FUEL SPRAY DATA WITH LDV

CONTRACT NAS3-20662

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Successful application of the lean premixing-prevaporizing combustor concept requires an understanding of the operational characteristics of a fuel-air preparation section. The stability limits, efficiency, emissions, autoignition and flashback characteristics of premixing-prevaporizing combustors depends upon the mixing and distribution of fuel droplets, air and vapor, the degree of vaporization, the droplet size distribution and the gas flow properties.

The data obtained in the course of this contract will be used to calibrate and verify an analytical computer model of fuel/air preparation sections.

MEASUREMENT CAPABILITIES

Solar Turbines International sponsored the development of a special instrument for combustion research in gas turbine combustion systems at Spectron Development Laboratories. The instrument is unique in its capabilities of simultaneous measurement of droplet size and two component velocities in the severe environment of an operating gas turbine combustor system (Fig. 1). The instrument is referred to as the Solar Laser Morphokinetomer (SLM) and incorporates the following capabilities:

- Measurement of a true two-dimensional velocity vector with a range of $\pm$(0.01-200 m/sec)
- Measurement of particle size (range 5-300 μm) simulxaneously with the measurement of velocity
- Specification of probe volume position coordinates with a high degree of accuracy ($\pm$0.5 mm)
- Immediate on-line data checks
- Rapid computer storage of acquired data.

The optical system (Fig. 2) of the SLM was constructed based on proven designs and incorporates an ultrasonic beam splitter to allow the measurement of a true two-dimensional velocity vector simultaneously with particle size. The optical system is designed so the instrument can be used in the backscatter observation mode. An off-axis detector with coincidence circuits has been added to further reduce the probe volume size.

A microprocessor (Fig. 3) with a limited storage capability permits immediate analysis of test data in the test cell. A NOVA 2/10 minicomputer is used for on-line data retrieval, temporary storage and limited in-cell data analysis. The test data are then transferred onto magentic tape for later, statistical analysis on an IBM 370/158 computer.

Before measurements can be made on an atomizer or spray nozzle, the instrument must be calibrated. Four experiments have been devised to achieve calibration; a spinning disk, a monodispersed droplet generator, a nitrogen flow tunnel and a calibrated spray nozzle. Each is briefly described below.

Fringe spacing for different optical parameters will be verified using a reference velocity calibrator. This consists of a disc with a steel pin protruding from the edge is rotated through the probe volume at predetermined velocities.

The monodispersed droplet generator will be used to assess the particle size measurement uncertainty of the SLM using water drops with sizes over the range of 15 to 300 μm. Typical microphotographs are shown in Figures 4. Any factors, such as refractive index, which might contribute to sizing errors using Jet A will also be evaluated.

Simultaneous measurement of particle size and velocity will be evaluated in a laboratory experiment. Glass beads of different size ranges 15-37 μm, 53-63 μm, 88-105 μm, 125-145 μm, 177-210 μm, 250-297 μm will be suspended in nitrogen in a fluidized bed and injected into a nitrogen stream. The particle stream exiting the tunnel will be analyzed with the SLM.

A pressure atomizer purchased and calibrated to provide a mean droplet diameter of 75 microns (Sauter Mean Diameter) by the Delavan Corp. will be evaluated at the operating conditions used during manufacturer's calibration in a spray nozzle test stand.

Fuel Spray Rig. When these experimental calibration procedures are completed in early January 1979, the SLM will be employed on the primary contract goal - the characterization of several fuel injectors under varying conditions of air pressure, temperature and equivalence ratio. These injectors will be installed in a special rig built for this purpose. It is shown in Figure 5 and 6 and is the SLM test cell.

Fuel Spray Characterization. During an experiment all pertinent data on air and fuel flow, and wall conditions, will be monitored on a data logger system. Data from the SLM will be automatically screened for validity, counted and stored on magnetic tape for later reduction.

The signal processing system is equipped with a small data acquisition system. This microprocessor is used to acquire large amounts of data in a histogram format and has programs which allow the recording of various system parameters in addition to measured data. The data which can be acquired with this system include: velocity histograms covering four decades of velocity variation; and particle size histograms which are programmed in terms of signal visibility measurements and correlated directly with a library

function which relates signal visibility to particle size. Also included in these programs are weighting factors which allow the normalization of the histogram such that equal sample space volumes are compared for the particle number density measurements. The microprocessor indicates the number of "events" or attempted measurements by the signal processor and it records the total data acquisition time, or the acquisition time for each measurement.

