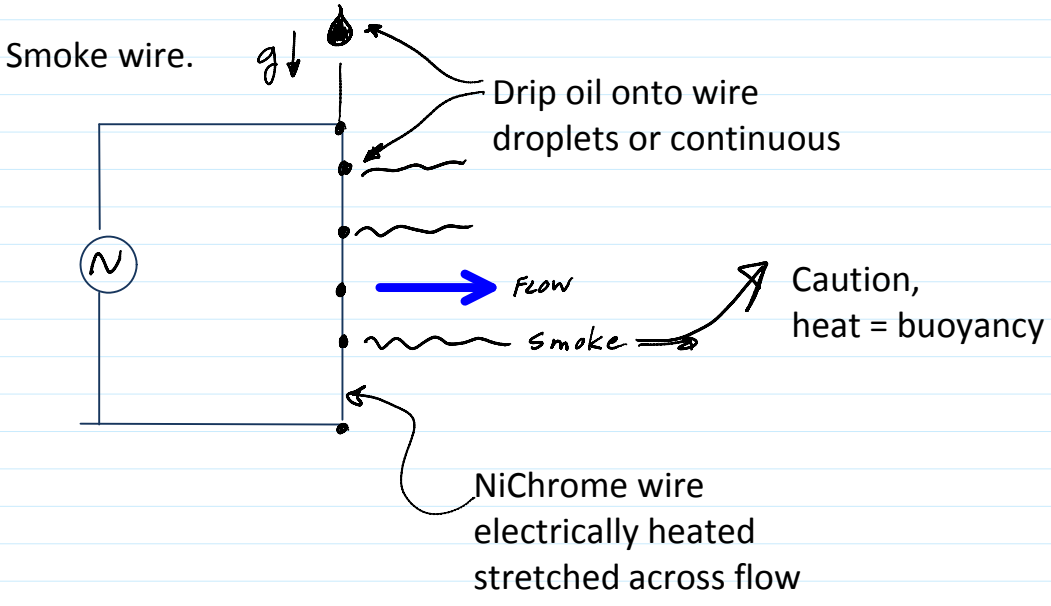
20.ParticleGenAir

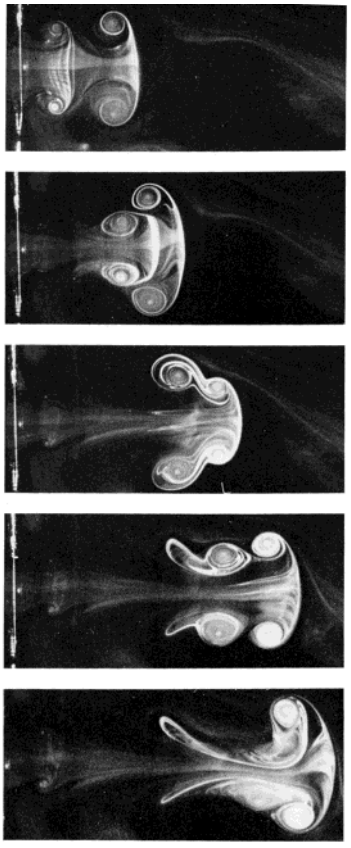
Monday, April 19, 2010
1:08 PM

Today: Particle generation and injection techniques in air and water
FCQs
Thursday: Refractive techniques
Lobby show Friday. Voluntary; for fun. Email me if you are willing to help set up or clean up.
Final Final due date for reports: Wednesday May 9

