

# PERFORMANCE OF A MULTIPLE VENTURI FUEL-AIR PREPARATION SYSTEM

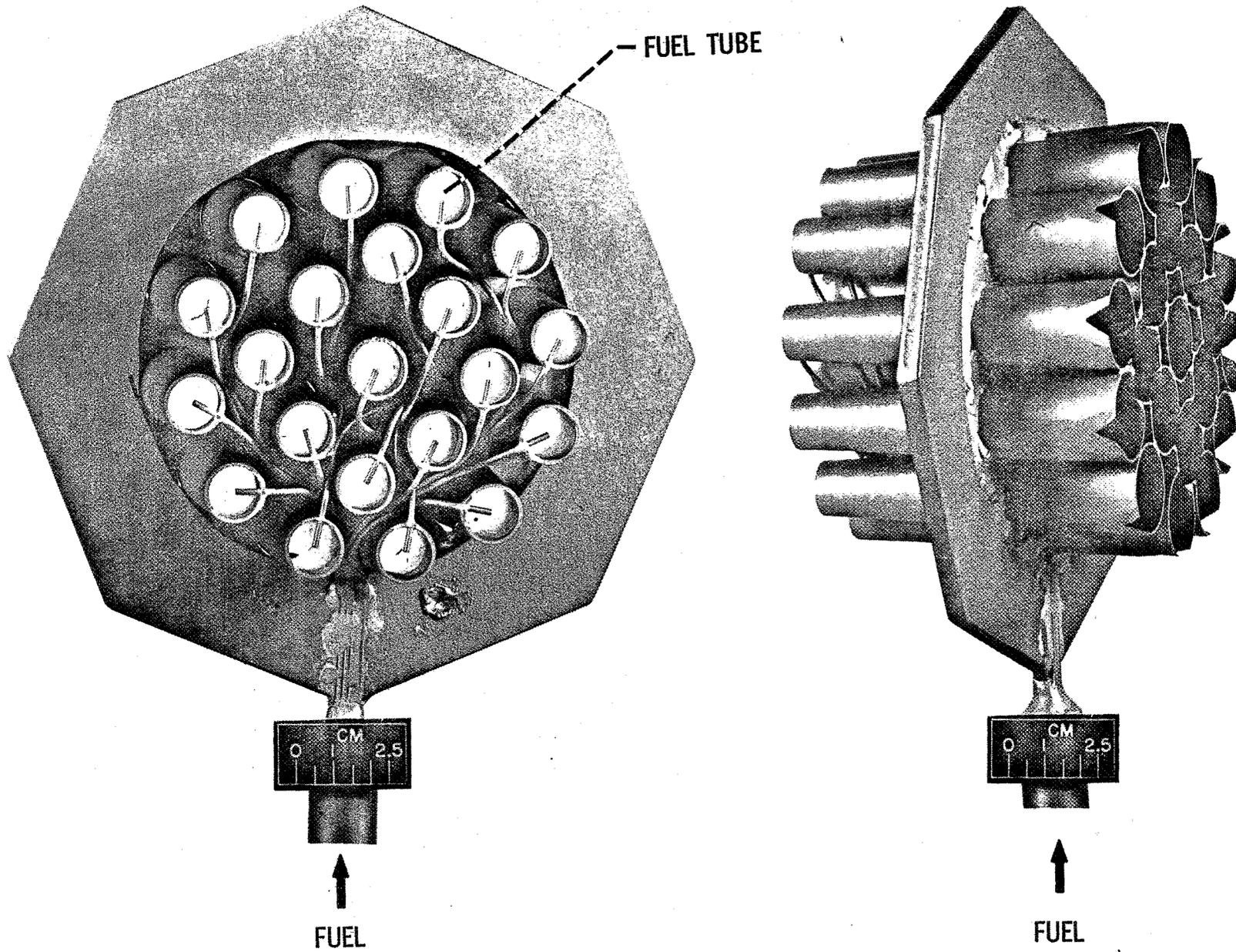
by

Robert R. Tacina

A premixed-prevaporized fuel preparation system was designed and tested for use in catalytic reactors for gas turbine applications. A Multiple Conical Tube fuel injector was previously tested that satisfied the goals for a premixed-prevaporized system (spatial fuel-air distribution was within 10 percent of the mean and nearly 100 percent vaporization was achieved at an inlet air temperature of 700K). The purpose of the conical tubes was to provide high velocity air for atomization and also straighten the inlet air velocity profile. A refinement of this injector was tried that used Venturi tubes instead of conical tubes to improve the atomization and shorten the residence time. Within this Multiple Venturi Tube fuel injector the throat velocity was increased for better atomization with the total pressure loss designed to be the same as the Multiple Conical Tube fuel injector.

Spatial fuel-air distributions, degree of vaporization, and pressure drop were measured 16.5 cm downstream of the fuel injection plane of the Multiple Venturi Tube fuel injector. Tests were performed in a 12 cm tubular duct. Test conditions were: a pressure of 0.3 MPa, inlet air temperature from 400 to 800K, air velocities of 10 and 20 m/s, and fuel-air ratios of 0.010 and 0.020. The fuel was Diesel #2. Spatial fuel-air distributions were within  $\pm 20$  percent of the mean at inlet air temperatures above 450K. At an inlet air temperature of 400K, the fuel-air distribution was within  $\pm 30$  percent of the mean. No distortion in the fuel-air distribution was measured when a 50 percent blockage plate was placed 9.2 cm upstream of the fuel injection plane to distort the inlet air velocity profile. Vaporization of the fuel was 50 percent complete at an inlet air temperature of 400K and the percentage increased linearly with temperature to complete vaporization at 600K. The pressure drop was 3 percent at the design point which was three times greater than the designed value and the single tube experiment value. No autoignition or flashback was observed at the conditions tested. These conditions, except for fuel-air ratio, are in the range where others have obtained autoignition. Thus the autoignition problem is not as severe for a catalytic combustor which operates at fuel-air ratios leaner than the normal flammability limit. Calculation of mean drop size from differing correlations are presented which shows a wide range of calculated mean drop size (13-160  $\mu\text{m}$ ).

