#4

OH SAY CAN YOU SEE ...

AN AIR QUALITY INTERPRETIVE PAMPHLET

NATIONAL PARK SERVICE

OH SAY CAN YOU SEE ...

A National Park ... mountains, lake, or seashore against a clear blue sky, the air fresh and invigorating. Clouds, fog, snow, rain may be acceptable additions - even volcanic ash. But the air is getting dirty, even in parks and wilderness areas far from cities. And views of scenic wonders are not the only things that suffer from pollution. That haze between you and your favorite landmark may also be detrimental to the health of animals (including humans), damage plants, or combine with precipitation to form the acid rain which kills fish and even damages buildings.

National Parks are like miners' canaries, the little birds that use to be taken into mines so that if the bird died, the miners knew the air was bad and it was time to do something. Sensitive natural ecosystems respond quickly to changes in the environment, warning when conditions change for the worse. Concern about air quality in National Parks was focused by the constuction of the Four Corners Power Plant near Farmington, New Mexico in 1963; its plume could be seen for many tens of miles and affected air quality and visibility in several southwestern parks. By the late 1960's and early 1970's smog began to appear in Yosemite Valley. Battles erupted over proposed coal-fired power plants on the Kaiparowits Plateau near Capitol Reef National Park. In the east, Great Smoky Mountains, Acadia, Shenandoah and others became hazy but not from natural haze. Public concern, expressed in magazine and newspaper articles decrying the loss of visual clarity, created political pressure for legislative action. In August 1977, Congress adopted the nation's first visibility requirements for national parks and wilderness areas by amending the Clean Air Act.

Provisions of the National Park Service Organic Act of 1916, laws establishing individual parks, the Wilderness Act of 1964, the National Environmental Policy Act of 1969, and the Endangered Species Act of 1973 had already established National Park Service responsibility for management of air resources. But the 1977 amendments to the Clean Air Act made this management part of a national effort, affecting activities <u>outside</u>, as well as inside, park boundaries.

The National Park Service mandate to manage air as a resource is a particularly important and difficult one. Visitor enjoyment and health, the preservation of cultural resources, and the integrity of natural systems depend upon it; yet it is quite a different sort of undertaking than management of most other park resources. The wind blows where it will, and sometimes park management must deal with pollution sources many miles away, some of which provide the livelihoods for large numbers of people.

To help meet these responsibilities, in 1978 the NPS established the Air and Water Quality Division (AWQD) with a technical staff based in Denver. The major tasks of the AWQD are:

1. Providing support to the NPS and Department of the Interior by preparing materials for use by Congress and by other agencies;

2. Reviewing Environmental Impact Statements;

3. Developing, reviewing, and analyzing policy positions on proposed air quality regulations;

4. Reviewing air quality permit applications for major new and modified industrial facilities whose activities might affect Air Quality Related Values (AQRV's) in parks;

5. Planning, designing, and implementing air quality-related research;

6. Incorporation of air quality concerns and issues into park planning;

7. Synthesis of air quality data from research and monitoring activities for park use in interpretation; and

8. Providing policy and technical information and assistance to parks and regions (at not cost to them).

The chances are that any question that cannot be answered in the field or region will end up at AWQD in Denver, and the people there will either answer it, or figure out who can.

POLLUTANTS: TYPES, SOURCES AND EFFECTS

Particular atmospheric pollutants that concern the NPS include:

- Sulfur Dioxide (SO_2): Sources include volcanoes, fossil fuel power plants, and copper/lead smelters. SO_2 can be extremely corrosive to stone, paint, and metals and damaging to lungs and plants. In the atmosphere it is converted to sulfuric acid and sulfates.

- Nitrogen Oxides (No_x): Key contributor to photochemical smog and nitric acid in acid precipitation. Irritates eyes, nose, and throat, suppresses plant growth, and impairs visibility. Often characterized by a brown cloud or plume. Sources include coal-fired power plants, auto emisions, coal gasification, and manufacturing and processing.