In air: smoke and fog
solids liquids

A) Smoke = soot usually, carbon particles



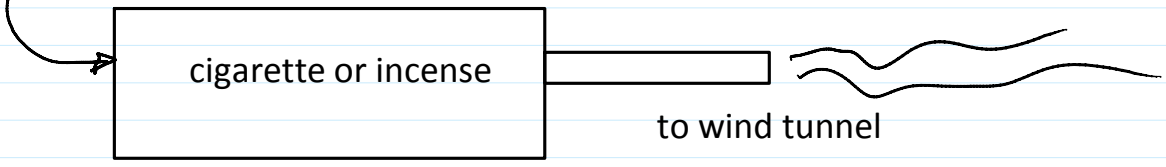


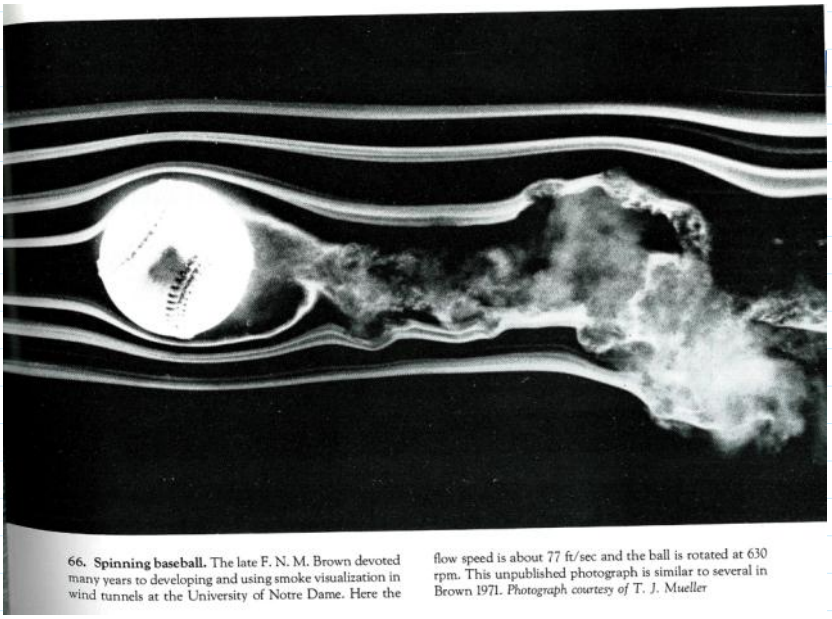
79. Leapfrogging of two vortex rings. Two successive puffs of air are ejected from an orifice of 8-cm diameter by a piston that is driven by the impacts of two pendulums. The flow is made visible by a smoke wire stretched across the orifice, at the left of the photographs. At this Reynolds number of about 1600 based on orifice diameter, the second ring travels faster in the induced field of the first, and has slipped through it in the third photograph. Then the process is repeated, the first ring slipping through the second in the last photograph. *Yamada & Matsui 1978*

Van Dyke, Milton. *Album of Fluid Motion*. 10th ed. Parabolic Press, Inc., 1982.

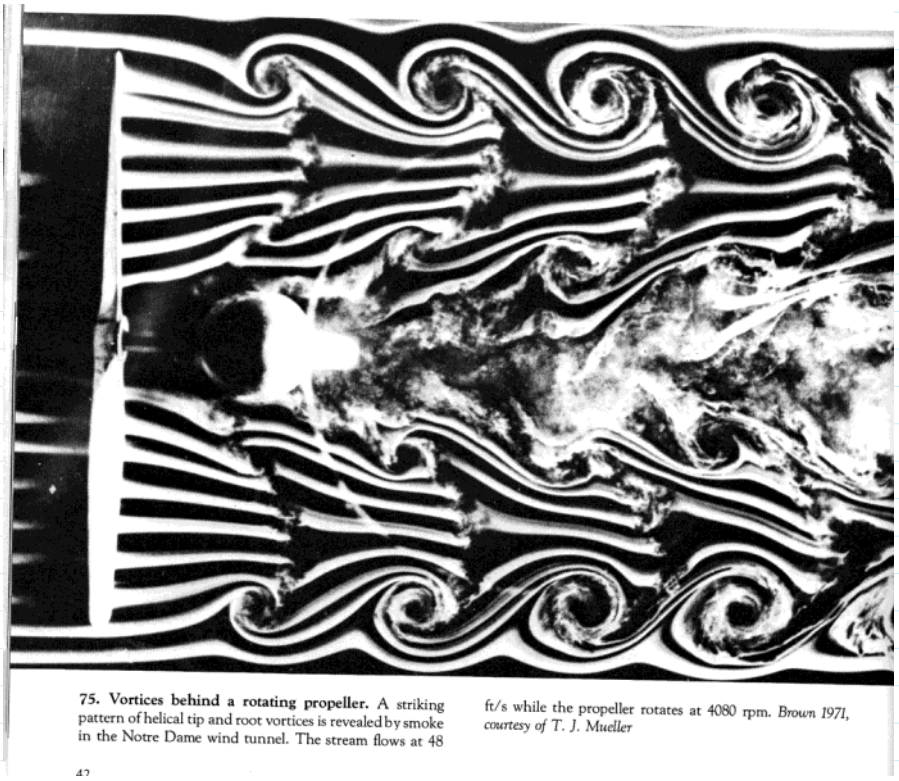
Most oils work. Veg is less toxic.
Generates 1μm particles. Penetrates into lungs, causes cancer, regardless of composition.