# MULTIPLE CONICAL TUBE FUEL INJECTOR



Comparison of Pressure Drop Through Various Single Element Tubes

$T_{in} = 300 \text{ K}, P_{in} = 414 \text{ kPa}$

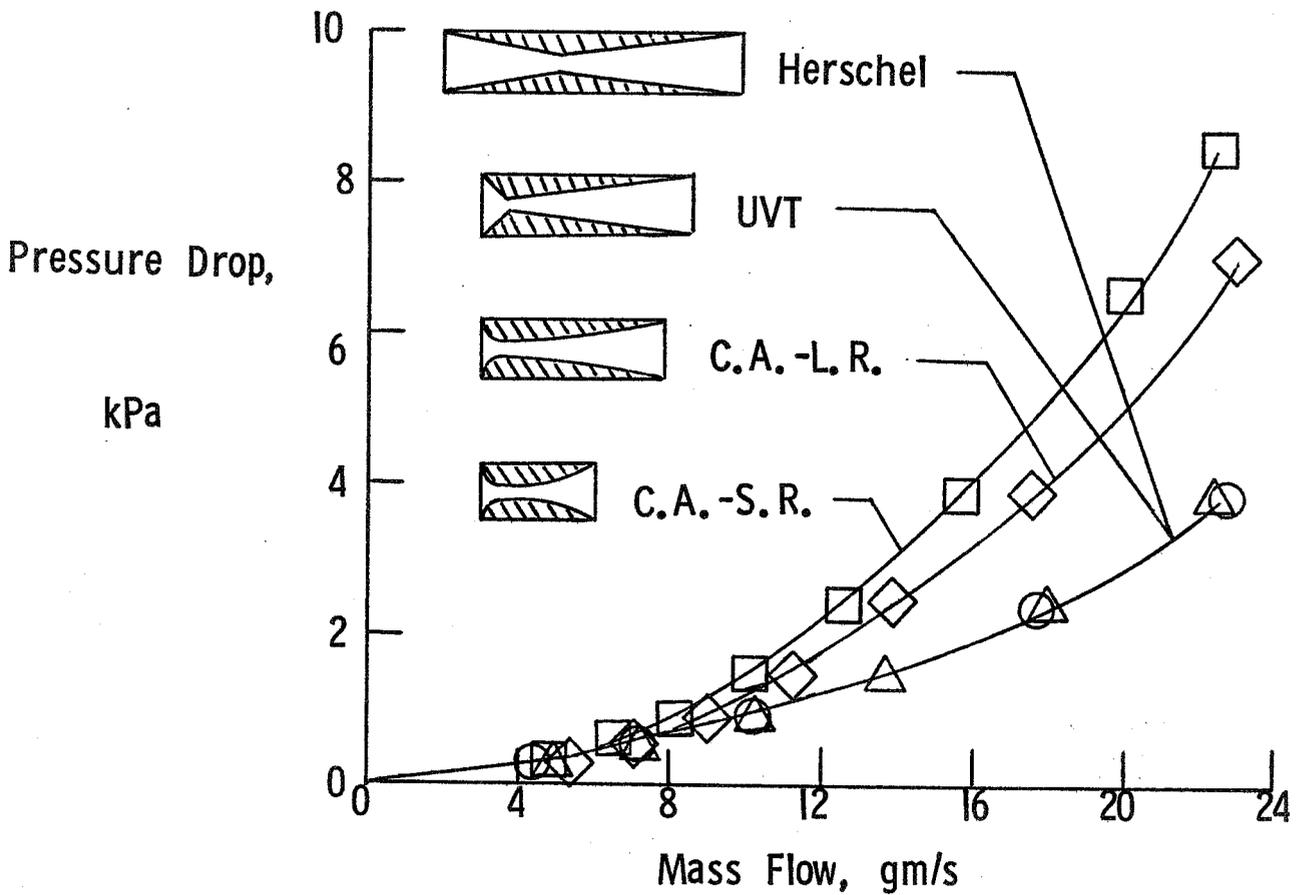
