

will determine more definitely whether certain applications will materialize. The commercial prospects in fields where conventional machines are available are particularly difficult to assess. It is obvious that a radically novel design for all types of equipment will be much more readily accepted for purposes where no alternative devices with similar performance characteristics are available. When conventional machines can be obtained that offer adequate performance and that have already gone through a lengthy process of technical development, it is not so easy to establish a revolutionary new type of product in direct competition. This would be the case even if certain marginal or even substantial advantages in performance, cost, or other features can be obtained, especially since most new machines must initially be more expensive with small production quantities. The first large-scale practical applications of Stirling engines might therefore be in fields where no alternatives are available with corresponding performance.

This situation already exists, and the first modern device of this type to be used in substantial numbers is as an air liquefier. This is a single-cylinder displacer machine, also similar to Stirling's original prototype, but driven by an electric motor, so that the cylinder head cools down sufficiently to condense the atmospheric air in contact with it. Although the coefficient of performance is lower than that of larger conventional machines, small quantities of liquid air can be produced more readily and conveniently. Since no alternative method for producing liquefied air in laboratory quantities existed before, this was a natural opening for regenerative machines.

Many other applications that are perfectly feasible at this stage of technical development have been proposed at various times. One example is power units for small boats which could use bottled gas as fuel. The almost uncanny silence of these prime movers should make them most attractive. The use of regenerative thermal machines as road transport power units will require first the development of a better

method for control with a short response time. The main advantage of these units is that the property of thermodynamic reversal can be used during braking, so that the energy stored every time the vehicle is slowed down or stopped can be recovered during the subsequent acceleration.

Open cycle machines could form part of the coolant loop in gas-cooled nuclear reactors to convert the heat generated during the fission processes. They can also be designed on a smaller scale as simple and compact air conditioners which are fully reversible at a flick of a switch, so that they can be used either for warming in winter or for cooling in the summer. This apparatus need not have any size limitation and it is possible to design them as miniature localized refrigerators. Such systems might have considerable importance with the new types of electronic equipment. In the past, when large numbers of vacuum tubes were used in electronics, a considerable amount of heat had to be dissipated, and the whole cabinet or enclosure containing this equipment had to be cooled, or ventilated. Transistors develop less heat than vacuum tubes, but may be closely packed so that local cooling by regenerative thermal machines could be advantageous.

Some electronic components, for example, infrared detectors and masers, can operate only in an ultralow temperature environment. Again, the solution may be the use of small devices to produce such local cooling effects, and equipment has already been developed for this purpose. On a more trivial plane, it is also possible to construct very small gadgets such as "cocktail coolers" with which one could cool individual drinks without diluting them by using ice.

Regenerative cycle studies are still in a very preliminary stage, and much research remains to be done to make an adequate evaluation of the best practical use. The above list is therefore largely speculative and not complete or inclusive, and its main purpose is merely to outline a very wide range of uses and to indicate the practical significance of the substantial research effort devoted at present to this area.