N86-11453

AEROSOL SEEDING SYSTEMS FOR THE NSWC WIND TUNNELS

William J. Yanta
Timothy S. Smith
Arnold S. Collier

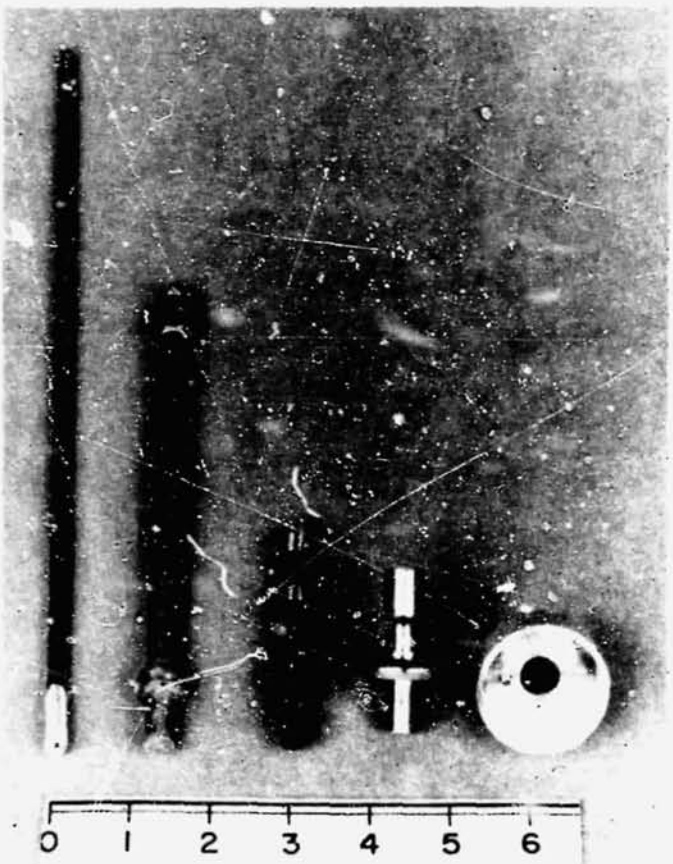
Naval Surface Weapons Center
Silver Spring, Maryland 20903-5000

AEROSOL GENERATOR LASKIN NOZZLES

Shown below are four types of Laskin nozzles which are used to generate the primary aerosol "mist". This mist may be used directly as LDV particles; however, in general, a wide range of particle size exists at this stage and requires the use of some type of mono-dispersion refinement technique. These techniques will be discussed later.

These nozzles rely on the shearing action of high speed air near a column of seeding liquid. Typically, olive oil or dioctyl phthalate (DOP) is used, but within the past year solid polystyrene particles in an alcohol suspension have been used with great success. Air, at a typical pressure of five psig, is supplied to the top of the nozzle which is merely a hollow tube. This air issues radially from one or more small jets located near the collar close to the bottom of the tube. When the collar is submerged in the seeding liquid, the hollow columns located in the collar become filled with liquid. The air from the jet shears the liquid into the fine mist.

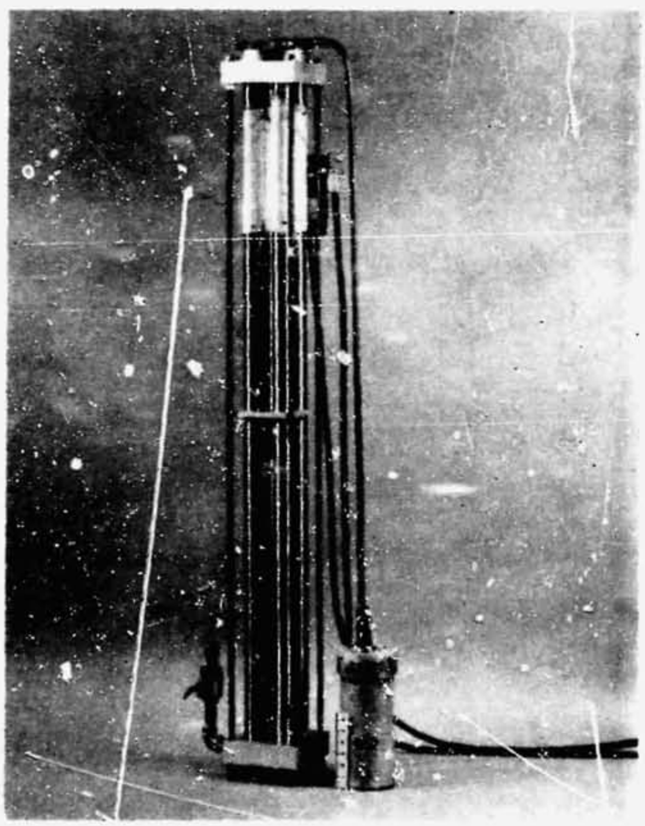
Shown from left to right is the "true Laskin" (Reference 1) followed by the four-hole and eight-hole nozzles (Reference 2). A new-version one-hole nozzle which utilizes a submerged particle impactor is also shown along with its impactor. The units of the scale are inches.



