6.7 EXPANSION SYSTEM FOR THE ANL 12-FT HYDROGEN BUBBLE CHAMBER *

J.D. Simpson

Argonne National Laboratory.

The purpose of this paper is to outline the design criteria, problems, and operating principle of the expander for the ANL 12-ft bubble chamber.

Until the advent of large chambers, the pulse period was usually as short as conveniently possible in order to avoid parasitic boiling problems which, not uncommonly, limited the minimum expanded pressure attainable. In large chambers, however, sizable pressure gradients are introduced within the chamber volume which increase as the expansion period decreases. Large pressure gradients not only produce variations in sensitivity through the chamber, but also produce thermal heating in the chamber fluid as they dissipate their energy. A reasonable compromise for the 12-ft chamber is a pulse duration of about 35 ms for hydrogen operation. This produces about 3 psi difference in the expanded pressure from top to bottom for 60 psi average drop.

The entire lower surface of the chamber is moved 1-1/8 in. to expand the chamber, providing about 1% volumetric change.

Figure 1 illustrates the important features of our design. In equivalent mechanical lumped constants, it consists of a mass (that of the real mass plus effective oil mass, totalling about 800 slugs), supported between two springs (that provided by the compressible chamber and that of accumulators). The large area of the main piston, together with a typical bulk modulus of 7000 psi for the hydrogen, provides an effective spring constant leading to a "natural" period of about 50 ms. Thus, to realize a 35 ms period, the accumulators need only to equal this spring rate. Air springs could provide this, but such springs have hyperbolic response. Consequently, higher accelerations result than if a linear system were used to obtain the same cycle period. To more nearly approach a sinusoidal piston motion, we plan to change the accumulators with liquid Freon-12,† which is quite compressible at moderate temperatures. An obvious method of "latching" such an oscillator would be to

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† Trademark, DuPont Corporation.

control the oil flow in the spring accumulator lines, but as other bubble chamber expander designs have suggested, separation of the latching system from the spring system can reduce energy losses in the hydraulics.

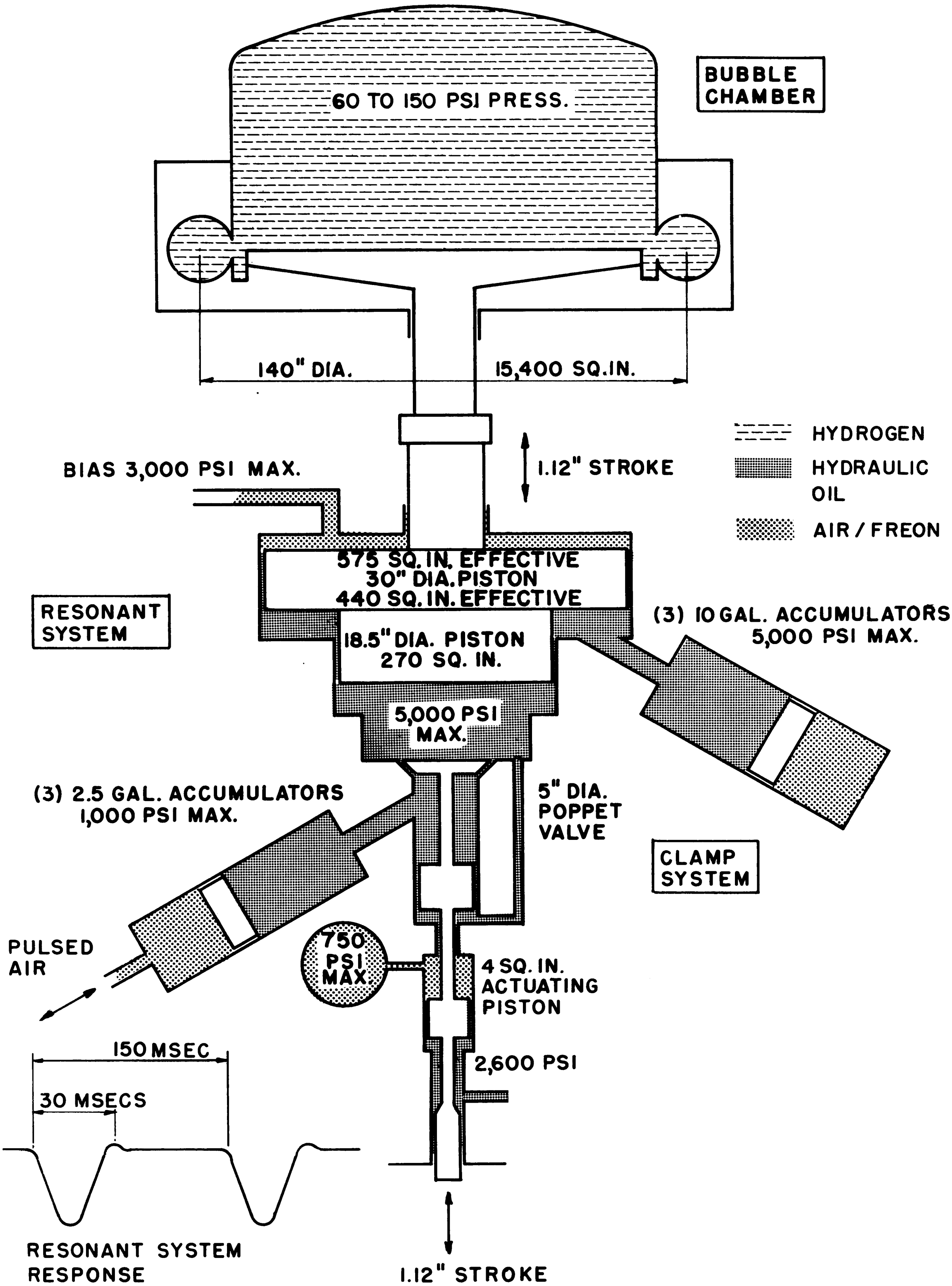
The "latch" or "clamp" system consists of the 270-in.^{2} piston, the 5-in. valve, and the 2.5 gallon accumulators. The valve is a nearly balanced poppet check valve. To pulse the expander, the valve is unseated by applying oil pressure below the 4-in.^{2} actuating piston and held open for at least one half the cycle. During the second half, the oil pressure is removed, but the poppet remains held up by the forward flow of oil through the valve. As the flow diminishes, the valve closes by the force of a pressurized air cylinder. Figure 2 shows an assembly drawing of this valve. All moving parts are of titanium, with the main body being of steel. There are nine porting holes to relieve the balance piston area. We have designed the valve to open in about 10 ms and have calculated the closing behavior (shown in Fig. 3). The total effective moving mass (metal and oil) is about 1-1/2 slugs. The remaining kinetic energy of the poppet at closure will be about 100 ft-lbs.