The data tapes will be processed by an IBM 370/158. The steps in this processing are: read header data and perform unit conversion for fixed operating conditions; read data in blocks, screen data against preset conditions, perform engineering unit conversion, apply anti-bias skewing factors, arrange data in matrices for storage, and arrange data in preselected output formats.

PROGRAMS AND PLANS

Calibration experiments have been built and debugged. SLM calibration is underway with completion scheduled for mid January. Software for data acquisition and for data handling are essentially completed.

Instrument bias studies have been completed by Dr. Farmer. The rig has been built, instrumented and installed. First atomizer tests should begin in mid January 1979. Atomizer characterization tests will continue through several months of FY 79.

1. Two equal intensity, coherent light beams are mixed at an angle.

2. A well-defined set of equally spaced interference fringes is formed by interference of the two beams.

3. Light scattered by a particle traversing the fringe set is modulated according to size and position of the particle.

4. Particle size is determined from the ratio of the amplitudes of (1) the modulated scattered intensity to (2) the average scattered intensity.

5. Particle velocity is determined by measurement of the signal time period.

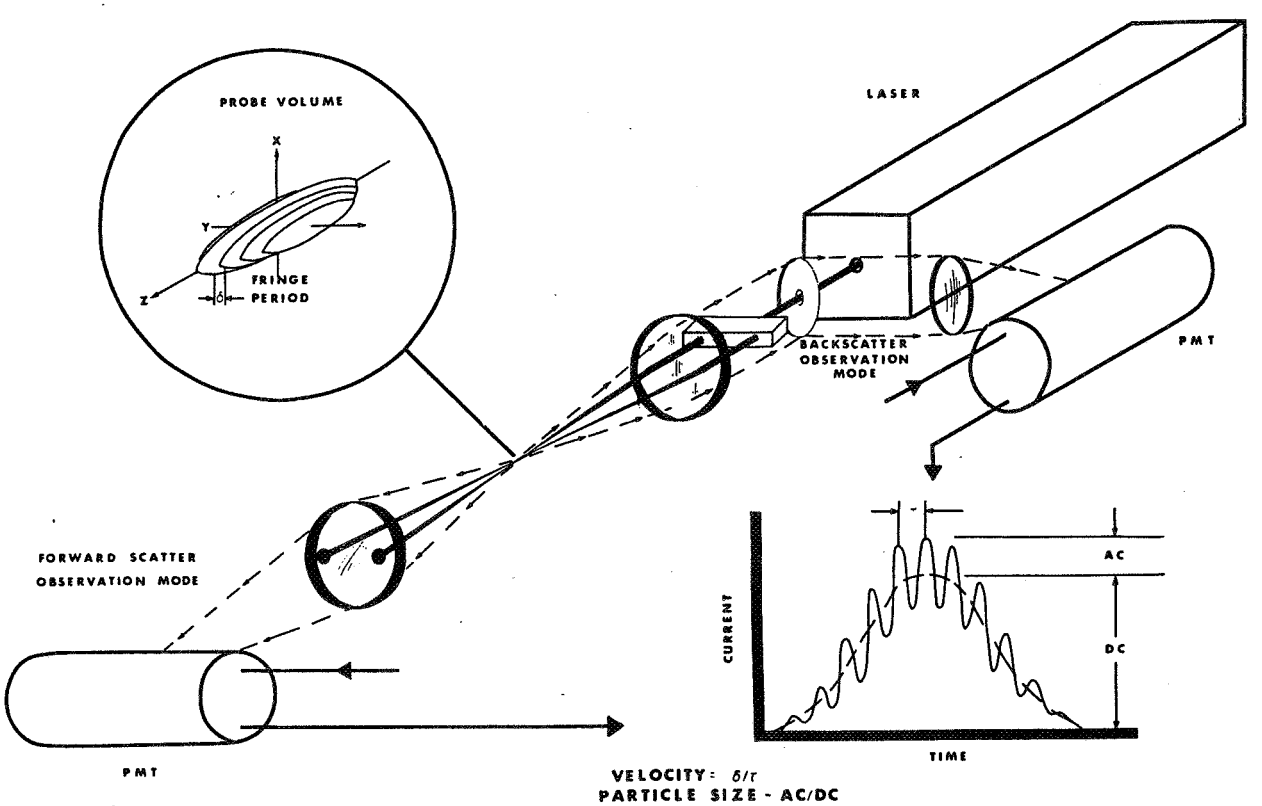