- Photochemical Smog, Hydrocarbons and Ozone: Result of interaction of pollutants in the air, especially nitrogen oxides and hydrocarbons, combining to create photochemical oxidants, especially ozone. Effects include poor visibility, eye irritation, respiratory problems, leaf drop, and damage to paint, textiles, etc. Sources include vehicle emissions, fossil fuel power plants, and various kinds of smelting, refining, manufacturing, and processing.

- Carbon Monoxide (CO): Carbon monoxide is a colorless, odorless, poisonous gas which is extremely toxic to humans at low concentrations. Natural sources of carbon monoxide, such as forest fires and respiration by plants and plankton, make a minor contribution to the atmosphere. Most carbon monoxide is derived from man-made sources as the result of the incomplete combustion of the carbon in fuels in automobiles, trucks and buses. Carbon monoxide is usually a localized pollution problem rather than one caused by emissions transported from sources miles away.

- Particulate Matter: May be a wide range of sizes, with the very fine particles often causing the worst effects; often responsible for poor visibility.

Effects can include cancer, damage to lungs, brain, and central nervous system, and interference with plant metabolism. When the fine particles are sulfates or nitrates, effects can also include acidification of soils, surface and ground waters, with resulting adverse impacts on plants and animals. Sources of SO_2, which ultimately forms into sulfates, include coal-fired power plants, copper smelters and other smelting processes. Particulates are also produced by diesel motors, most kinds of mining, and industrial activities.

- Hydrogen Sulfide (H_2S): A highly toxic and corrosive gas resulting from copper/lead refining, oil and gas wells, smelting, and other processing, with small amounts coming from natural sources such as geysers, volcanoes, and swamps. Can be deadly to animals (including humans) and damaging to plants.

- Hydrogen Fluoride (HF): Result of aluminum production, fertilizer production, coal-fired power plants, coal gasification. Readily accumulates in pasture plants, posing danger to grazing animals.

WHAT WE'RE SEEING

Visibility

Air quality conditions are affected by many factors such as meteorology, topography, and illumination/sun angle. For the contiguous 48 states, under ideal conditions the maximum possible visibility can be approximately 250 km, with a theoretical upper limit of 391 km. The best visibility is found in the Southwest, where it averages 110 km (68 mi) and sometimes reaches 250 km (155 mi). In the Pacific Northwest visibility averages 25 km (16 mi), 72 km (45 mi) in the northern and central plains, and less than 24 km (15 mi) east of the Mississippi and south of the Great Lakes. Studies based on NPS and other longer-term data show that from the mid-1950's to the early 1970's visibility decreased 10% to 40% in rural areas in the Northeast, and 10% to 30% in the Southwest, but through the later 1970's visibility increased 5% to 10%.

Clear air is much more sensitive to pollution than already-polluted air. If the visibility is 120 miles and a tiny amount of sulfate aerosol (only 2 micrograms per cubic meter of air - a microgram is 1 millionth of a gram) is added, visibility goes down to 80 miles. However, if the visibility is only 15 miles to begin with, and the same 2 micrograms of sulfate aerosol is added, the visibility only drops to 14 miles. For 5 miles initial visibility, the same addition only causes a drop to 4.9 miles. Sulfates, which originate primarily from industrial facilities, are the major contributors to visibility degradation in the Southwest, and are also precursors of acid rain.

Trajectories

Where the air mass over your park came from determines what it brings to you... and where it is heading determines who will get that stuff next. In the Southwest, air masses approaching from the west pass over the populated areas of Southern California and are usually slow moving, picking up a sizeable load of concentrated pollutants. Air masses approaching from the southwest or southeast pass over the smelters of southern Arizona and New Mexico, which can contribute significant amounts of sulfates to air over the Colorado Plateau. (During the

9-month smelter strike of 1980 sulfate concentrations decreased between 50% and 90%, and a 16-month strike in 1969-70 showed even greater decreases.) By contrast, air masses coming from the north and northwest are usually associated with clear conditions, as they move quickly and do not have time to pick up large loads of pollutants.