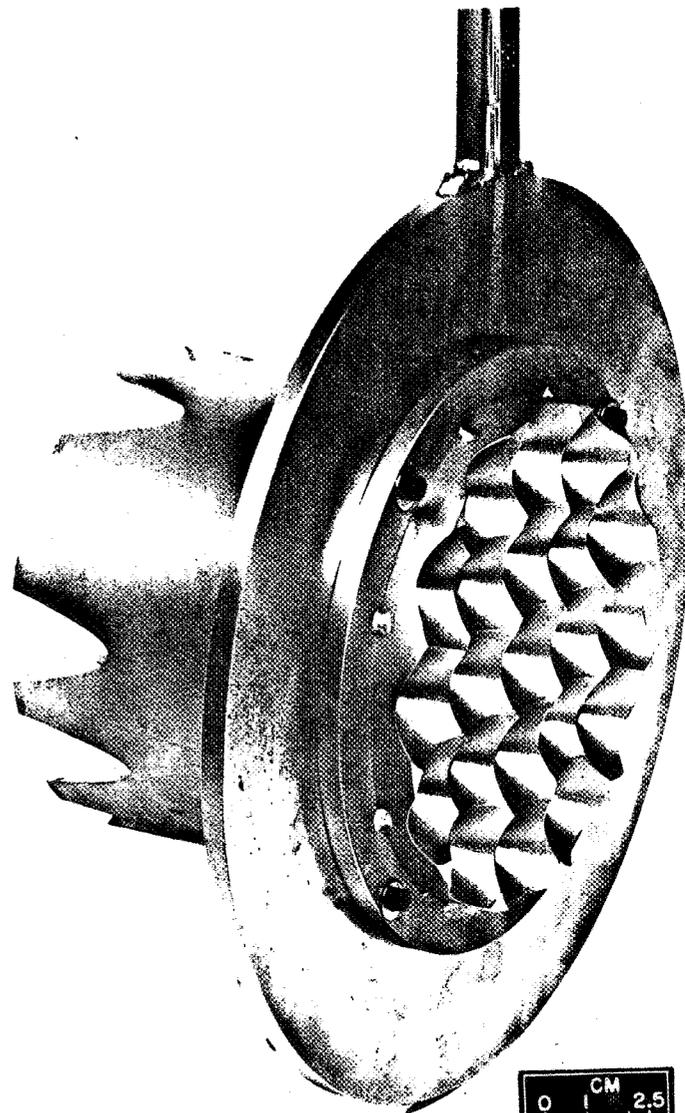
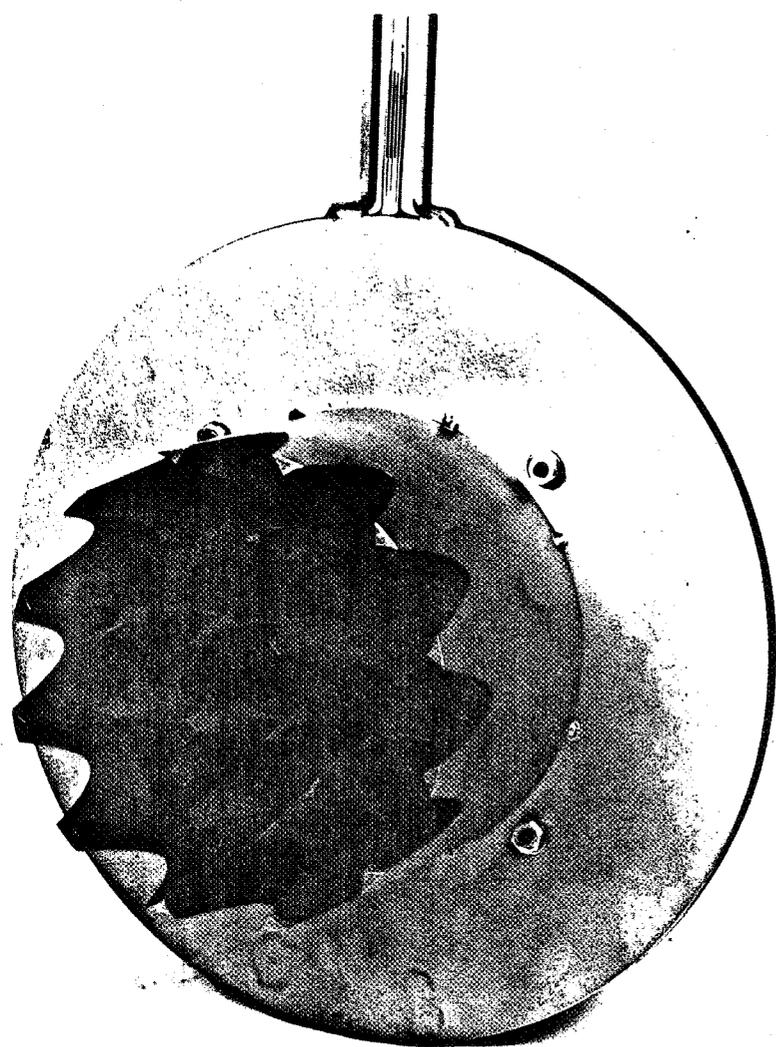
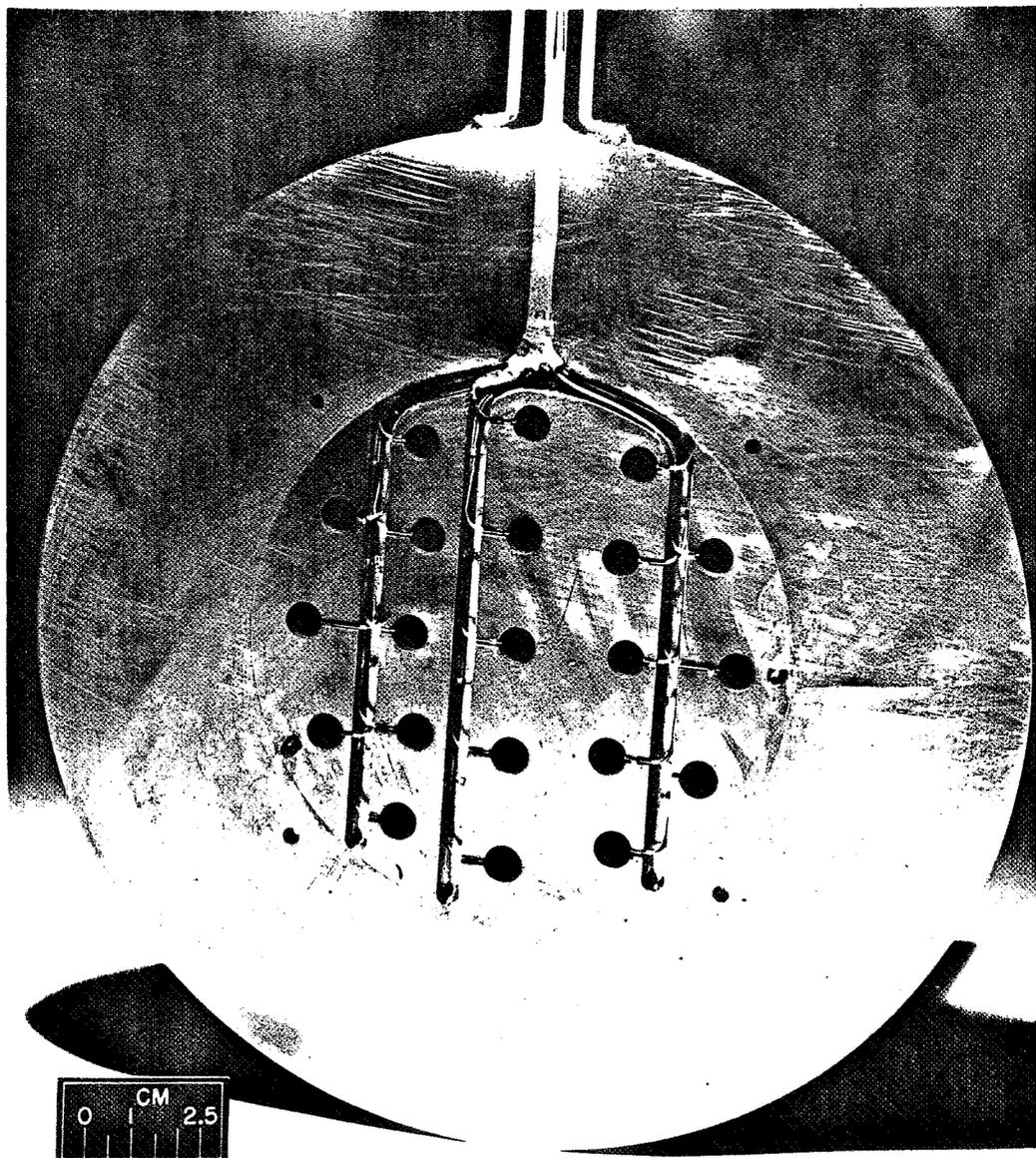