Figure 1. Interferometric Measurement of Velocity and Particle Size

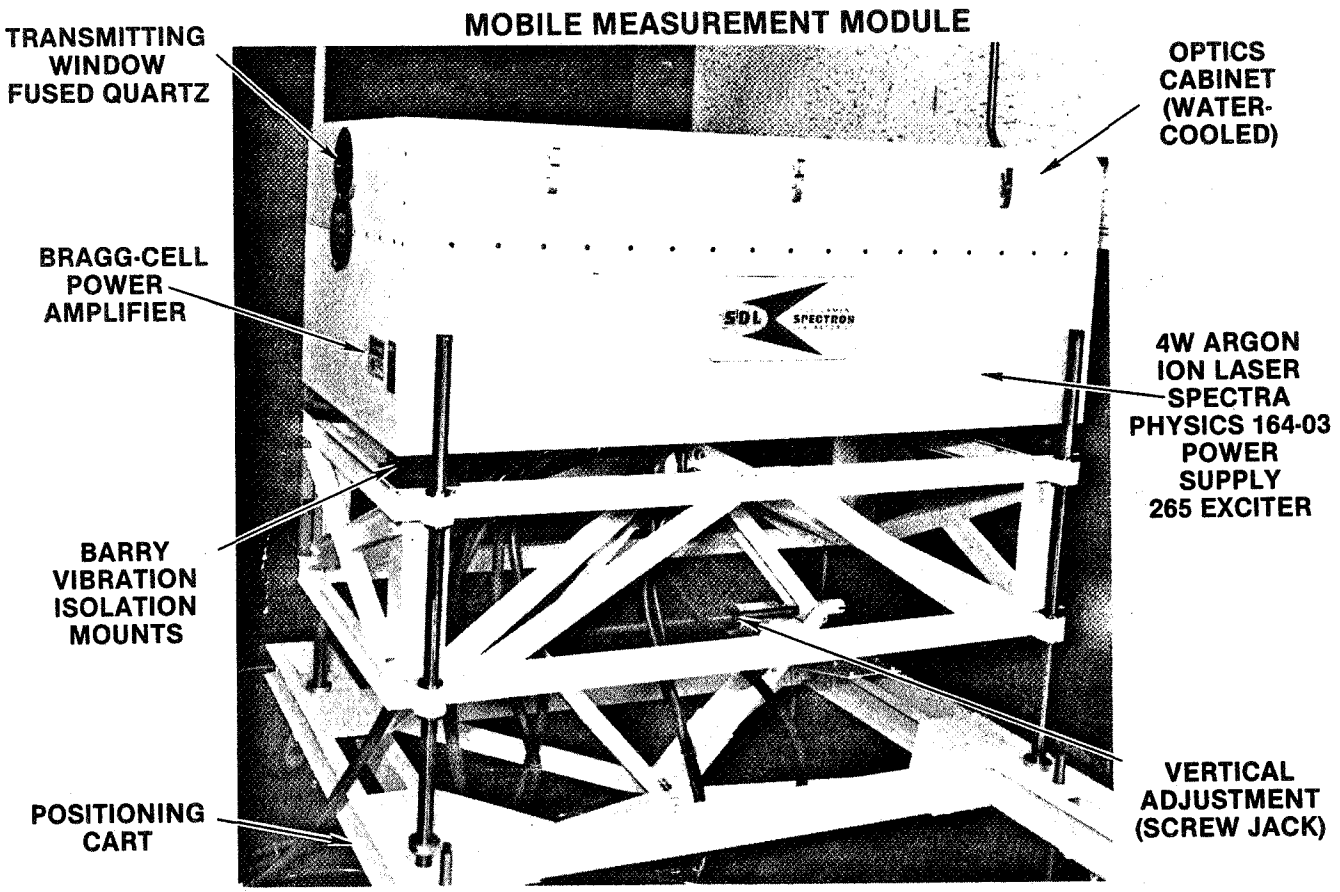

Figure 2. Mobile Measurement Module

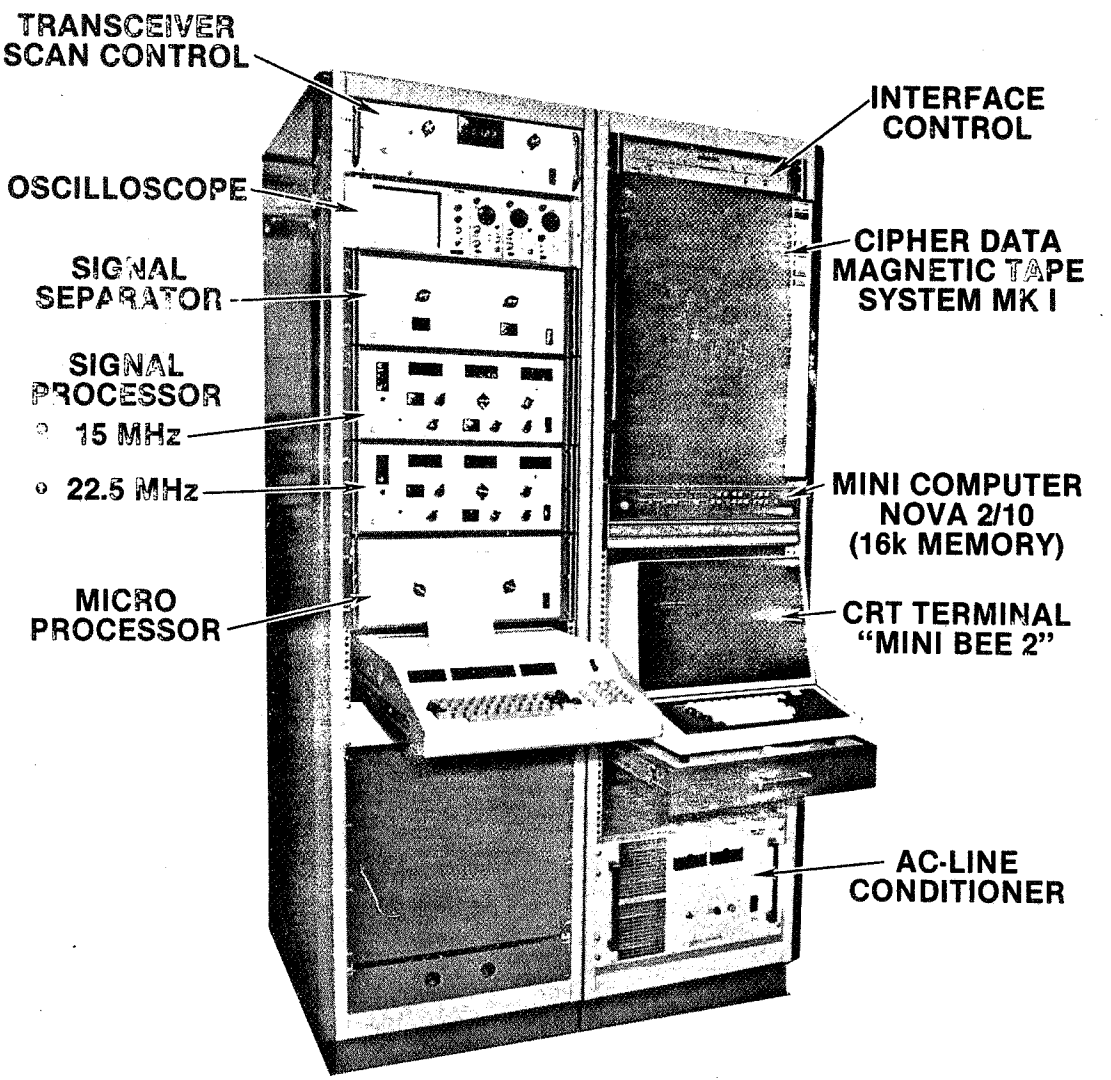

Figure 3. Signal Processing and Data Acquisition Module

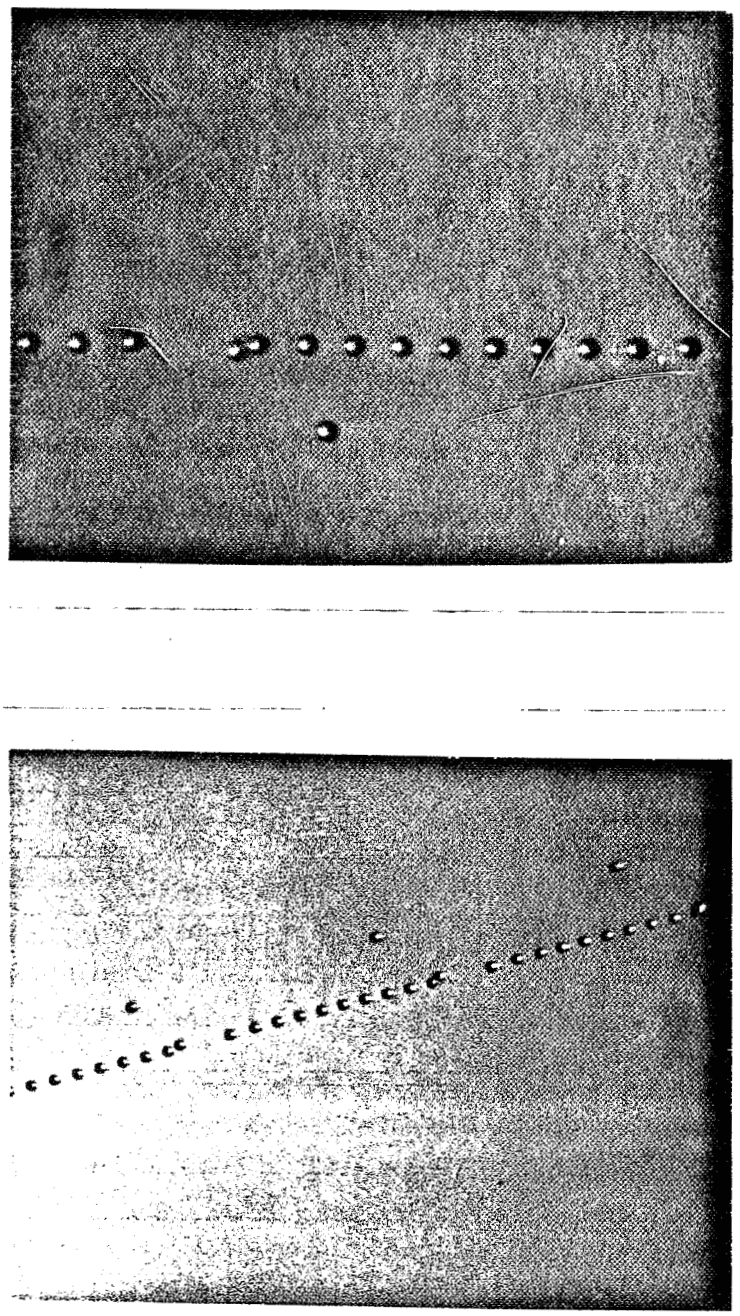

Figure 4. Droplets Produced by the Monodispersed Droplet Generator. An Electronic Deflecting Circuit Permits the Selection of a Small Number of Droplets for use in Calibration

