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FAST ALL-METAL SIX-INCH VALVE*

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Summary

A stainless steel, six-inch valve capable of closing in approximately 10 milliseconds has been developed at the Stanford Linear Accelerator Center. The valve will be automatically and remotely operable, allowing it to be used in the SLAC beam switchyard area where high radiation levels will prohibit personnel access. The problems of triggering mechanical release, valve gate acceleration and deceleration, and vacuum sealing without elastomers appear to be solved.

The knowledge gained relating to this type of gate valve predicts the future design of a valve with a 24-inch opening, capable of operating in time intervals of five to six milliseconds.

Introduction

Consistent with advances of linear accelerators of the SLAC type, certain mechanical components in the vacuum system complex had to be produced. This was necessitated by the high probability of implosive failure of a thin window in the vacuum complex of such a high intensity particle accelerator, with subsequent pressure-shock waves in the beam tubes. These pressure shocks, in the velocity range of Mach Number = 2 - 7,† unless valved off and isolated, could damage sensitive and expensive equipment.

Protection of such equipment in the beam switchyard of the Stanford accelerator will be obtained by the location of fast gate valves with closing times approaching ten milliseconds. The six-inch, stainless steel valve has been developed for automatic and remote operation in a radiation field. Initial problems of triggering mechanical release, valve gate acceleration and deceleration, and vacuum sealing without elastomers appear to be solved and are discussed below.

Valve Description

The fast all-metal six-inch valve is a gate type, automatically and remotely controlled, with master control position indication and a non-service operation interval of 500 cycles. Figure 1 indicates the main subcomponent and general detail assembly. Figure 2 presents certain mechanical features of the fast valve.

Figure 3, a graph of total time interval in milliseconds plotted versus total gate travel distance in inches, clearly shows the requirements of acceleration and deceleration. Velocities as great as 120 feet per second are reached in closing the gate. Such velocities are necessary and generate interactions of the mechanical parts that occur in time intervals of several hundred microseconds.

Deceleration magnitudes are many multiples greater than acceleration magnitudes. This required a sequential mass deceleration by three means. First, the accelerating springs are isolated and decelerated by impact rods which transmit the deceleration force into the upper part of the valve to prevent impact distortion of the vacuum seat. Second, the momentum of the rail and cam guided gate assembly shown in Fig. 2 is split in two opposite directions by cam and roller action. Third, the gate strikes an elastically supported seat with sufficient impulse to coin the lead metal seal ring.

A spring accumulator system located in the pneumatically controlled, aluminum cylinder piston assembly permits automatic connection and retraction of the gate mechanism.

Solenoid magnetic action initially triggers the gate acceleration when a signal level electronic pulse is received from the detection transducers.

Open-closed position indication is achieved by microswitches, lights and meters in the master control room. Substation actuation of each valve can be made for circuit check purposes in the SLAC installation.

Sequence of Valve Operation

As part of the valve system, pressure transducers are located approximately 100 feet from the valves near the sensitive equipment and instruments. When a shock wave enters the switchyard beam tube of the SLAC accelerator, a signal is generated and electrically fed to the trigger circuit of the valve.

The trigger circuit releases the magnetic field of the valve solenoid. This action permits the rail guided gate to be accelerated by the main springs. The gate is cam guided to a vacuum seal and automatically locked in this position by toggle action.

The spring accumulator system located in the pneumatically controlled upper aluminum cylinder causes an automatic recoupling action of the retraction cylinder assembly.

At a command from the master control room or substations, the valve can be retracted ready for another fast closure.

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† Mach Number is the ratio of velocity of propagation divided by local ambient sonic velocity $V/a = M$.

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Test Methods

Five different major types of investigative test methods were employed in the development of the valve with a view to their application in checking valve action for the total number of valves required. These methods utilized the following observational devices and techniques:

1. Electronic oscilloscope plus polaroid camera pictures.
2. Visual inspection coupled with mechanical precision measurement.
3. Electro-optical photocells coupled with electronic interval timers.
4. Necessary vacuum test equipment.
5. High-speed motion pictures.

Because the first four methods are essentially conventional, only the fifth will be briefly described. A rotating-prism type high-speed movie camera (RED LAKE) filmed the valve action at 16,000 frames per second. From each 100 feet of film approximately 20 feet were at the correct speed and useful. A one-millisecond timing mark was superimposed on the film to allow individual frame analysis and evaluation. These movies allowed detailed visual observation to be made.