fig. 3

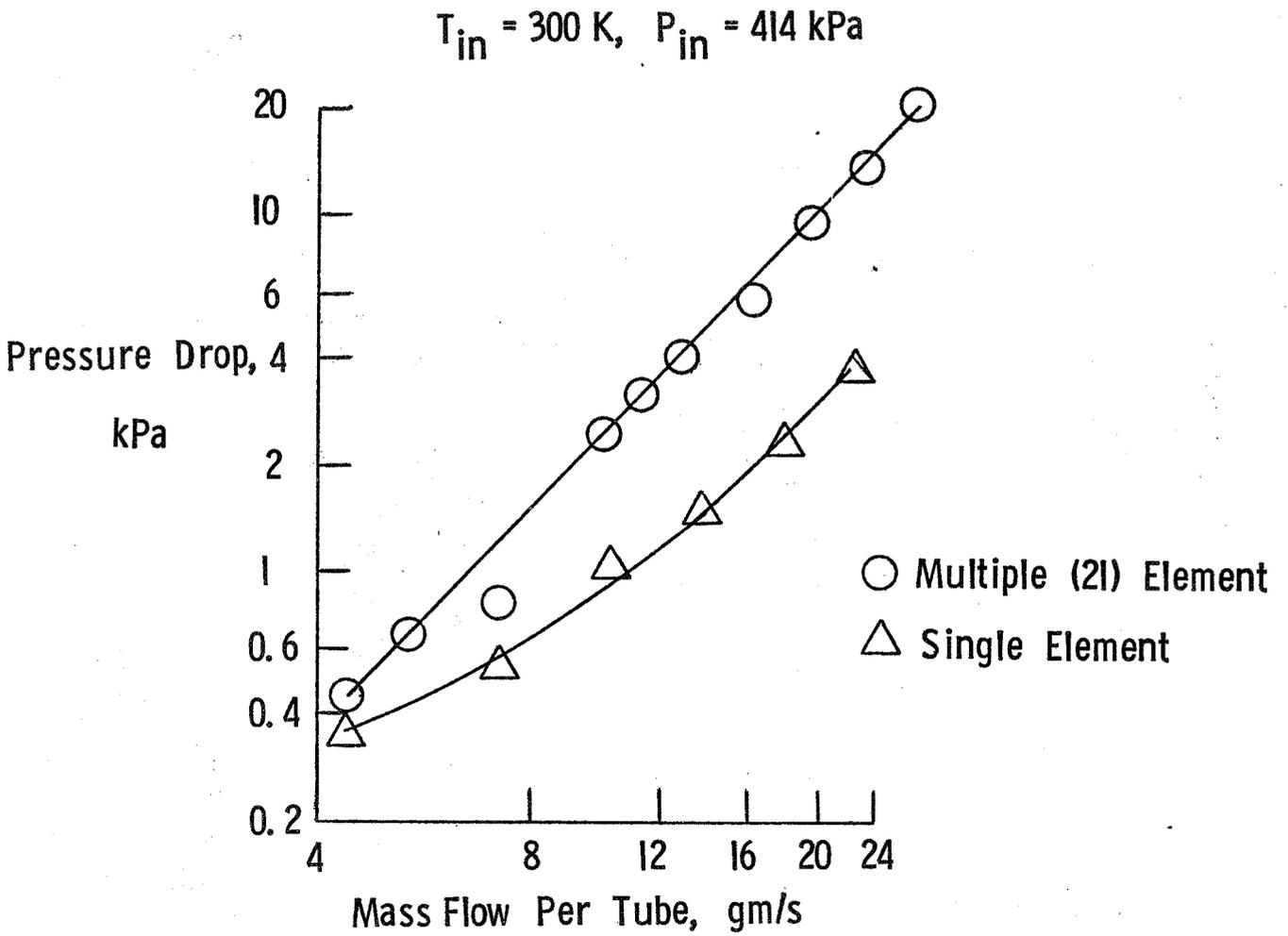
# MULTIPLE VENTURI TUBE FUEL INJECTOR

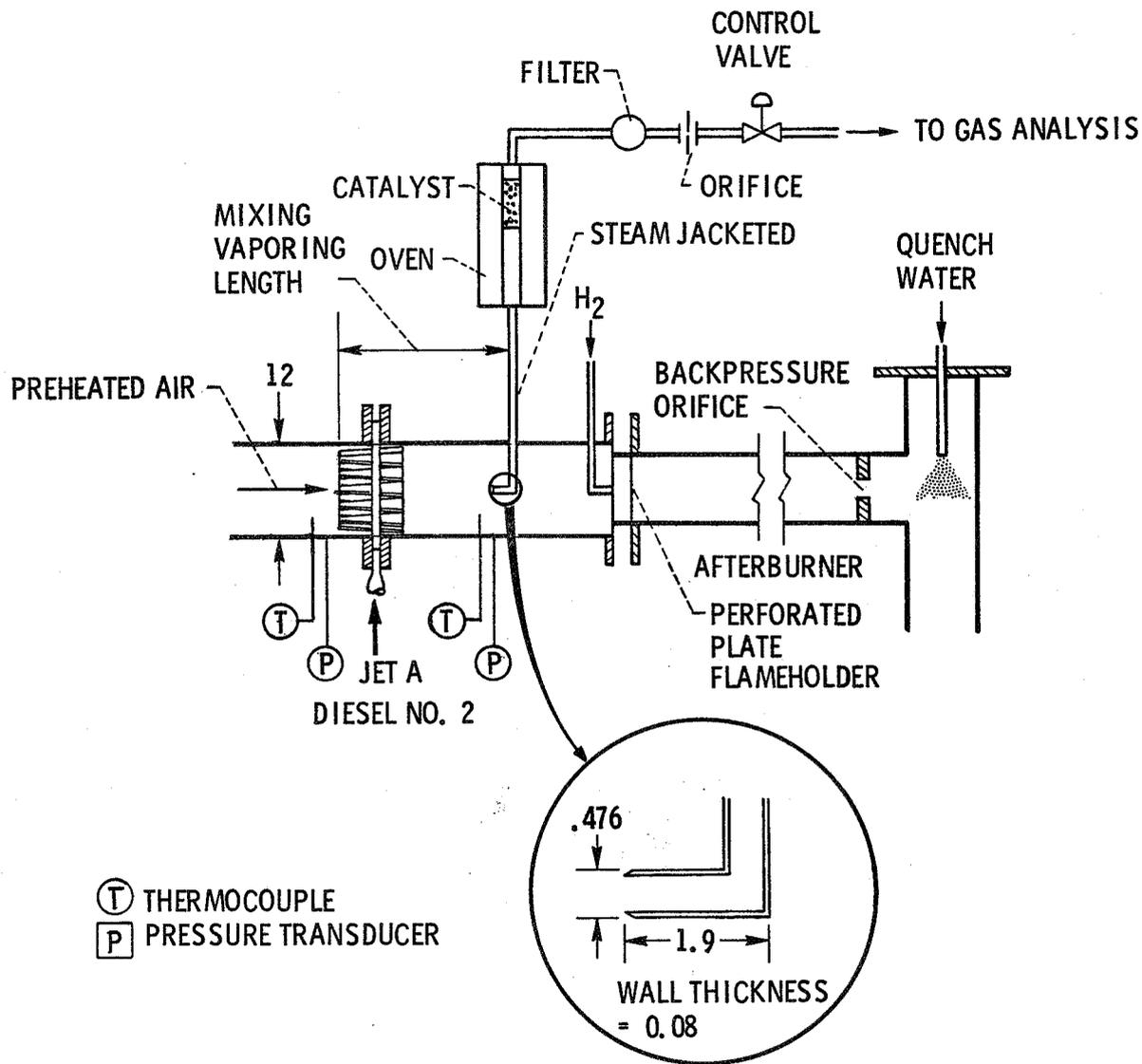


# MULTIPLE VENTURI TUBE FUEL INJECTOR FUEL TUBES



### Comparison of Pressure Drop of Single Element UVT Tube