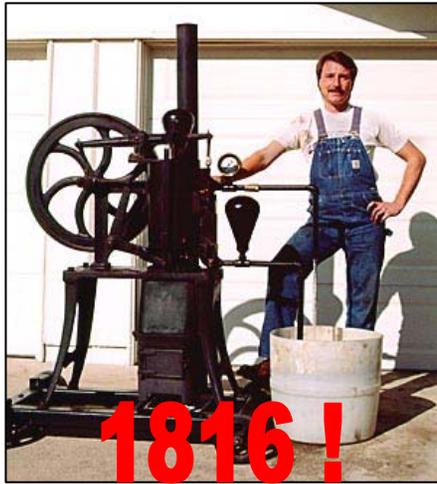


“Any sufficiently advanced
technology is
indistinguishable from
magic.”

Arthur C. Clarke

**Science = Exploration,
Mystery, and Magic**

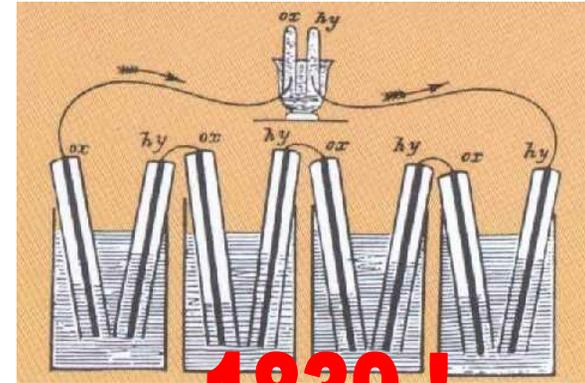




1816 !

1816

**by Rev. Robert Stirling
of Scotland
Stirling Engine**



1839 !

**Sir William Robert Grove &
his "Gas Voltaic Cell"**

New Technology?



Ion Propulsion

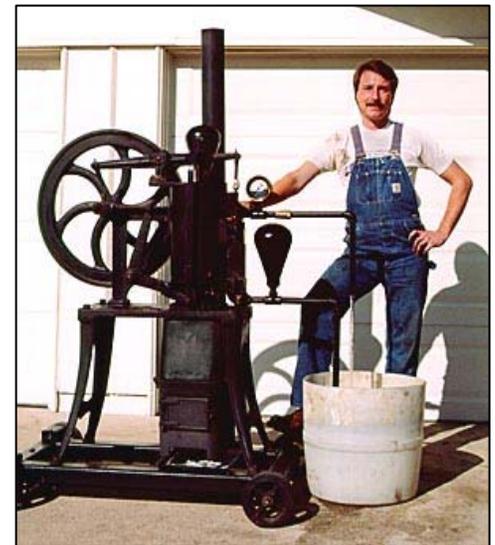


Stirling History

- Stirling engine invented in 1816 by Rev. Robert Stirling of Scotland
- Kinematic engine with crankshaft and flywheel
- Competed with early steam engines as higher efficiency alternative
- Efficiency was high because Robert Stirling's original patent included the economizer, known today as a regenerator.
- Operated at 1 atmosphere of air mean cycle pressure
- As popular as steam engines until the development of boiler code, high pressure boilers



