Refrigeration

Freon-Free Freeze

If you were to double the pressure within a container of air, its absolute temperature would double.

Since absolute zero is about -460 degrees F, air starting at 70 degrees would begin at 70+ 460 = 530 degrees above absolute zero.

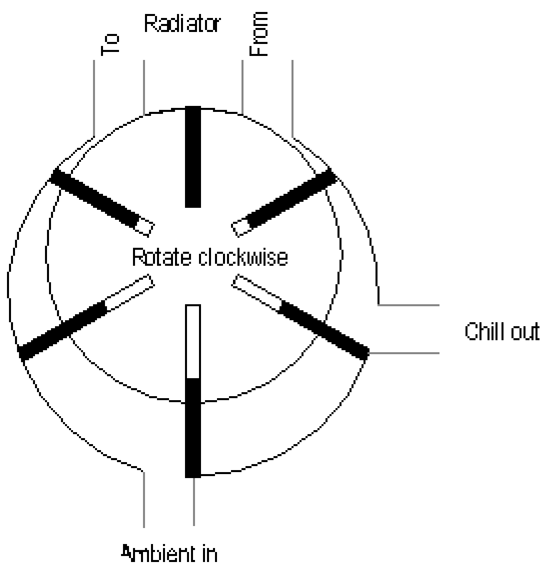
Generally we aren't aware of all this heat, because air stores very little of it, and so it dissipates almost instantly. However, if you have been around air compressors, you know they get hot, and now you know why.

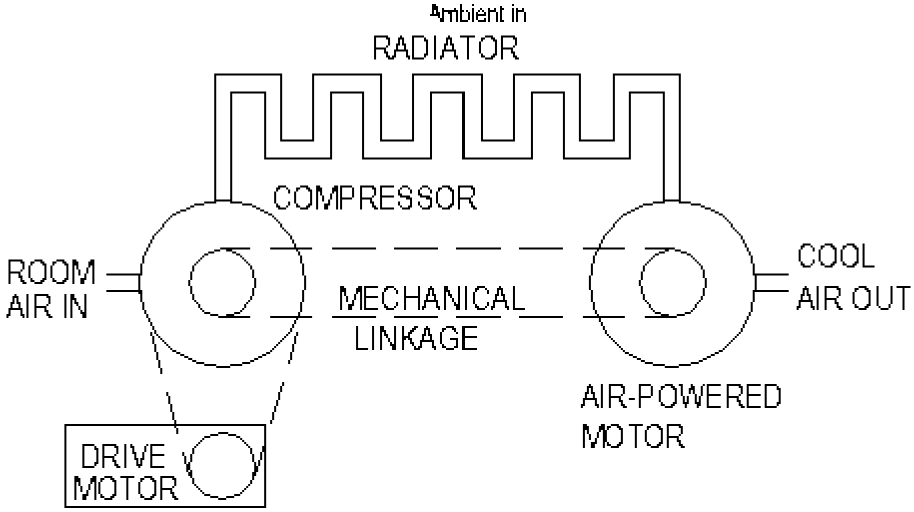
When air expands, it cools according to the same ratios. If you have had much experience with air-powered tools, you know that frost can form as the air expands through them. Under these conditions, air is first compressed, its increase in heat is allowed to escape, and now as it expands it cools to a lower temperature than that at which it was stored.

So why isn't this principle commonly used in refrigeration today? Ask the refrigeration industry. Theory says it must work, and the frost on my air-powered grinder says it does work. Furthermore, this process is often used commercially to achieve cryogenic temperatures.

Consider the drawing below of a rotary compressor (think: obsolete smog pump on older cars) for a practical air-based refrigerator system:

1. Ambient air is compressed on the left.
2. The resulting heat is dumped through the radiator.
3. The air that has been cooled by the radiator is allowed to expand through an air-powered motor on the right.
4. This expansion reduces the temperature further – to below the temperature of the input air.
5. The mechanical energy from the air motor is returned to assist the drive motor in powering the compressor. There would be less energy returned of course, because the volume of the cooler air at the right end of the radiator would be less than that of the hot air entering the left end of the radiator (although obviously they would be at the same pressure).





For mechanical simplicity, the entire system (except the radiator) could be combined on a single shaft as shown:

Take another look at this illustration:

- By applying pressure to the “to” side of the radiator port, it becomes an air or steam-driven motor, turning counter-clockwise.
- By switching the pressure to “from” port, you could drive it clockwise, albeit at a slightly reduced efficiency.
- By placing the “in” and “out” ports outside a space to be heated, and the radiator on the inside, and applying power to rotate it clockwise, the unit becomes a heat pump.

