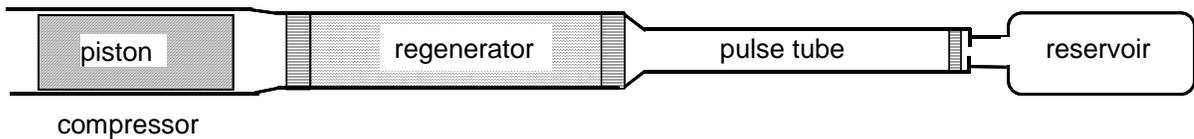


Sage Model Notes

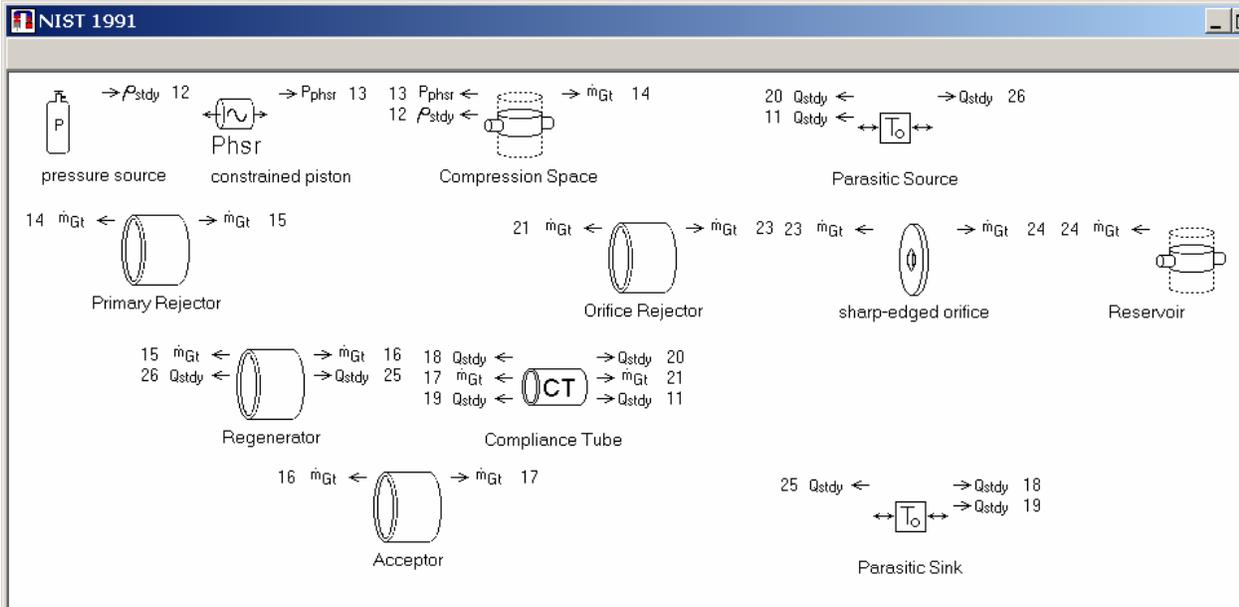
NIST91.ptb

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A model for a large pulse-tube prototype cooler tested circa 1991 by Ray Radebaugh and others at NIST (National Institute of Standards and Technology), Boulder, CO. The machine was a single-orifice pulse-tube refrigerator with a piston-type air compressor connected to the compressions space via a duct and in-line arrangement of regenerator and pulse tube. Cooling power was about 20 W at 80 K. Here is a rough schematic of the hardware layout:



This was one of the early models created under Sage. Although it has been updated a bit to remove obsolete components it does not group components into submodels. All components are visible in the top-level edit window, arranged with warm parts at the top and cold parts at the bottom:



The combination of *constrained piston* and *compression space* implement the compressor. Gas flows directly from the compression space to the warm heat exchanger (*primary rejector*), omitting the actual connecting duct between two. Instead the *compression space* just includes the duct volume in its mean volume. It is no problem to actually include a separate tubular component representing the connecting duct in the model. But this is an early Sage models and they were often over-simplified compared to more recent models.

The remaining components after the compressor, starting with the *primary rejector* and ending with the *reservoir* are arranged from left to right according to the in-line physical layout. The orifice serves to phase-shift the flow relative to the pressure so as to accomplish an approximation of the stirling cooling cycle.

Cold Temperature The file is currently set up for a cold-end temperature of 80K. To change it change the *Tinit* input for the *acceptor* (cold heat exchanger) and *T* for the *parasitic cold sink*. These remain fixed at the specified temperature. Also, you might want to change *Tinit* at the positive end of the regenerator and negative end of the *pulse-tube*. These changes are not strictly necessary because the regenerator and pulse-tube temperatures are solved, with *Tinit* only providing initial values.

Net cooling power is available in the top-level user-defined variable *Qlift*. Included in *Qlift* are the heat flows absorbed by the helium in the cold hx, less the conduction losses down the regenerator and pulse-tube canisters and the radiation loss down the pulse tube.

Optimization

The file is set up to optimize (solve for) orifice area to maximize net heat lift *Qlift*, itself a user defined variable, defined in terms of two other user defined variables *Qgross* (gross heat lift) and *Qloss* (parasitic conduction losses). *Qgross* and *Qloss* are defined in lower-level model components and exported to the root model for use in the objective function expression.