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DEVELOPMENT AND IMPLEMENTATION OF ADVANCED DIAGNOSTIC TECHNIQUES*

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The objectives of this work are to establish the performance and limitations of two optical techniques for spray characterization, and to design and build an instrument based on these techniques.

Two techniques have been identified which offer great potential in the measurement of sprays. The first is referred to as "IMAX", and it consists of a nonintrusive pulse height analyzer. The second is referred to as "Visibility/Intensity (V/I)" and it performs a size measurement by examining the visibility and the pedestal intensity of a Doppler burst. The research conducted over this past year indicates that the IMAX technique provides a larger dynamic range and higher accuracy than V/I. It also shows that the two-color IMAX concept provides a higher S/N primarily because of the high efficiency in spectrally separating the two signals.

The two-color IMAX concept is described in Figure 1a. Two small beams of a given wavelength (4880Å) are crossed in the middle of a larger beam of different wavelength (5145Å) thus identifying a region of almost uniform intensity within the large beam. The two small beams will interfere where they cross and a fringe pattern will be formed in the middle of the large beam. Droplets crossing the fringes also cross the middle of the large beam. Since the peak intensity of the large Gaussian beam is known, a unique relationship between droplet size and scattered light is established. The velocity of the droplets is also measured using the classical Doppler approach. Figure 1b shows a schematic representation of the breadboard system used to acquire the reported data.

The size distribution of two kinds of sprays are reported here. The first is produced by a Berglund-Liu droplet generator with dispersion air. Monodisperse, bimodal, and trimodal sprays with an angle of about 10° were thus produced, and the results are shown on Figure 2a. The theoretically predicted sizes are 49 μm, 62 μm, and 70 μm, respectively. Good accuracy and resolution can, therefore, be observed. The second spray was produced by a pressure nozzle. The results are shown on Figure 2b. In order to test the resolution of the system, data were obtained using three different size ranges: 5 to 50 μm; 10 to 100 μm; and 20 to 200 μm. This is one of the most difficult self-consistency tests imposed on any technique, and most available techniques will show a shift in the predicted data. IMAX shows excellent matching of the data.

The Visibility/Intensity Technique is described in Figure 3. This technique makes use not only of the visibility of a Doppler signal but also the peak intensity of the pedestal. Both parameters are available in the signal and their cross-correlation can be used to eliminate faulty signals produced in many practical environments. This technique will especially prevent small

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particles (high visibility) from appearing as large. Figure 3 shows a Doppler trace where both the visibility and the peak intensity of the pedestal are indicated. There is a relationship between the size of the droplet and the amount of scattered light given by Mie theory. This relationship can be used to eliminate signals with an apparently different size by using the following logic: Droplets that produce a certain visibility are associated with a given size; hence, they should scatter light with a given intensity (characterized by I_p). Two exceptions are contemplated: First, droplet with the correct visibility will scatter different amounts of light due to the Gaussian nature of the probe volume's intensity; second, droplets with an erroneous visibility will not scatter light with an intensity corresponding to their apparent size.

Results for both Visibility/Intensity and visibility only are shown in Figure 4. Figure 4a shows the data of the spray formed of primary droplets and doublets. Figure 4b shows results similar to Figure 4a but obtained with visibility only. Notice how much broader the later distributions are. Figure 4c shows a spray containing primary droplets, doublets and triplets. Figure 4d shows results similar to Figure 4c but obtained with visibility only. Notice that the later distribution is broader and the resolution is not as fine.

Both the accuracy and resolution of these measurements are very good. The theoretically predicted sizes are 53 μm, 66 μm, and 76 μm. The corresponding measured diameters are (52 to 54), (63 to 65), and 73 μm.

Larger errors (about 20%) can be expected when measuring the size at a higher visibility (80%).

Based on the above concepts, an Advanced Droplet Sizing System (ADSS) was developed. Photographs of the optics and electronics are shown in Figure 5. Very exhaustive tests are presently being conducted to establish and ensure the performance of the ADSS.