Radiation Refrigerator

This idea is based upon the fact that on a clear night, about 20 to 40 BTU per hour can be radiated into deep space for every square foot of flat-black surface.

The design goal (untried) here is to keep two gallons of water or milk below 45 degrees on a 100 degree day, in a box 12"x 18" x 12" deep.

If we allowed 2 gallons of water (or milk) to rise in temperature from 32 degrees F to 45 degrees F, this would mean we were losing 217 BTU (2 X 8.345lbs X 13 degrees).

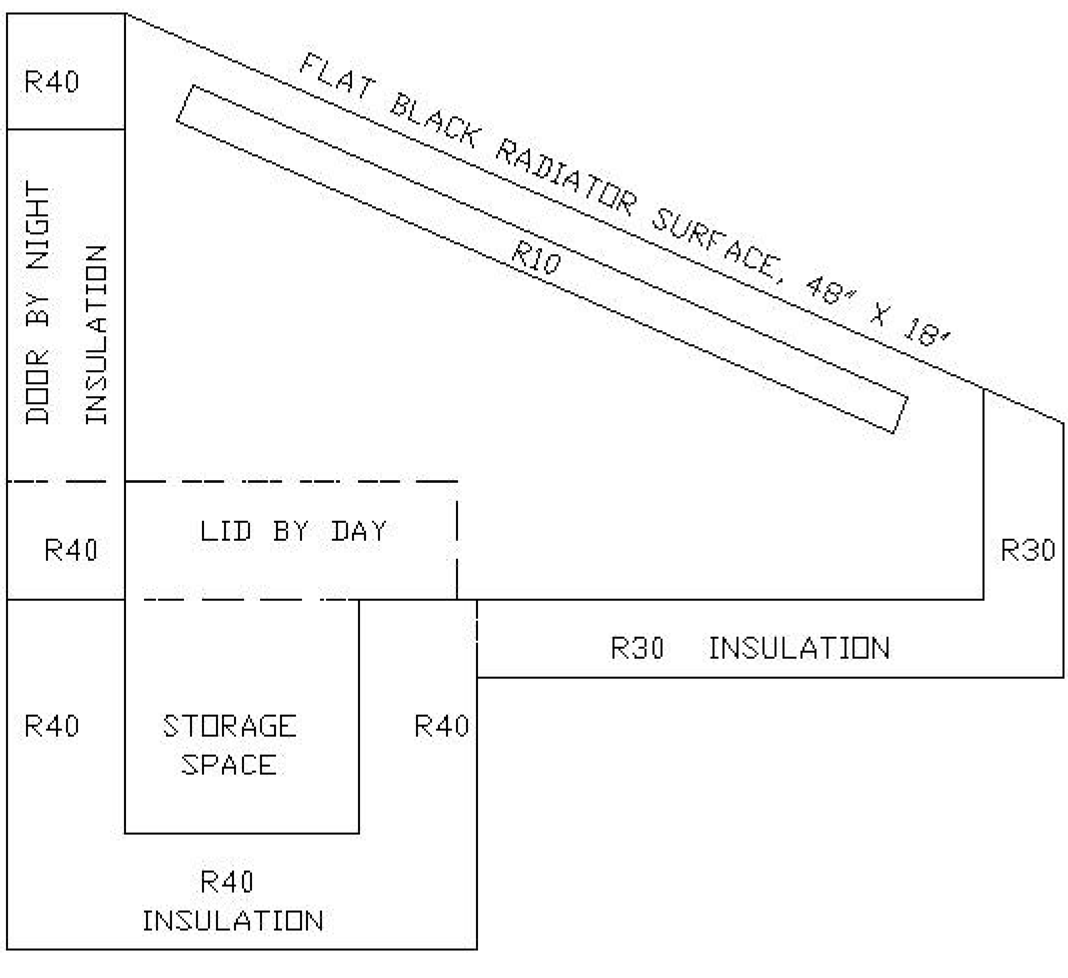
With 8 square feet of surface area on the box, we would be obtaining
27.125 BTU per square foot (217/8=27.125).

If we defined the non-cooling portion of the day as 16 hours, we would be warming the stored fluid by 27.125/16 = about 1.7 BTU per square foot per hour.