Reverend Robert Stirling



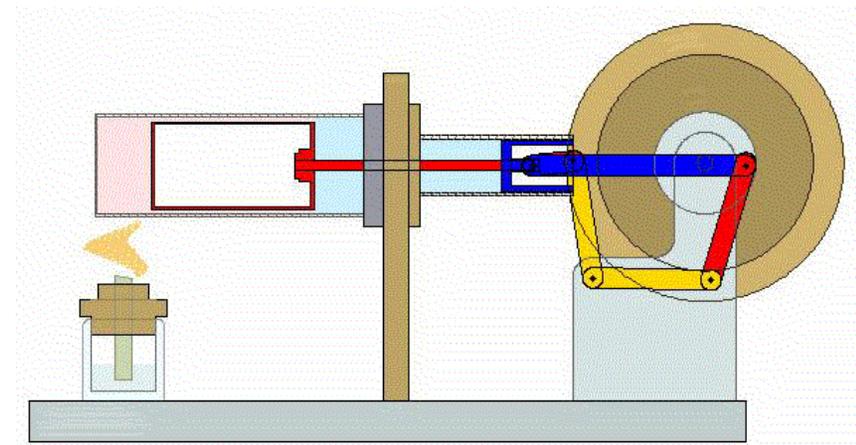
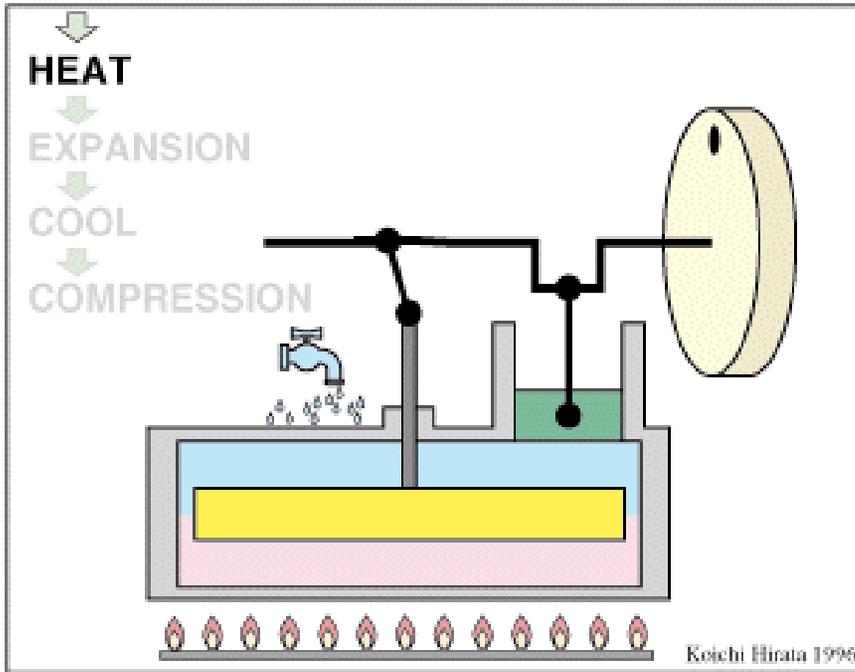
How Does a Stirling Engine Work