and Multiple Element UVT Tube Array





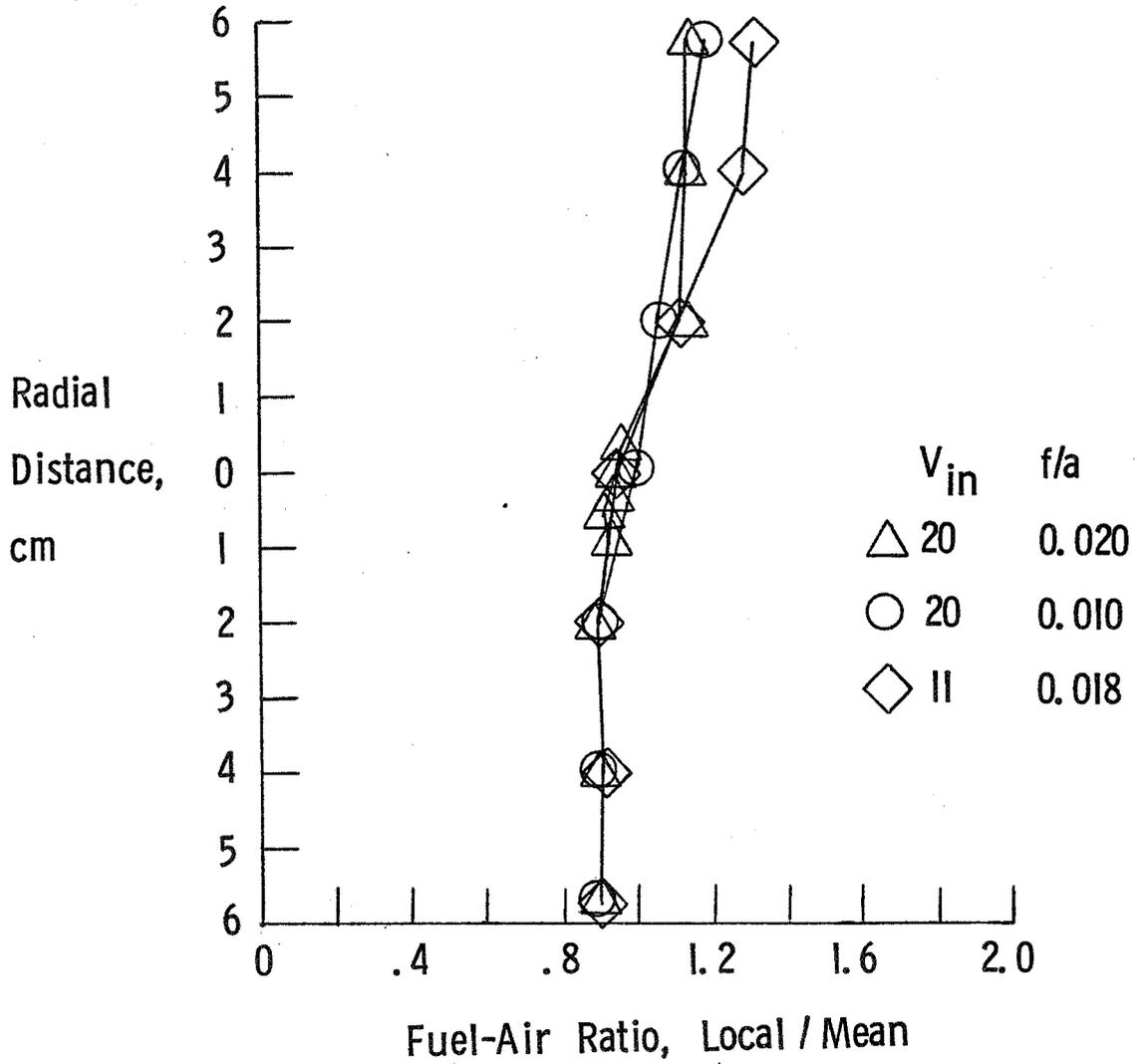
Rig schematic. (Dimensions in cm.)

E-9546

### Spatial Fuel-Air Distribution

#### Multiple Venturi Tube Fuel Injector

$T_{in} = 980 \text{ K}$ ,  $P_{in} = 0.3 \text{ MPa}$ , vap. length = 16.5 cm



Effect of Inlet Air Temperature on Spatial Fuel-Air Distribution

Multiple Venturi Tube Fuel Injector

$P_{in} = 0.3 \text{ MPa}$ ,  $V_{in} = 10 \text{ m/s}$ ,  $f/a = 0.010$ , vap. length = 16.5 cm