IMAX CONCEPT
FOR SPRAY CHARACTERIZATION

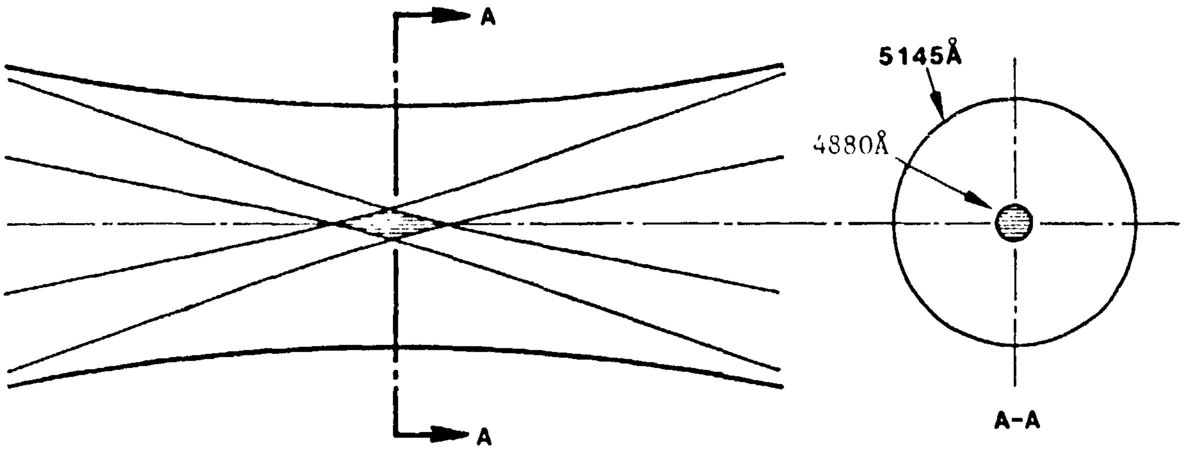


Figure 1a. Probe Volume of Two-Color IMAX Technique

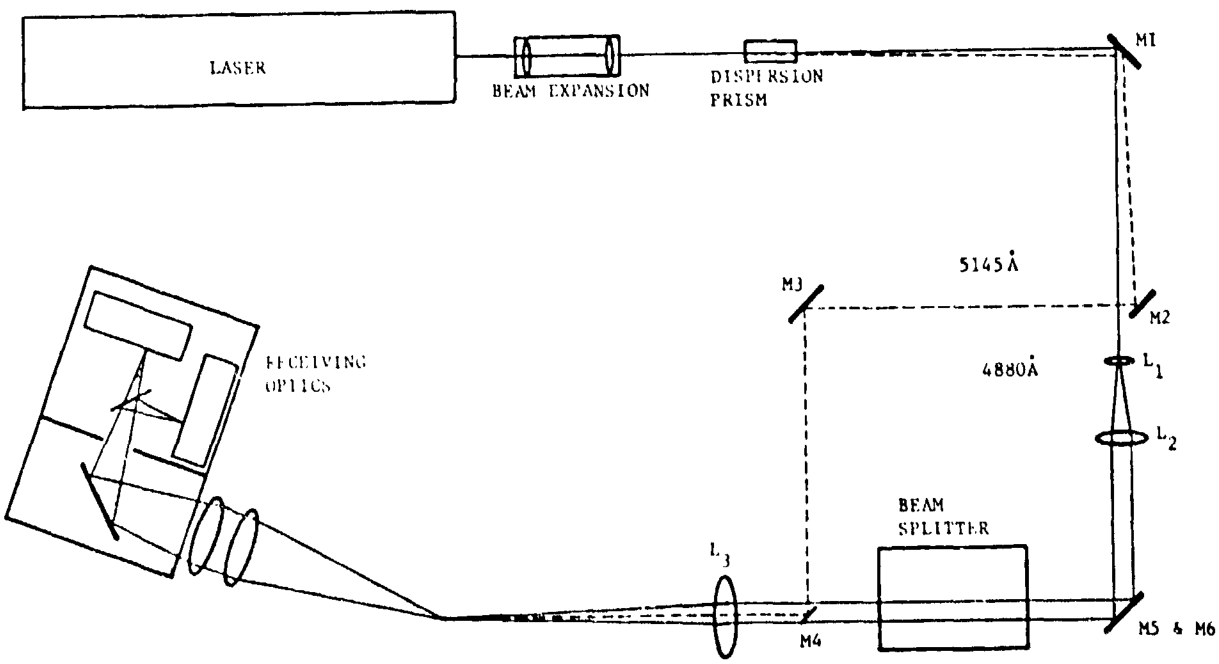