Present Results

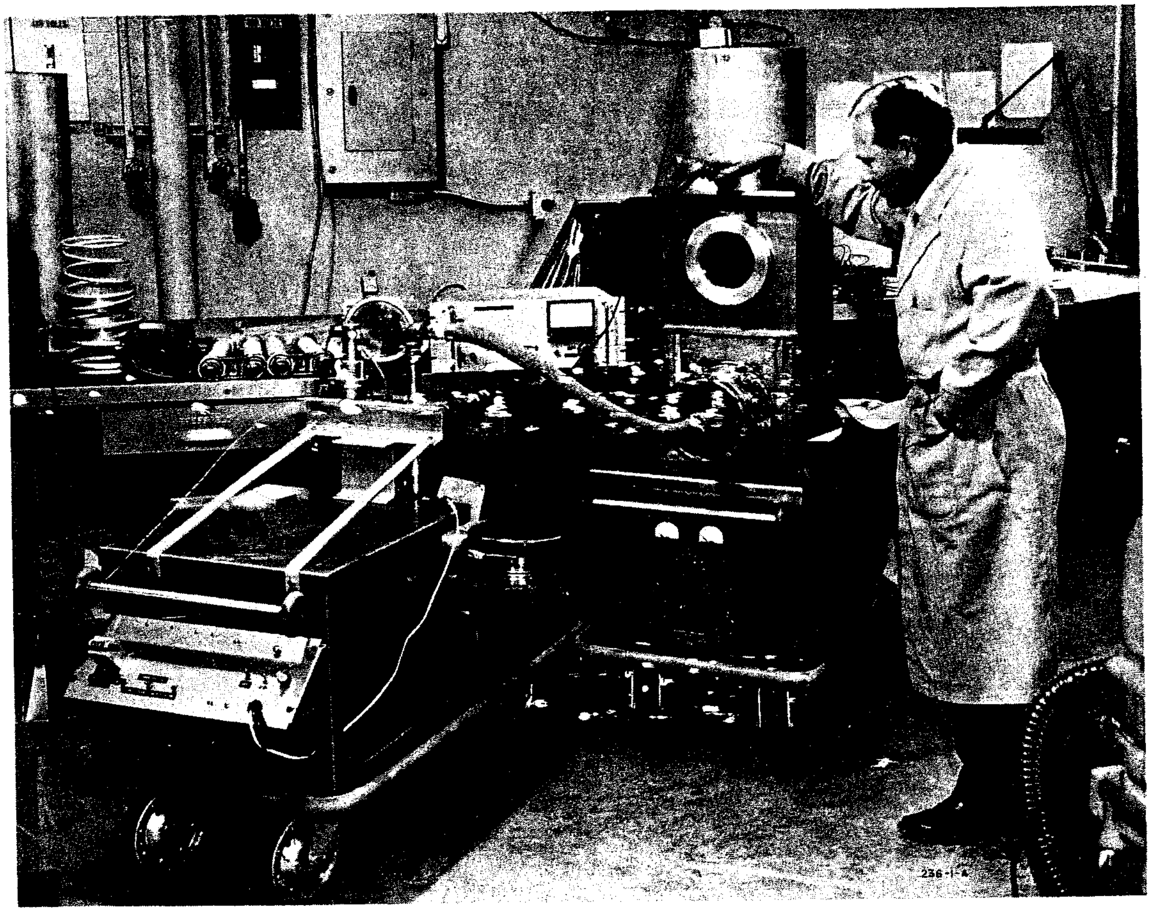
Design of the valve was started in June 1964 and completed in February 1965. A successful design is indicated. The following remarks concerning certain subcomponents may be of interest:

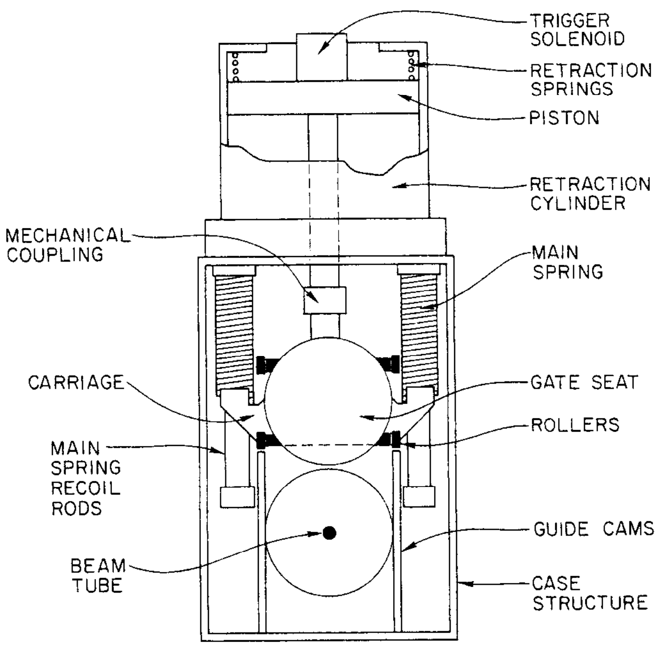
1. The vacuum bellows has completed 10,000 cycles of operation successfully. Further tests are planned.
2. The locking and release mechanisms are made of tool steel.
3. The drive springs are now preset before installation into the valve.
4. The gate seat has withstood more than the required 500 cycles of operation. Further development work to increase the reliability of the gate seat is planned.