ACID DEPOSITION - WHAT HAVE WE DONE TO THE RAIN?

Usually called "acid rain," this condition can also occur without liquid precipitation, so "acid deposition" is more accurate. Besides being one of the greatest external threats to parks, it is of global concern because the atmosphere can carry pollutants great distances. (As this is written cross-border acid rain is a hot political issue between Canada and the United States.) Complex chemical reactions occur while materials are in the air, producing both wet and dry acidic, highly corrosive compounds. When these fall back to earth they damage stone, wood, and metal; impede the growth of forests and crops, cause disruption of food chains, and even wipe out entire aquatic populations. More discoveries are constantly being made. Obviously, this can profoundly affect both natural and cultural resources in parks.

The National Atmospheric Deposition Program (NADP) was established to monitor this situation. The NPS, with 17 stations, is part of the Interdepartmental Task Force, which participates in the nationwide NADP monitoring network. Like the other air quality monitoring efforts, this network allows a small number of stations at key locations to provide cost-effective coverge for an immense area.

TWO MAGIC WORDS: "PSD" and "INCREMENT"

In the Clean Air Act Amendments of 1977 Congress gave responsibility for protecting air quality, and resources sensitive to changes in air quality, to the Environmental Protection Agency, the states, and federal land managers (FLM's), and created some specific tools for them to use. The Prevention of Significant Deterioration (PSD) program has four major purposes:

- "to preserve, protect, and enhance air quality in national parks, monuments, seashores, and other areas of special national or regional natural, recreational, scenic, or historic value;"

- "to assure that any decision to permit increased air pollution in any area ... is made only after careful evaluation of all the consequences of such a decision and after adequate procedural opportunities for informed public participation in the decision-making process;"

- "to protect public health and welfare from any actual or potential adverse effect(s) ... from air pollution or from exposures of pollutants in other media, which originate as emissions into the ambient air;"

- "to insure that economic development will occur in a manner consistent with the preservation of existing clean air resources."

To do this a classification system was set up, with various areas of the country designated class I, class II, or class III. A class III area allows for the greatest degree of air quality deterioration. However, no such areas exist to date. The amount of additional pollution - "increment" - allowable in any area depends on its classification, with class I allowing the least. The law sets "a national goal of the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory class I Federal areas, which impairment results from manmade air pollution." Class I areas include: international parks; national wilderness areas and national memorial parks in excess of 5,000 acres; and national parks in excess of 6,000 acres. (Currently there are 158 federal class I areas, managed by the USFS, USFWS, or the NPS. The NPS has 48 of them.) All other involved areas were designated class II but they can be redesignated, either by states, or in some cases, by Indian tribes. Existing areas exceeding 10,000 acres which are national monuments, primitive areas, preserves, recreation areas, wild and scenic rivers, wildlife refuges, lakeshores, or seashores; or are newly established national parks or wilderness areas in excess of 10,000 acres can only be redesignated as class I. All other areas initially classified as class II (other than class II "floor areas") can be redesignated as either class I or III. Class II "floor areas" which include several National Monuments, can only be redesignated to class I status.

For each land classification under the PSD program the law established maximum allowable increases (increments) over baseline concentrations of certain pollutants (i.e., sulfur dioxide and particulate matter). These increments may not be exceeded in class II or class III areas. Class I area increments may be exceeded by limited amounts if a new major source applicant can prove that, to the satisfaction of the FLM, Air Quality Related Values (AQRV's) in that area will not be affected. Major Emitting Facilities (MEF's) must submit a preconstruction permit application to the EPA, or to the state if it has been delegated the authroity by the EPA. The Federal Land Manager of any area whose AQRV's might be affected is notified of the permit application and has the opportunity to comment. By law, the FLM has an affirmative responsibility to protect AQRV's. No permit shall be issued if the FLM can convince the permitting authorities that one or more AQRV's will be adversely affected, regardless of whether the allowable increments would be violated. Conversely, if the MEF can convince the permitting authority and the FLM that no damage to AQRV's will occur, the source may be allowed to exceed the class I legal limits.

