THE AMES 102 - 25.4-MM LIGHT-GAS-GUN MODEL LAUNCHER

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INTRODUCTION

A Hypersonic Free-Flight Facility, designed for the purpose of studying the aerodynamics and physics of entry into planetary atmospheres, has recently been completed at the Ames Research Center. For use in the three ballistic ranges that have been incorporated in this facility, four light-gas-gun model launchers have been constructed having launch-tube bores of 7.12, 12.7, 25.4 and 38.1 mm. The 25.4-mm launcher was the first to be installed and tested. This paper presents the pertinent mechanical features of this gun, along with a portion of the performance data obtained during the initial development firings.

GENERAL DESCRIPTION

This gun is of the deformable-piston type which has a slender tapered bore at the high pressure end of the pump tube and which utilizes a heavy, relatively slow-speed piston. The desired mode of energizing the propellant gas is that of isentropic compression where the attempt is made, by use of the slow-speed piston, to minimize the buildup of strong shocks during compression.

An overall view of the 25.4-mm gun installed in the Gun Development Range of the Hypersonic Free-Flight Facility is shown in figure 1. The gun is essentially unrestrained in the longitudinal direction and is allowed to slide in its supports during firing. The launch tube, seen in the upper left in figure 2, consists of a 3/16-in.-wall seamless-tube liner supported externally by a heavy split-rectangular block clamped by a double row of bolts. The high pressure end of the pump tube can be seen in the right foreground. Figure 3

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presents a closeup of the breech end of the launch tube separated slightly from the end of the high-pressure section of the pump. The ruptured petalling diaphragm from the previous shot can be seen at the center of the coupling. A schematic of the overall gun is shown in figure 4. The 102-mm (4 in.) bore pump tube is 25.3 m (83 ft) long, and the launch tube, 7.92 m (26 ft) or 312 calibers long. The powder chamber volume (6600 cc) is relatively small. A slow-burning powder is used so that burning continues as the piston traverses the first portion of the pump tube. This serves to minimize the initial acceleration of the pump piston which in turn minimizes the generation of shocks in the propellant gas (hydrogen). To facilitate assembly and disassembly, the launch tube is coupled to the pump tube during firing by hydraulic means. Contained within the assembly at the high-pressure end of the pump is a hydraulic piston constructed with a segmented spline shoulder. A ring nut threaded on the end of the launch tube breech has a similar segmented shoulder. When the launch tube and pump tube are brought together during assembly, the spline segments of the nut and piston are oriented so that the one slips past the other. The nut is then rotated so that the shoulder segments oppose each other. Hydraulic pressure is then applied to the piston, which forces the launch tube nut against the pump tube face with a holding force of 1-1/2 million pounds. Disassembly after a round, then, entails simply releasing the hydraulic pressure, rotating the launch tube nut a fraction of a turn to disengage the mating segmented shoulder surfaces, and finally moving the entire pump tube assembly rearward by means of a hydraulic piston located at the powder chamber.

A single seal is used to seal the high-pressure gas at the juncture between the pump and the launch tube. The arrangement, which has proven to be very successful, is illustrated schematically in figure 5. The seal itself is a mild steel ring with a trapezoidal cross section with sides canted 15° and looks somewhat like a Bellville spring. During assembly, when the launch tube is mated with the high pressure coupling, a preload pressure is applied which deforms the seal, expanding it radically outward against the coupling and inward against the shoulder on the launch-tube breech. Pressures exerted between the seal and the mating surfaces are in excess of the yield strength of the steel seal. For the rounds fired to date with this gun and with several other guns at Ames using this type of seal, there has never been the slightest indication of any gas leakage through this joint.

INSTRUMENTATION

Powder gas and hydrogen pressures are monitored during firing with standard strain-gage ballistic cell pressure transducers. Hydrogen pressure, however, is measured during only a portion of the pumping cycle, the gage being located at a position ahead of the tapered coupling. Pump-piston velocity is determined from time measurements made at three points in the pump tube, before entry into the tapered section, with make-circuit wire probes. A microwave reflectometer similar to that developed at Arnold Air Force Station is used to measure the position-time history of the model during launch. A schematic of the reflectometer is shown in figure 6. Microwave radiation is coupled to the launch tube through a bidirectional coupler which was designed to allow passage of the model through this exciter without damage to the model. Fastened to the launch-tube muzzle, the exciter assembly has a bore which expands from launch-tube bore diameter to a cylindrical section 1-1/2 times launch-tube bore. Microwave radiation is fed from the klystron into the bore at this cylindrical section through two transmission slots located 180° apart. Plastic windows, transparent to microwaves, are located between the slots in the exciter body and the waveguide and provide a barrier which protects the waveguide from damage by the propellant gas during launch. A horn reflector is attached to the end of the exciter to reduce end losses. The microwaves reflected from the model are picked up from the launch tube through two receiver slots located 90° from the exciter slots. The reflected signal is then detected, amplified, and recorded on five dual-trace oscilloscopes which provide a continuous recording of the launch cycle of ten oscilloscope sweeps. A convenient trigger for the display oscilloscopes is provided in a novel manner by the light emitted by the hot propellant gas. A photodiode, mounted at the muzzle and slightly off bore line, is positioned so that it looks down the launch-tube bore toward the breech. When the petalling diaphragm ruptures, radiation from the heated hydrogen in the reservoir is transmitted through the plastic models and is seen by the photodiode, which acts as a switch to trigger the scopes.

