THRUST AUGMENTATION OF A SHROUDED NOZZLE

N95-70864

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SUMMARY:

The test seeks to find the effectiveness of thrust augmentation due to air entrainment at the rocket nozzle exit. Shrouds are attached to the primary nozzle to entrain the ambient air for further expansion. Compressed air is used to simulate a propellant in the primary flow; therefore, combustion and afterburning are excluded. Perfect expansion is used in the primary (unshrouded) nozzle to further rule out the suspicion that the shrouds simply act as a nozzle extension in the event that thrust augmentation is observed. The goal is to find the effectiveness of thrust augmentation as the result of air entrainment alone. Thrust and flow data are recorded for different shrouds at over, fully, and under-expanded conditions. Recorded mass flow rate data will be used to calculate the entrainment rate. Results of this experiment will be verified with a computer code.

DISCUSSION:

The test setup consists of a simple nozzle/shroud apparatus which, supported by four tabs, hangs above a thrust measuring load cell(see Figure 2). Shrouds can be adjusted or removed from the four bolts welded to the nozzle. The load cell is calibrated by placing weights upon a plate resting on the four bolts. Data collected(see Figure 3) includes upstream, chamber, and venturi pressure, upstream and downstream temperature, and thrust. The mass flow rate is found by recording the temperature and venturi pressure in the supply line. Data is stored on paper by a chart recorder.

A CFD code is currently being revised that will account for the air entrainment. Grids for this code have already been generated by a program called 3DGRAPE. Figure 4 is an example of the grid corresponding to the nozzle and shroud at zero distance from each other.

So far, data has been recorded for the fully expanded case. Figure 5 shows the thrust changes for the test shrouds, along with their corresponding geometries. Not enough data has been recorded to draw any meaningful conclusions.

REFERENCES:

TITLE: Experimental and Theoretical Investigation of the Rocket Engine-Nozzle Ejector (RENE) Propulsion System
SOURCE: Air Force Rocket Propulsion Laboratory
Research Technology Division

Air Force Systems Command
United States Air Force
Edwards Air Force Base, California 93523