VAPORIZATION-CONDENSATION GENERATOR

One way to produce mono-disperse aerosols from the course primary mist is to use a vaporization-condensation generator, shown here. Located inside the seeding liquid reservoir (lower right corner of the figure) is the Laskin nozzle and an amount of seeding liquid sufficient to submerge the nozzle collar. Air is supplied to the nozzle and poly-disperse mist is forced along with the air up the copper tube on the right side of the generator to the top where a manifold is located. There, the mixture is supplied to four vertical stainless steel tubes which are heated at the top by electrical heater tapes up to roughly nine hundred degrees Fahrenheit. This high temperature causes the walls of the tubes to radiate enough energy to the mist droplets to vaporize them. Solid impurities in each droplet do not vaporize but remain intact. These condensation "seeds" along with the vapor travel down the tubes to a region which is at approximately room temperature. Condensation takes place in a uniform manner which produces a mono-disperse aerosol. This aerosol is then collected by another manifold located at the bottom of the generator and passed on to the wind tunnel via a large diameter flexible hose.

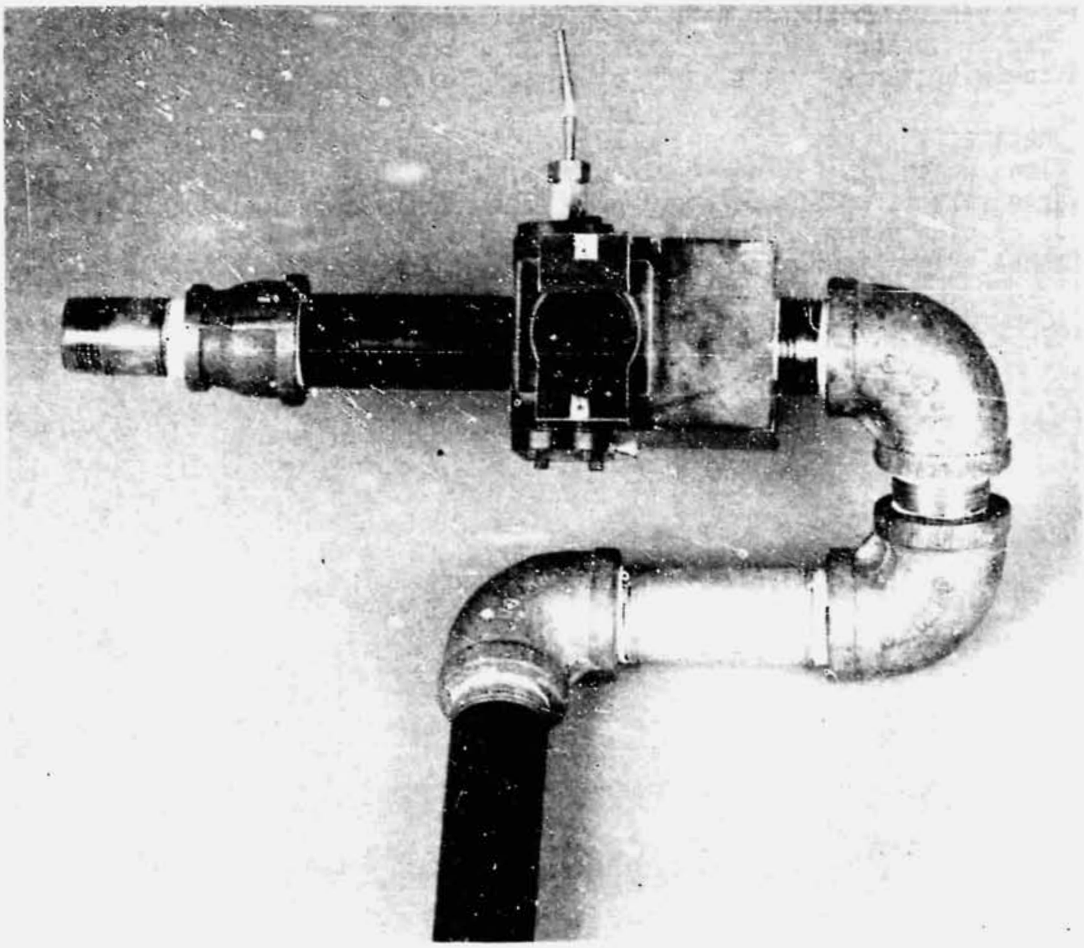
One item that makes this generator rather unique is that it can be used to seed flows which have local static pressures of up to ten atmospheres. Also, the large size of this generator facilitates production of relatively large amounts of highly mono-disperse aerosol continuously. The units of the scale are inches. This is a scaled version of the generator described in Reference 3.