GUN PERFORMANCE

The performance results obtained during the first eleven rounds are shown in figure 7. The variation of model-launch velocity is plotted as a function of piston velocity for several values of initial pump-tube pressure. The piston velocity is determined over the interval of approximately 1 to 2 meters ahead of the start of the taper in the high-pressure coupling.

CONCLUDING REMARKS

During the initial development rounds this 25.4-mm model launcher has performed very well in most respects. The convenience of the hydraulic system used to couple the launch tube to the pump tube, as well as several other handling features, makes possible a frequency of operation of two rounds per day. The development of a seal at the high-pressure joint which does not leak has not only aided in providing improved performance but has also served to reduce the erosion occurring at this joint to an insignificant amount. It is anticipated that velocities appreciably higher than the maximum of 26,800 ft/sec obtained during the initial rounds will be achieved with further development.

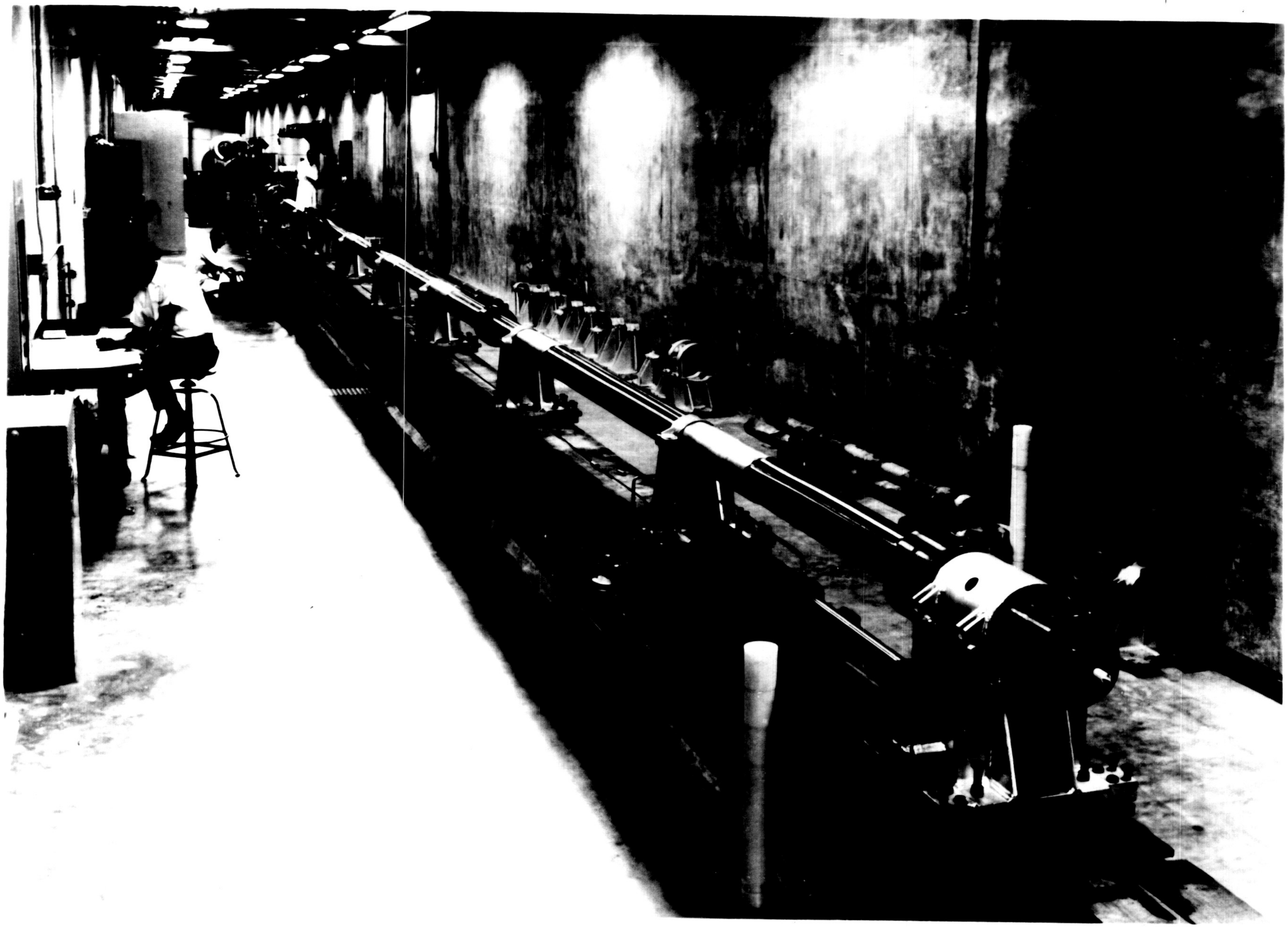


Fig. 1.- Ames 102-25.4-mm light-gas gun, Gun Development Range, HFFF.