REPORT
NUMBER: AFRPL-TR-65-66, April 1965

Figure 1: Air Entrainment by a Shrouded Nozzle

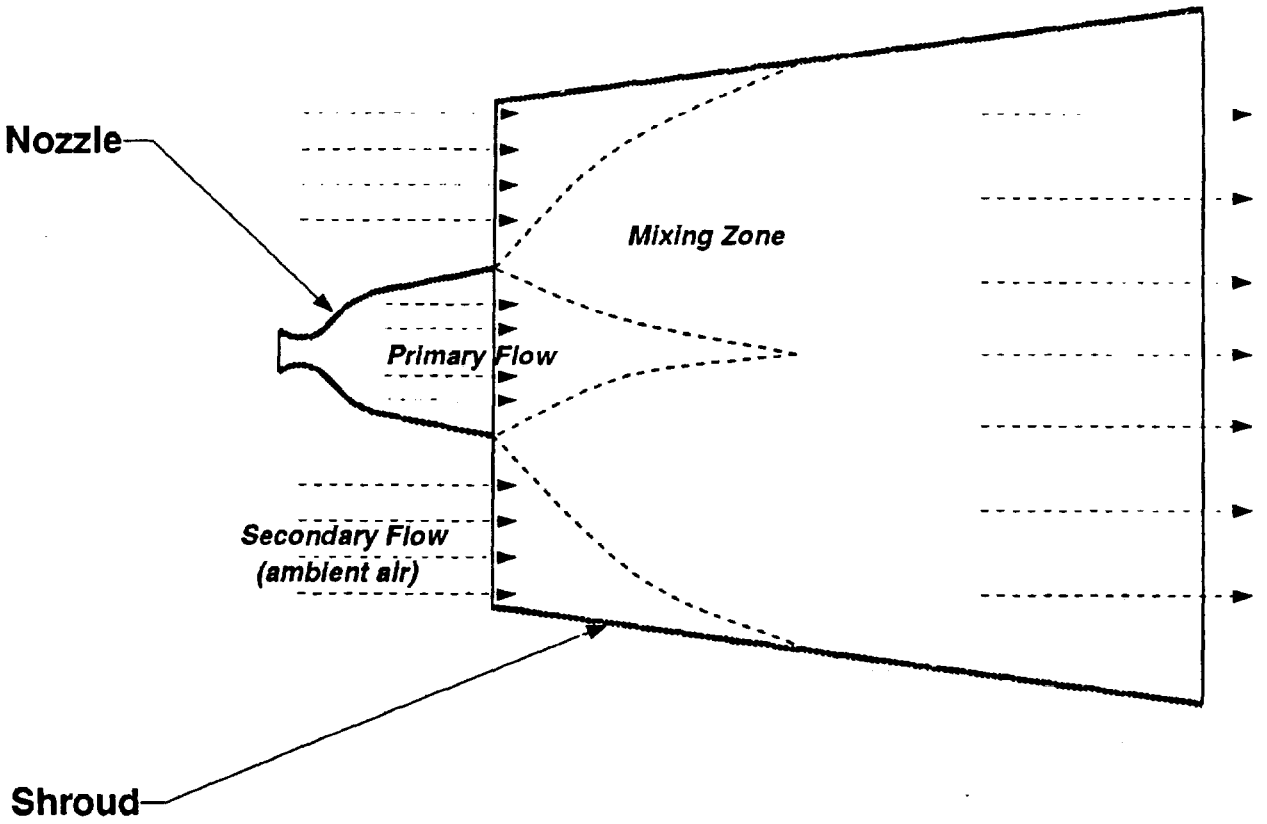


Figure 2: Ejector Rig Setup (partial half section)