Figure 1b. Schematic IMAX Breadboard System

IMAX DROPLET SIZE MEASUREMENTS

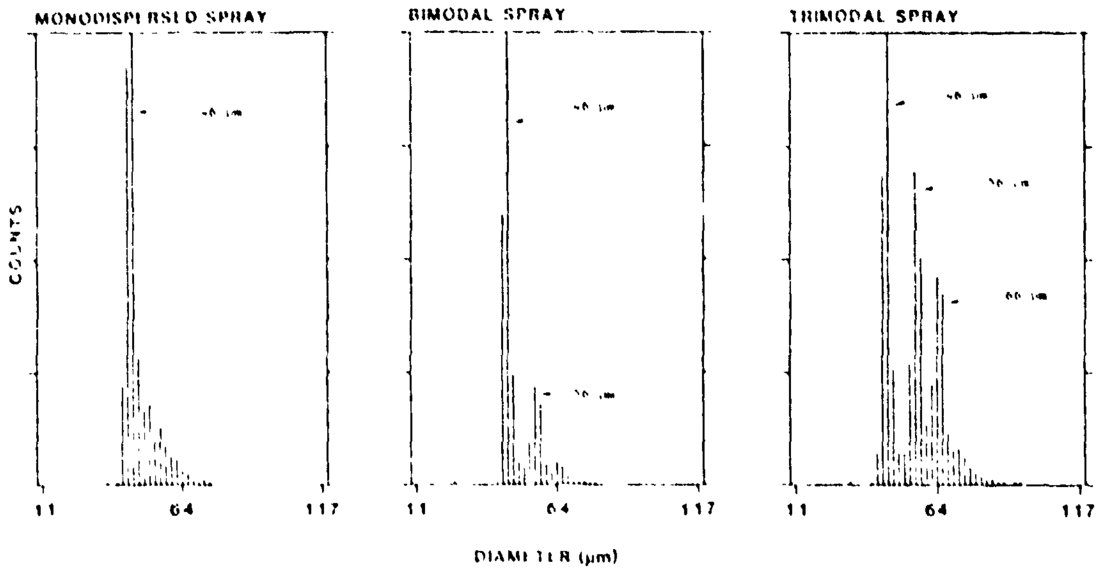


Figure 2a. Size Distribution of Spray Produced by a Berglund Liu Generator with Dispersion Air