A-33714

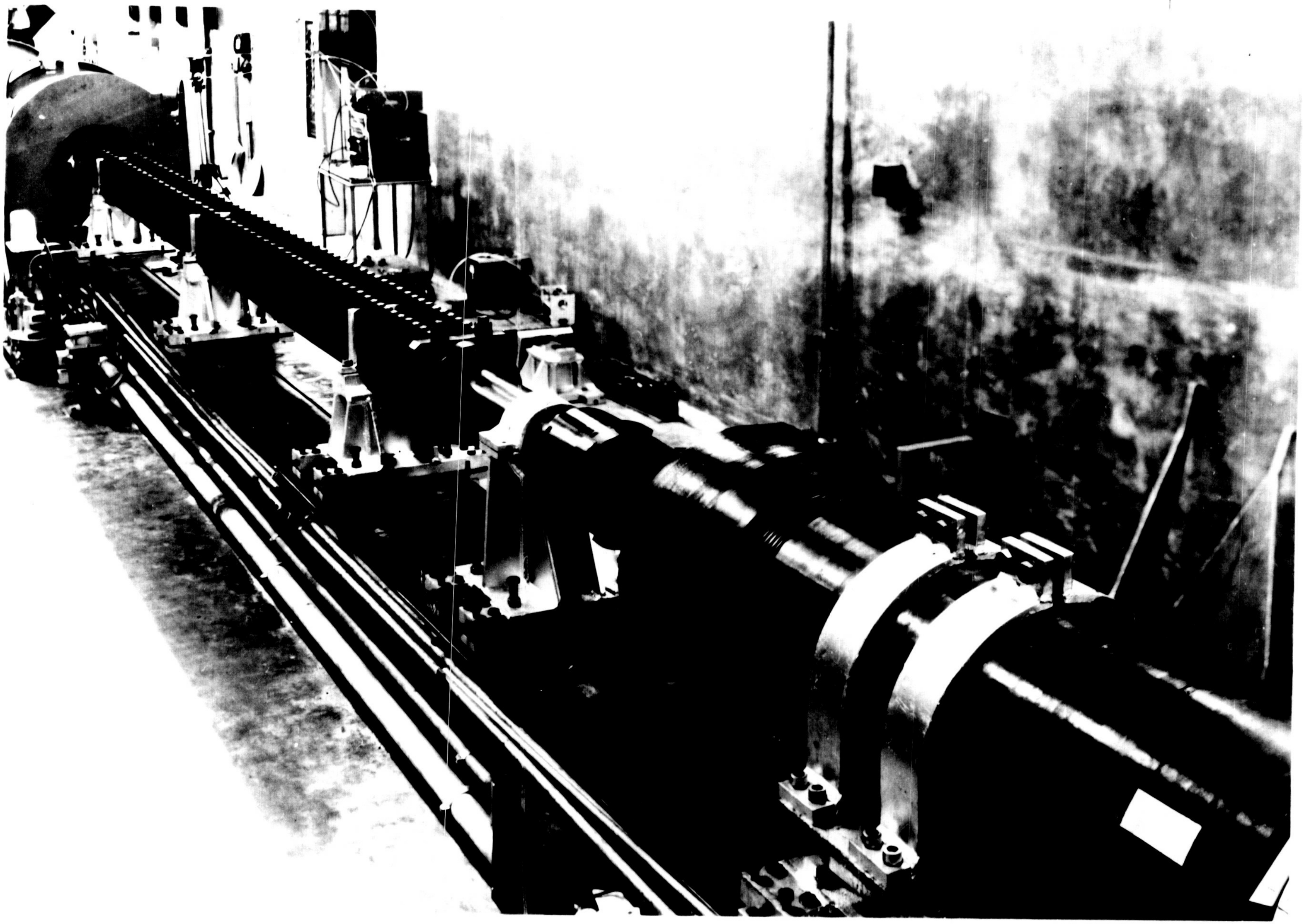


Fig. 2.- Ames 102-25.4-mm light-gas gun, split-clamp launch tube.