Charles's Law

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

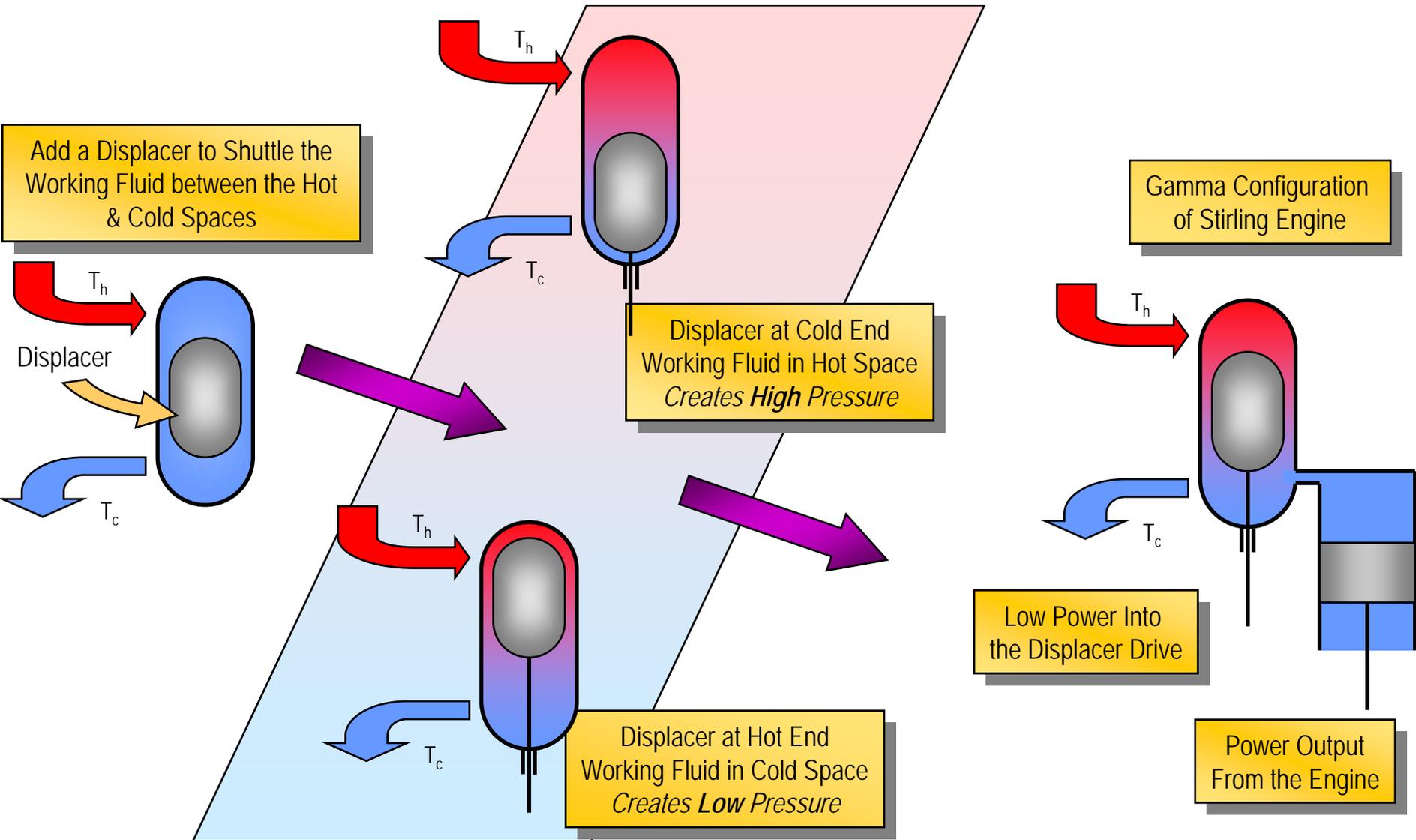


Stirling Operation



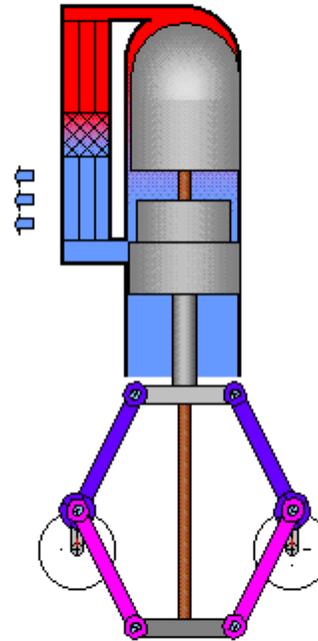
The Key
Economizer = Regenerator =
Displacer

Stirling Operation



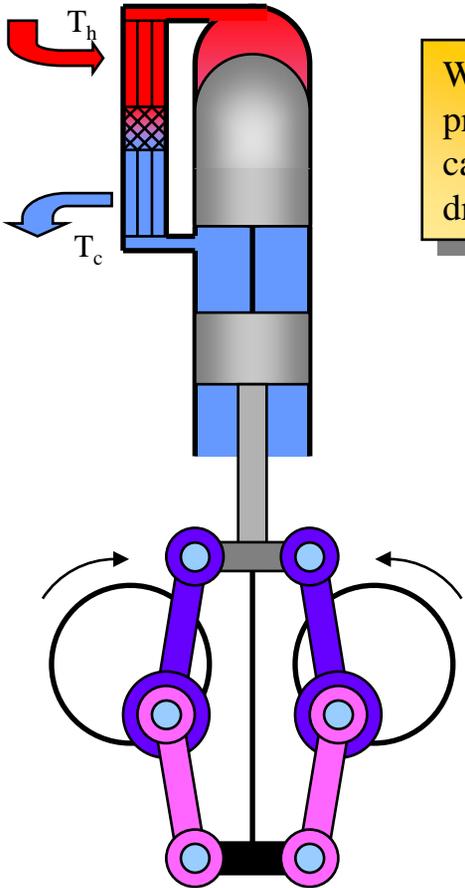
Rhombic Drive Stirling

- Rhombic drive provides linear motion
- Sliding seals are used and the internal pressure is raised
- Use gas other than air, such as helium or hydrogen
- Greatly increases the power and efficiency
- Including the regenerator (aka, the economizer)