Alt technique:
pressurized air





66. **Spinning baseball.** The late F. N. M. Brown devoted many years to developing and using smoke visualization in wind tunnels at the University of Notre Dame. Here the flow speed is about 77 ft/sec and the ball is rotated at 630 rpm. This unpublished photograph is similar to several in Brown 1971. *Photograph courtesy of T. J. Mueller*



75. **Vortices behind a rotating propeller.** A striking pattern of helical tip and root vortices is revealed by smoke in the Notre Dame wind tunnel. The stream flows at 48 ft/s while the propeller rotates at 4080 rpm. *Brown 1971, courtesy of T. J. Mueller*

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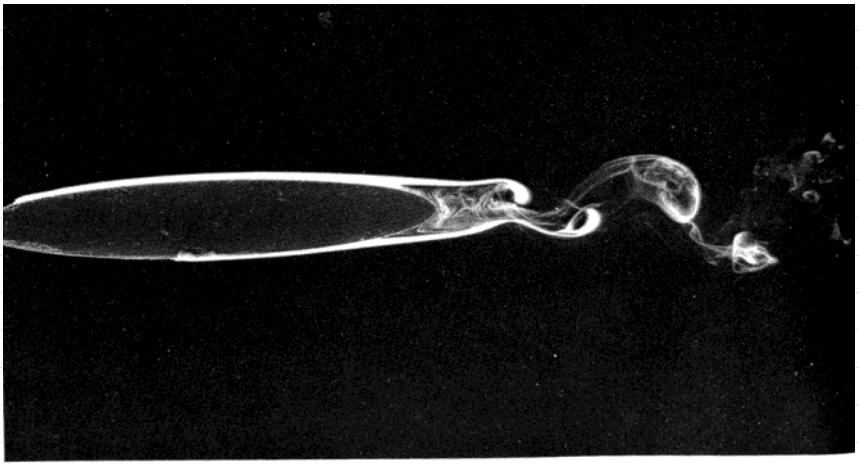
Chemically generated particles:
TiO_2 Titanium dioxide particles from
titanium tetrachloride + water vapor = dense TiO2 smoke + HCl
HCl + water vapor = hydrochloric acid vapor
Spectacular smoke, but toxic, and hard on equipment, corrosive

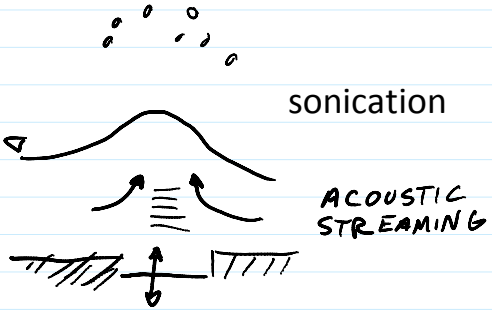


32. Laminar separation on a thin ellipse. A 6:1 elliptic cylinder is held at zero angle of attack in a wind tunnel. The Reynolds number is 4000 based on chord. Drops of titanium tetrachloride on the surface form white smoke, which shows the laminar boundary layer separating at the rear. *Bradshaw 1970*

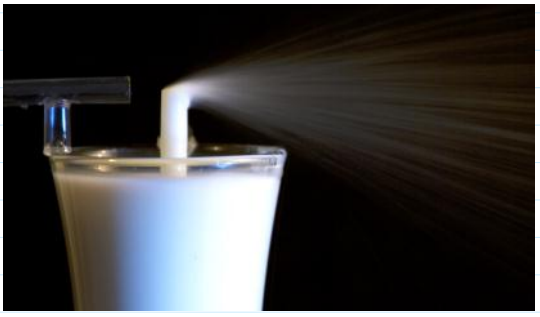
B) Fog = aerosols of liquids

Water fog: Safe, but evaporates quickly

- ultrasonic humidifier
- medical nebulizer
- dry ice (solid CO_2)



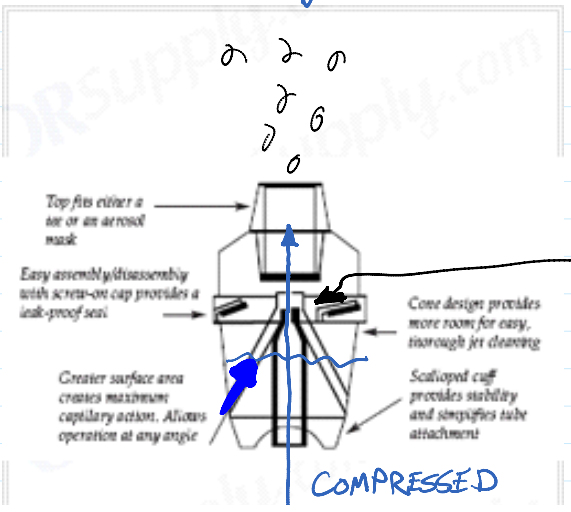
sonication



transducer = diaphragm
vibrates @ n MHz

Matt Blessinger
Get Wet 2009

Bernoulli atomizer
Jet nebulizer
Small Volume Nebulizer (SMN)