#2

A-34267

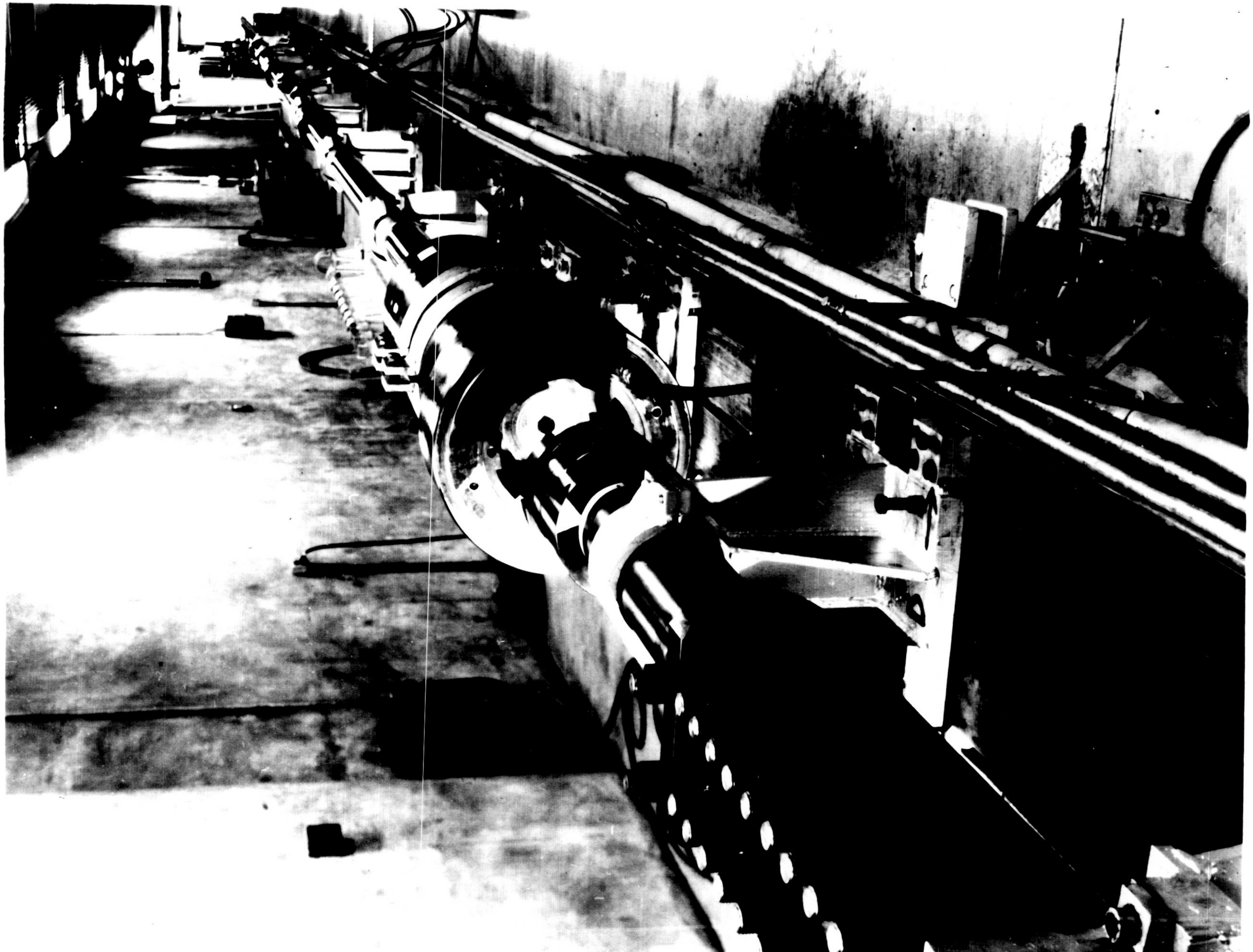


Fig. 3.- Ames 102-25.4-mm light-gas gun, launch-tube breech and high-pressure end of pump tube.