Birth of the Free-Piston Stirling

Rhombic Drive Stirling Engine

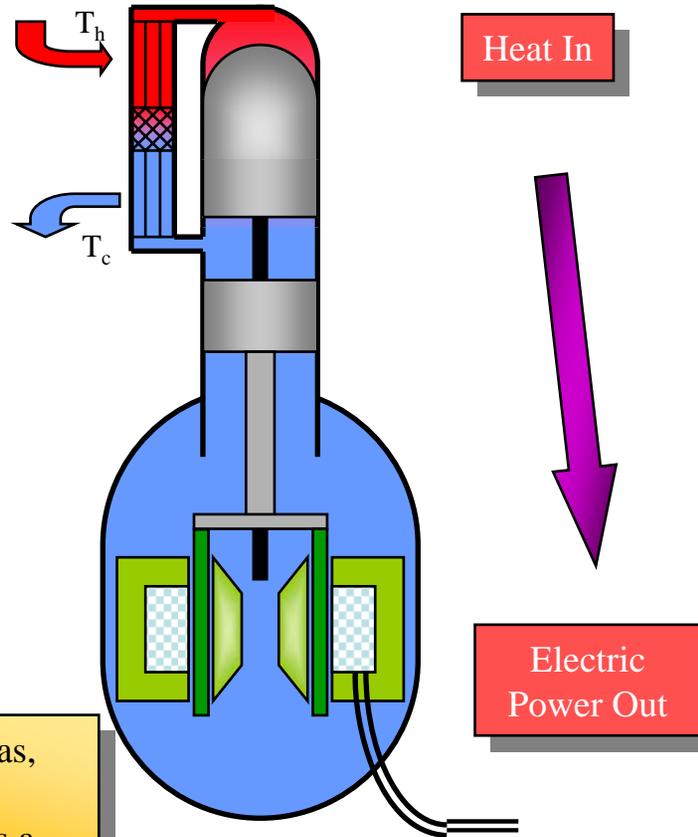


With the appropriate areas and pressure, the displacer drive rod can become unloaded, i.e. self driving operation

With the addition of a load, such as a linear alternator, the Stirling engine becomes a Stirling power convertor

With proper masses, spring rates, areas, and damping coefficients (dynamic tuning), the convertor will resonate as a Free-Piston Stirling Convertor

Free-Piston Stirling Power Convertor

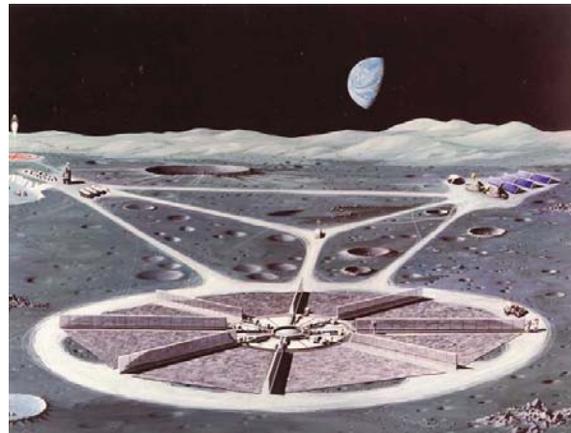


How Can We Use Stirling in Space?

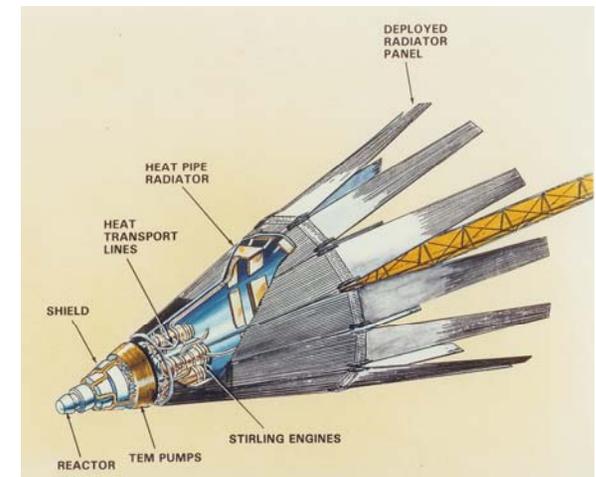
- Could be **solar heated** if used in earth orbit
- **Nuclear power system**, either **surface** power or **flight**
- **Radioisotope** heat source for **deep space**
- To **remove waste heat** from electrical systems and habitats.