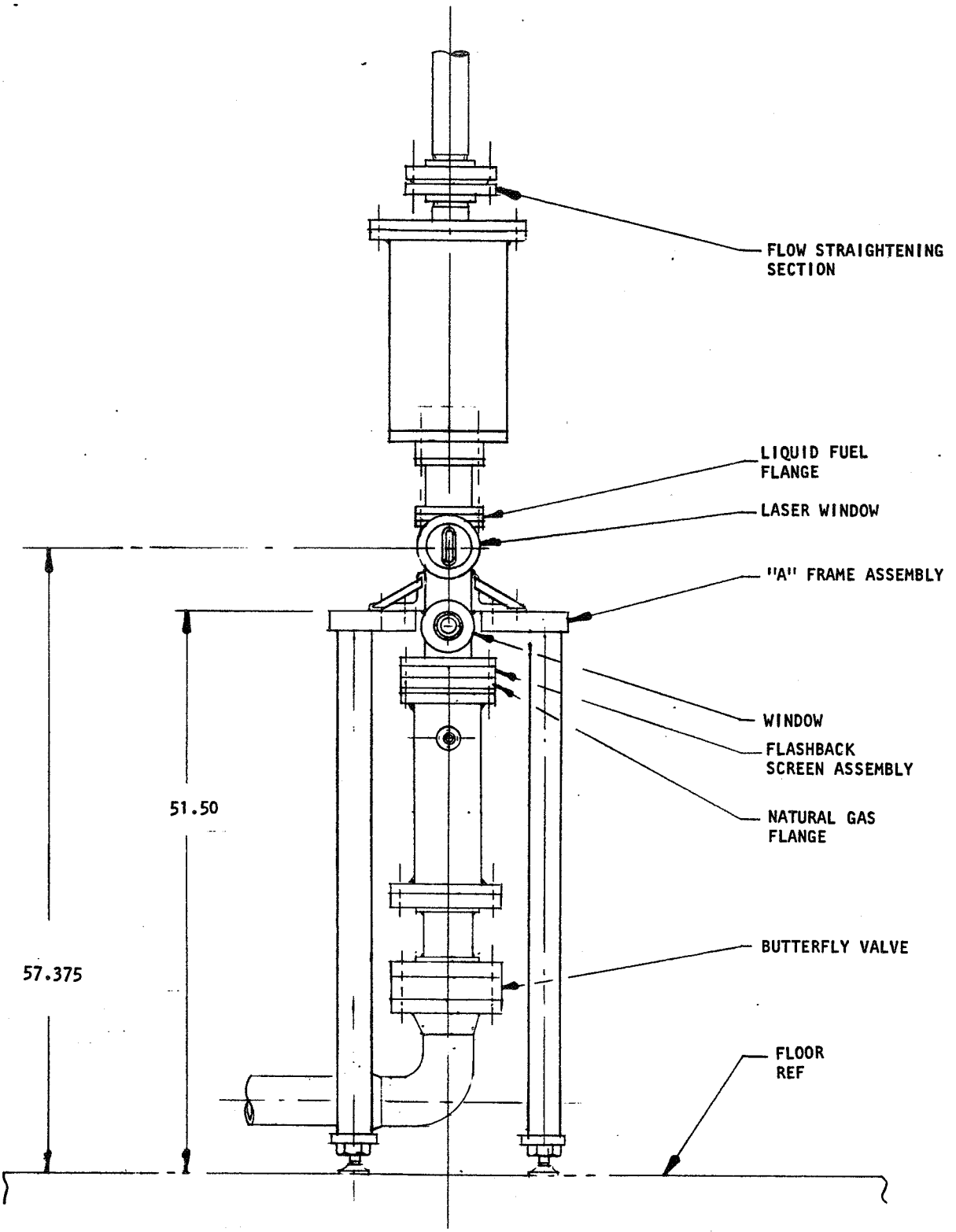

Figure 5. Fuel Atomization Rig Mounted on A-Frame

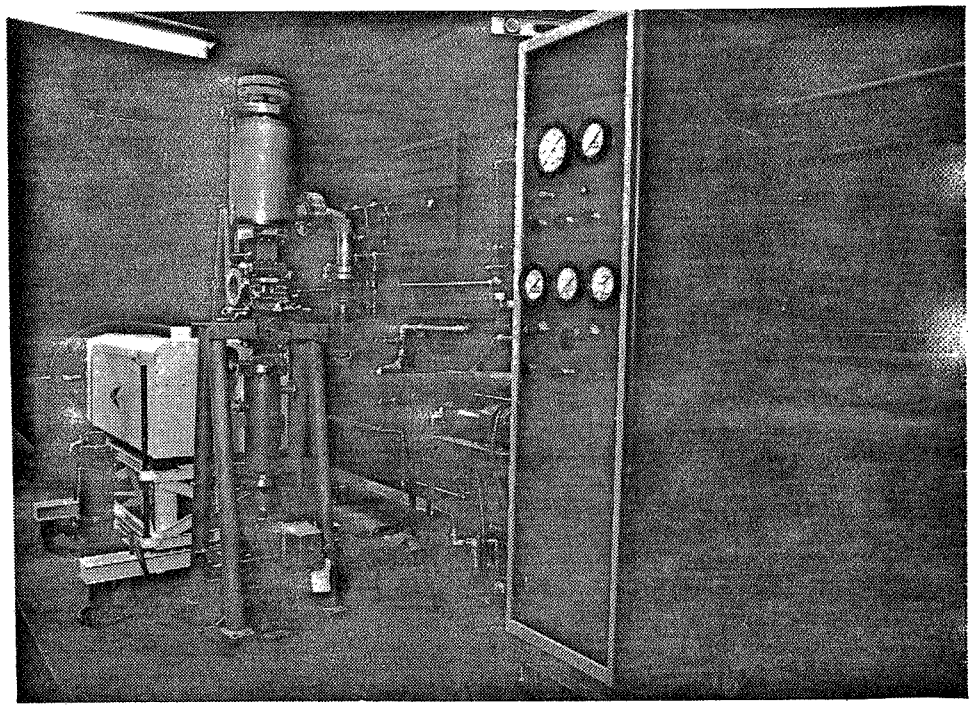

Figure 6. Fuel Spray Rig in Test Cell. SLM Optical System is in the Background