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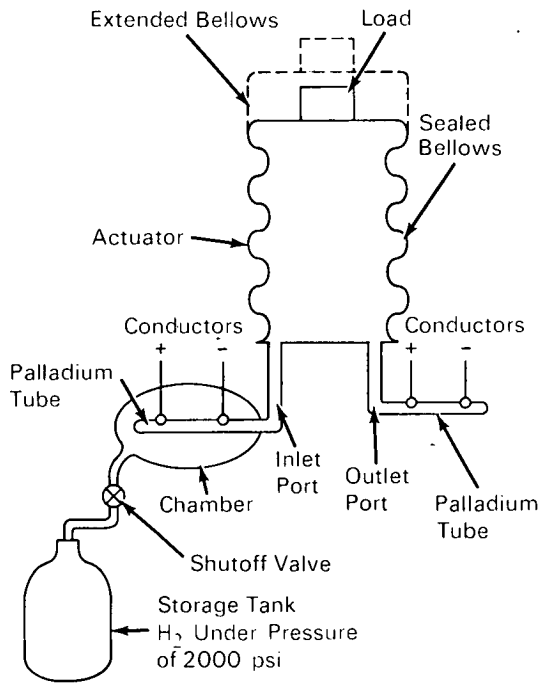
# NASA TECH BRIEF



## Concept for a Gas Operated Actuator

A palladium valve, permeable to hydrogen gas, can be used to fill a bellows mechanism from a source of hydrogen to power an actuator. A similar valve can be used to provide retraction. The valves would have no moving parts, and would be heat operated. An actuator operated in this manner could have numerous industrial applications.




As shown in the schematic diagram, the conceptual actuator consists of a sealed bellows which is provided with inlet and outlet ports. A supply of hydrogen under pressure (typically 2000 psi) is contained in the storage tank. The tank is connected by tubing and a shutoff valve to a chamber completely enclosing a sealed-off palladium tube connected to an inlet port. Electrical connections join a portion of the tube to an electrical source.

A second closed-off palladium tube is connected to an outlet port. Electrical connections link a portion of the tube with source which may be different from the first source. The tubes constitute palladium valves, used initially to extend the bellows by inflating it with hydrogen under pressure, and subsequently allowing the bellows to return to the initial unextended state (or any intermediate state) by exhaust of the hydrogen gas.

A section of the palladium-silver or other palladium alloy tubing can be brought to a temperature sufficiently high, about 450°F, to effect a substantial increase (approximately 100 times the permeation at 50°F) in hydrogen permeation by conductors inducing electrical current between two spaced points on the tubing. Thus if the chamber is initially filled with hydrogen under pressure, and the tube is at a low temperature, about 50°F, hydrogen will not pass rapidly from the chamber into the interior of the bellows. When the heated tube becomes much more permeable, the pressurized gas will transfer through the heated palladium membrane made up of the wall of the tube and will enter the interior of the bellows. After sufficient hydrogen has passed, the bellows will be extended (indicated by the broken line in the figure), moving the load.

When the current is turned off, the palladium membrane will no longer be as permeable to hydrogen and the bellows will remain "latched" in the extended position under the pressure of the contained hydrogen. To return the load to the initial position (or any intermediate point), the outlet palladium tube is heated by

(continued overleaf)

applying an electrical current through the conductors. The extent of retraction of the bellows under the force exerted by the load (or by a built-in spring force of the bellows itself) will depend upon the length of time that current is applied. It is obvious that although the actuator provides a linear movement, suitable motion transformation could provide a rotary movement; also by switching power between the tubes, a form of alternating movement is obtainable.

Passage of hydrogen through the membrane is due to the formation of palladium hydride on the surface of either tube in contact with the hydrogen; the elevated temperature causes decomposition of the hydride to reform hydrogen on the other surface. Since this hydride forming reaction is reversible to some extent through the walls of either tube, it may be preferable to contact the transferred hydrogen with a hydrogen reactive gas such as oxygen to form water.

## Notes:

1. One limitation on the use of the actuator is that although palladium is permeable to hydrogen at any temperature above absolute zero, the rate of diffusion through the palladium membrane is extremely small until the critical temperature is reached. Thus the actuator would only be suitable for relatively short term use (on the order of hours) because the diffusion rate would be so low at temperatures below critical, the actuator would remain latched. Such limits can only be established after construction of an actuator according to the concept.
2. No further documentation is available. Specific questions, however, may be directed to:
   Technology Utilization Officer
   NASA Pasadena Office
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B70-10516

## Patent status:

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

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