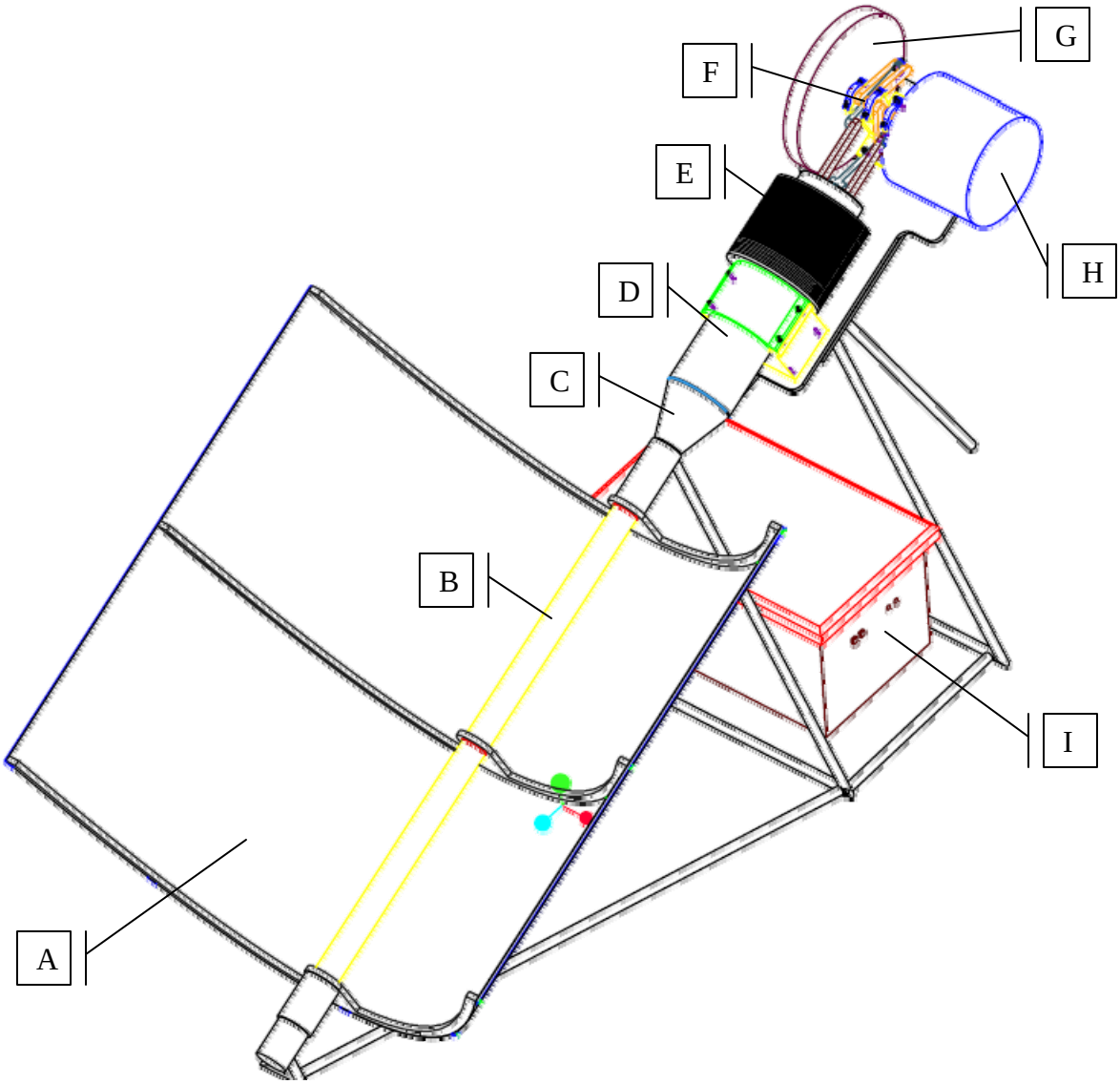
Group D1
Solar Power Rangers

Operation

The operation of the product can be broken down into three subsystems: collection of the solar energy, conversion of the solar energy into mechanical and then electrical energy, and the simultaneous usage and storage of that energy.



Collection:
The collection subsystem is implemented by mounting on the truss structure a parabolic trough coated with a highly reflective metallic material that focuses incident light on an evacuated solar tube. The trough [A], which is oriented in the plane of motion of the sun (east-west), is free to rotate about the focus (the tube) such that it may be manually adjusted daily based on the sun's relative position (a function of the time of year and the latitude) in order to maximize the incident light. The bottom trough endplate incorporates tick marks indicating the angular orientation of the trough, so that it can be easily set once the proper angle has been determined.

The tube [B] is located at the focus of the parabolic trough so that all light incident on the trough is focused onto the tube, which encases a heat pipe. The tube is inclined at a 30^o angle, such that natural convection of the heat transfer fluid contained in the heat pipe ensures that the bulb at the elevated end of the pipe achieves the highest temperature.

Conversion:
The conversion subsystem is comprised of the Stirling engine and electric generator. The Stirling engine is powered by the heat from the bulb of the heat pipe, which is inserted into a heat exchanger [C] built into the engine. The hot heat exchanger heats the working fluid (air) in the cylinder [D], which expands to push the power piston, causing the displacer piston that is 90^o out of phase with the power piston to displace the air to the cold end of the chamber. At the cold end of the chamber, the annular-fin heat sink [E] dissipates heat to the environment through natural convection. The crankshaft [F] continues rotating due to the momentum of the flywheel [G], which causes the power piston to then compress the air at lower temperature while the displacer piston moves the air into the hot chamber and the cycle repeats itself. The rotating crankshaft powers a generator [H], which supplies the electricity to the electrical subsystem.

Usage/Storage:
The electricity from the generator is then directed to the electrical subsystem, which manages the simultaneous usage and storage. 20 W of electric power are provided to the load, while any unused power is directed to the battery box [I] for storage.

Off-design Issues and Safety Concerns
The environment presents certain off-design issues to be taken into consideration. The structure is designed to support not only the weight of the trough, tube, engine, flywheel, and generator, but also withstand the force of winds of up to 54 mph. The trough would produce considerable drag, which could potentially create a higher load for the structure to bear or act to tip the structure over. To avoid this, the base of the structure could be weighted down with sandbags or staked into the ground. Rain is also a concern, but all electrical components are housed in the waterproof electrical box, and the trough is tilted at 30^o so that all water will run off the bottom. The linkages to the crankshaft would have to be oiled frequently in a wet environment. Finally, cloudy days also pose a problem, as not as much solar radiation will reach the trough; however, the engine is capable of running on temperature differences smaller than those it was designed for.

The safety concerns with this product are rather obvious. The hot heat exchanger of the engine could reach temperatures of up to 400^o C and should be avoided. Cylinder pressure is not an issue: the maximum expected pressure in the cylinder is 127.8 kPa, which is well under the allowable pressure of 48.2 MPa. Additionally, the moving parts (i.e. linkages and flywheel) will not pose any threat since the engine is not expected to run faster than 9 rpm.