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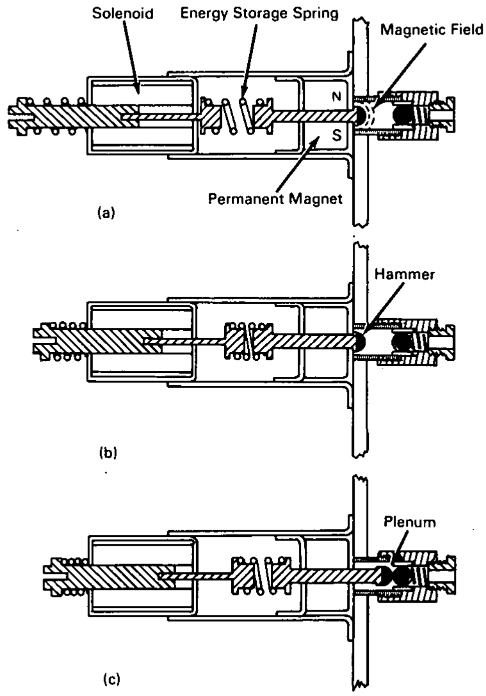
# NASA TECH BRIEF



## Solenoid Hammer Valve Developed for Quick-Opening Requirements




A quick-opening, lightweight, valve, which requires only a low amount of electrical energy to open, and closes by the restoring action of the mechanical springs, has been developed. The rise time of the gas pulse released by the valve and the effects of variation in spring constants and stroke were measured. Best performance obtained to date is a rise time of 125 microseconds obtained with an energy input of 3 joules. Potential reliability was demonstrated by the successful completion of 252,000 valve operations with no apparent degradation of the mechanism. This valve design should be applicable to many quick-opening requirements in fluid systems. In one configuration the hammer at the full extent of its travel can reseal the plenum, thus permitting only momentary gas flow for sampling or injection operations.

The operation of very fast gas valves is almost invariably electromagnetic. In applications where speed of opening is of greatest importance, and where size or mass of the associated circuitry and energy supply is not an important constraint, it is usual to employ thin metallic diaphragms driven by very rapidly applied magnetic fields. During the time interval between switching on the field against one side of the diaphragm and the diffusion of the field through the diaphragm, there is a strong flow of eddy currents in the metal; these interact with the field and result in a strong acceleration of the conductor away from the

(continued overleaf)

field. Extremely rapid acceleration can be achieved this way.

If, however, the quantity of energy necessary to operate the valve is itself an important consideration, the eddy-current valve appears much less favorable. It is very difficult in such a device to deposit the majority of the magnetic energy where it is needed, i.e., in the immediate vicinity of the moving diaphragm surface.

This valve employs a solenoid to compress a spring, then utilizes the spring energy for actuation. Since the solenoid plunger is used only for compressing the spring, the weight and velocity of the plunger do not limit the opening time of the valve. The valve mechanism consists of a solenoid, a lightweight hammer, a permanent magnet, a sealing ball, and a combination plenum chamber and ball seal. Three springs are required, the main energy storage spring, a ball seal spring, and a light spring for returning the solenoid plunger after each stroke. Figure (a) shows the valve in the normal standby condition prior to application of power. The hammer is held in position by the permanent magnet and the gas is sealed by the spring-loaded ball. Both the energy-storage spring and the solenoid plunger return spring are unstressed and in their free lengths. Actuation is initiated by discharging a capacitor through the solenoid. The solenoid armature is driven forward, compressing the energy-storage spring. During the compression stroke, figure (b), the hammer remains locked in position by the permanent magnet until impacted by the solenoid plunger. The impact unseats the hammer and transfers momentum from the plunger to the hammer. The hammer is then accelerated by the force exerted by the energy-storage spring, reaching maximum velocity at impact with the ball. The trapped gas is released upon impact of the hammer and ball as shown in figure (c). The opening time of the valve is independent of valve closing time. The seal is closed by action of the valve seal spring as the energy-storage spring withdraws the hammer from its plenum seat. The solenoid plunger and hammer then return to their original positions shown in figure (a).

**Note:**

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**Patent status:**

No patent action is contemplated by NASA.

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