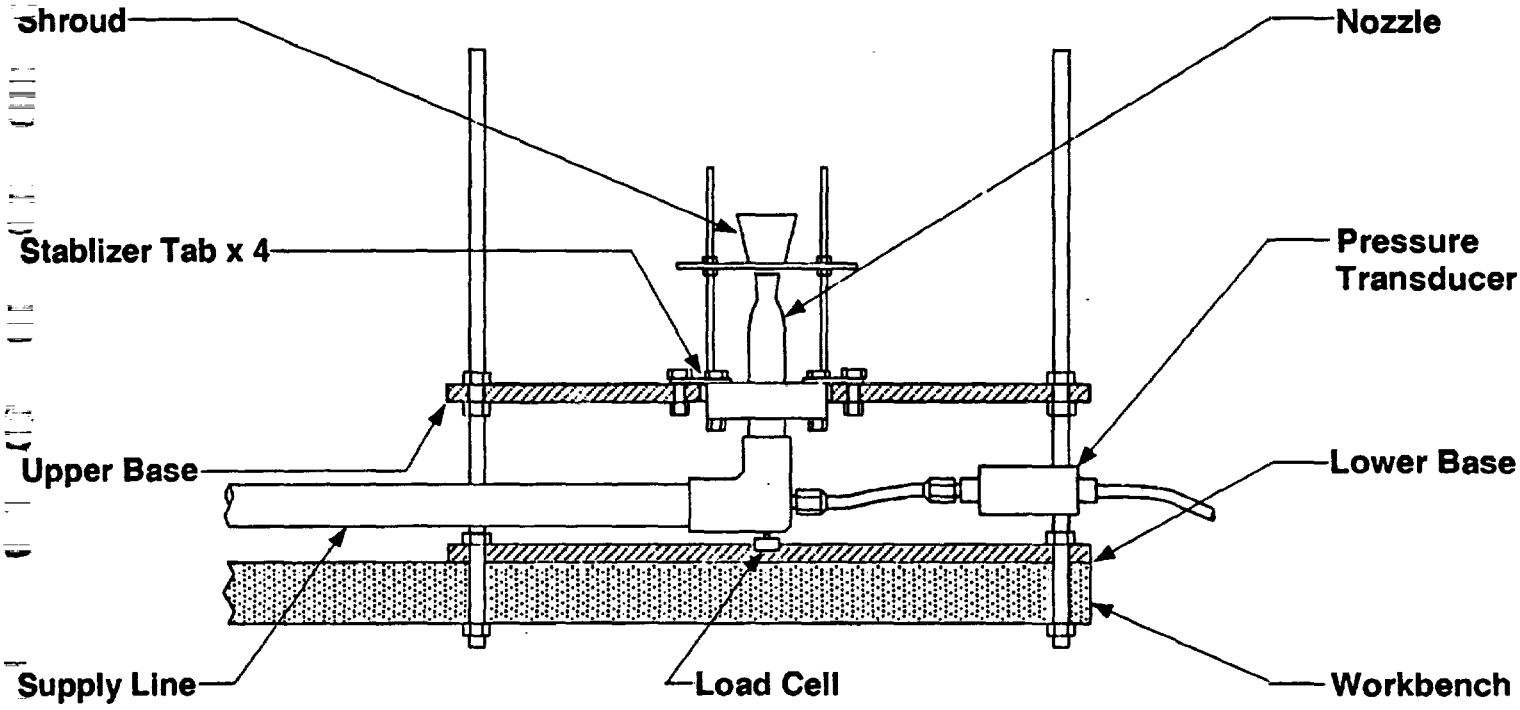
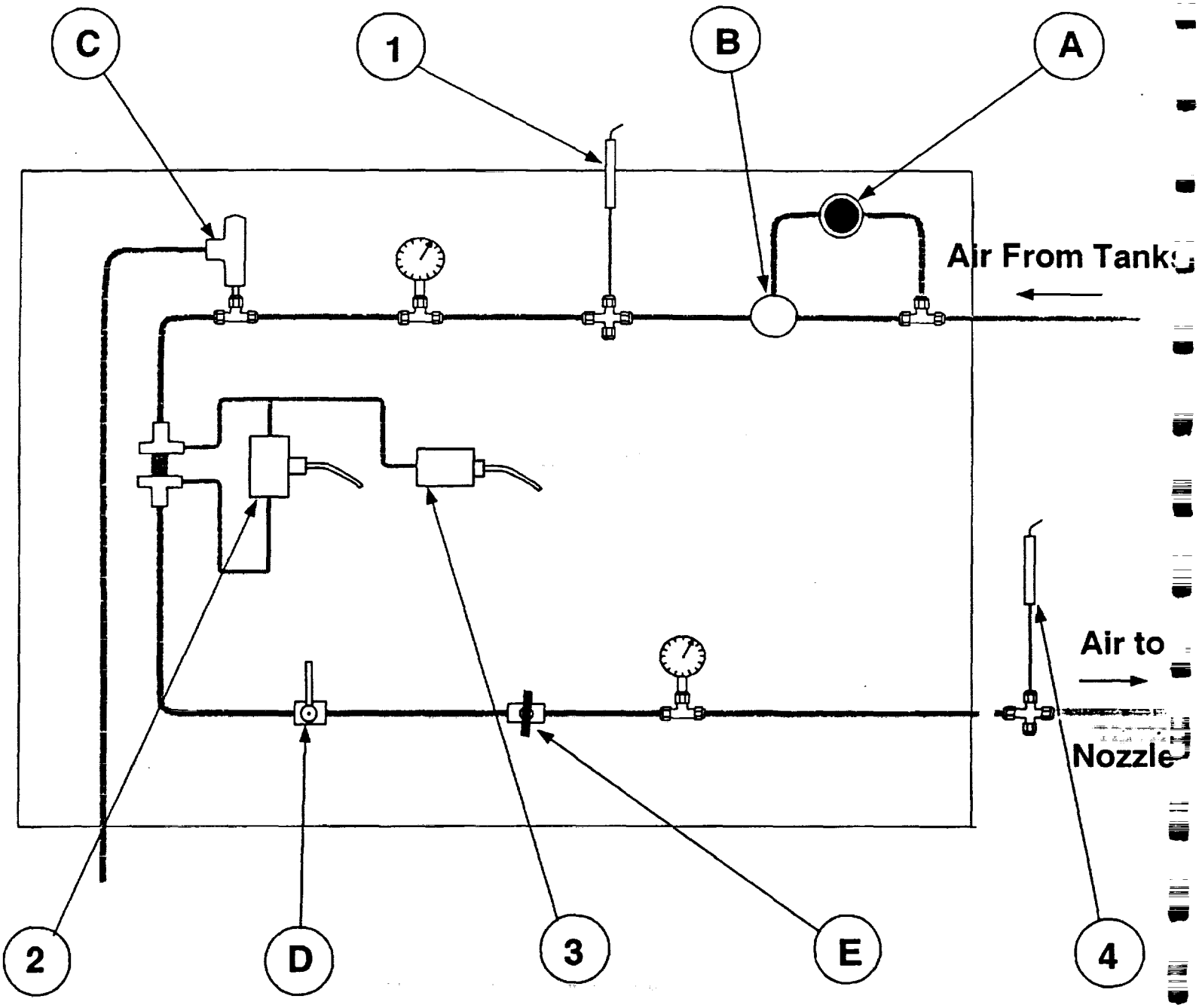


Figure 3: Vertical Control Panel



Valves:

A. Regulator

B. Reduction

C. Safety

D. Butterfly

E. Needle

Sensors:

1. Upstream Thermocouple
2. Venturi Pressure Transducer
3. Upstream Pressure Transducer
4. Downstream Thermocouple

Figure 4: Nozzle/Shoud Grid

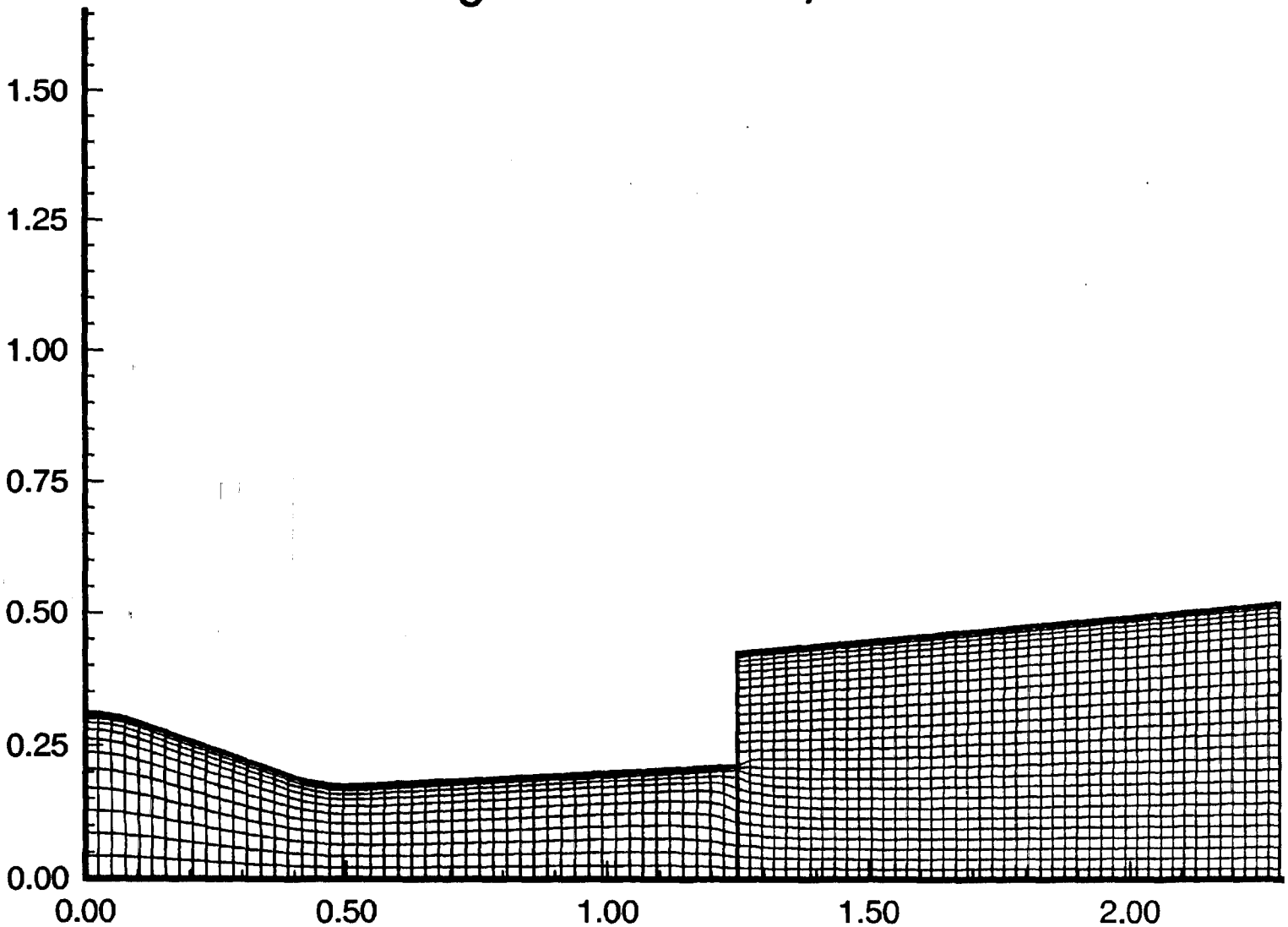


Figure 5: Initial Data

Shroud	Thrust (lb. force)	Thrust Change (lb. force)	A (in.)	B (in.)	L (in.)
none	11.1	-------	-----	------	-------
first	11.3	.2	.85	1.04	1.04
second	11.1	.1	.85	.93	.93
third	11.1	0	.74	.90	.90
fourth	11.0	-.1	.74	.81	.81
fifth	11.2	.1	.67	.82	.82
sixth	11.0	-.1	.67	.74	.74
seventh	11.2	.1	.67	.74	1.48

Theoretical thrust for 90 psi. chamber pressure is 9.953 lb. force.

The chamber pressure for all the above is 91 psia.