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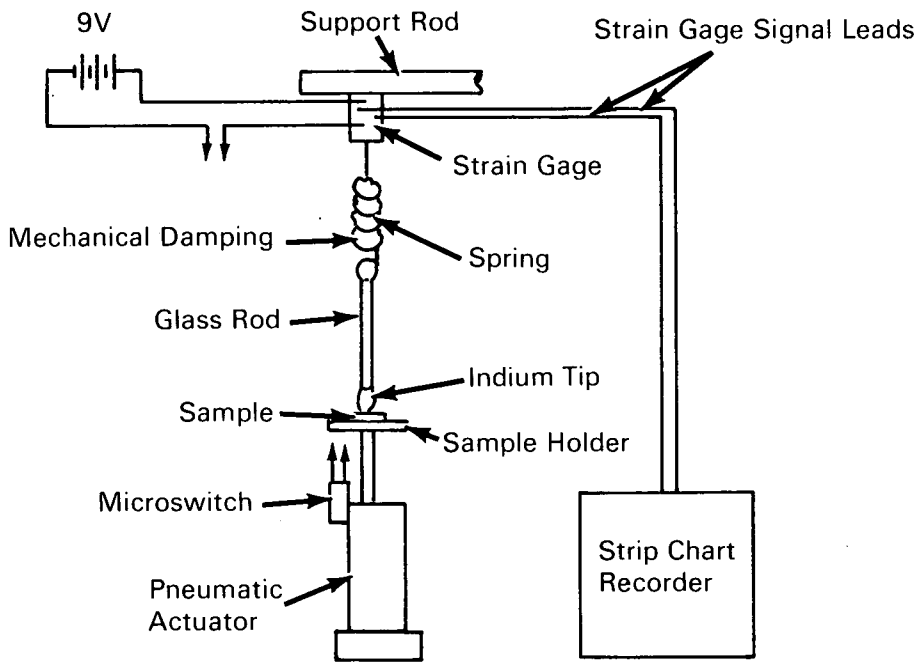
## Indium Adhesion Provides Quantitative Measure of Surface Cleanliness




### The problem:

To develop a means of measuring surface cleanliness that detects hydrophobic as well as hydrophilic contaminants, that can be used on rough as well as smooth surfaces, and that gives quantitative results.

### The solution:

Adhesion between solids will occur if one of the substances is soft and if their interfacial energy is less than the sum of their individual surface energies. Therefore, a small amount of indium, a very soft material which does not work-harden, on the tip of a probe will adhere to a clean surface. The force needed to pull the indium tip away from the surface provides a quantitative measure of cleanliness.

### How it's done:

Indium is melted in a ceramic crucible and then maintained at a temperature of 160° to 175°C. The indium surface must be skimmed before it is applied to the probe tip. One end of a clean pyrex glass rod is heated in a blue flame to a temperature just below the softening point of the rod. It is then cooled to below 200°C, dipped into the molten indium, and quickly withdrawn. The end of the resultant indium droplet must be broken off with tweezers in order to provide a fresh indium surface. The freshly formed surface must be used within two minutes.

The cleanliness testing should be performed in a reasonably clean area with the relative humidity below

(continued overleaf)

60%. The indium-tipped rods and the test specimen must be at a temperature between 20° and 35°C. The test specimen and the glass rod are both placed in their holders, and the measuring apparatus activated. The specimen is fastened to a table-like holder which is mounted on a pneumatic actuator. The specimen is raised until it presses perpendicularly against the indium tip. The specimen is then allowed to fall by gravity at a uniform rate limited by the pneumatic actuator. A strain gauge measures the force on the indium tip through a coil spring that translates the forces applied into motions large enough to be easily controlled. Mechanical damping of the spring prevents oscillations in the system. The signal from the strain gauge is fed to a strip chart recorder.

The coefficient of adhesion ($\sigma$), the ratio of the tensile force for adhesive failure to the joining force, provides numerical results of cleanliness testing ranging from 0 for dirty surfaces to as high as 1 for clean ones. A well-defined maximum value of $\sigma$ is obtained with a joining force of 10 grams, with little effect from creep if contact is maintained for less than 10 seconds. Normal variations in room temperature are not critical. Sensitivity is enhanced by repetitive cycling with the same indium tip applied several times to the specimen.

**Notes:**

1. Satisfactory results were obtained in evaluation tests with a joining force of 10±1 grams, 5-cycle testing, and temperature of 23±2°C. Materials chosen for test surface specimens included fabricated Kovar and type 304 stainless steel, unglazed ceramics, monocrystalline sapphire, and both optically polished and ground glass. Results of tests on the clean surfaces showed a variation of less than 10 percent. Contamination levels from several monolayers to less than one monolayer may be detected.
2. Cleanliness of low-surface-energy materials, such as teflon, may not be tested directly, but may be inferred from the behavior of an indium tip used with a clean reference surface after having been pressed against the surface of the low energy material. In this case the $\sigma$ value will depend upon the cleanliness of the surface of the original low-surface-energy specimen. The exact relationship, however, between the high- and low-surface-energy test specimens is not well defined as is the direct method, and will depend to a great extent upon the exact nature of the contaminant involved.
3. Inquiries concerning this innovation may be directed to:

   Sandia Office of Industrial Cooperation
   Sandia Laboratories
   Post Office Box 5800
   Albuquerque, New Mexico 87115
   Reference: B68-10342

**Patent status:**

No patent action is contemplated by AEC or NASA.

Source: G. L. Krieger and G. J. Wilson (SAN-10024)