In addition to the increment provisions, facilities must also comply with National Ambient Air Quality Standards. These standards, applicable nationwide, set pollution levels acceptable for protecting the public health and welfare. A proposed facility must not violate them under any circumstances.

MONITORING - HOW DO YOU SEE AIR?

Air quality monitoring is fundamentally important. For years there have been stories of deteriorating air quality - "Why, when I was boy I could see that mountaintop plain as anything!" - and probably most of these recollections are true. But legislation and enforcement cannot be based on anecdotes.

Visibility and fine-particulate monitoring are done with a network of monitoring stations placed at various park units throughout the United States. Data from these stations help to delineate the mobility of air masses over large areas. Analysis of data yields information about air pollution transport into parks with monitoring stations as well as adjacent units that may not have any monitoring instrumentation. The program provides:

- an "early warning system" for pollution problems, which might make it possible to intervene before serious damage occurs;

- baseline data to identify trends and make projections;

- a basis for evaluating actions taken to protect visibility and other AQRV's;

- a way to learn how air quality is affected by various types, quantities, rates, and locations of pollutants;

- a scientific basis for making policy decisions.

One part of the monitoring effort has been Project VIEW (Visibility Investigative Experiment in the West) which, beginning in 1978, has set up 30 stations in the Southwest and Intermountain West to measure visibility over an extended period of time. Types of VIEW monitoring include:

- Visibility Monitoring: performed with instruments shown in Appendix D. The NPS is charged with preserving visual resources within national parks, which requires being aware of the important vistas in NPS areas and how they may be affected by air pollution.

- Criteria Pollutant Monitoring: monitoring the levels of particular pollutants (particulates, sulfur dioxide, carbon monoxide, ozone, nitrogen dioxide, and lead) for which national ambient standards have been or are being set. This is to assure that the national standards, especially for class I and class II areas, are not being violated. The NPS achieves this by gathering information on potential effects of emission sources proposed for construction near parks; by determining how factors such as wind patterns, precipitation, etc., may affect pollutant levels in parks; by confirming that park activities requiring permits (i.e., prescribed burns) meet the permit conditions; and by assessing the impact of pollutants on park AQRV's.

- Air Quality Related Values Monitoring: may involve any combination of visual examination, photography, data collection on sensitive or "indicator: species which react to air quality changes before hardier species do, and air, water and soil sampling to establish baseline data and identify how air pollutants are affecting these resources.

OTHER RESEARCH

Perceived Visual Air Quality: research involving visitors' perceptions of visible pollution in parks. Through the use of comparison slides as well as actual views, visitors have been asked their response to overall (regional) haze as well as haze with obvious bands (plumes) and the effect each has on the landscape. These responses do not seem to be significantly affected by factors such as race, socioeconomic status, age, or gender. The study has found that for most observers: a scene under clean air conditions is most vulnerable to added amounts of pollution; any addition of color to a scene makes air quality seem better; the eye is very sensitive to additonal regional haze as well as to even small contrasts between layers of haze; plumes located where they do not obscure scenic features have minimal impact, while the more these features are obscured, the lower the perceived air quality; and dark plumes are more intrusive than light plumes. The study methods allow comparison of perceived air quality at vistas in different parks, or different vistas within the same park.

SO WHAT DOES ALL THIS HAVE TO DO WITH ME?

Field people are the backbone of the air quality effort. Field staffs do the day-to-day monitoring which provides the scientifc basis for air resource management. Park staffs are the first to know about proposed developments which may affect the air quality in the parks. Once a potential air quality issue is identified the park staff should inform the regional office or Air and Water Quality Division. Action can then be taken to prevent or remedy the problem. Park personnel can also ensure that their own activities, and those of the concessionaires, are within the law. The park staff should inform other employees and park visitors that through conservation we can all help to keep the air in our parks clean.

Clear air is a basic necessity of life. Through energetic followup of the responsibilities given us in the Clean Air Act, through the accumulation of baseline data, by the extensive process of assessing PSD permits, in jobs large and small we can and must work to assure that national parks will always be places where the mountains shine against the sky.