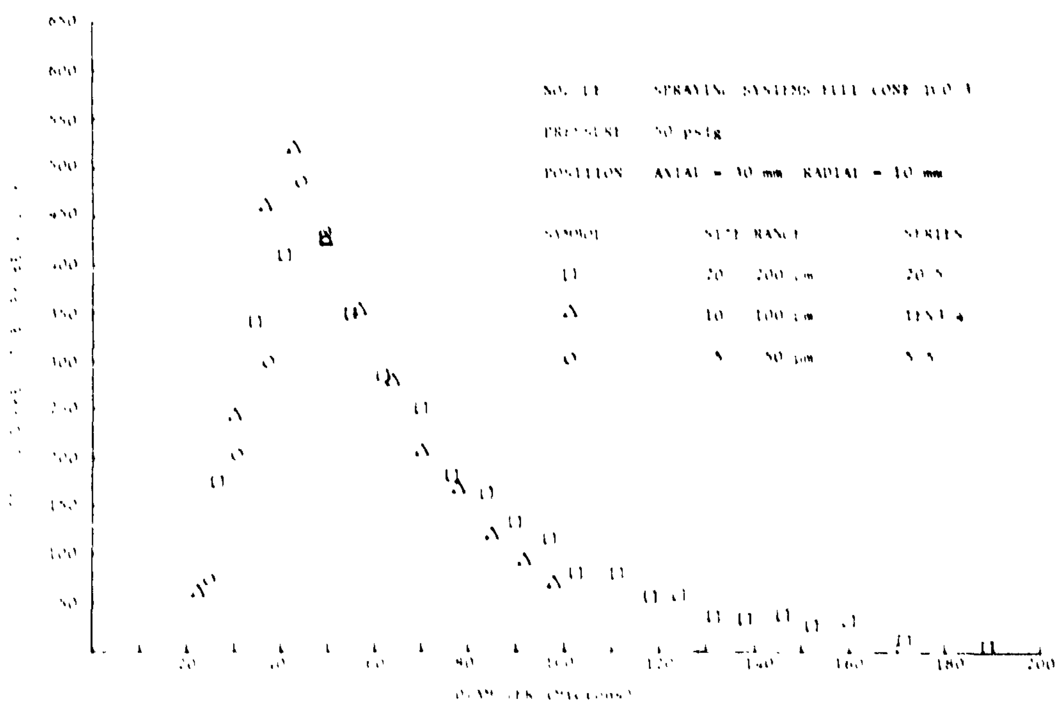
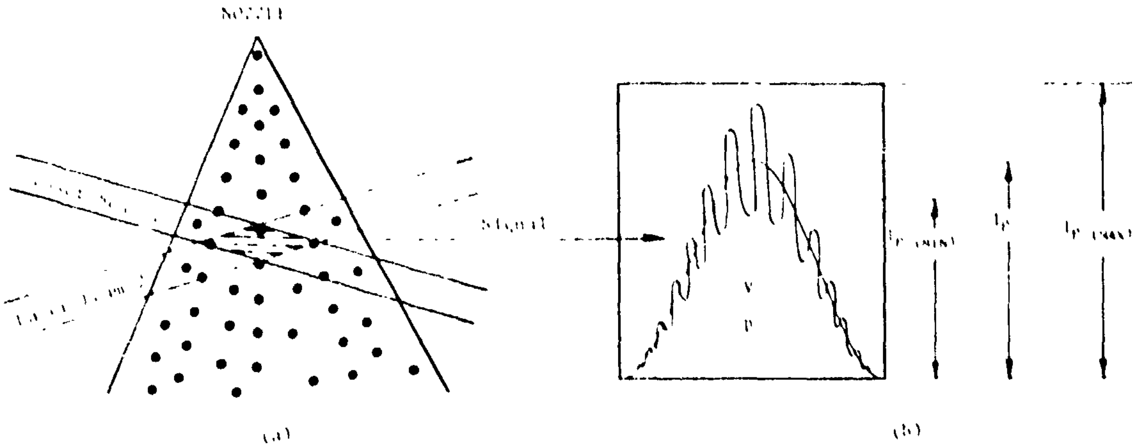


Figure 2b. Size Distribution of Spray Produced by a Pressure Nozzle

THE VISIBILITY/INTENSITY TECHNIQUE



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SIZE DISTRIBUTIONS OF BIMODAL AND TRIMODAL SPRAYS WITH VISIBILITY AND VISIBILITY/INTENSITY