MINIATURE AEROSOL NOZZLE

Particle generators can be characterized using a miniature aerosol nozzle such as the Mach 3 nozzle shown here. By measuring the velocity lag which a particle experiences as it flows through a calibrated, rapidly accelerating flowfield, and comparing this lag to numerical predictions (Reference 4), a mean particle size can be determined.

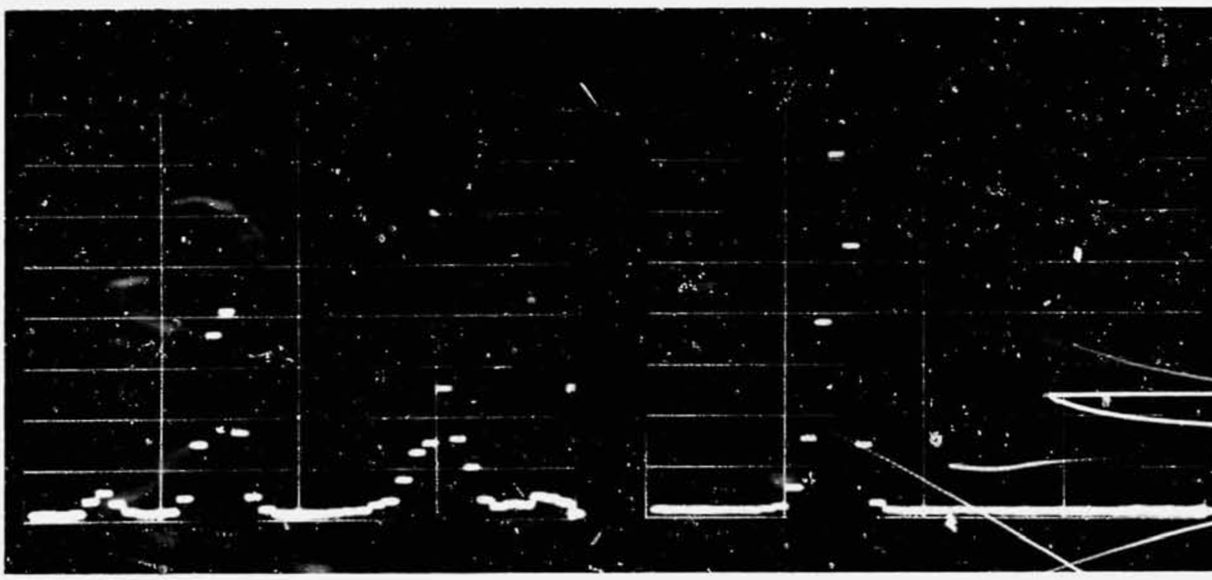
This particle aerosol nozzle is actually a complete wind tunnel test section. It consists of a nozzle, diffuser, pitot probe and test cell with optical ports and can be used with a variety of gas supply and dump tank configurations. It is capable of sizing liquid particles (with a specific gravity of one) as large as 15 microns in diameter. Larger particles are subject to shattering. The diameter of the windows is approximately 1.25 inches.