APPENDIX

Selected Bibliography

1. Malm, W.C. and James Littlejohn, 1981, "Information to Help Interpret the Seasonal Visibility Reports of Project VIEW (Visibility Investigative Experiment in the West)," distributed by WASO Air Quality Division for use by NPS park areas participating in this research project, March 1981.

2. Air Resources Management Manual

3. "Visibility 101" and "201" by Bill Malm

4. Walther, Eric G., R.M. Newbarn and R.M. Tree, 1981, National Park Visibility Measured in the EPA/NPS Regional Network (Data Volumes 1-21) Visibility Research Center Report to EPA/EMSL, Las Vegas, Nevada under Cooperative Agreement NO. CR 8057-8-8020; for Project VIEW (Visibility Investigative Experiment in the West) data analysis.

APPENDIX

Monitoring Instruments

1. Multiwavelength Contrast Teleradiometer

An instrument invented for this study, to accurately and conveniently measure visibility variables. It is a 0.5 meter focal length telescope with a filter wheel and a photodiode detector. It compares the apparent radiance of a distant object with that object's background. (If that contrast drops below 2%, the average person can no longer see the object). As the degree of contrast to a large extent is determined by air quality along the sight path, in effect the instrument is measuring the quality of the air between. A line drawing is attached.

2. Particulate Sampling

A measurement of the aerosol particulate matter in the air is not a measure of visibility, but it is a measure of the matter which causes reductions in visibility. A proper aerosol sampler for visibility related monitoring should collect the coarse and fine mode particles in separate fractions, on a filter medium which allows for chemical analysis. The separation into coarse and fine fractions allows measurement of the strongly scattering accumulation mode particles without distortion by the optically inefficient coarse particles. The coarse particles cannot be completely ignored, as they can cause visibility reduction when present in large quantities. The chemical analysis will be desired to distinguish between various primary components (sulfate, nitrate, organic carbon, sooty carbon, soil elements) and to examine trace metals for indications of the source of the aerosol. Lead is a tracer for automobiles, and other elements may be tracers for other sources (e.g., copper for copper smelters).