AMES 102-25.4 mm LIGHT GAS GUN

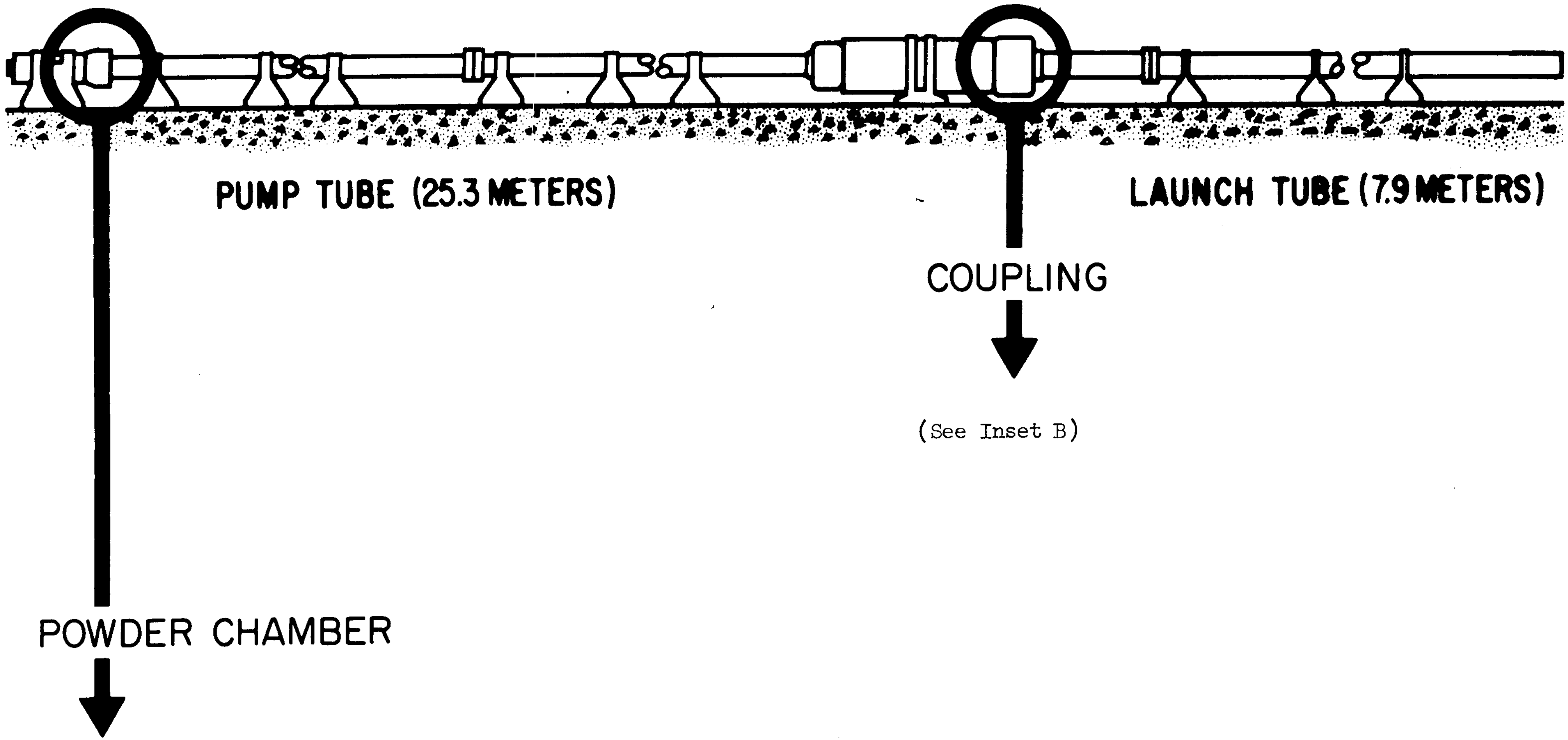


Fig. 4

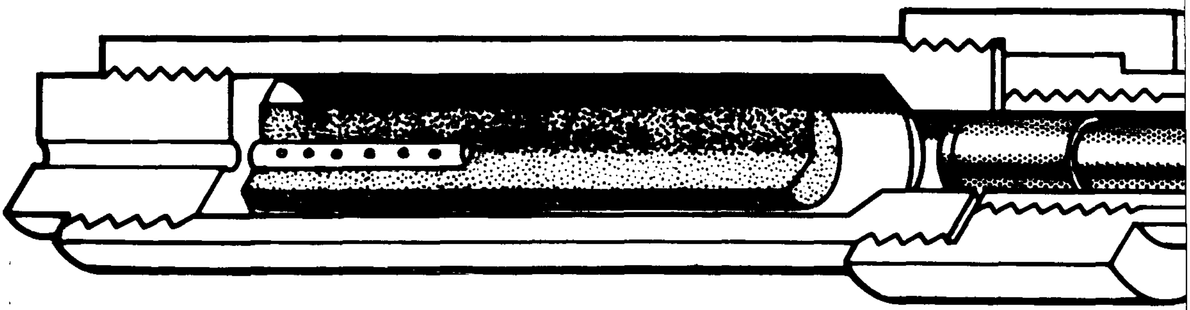
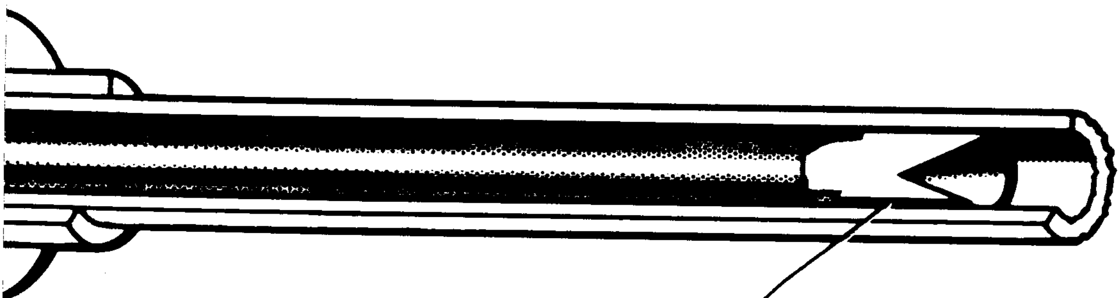


Fig. 4(a)