ORIGINAL PAGE IS
OF POOR QUALITY

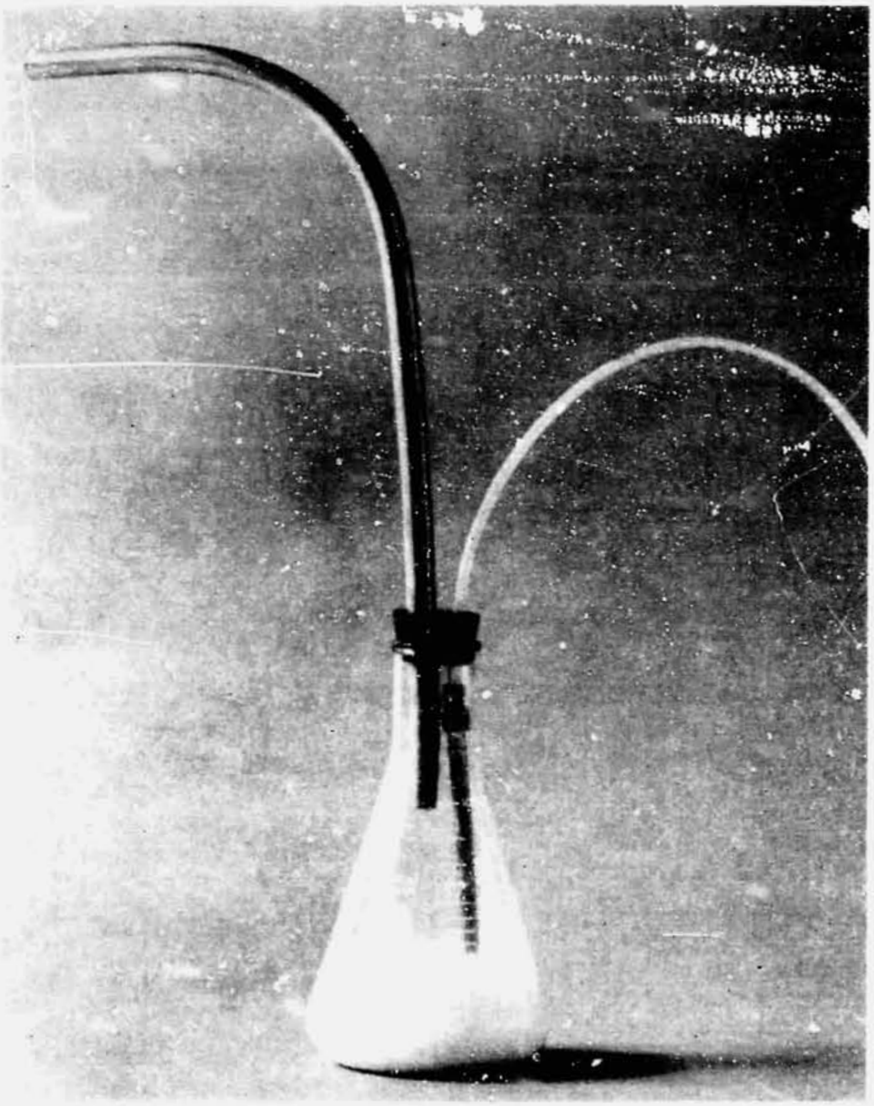
PARTICLE GENERATOR CHARACTERIZATION

Shown below are two histograms of particle size distributions from a particle generator. The histogram on the left shows the particle size distribution of the coarse aerosol from a Laskin nozzle. By employing the Vaporization Condensation Generator shown previously to refine the coarse aerosol, passing the resulting particles through the miniature aerosol nozzle and measuring the particle velocity at a known distance downstream of the throat along the nozzle centerline, the particle size distribution was determined. The histogram on the right shows these results. Note the disappearance of the doublet peak at d = 3.0 microns.



SOLID PARTICLE GENERATION

Solid particles of uniform diameter are available commercially in a variety of diameters, materials and properties. When solid particle seeding in gas flows is desired, the simple particle generation scheme shown here can be used. In this generator, house air is sent through a Laskin nozzle and generates a coarse aerosol from a solution of solid particles in a volatile solvent. By adjusting the concentration of solids in solution such that the probability of having more that one particle in an aerosol droplet is small, the resulting seed will consist of only one particle. The optimum concentration was experimentally determined to be 0.25% by volume. The only limitation of this particle generating scheme is that the size of the coarse aerosol be large enough to contain the solid particle.