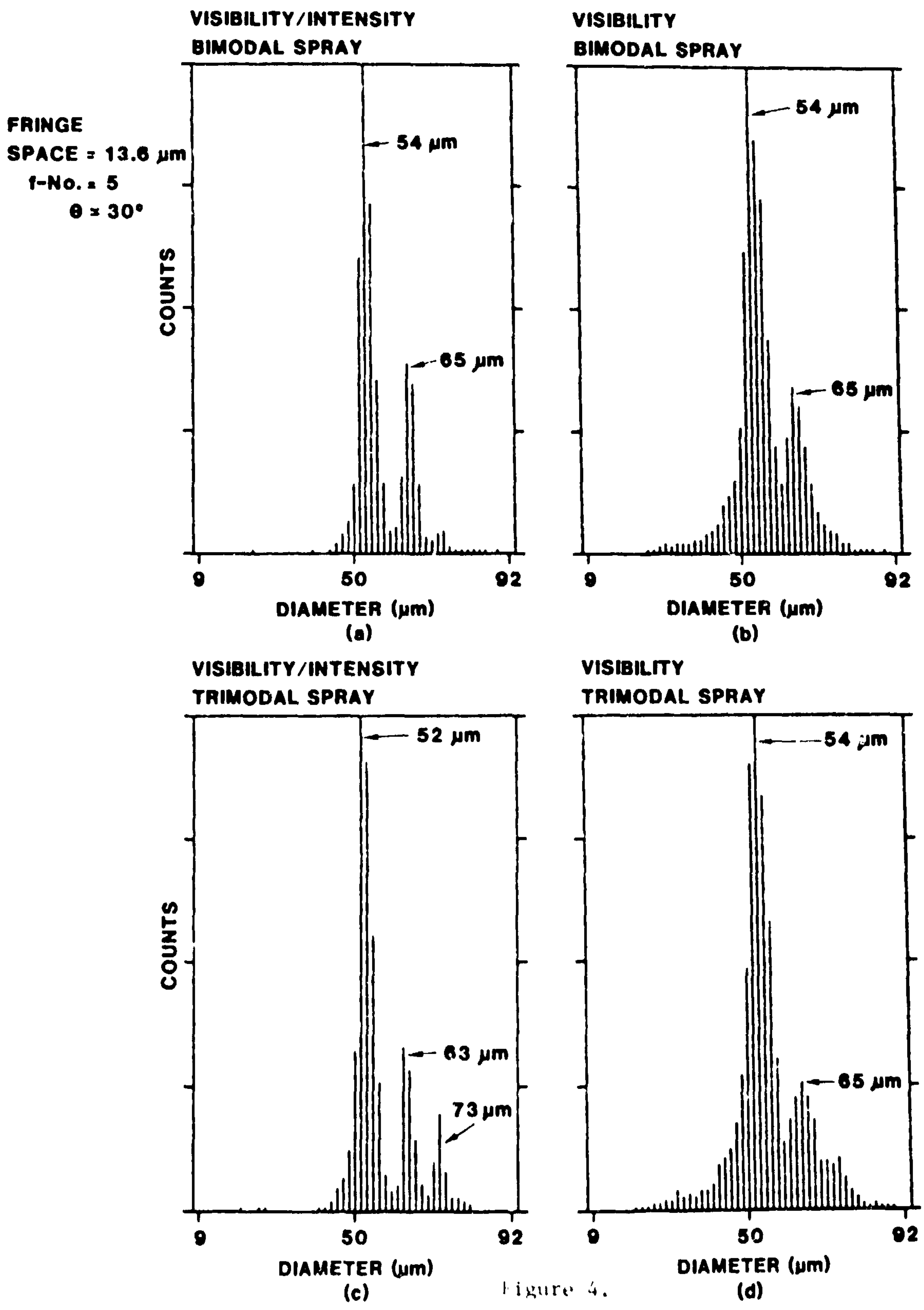

Figure 4.

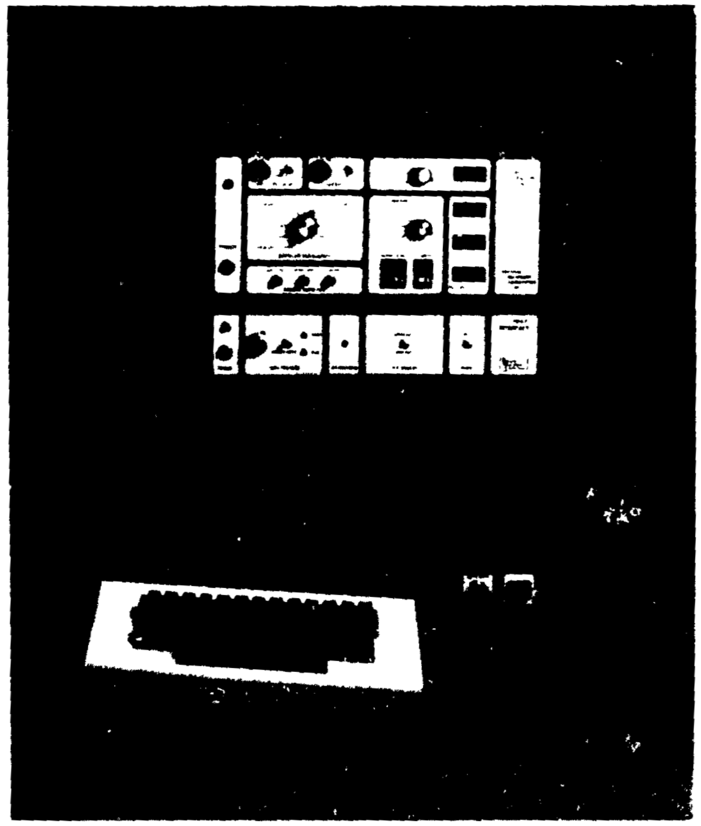

Figure 5. Electronic Components and Optical Heads of the Advanced Droplet Sizing System