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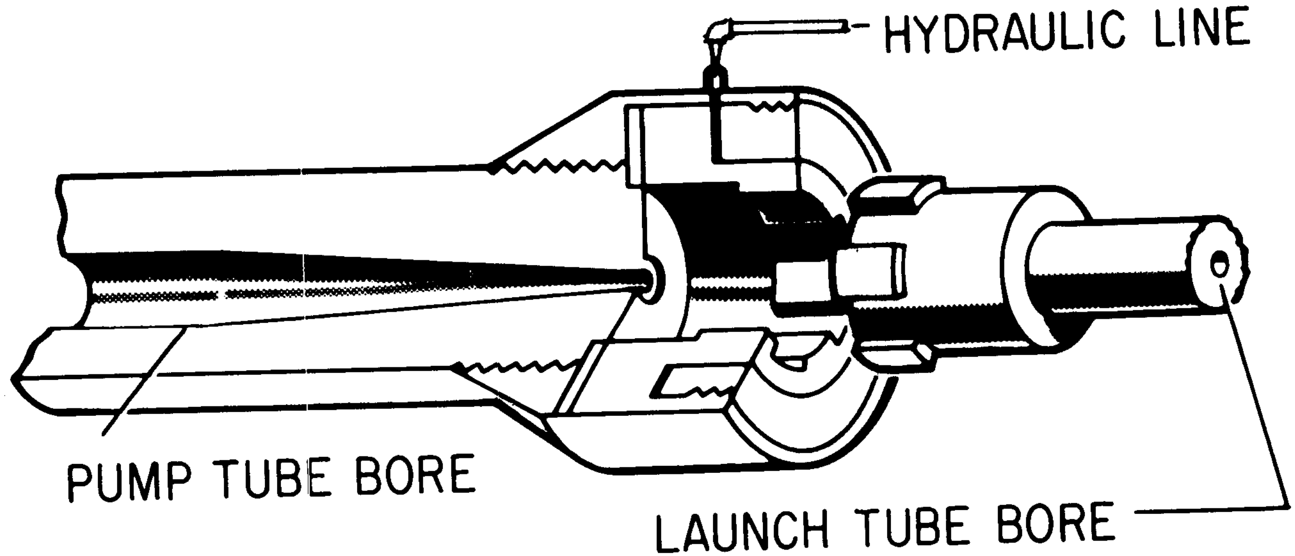

(B)

Fig. 4(b)