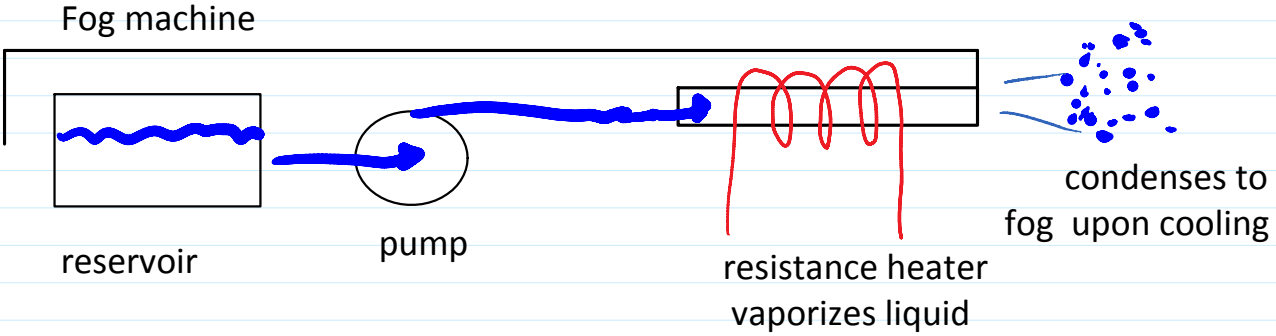
Inexpensive: $3
Makes 1 µm to 100µm droplets
Larger droplets impact on surfaces, can't exit device.

Liquid is delivered to jet exit by capillary action

Dry Ice Vapor: Dry ice = solid CO2
Sublimates (solid to gas) at 1 atm, -78 C (-109 F)
http://www.dryiceinfo.com/fog.htm
Submerge in hot water: much water fog created.
Fog production drops for water temperature < 50 F
60 Pounds of Dry Ice and a Swimming Pool, 2007. http://www.youtube.com/watch?v=uhXA9ON6igk&feature=youtube_gdata_player

Stage fog = Water + glycerin or propylene glycol. Additive slows evaporation

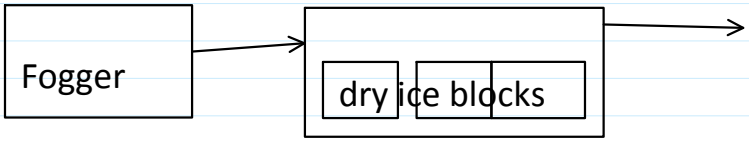
Fog machine



Small machines: heater too small to run continuously. Buy at Target, 1 month before Halloween for $25.

Large machines: can run continuously. For professional stage and theaters. $1000. Mfg: Roscoe, Le Maitre. 1 gallon lasts 4 hrs.

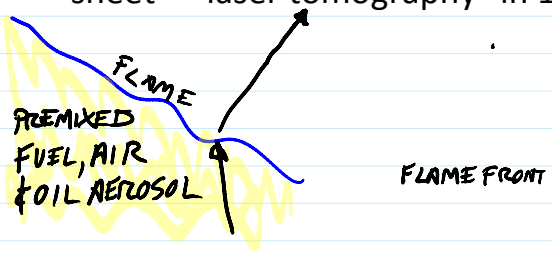
Health effects are minimal, except to asthmatics and opera singers.



For fog-on-the-ground: chillers

C) Oil aerosols
Won't evaporate unless burned. Oil has low vapor pressure.
Use medical or Bernoulli atomizer/nebulizer

Can be used to mark flame fronts. Illuminate fog with a laser sheet = "laser tomography" in 1980s.



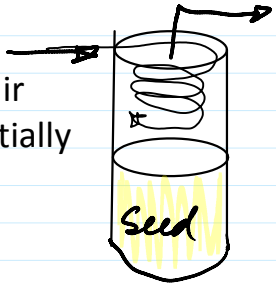
Danger! Oil aerosol will coat lungs ⇒ pneumonia ⇒ death

D) Dusts

AlO_2 = alumina, aluminum dioxide. Polishing powder, available in submicron diameters. Inexpensive.

Won't burn; is already fully oxidized. Good for imaging individual particles in flames.

Aerosolize in a cyclone seeder:



Large particles centrifuge to walls. Only small particles that track the flow can exit through the center. Like a Dyson vaccuum cleaner.

For heavy seeding, try a fluidized bed.

air injected below