fluid at the inlet to be approximately equal to that of the space. The over-all effect of this is equivalent to an abstraction of heat during one polytropic phase, storage in the regenerator, and subsequent recovery during another polytropic phase.

In contrast to the Carnot cycle, which is only a theoretical principle and cannot be realized in practice, many real machines operate on regenerative cycles. Only five moving parts are needed for a simple device of this type, as shown on this page. Although in some respects the operation of a regenerative power producer resembles that of an internal-combustion engine, it is rather more difficult to understand. Instead of compressing a charge of air and fuel and igniting it, so that the force of explosion drives down a piston in the cylinder, regenerative machines accomplish the same objective by a more efficient, but less powerful, gradual heat addition.

The working fluid is enclosed in a system comprising the variable spaces in two cylinders and a regenerator in a connecting duct. The two pistons produce alternating compression and expansion effects; during compression, heat is rejected by the gas, and during expansion heat is absorbed. Since there is a phase difference between the movements of the pistons, most of the gas is in the right cylinder during the compression phase, and during expansion it is mainly in the left cylinder. The "expansion space", in the left cylinder, therefore, continuously takes in heat from the outside while the "compression space" in the right cylinder rejects it. The volume changes produce a cyclic variation in pressure, and the energy conversion during a cycle is due to the differences in mean pressure when the pistons move into or out of the cylinders. Since torque will be partly positive and partly negative during each cycle, a flywheel is used to even out the fluctuations in energy. Depending only on the temperature levels of these two spaces, there will be a

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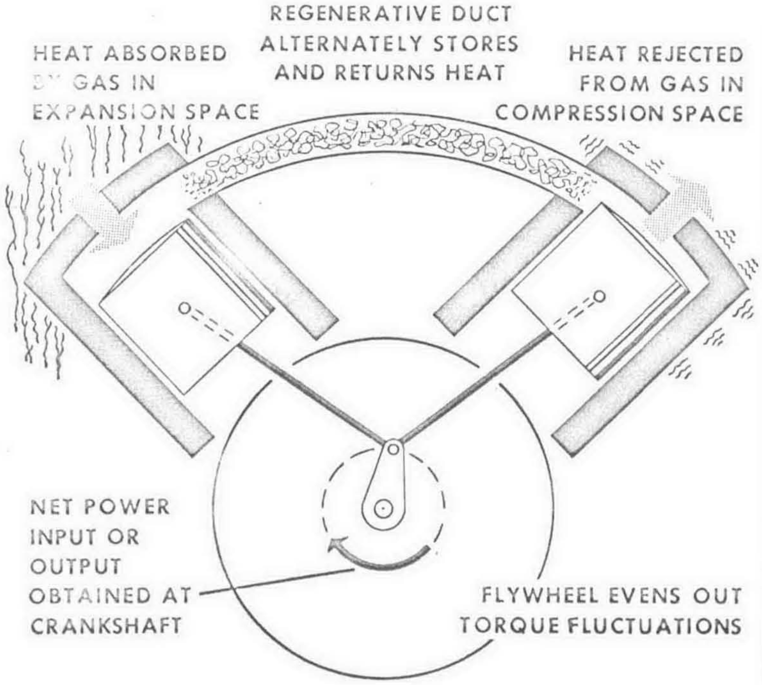

The two variable-volume working spaces of a basic closed-cycle regenerative thermal machine are connected by a duct which contains the regenerator.

mechanical work output or input equal numerically to the difference between the heat supplied and rejected.

The original design, as shown on page 4, used a different mechanism to achieve the same result. In these models, compression and expansion are performed by only one piston, and the relative distribution of the gas between the compression and expansion space is changed by means of a "displacer". This type has had the most extensive technical development, and recently-described high-efficiency engines and air liquefiers are of this type. There are many alternative designs which may be much more efficient mechanically and thermodynamically. The patent literature is rich in devices which use the same working principle, but with an entirely different mechanical configuration. Most of these machines existed only on paper until recently, and a detailed study of them is in progress to determine their field of application.

Thermodynamic Reversibility

As stated above, regenerative gas cycles can operate both as prime movers and as refrigerators. In fact, this corresponds to only two out of four possible basic functional conditions, differing from each other according to prevailing temperatures and directions of heat and mechanical energy transfer. On page 6, four operational modes are illustrated.