HIGH PRESSURE GAS SEAL

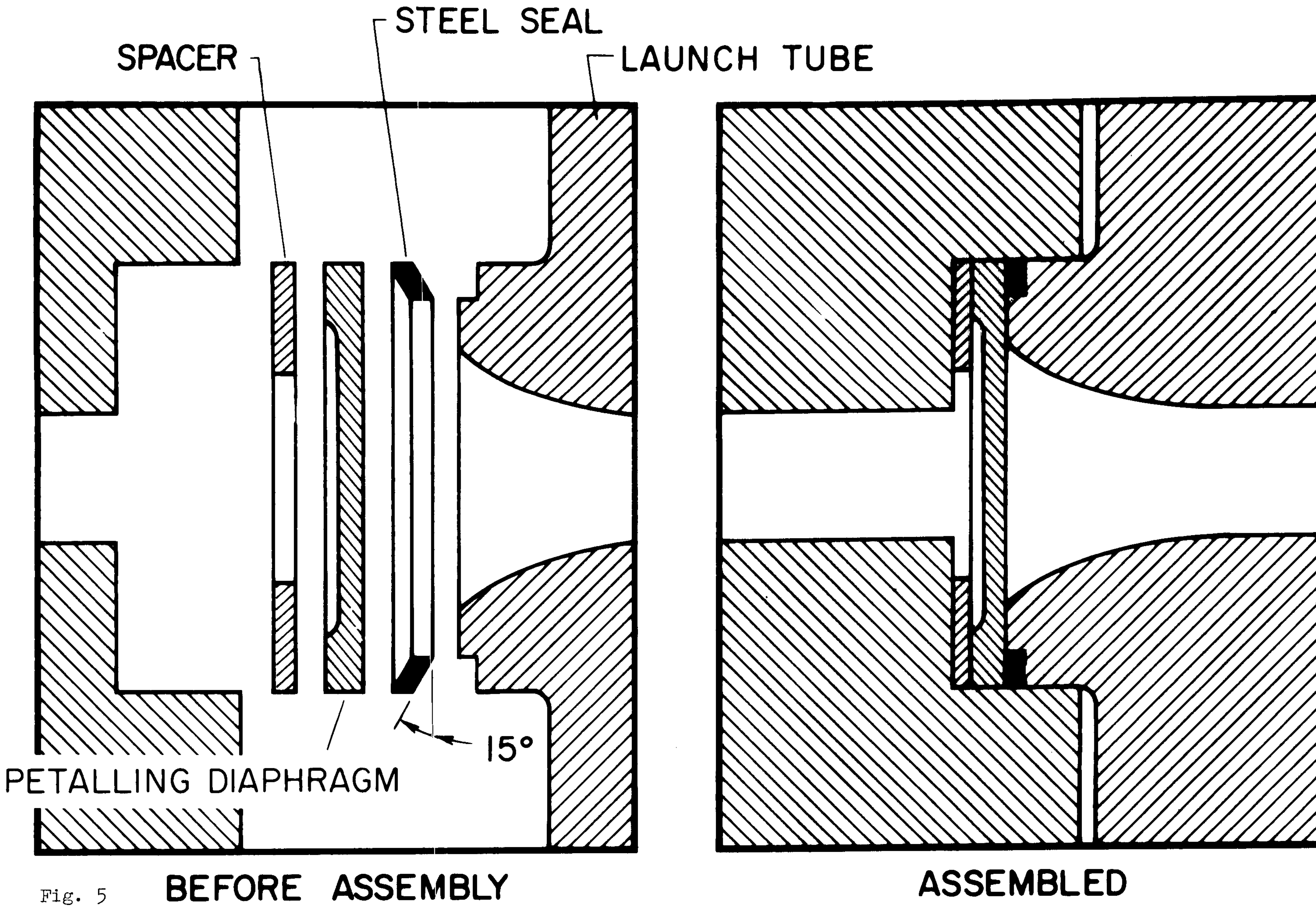

Fig. 5

102-25.4mm LIGHT GAS GUN MICROWAVE REFLECTOMETER

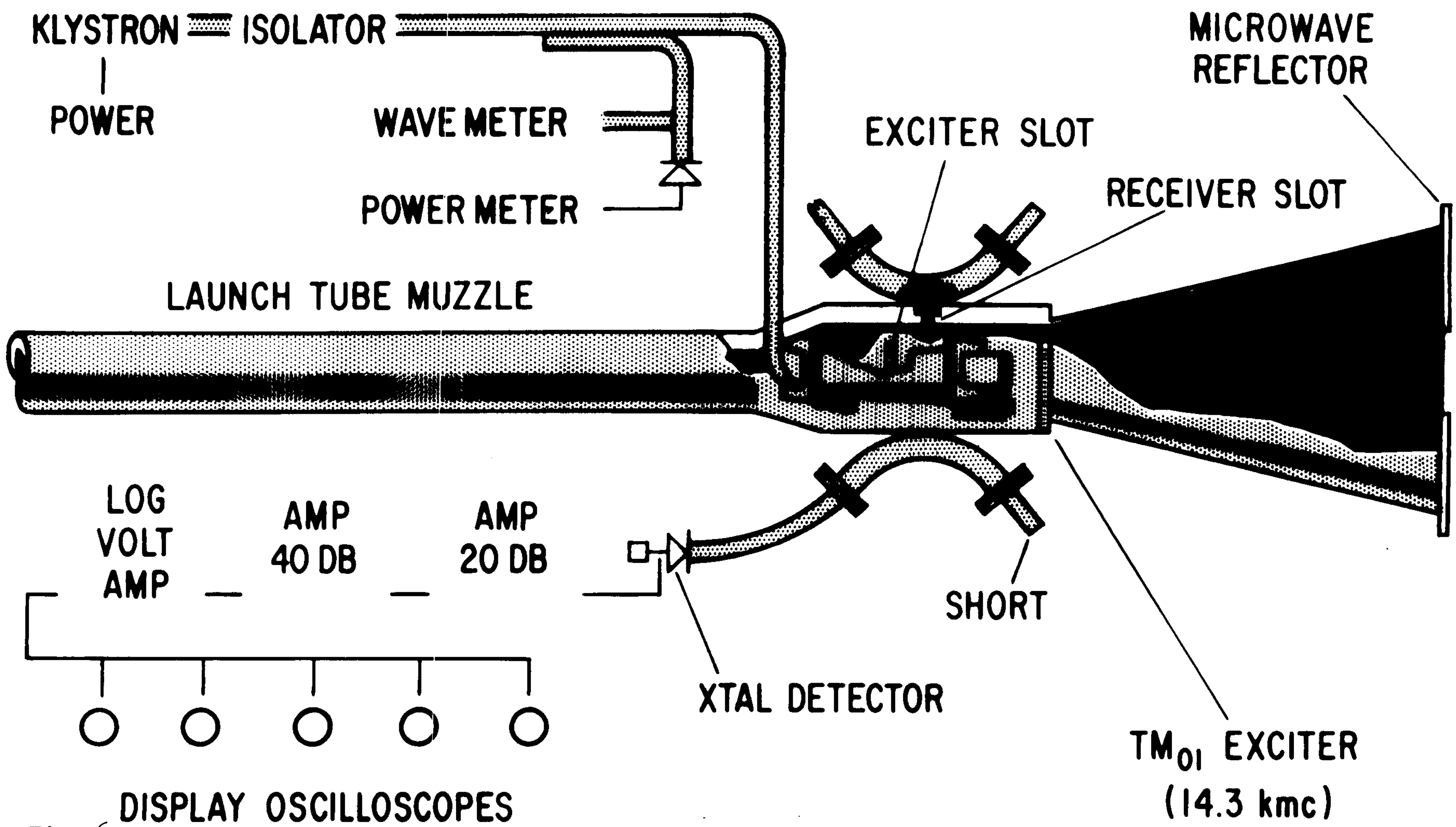

Fig. 6

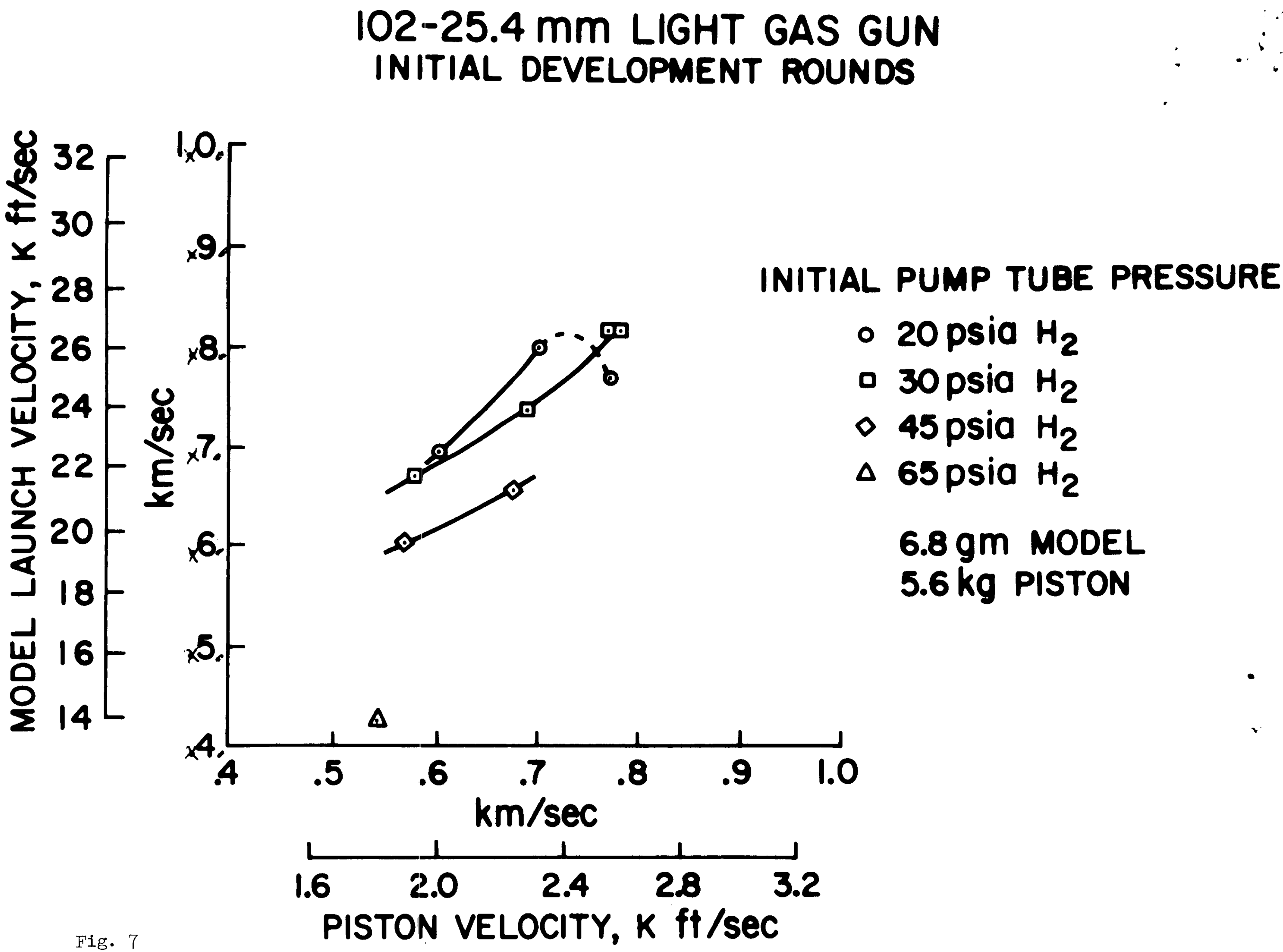
102-25.4 mm LIGHT GAS GUN
INITIAL DEVELOPMENT ROUNDS
MODEL LAUNCH VELOCITY, K ft/sec
32
30
28
26
24
22
20
18
16
14
km/sec
1.0
.9
.8
.7
.6
.5
.4
INITIAL PUMP TUBE PRESSURE
20 psia H_2
30 psia H_2
45 psia H_2
65 psia H_2
6.8 gm MODEL
5.6 kg PISTON
.4
.5
.6
.7
.8
.9
1.0
km/sec
1.6
2.0
2.4
2.8
3.2
PISTON VELOCITY, K ft/sec

Fig. 7