If we had an average daytime outside temperature of 100 degrees, the temperature difference would be 100-32 = 68 degrees. If we divide this by 1.7 BTU per hour, our insulation would need an "R" value of 68 / 1.7 = R40.

Counting on at least 2 hours of 20 BTU per square foot per hour radiation per night, the radiator surface area we would need to dump 217 BTU during this time would be: 217 BTU/2 hours/20 BTU per hour = 5.4 square feet.

Now this is a lot larger than the top our 12" x 18" cold storage box, so a cross-section of the radiation refrigerator that I haven't built yet, would look something like this:



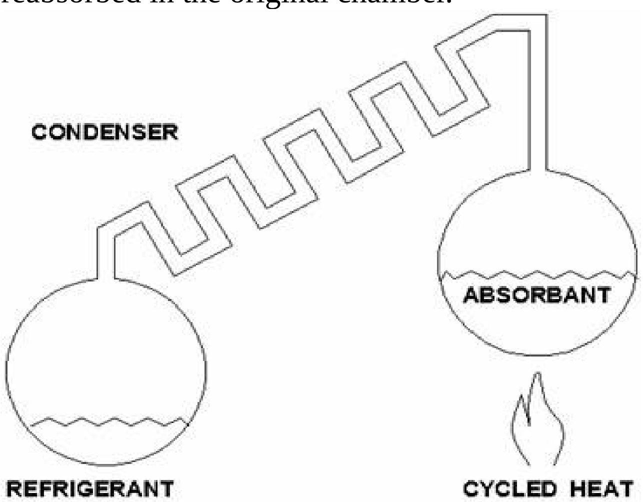
Solar Cooling

Sounds like an oxymoron – but wait! Some of you are familiar with propane-powered refrigerators common in motor homes and camp trailers. Does it make any sense to get cooling out of a flame? There's a trick to it; it's called absorption cooling.

A refrigerant is absorbed into a liquid or solid at normal temperatures, but driven out when the temperature is raised beyond a certain point. This vapor then passes through a tube to a cooler place where it is condensed and stored in another container in liquid form.

When the heat is off, the material in the original chamber begins to reabsorb refrigerant vapor in the system and a vacuum is created.

This causes the refrigerant to draw heat from (cool) its environment as it evaporates, while being reabsorbed in the original chamber.



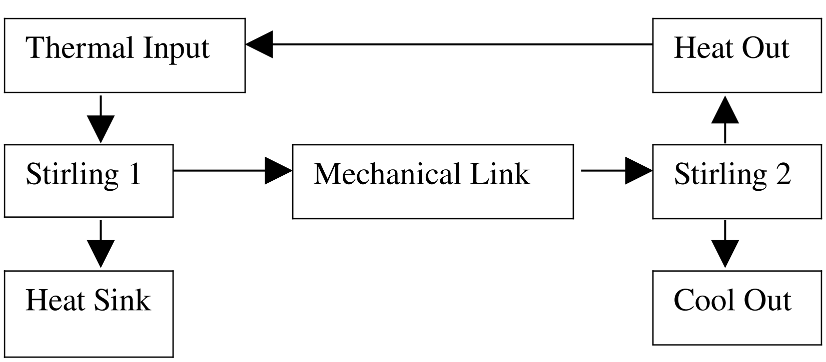
As a residential solar cooler, consider an absorbent system heated by concentrating the morning sun on the east side of the house. This drives the refrigerant through the condenser where the heat is exhausted out of the dwelling, and into the other container in liquid form.

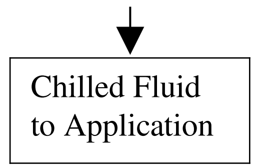
By the afternoon, the sun has moved on and the reabsorbing process begins, cooling the dwelling. It might well be practical to use the condenser to also provide the cooling surface, by re-routing the air downward into the dwelling. Conceivably the entire process could be passive if the condenser were above the dwelling. This is because the heat and cold would naturally flow upward and downward, respectively.

Linked Stirling

In the "Engine" category you will find a remarkable device called a "Stirling Engine". As an engine it produces mechanical energy if you have sources of hot and cold, but it has another trick. If you mechanically rotate it, it will actually produce a temperature difference. In fact, specially-built Stirling engines are used to achieve cryogenic (super cold) temperatures.

Use linked Stirling engines for cooling applications





The most efficient linkage would be to have both displacer pistons and both power pistons sharing the same rods. A free-piston style would optimize efficiency and minimize complexity.