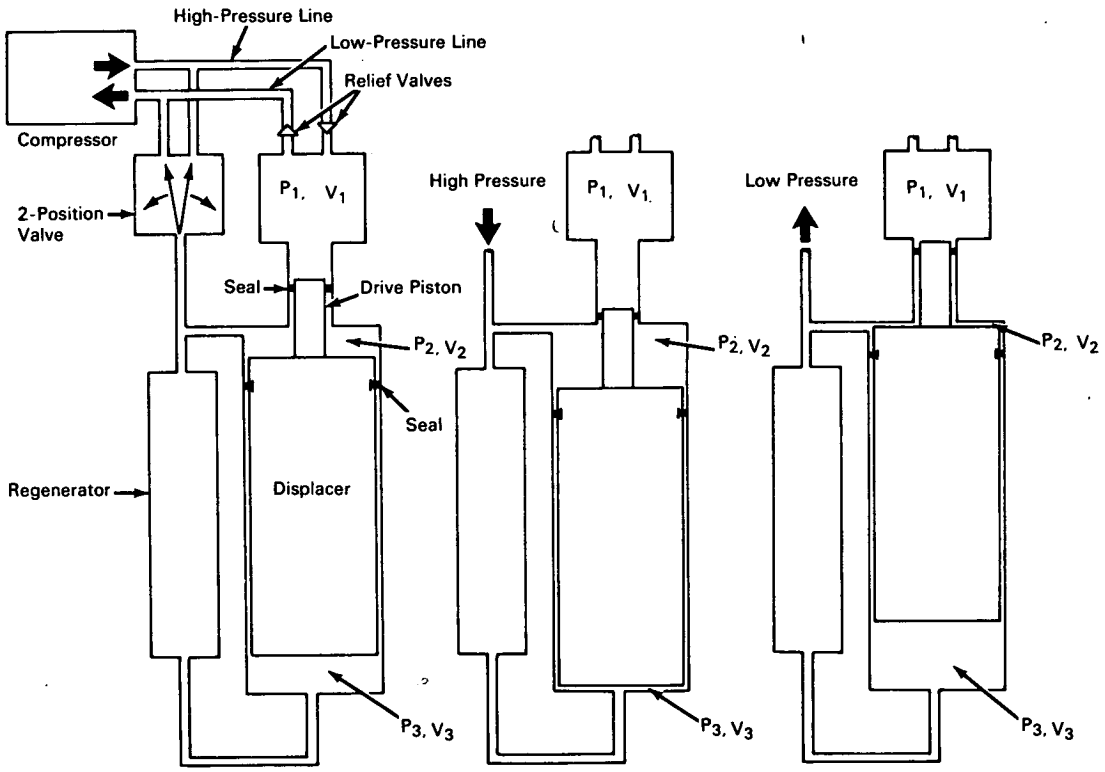
May 1967

Brief 67-10128

NASA TECH BRIEF

Improved Cryogenic Refrigeration System



The problem:

To simplify the valving arrangement (and crankshaft configuration) in gas-balancing and Stirling-cycle refrigeration systems which are used to produce temperatures below 173°K (−100°C).

The solution:

The multiport sequencing valve employed in the conventional systems is replaced by a simple two-position shuttle valve which connects the displacer and regenerator alternately to the high-pressure supply line or the low-pressure return line of the compressor. This improvement is based upon (1) the establishment of a constant pressure on one end of the drive piston which moves the displacer and (2) the inherent time delay caused by fluid friction in the regenerator.

How it's done:

The first figure is a schematic of the overall system showing the constant pressure P_1 in auxiliary volume

(continued overleaf)

V_1. The net force on the drive piston is either upward or downward; the relief valves are required only to maintain P_1 against small leaks that might be present. The inherent friction of the generator provides a time delay in developing pressure P_2 relative to pressure P_3 in volumes V_2 and V_3, respectively. The two-position valve, which is actuated by a linkage from the drive piston, allows the refrigeration cycle to be self-starting.

The second figure shows the displacer in the lowest position, at which time the two-way valve connects the high-pressure line of the compressor to volume V_2 and the top of the regenerator. The displacer remains in this position for a short time, because P_2 is greater than P_3 as a consequence of the time delay introduced by the regenerator. Subsequently P_2 and P_3 become equal at a value larger than P_1, and the resultant force urges the displacer upward.

The third figure shows the displacer in the uppermost position, with the gas volume V_2 displaced into V_3, as would be required in the gas-balancing cycle. At this time, the two-way valve connects the top of the regenerator and V_2 to the low-pressure port of the compressor. The displacer momentarily remains stationary (again as the result of the time delay in the regenerator) because P_3 is larger than P_2. When P_3 becomes equal to P_2, at which time both pressures are less than P_1, the resultant force urges the displacer downward to drive the cold gas out through the regenerator as required. The thermodynamic cycle then repeats.

Notes:

1. A prototype of a single-stage refrigeration unit incorporating the new valve arrangement required only 1 hour to liquefy nitrogen.(78° K).
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B67-10128

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Walter H. Higa

(JPL-731)