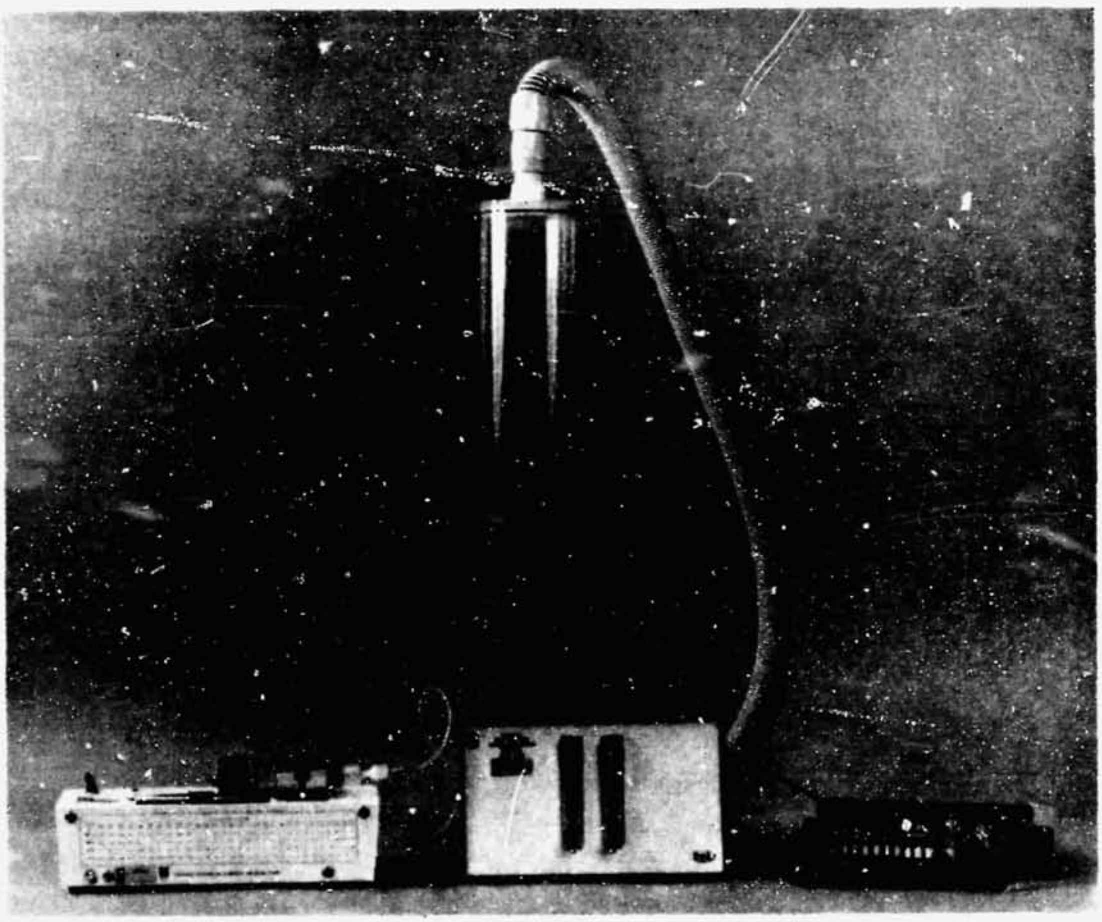


LARGE PARTICLE GENERATION

Below is a photograph of a Berglund-Liu Vibrating Orifice Monodispersed Particle Generator (TSI Model 3050). One noteworthy characteristic of this unit is its ability to produce a monodispersed aerosol with a droplet diameter of 0 to 400 microns.

The syringe pump shown on the left forces liquid at a constant feed rate through an orifice located in the generator shown in the center. A piezo-electric ceramic driven by a signal generator, shown on the right, induces a vibration on the orifice. The vibration causes the orifice to shear off a particle from the liquid stream at each cycle. Air is mixed at two stages in the system to disperse the individual droplets and therefore reduce agglomeration (see Reference 5 for a detailed description of operation).

The size of the aerosol droplet can be changed by varying the diameter of the orifice, the concentration of solute in the liquid solution, the orifice vibrating frequency or any combination of three. By using a dissolved substance as a solute, solid particles may be generated.



REFERENCES

1. Drew, R. T. and Bernstein, D. M. The Laskin Aerosol Generator. Journal of Toxicology and Environmental Health, 4:661-670, 1978.

2. Echols, W. H. and Young, J. A. Studies of Portable Air-Operated Aerosol Generators. NRL Report S929, Naval Research Laboratory, Jul 1963.

3. Liu, Y. H., Whitby, K. T., and Yu, H. H. S. A Condensation Aerosol Generator for Producing Monodispersed Aerosols in the Size Range, 0.036μm to 1.3μm. Journal De Recherches Atmospheres, pp. 397-406, 1966.

4. Yanta, W. J. Measurements of Aerosol Size Distributions With a Laser Doppler Velocimeter. Aerosol Measurements, National Bureau of Standards Special Publication No. 412, Oct 1974.

5. Berglund, R. N. and Liu, B. Y. H. Generation of Monodisperse Aerosol Standards. Environmental Science and Technology, Vol. 7, pp. 147-153, Feb 1973.