Solar Dynamic System



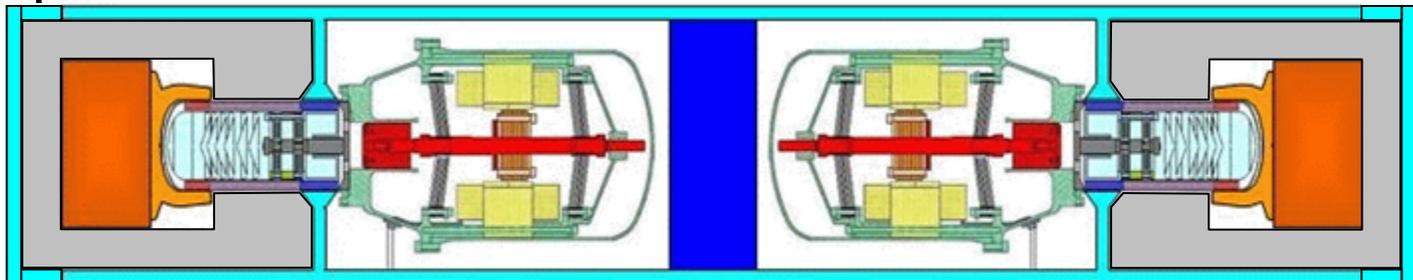
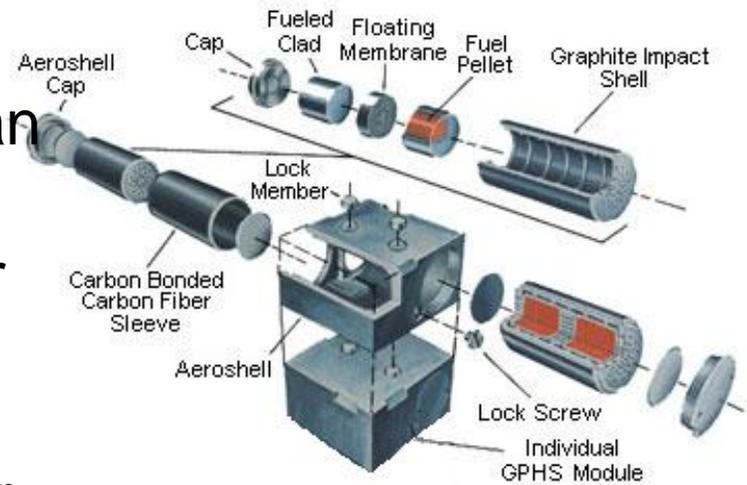
Nuclear Lunar Station



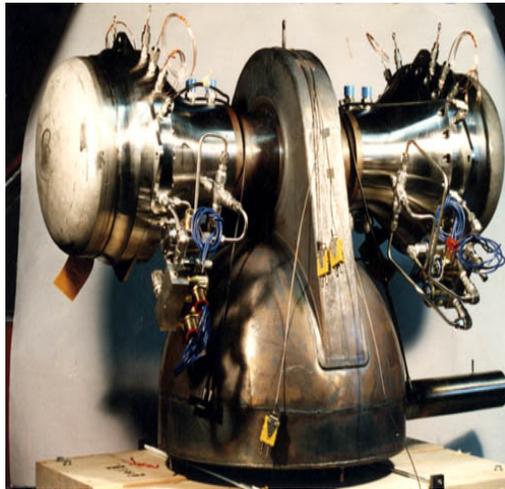
Nuclear Flight System

Why Would We Use Stirling in Space?

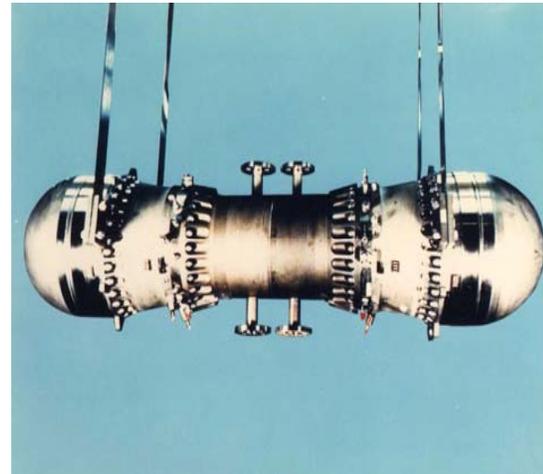
- Reduce the use of plutonium
- Stirling is 4 times more efficient than other options
- Specific power (W per kg) is higher than other options
- The best option for deep space probes that cannot use solar power in deep



The Current Technology



**CFIC/CPG 5-kWe solar terrestrial
convertor**



**NASA/MTI 25-kWe Space Power
Demonstrator Engine**



For Teachers only:

Lesson Connections:

- Gas Laws
- Kinetic theory
- Simple Machines

Top Secret:

Can you think of others?



INAAPT

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**NASA Power Systems
New Space Technology
Using Stirling Engines**

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**NASA Network of Educator Astronaut Teachers
NASA Ames Airspace Educator
NASA Spaceward Bound Mojave Expedition 2007**

Links:

Stirling Engines Website

<http://www.stirlingengine.com/>

Stirling Engine Forum

http://www.stirlingengine.com/bboard/q-and-a.tcl?topic_id=5&topic=Stirling%20engines%20for%20education



Test tube Rhombic Stirling Engine Site

http://www.geocities.com/~rrice2/my_engines/ttr/ttr.html

Test Tube Stirling Engine Lab

<http://www.mech.canterbury.ac.nz/documents/testtube.pdf>