Cost figures for this SLAC developed valve have been approximately one-fifth the cost of commercial quotes.

Future Developments

A type of valve unique in valve technology has been produced. The knowledge gained relating to this type of valve predicts the future design of a valve with a 24-inch opening, capable of operating in time intervals of five to six milliseconds.





SCHEMATIC ARRANGEMENT OF PARTS

FIG. 1 - FAST VALVE - BSY

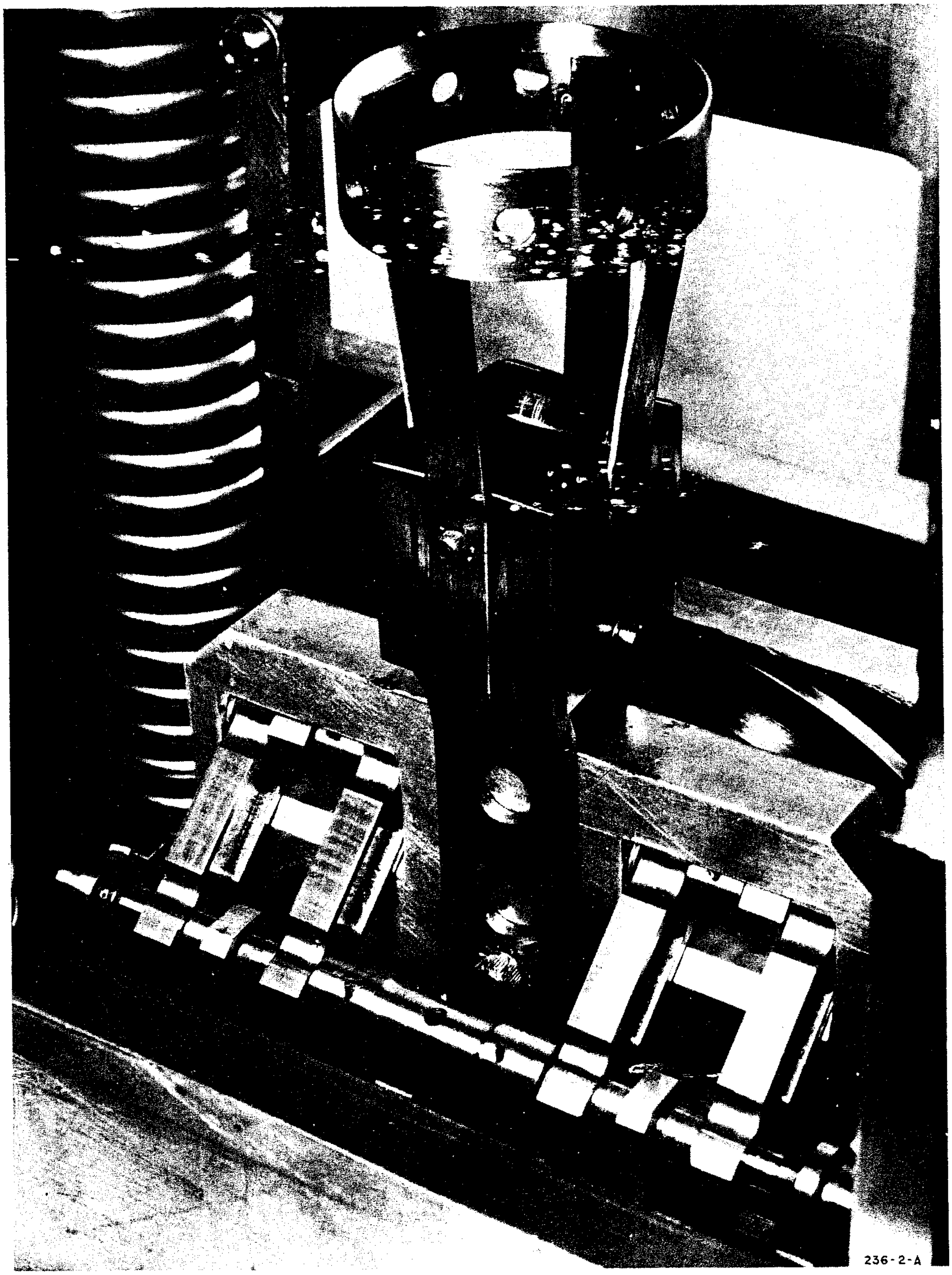


FIG. 2 - VALVE DETAILS

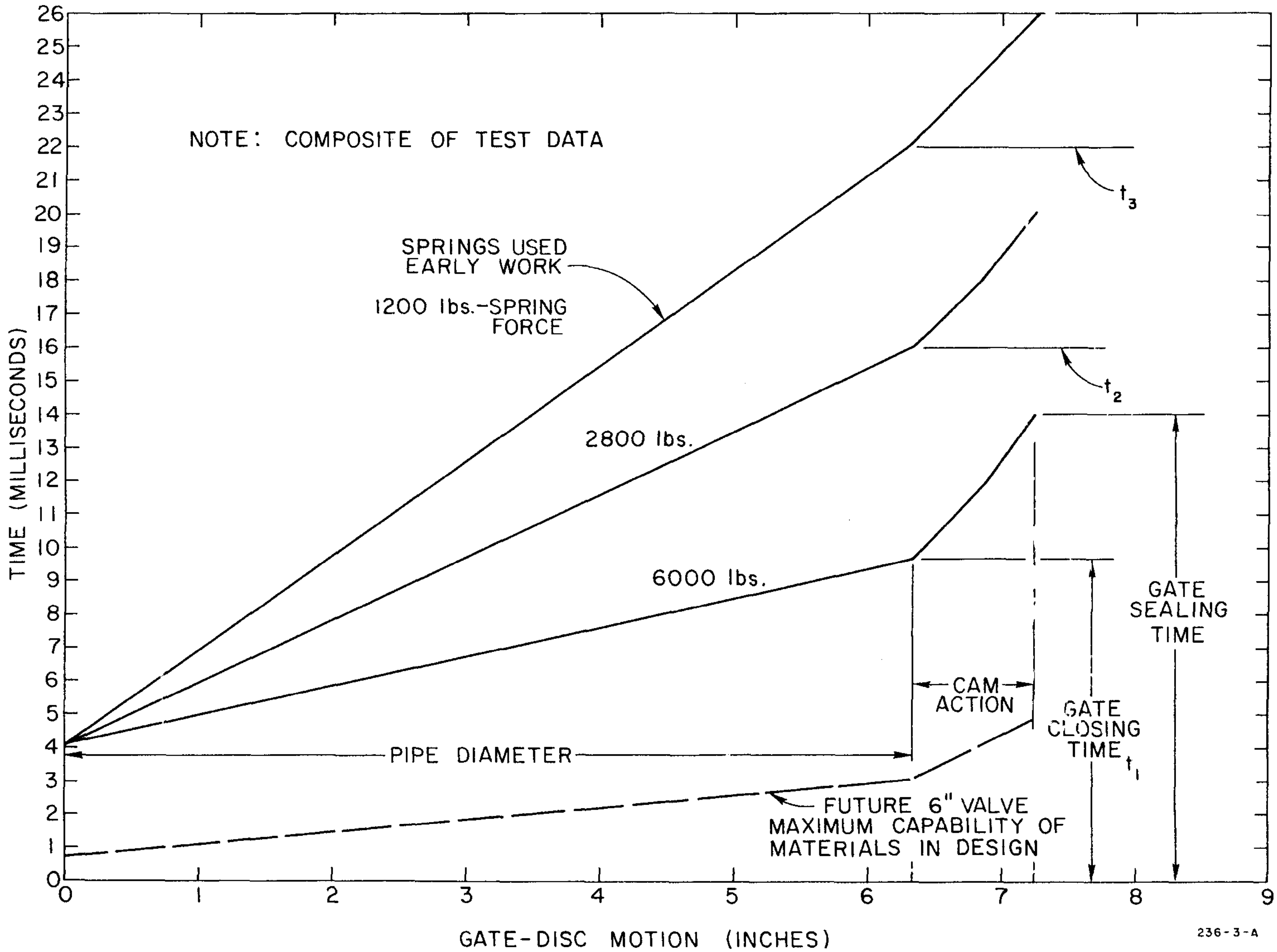


FIG. 3 - VELOCITY GRAPH