come to rest against abutments at the ends of grooves in a piston skirt. This shuttle-valve design obviates the custom-
ary complex valve mechanism, actuated from an engine crankshaft or camshaft, yet it is effective with every type of two-
cycle engine, from small high-speed single cylinder model engines, to large low-speed multiple cylinder engines.

- **Variable Compression Ratio**
  The piston has a stepped configuration: It includes a narrower power sec-
tion (the upper portion in the figure) and a wider compressor/supercharger section (the lower portion in the figure).
  The variable-compression-ratio mechanism includes a high-pressure oil lubri-
cation circuit acting in unison with the pulsating flow and pressure of the air caused by the reciprocation of the com-
pressor/supercharger section of the pis-
ton. In terms that are necessarily over-
simplified for the sake of brevity, the operation of this mechanism involves in-
teractions among pressures and flows of air, oil, and combustion gases, to vary the axial position of a floating combus-
tion bowl in the power section of the piston and thereby vary the compression ratio. The design of the mechanism is such that when the throttle opening is suddenly changed, the compression ratio becomes adjusted relatively quickly to the value at which the engine operates most efficiently.
  - **Supercharging**
    The stepped-piston arrangement obviates the complication and high cost of “add-on” supercharging mechanisms like those used on prior engines. During the compression stroke, the motion of the compressor/supercharger section of the piston gives rise to a flow of air at high pressure from the compressor cylinder through one-way transfer valves, through a plenum, into the power cylin-
der. This flow contributes to scavenging and cooling of the power cylinder. The highly compressed air continues to enter the plenum and power cylinder after the exhaust ports are closed and the supercharging of the cylinder has been completed. The compressed air that continues to enter the plenum after
  the inlet ports are covered by the rising power piston is retained in the plenum under pressure until the end of the ex-
pansion stroke, when the exhausting power piston opens the exhaust ports. Soon after this, the abutments in the pis-
ton skirt make contact with the projections on the reciprocating shuttle inlet valve, forcing the valve to the open posi-
tion, in which the compressed air rushes from the plenum into the power cylin-
der, thereby effecting the initial scavenging. An additional benefit of the stepped-piston arrangement is that the blow-by gases and particulate matter that escape past the power-piston rings are isolated from the crankcase and returned to the power cylinder on the fol-
lowing stroke.

  *This work was done by Bernard Wiesen of Wiesen Engine for Glenn Research Center.*
  *Inquiries concerning rights for the commer-
cial use of this invention should be addressed to NASA Glenn Research Center, Innovative Part-
nerships Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18043-1.*

#### Flexible Structural-Health-Monitoring Sheets

*Marshall Space Flight Center, Alabama*

A generic design for a type of flexible structural-health-monitoring sheet with multiple sensor/actuator types and a method of manufacturing such sheets has been developed. A sheet of this type contains an array of sensing and/or ac-
tuation elements, associated wires, and any other associated circuit elements incor-
porated into various flexible layers on a thin, flexible substrate. The sheet can be affixed to a structure so that the array of sensing and/or actuation ele-
ments can be used to analyze the struc-
ture in accordance with structural-
health-monitoring techniques. Altema-
tively, the sheet can be designed to be in-
corporated into the body of the struc-
ture, especially if the structure is made of a composite material.

Customarily, structural-health moni-
toring is accomplished by use of sensors and actuators arrayed at various loca-
tions on a structure. In contrast, a sheet of the present type can contain an entire sensor/actuator array, making it unnec-
essary to install each sensor and actuator individually on or in a structure. Sensors of different types such as piezoelectric and fiber-optic can be embedded in the sheet to form a hybrid sensor network. Similarly, the traces for electric commu-
ication can be deposited on one or two layers as required, and an entirely sepa-
rate layer can be employed to shield the sensor elements and traces.

  *This work was done by Xinlin Qing and Fuo Kuo Chang of Acellent Technologies for Marshall Space Flight Center. For further in-
formation, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-32510-1.*

#### Alignment Pins for Assembling and Disassembling Structures

*John F. Kennedy Space Center, Florida*

Simple, easy-to-use, highly effective tool-
ing has been devised for maintaining alignment of bolt holes in mating struc-
tures during assembly and disassembly of the structures. The tooling was originally used during removal of a body flap from
  the space shuttle Atlantis, in which mis-
alignments during removal of the last few bolts could cause the bolts to bind in their
holes. By suitably modifying the dimen-
sions of the tooling components, the basic design of the tooling can readily be
adapted to other structures that must be maintained in alignment.

The tooling includes tapered, intern-
ally threaded alignment pins designed
to fit in the bolt holes in one of the mat-
ing structures, plus a draw bolt and a