Calculated energy losses in the system are about 6000 ft-lbs per cycle typically, with about 30,000 ft-lbs of initial energy in the system. This is then a relatively higher "Q" device. The dissipated energy is restored by controlling the air pressure in the clamp. During the downstroke of the piston, the air is maintained at lower pressure than during the return stroke. Air for this is furnished by two 60-hp air compressors.

The hydraulic fluid to be used is Skydroil because of its high bulk modulus and excellent lubricating properties. This requires ethylene-propylene to be used for all elastimer seals.

We feel that this system will provide a desirable range of operating conditions for the 12-ft chamber.

LIST OF FIGURES



12 FT. BUBBLE CHAMBER-EXPANDER SYSTEM-SCHEMATIC

Fig. 1

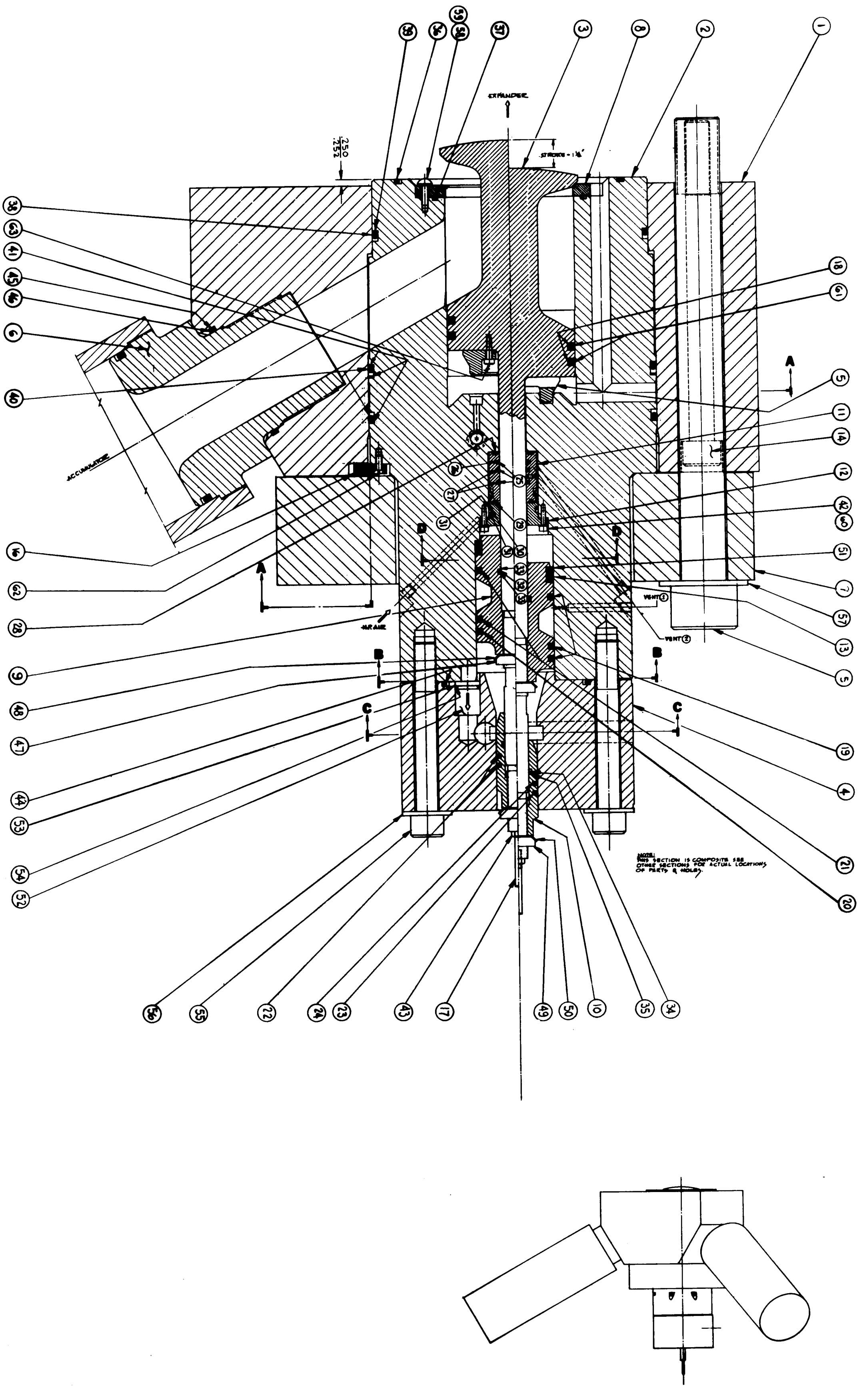
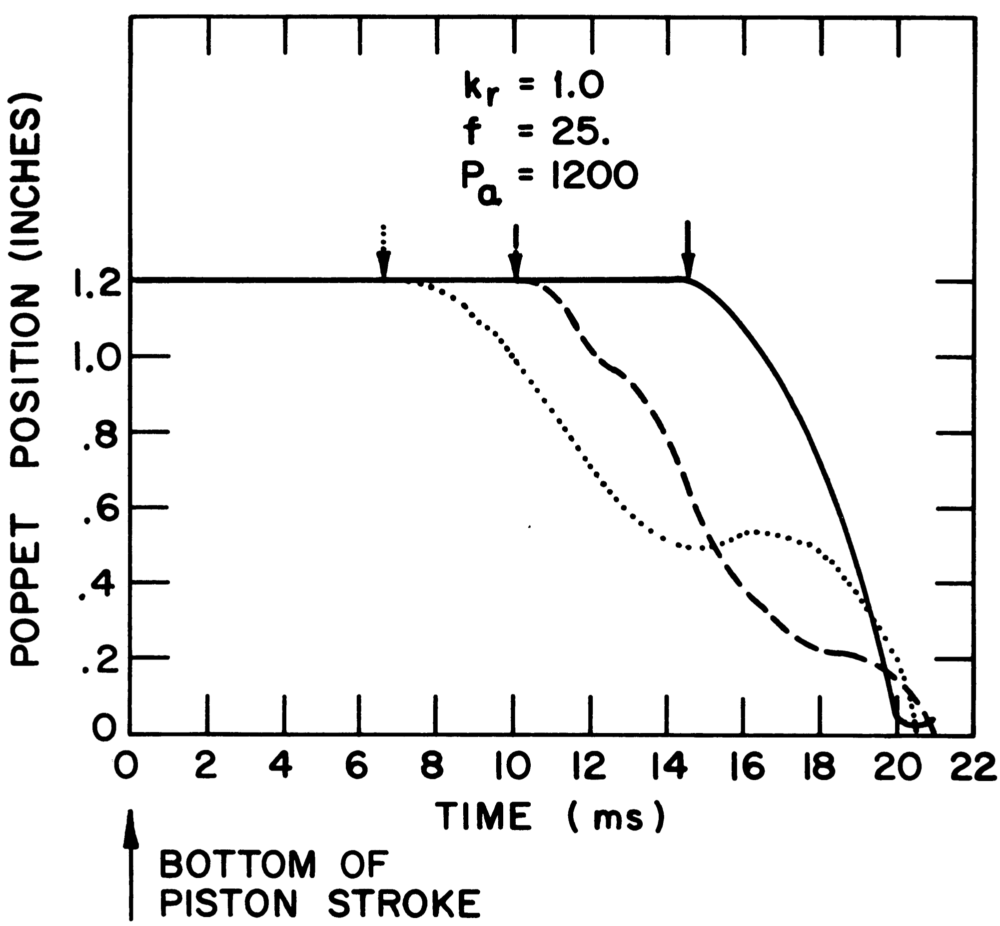


Fig. 2



CALCULATED POPPET POSITION
— vs —
TIME AT CLOSURE

Fig. 3