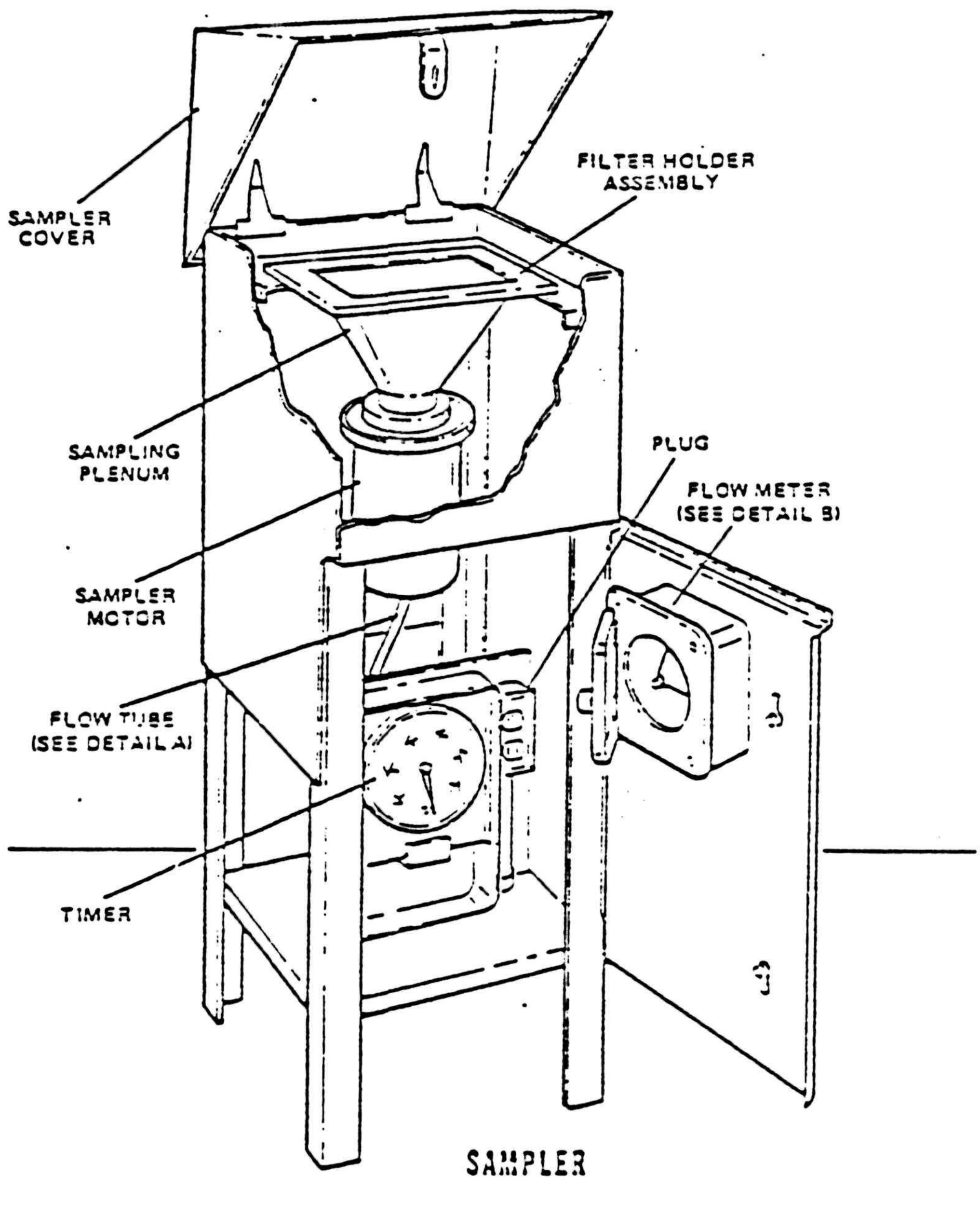
The standard HIGH VOLUME SAMPLER (see attached) has been used in air pollution monitoring for many years. It is a simple device, consisting of a support screen for a filter, and a vacuum cleaner blower to draw air through the filter. The air is forced through a slightly constricting orifice, and the pressure difference across the orifice is measured by a recording pressure gauge as a measure of the flow rate. The filters typically used are 8 x 10 inch glass fiber matrix filters. These samplers cannot provide either the separation of the fine mode particles nor the desirable filter medium for chemical analysis. There is abundant evidence that atmospheric gases are trapped and oxidized to particulate matter on the filters used. The matrix type of filters used in high volume sampling are not appropriate for chemical analysis by x-ray methods. High volume filters are typically analyzed for total mass, trace metals, sulfates, and nitrates by state air quality agencies.

The two types of aerosol sampler recommended for routine visibility monitoring are the VIRTUAL IMPACTOR DICHOTOMOUS SAMPLER and the STACKED FILTER UNIT. There are a variety of other instruments, some of which can give detailed information on the particle size distribution. These are expensive, labor intensive, require highly trained operators, or are subject to a variety of inaccuracies and difficulties. These methods include cascade impactors electrical aerosol analyzers, optical particle counters, and transmission gauges. They cannot cost effectively produce the data of greatest interest and so will not be further considered here.

