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SOLAR ENERGY
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installment 13

There is a need for engines that work between slight differences in temperature to operate pumps and control mechanisms which are part of solar heating systems.

The engines needn't be small and they needn't be very efficient. In fact, they cannot be very efficient if, as I have said, they are to work between small temperature differences since the maximum efficiency possible in a heat engine is $1 - \frac{t\ cold}{t\ hot}$ (where T is expressed in degrees above absolute zero rather than the freezing point of water).

In past articles I have mentioned two engines that are especially useful although neither is efficient in the customary sense. The freon control mechanism that operates the skylid mentioned several chapters ago is really an engine but one that instead of repeating its power cycle rapidly does so usually only once a day - because it relies on the motion of the earth itself - or a massive cloud cover to shift the flow of heat from one side to another.

The other engine that is especially useful is the convection engine. Hot air rising, cool air sinking - a moderate size convective air loop rock storage system can eliminate the need for a ½ hp motor by the use of convection. A properly designed engine can double as a thermostat since its fuel, solar energy, is delivered to it when it should run and shut off when it should stop running. Dealing with engines that have these characteristics makes me reluctant to hook up conventional electric motors and thermostats for here the equipment doesn't want to do what you want it to do, but must be arranged and guided every step of the way.

We have built a couple of engines at Zomeworks that work with small differences of temperature and which appear to hav... good qualities

BUBBLE PUMP

Bubbles are like negative weights - they rise in liquids with a force equal to the weight of the liquid they displace.

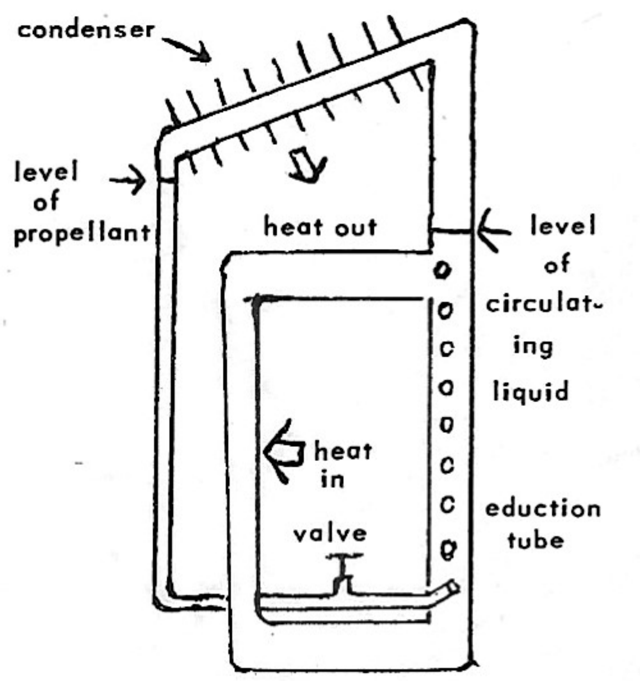
Bubbles of compressed air have been used to pump water and oil out of wells (see Air Lift Pumps, Kent's Mechanical Engineer's Handbook, 11th Edition. sec. 2-74) and Pumping by Compressed Air by Edmund M. Ivens, John Wilez, 1914) with efficiencies reported in Kent's Mechanical Engineer's Handbook of 70% and Ivens' Pumping by Compressed Air of 37%.

To make compressed air one needs an air compressor - however, bubbles of other gases can be made without a compresser. If the liquid to be pumped is hot and another propellant liquid with a low boiling point is introduced into the hot liquid, bubbles of gas of the propellant liquid are formed, and these can be used in place of compressed air.

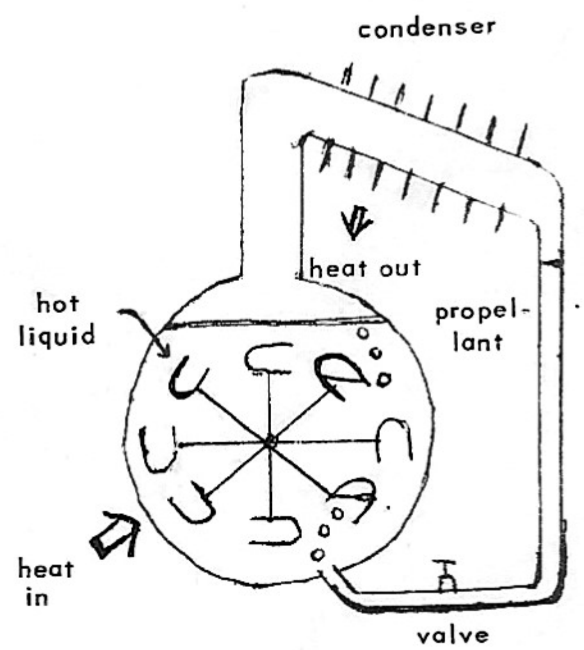
At the top of the eduction tube (see fig. 1) (the tube within which the bubbles rise) place a condenser at a lower temperature than the circulating liquid and its gas bubbles - the propellant liquid condenses and then returns by gravity to the bottom of the eduction tube where it begins the cycle again. This kind of bubble operated heat engine can be used merely to circulate liquid in a heat exchange system or a turbine can be put into the circulating loop, (see fig. 2) and mechanical energy can be extracted.

With sufficient heat the theoretical efficiencies of such a heat engine are as high as 70% of the max carnot efficiency so that with a circulating liquid temperature of 200 degrees F and a condenser temperature of 100 degrees F an engine efficiency of 10% should be possible (see fig. 3). Again multiplying this efficiency by the max efficiency of an eduction pump 70% and a turbine-90% and efficiency of over 6% is possible.

The condenser may have to be considerably higher than the top of the eduction tube to give the propellant the necessary head to force it back again into the bottom of the eduction tube. This, of course, depends on the relative specific gravities of the circulating liquid and the propellant. Another matter is the miscibitity of the two liquids - highly immiscible pairs such as hexane-water and carbon tetrachloride - water are best. The temperature at which the propellant boils at a given pressure can be found by checking the vapor pressure of the azeotrope formed by the two components.



EDUCTION PUMP FOR CIRCULATION



BUBBLE WHEEL