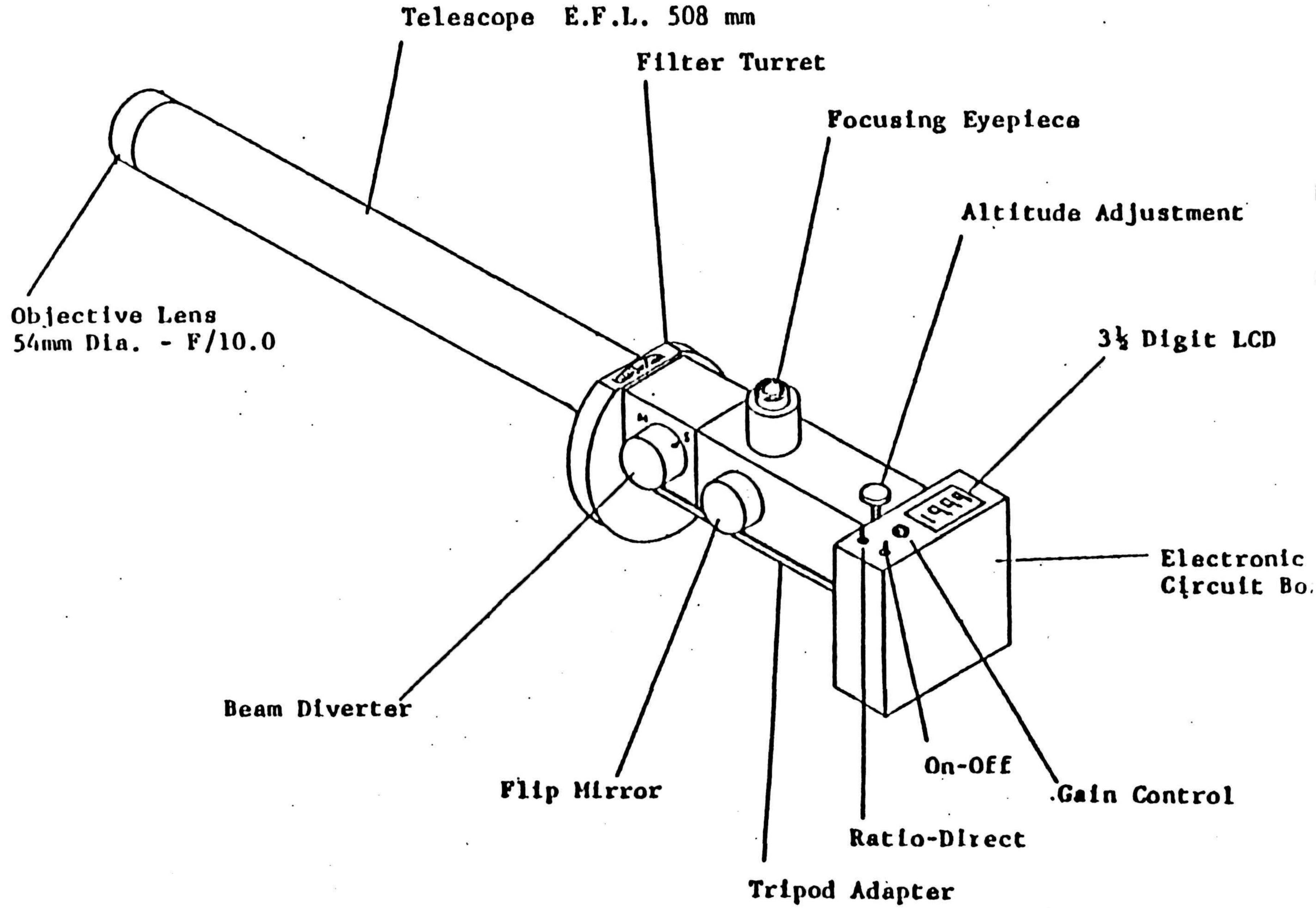
The stacked filter unit uses two filters that the entire airflow must pass through in series. The top filter is comparatively coarse (pore size equals 8 microns) and is estimated to capture particles as small as 3 microns diameter. The bottom filter has a pore size of 0.3 microns and may be regarded as an absolute filter. Both filters are the "nucleopore" type (membrane filters with strictly defined pore sizes, polycarbonate plastic), and are coated preferentially on one side with grease to reduce particle bounce. It is apparently important that the greasy side be facing up when the filter is installed. The flow rate is controlled by a needle valve and rotameter. This instrument is much less expensive to purchase than the virtual impactor, but there are difficulties in handling and analyzing the filters.

The virtual impactor dichotomous sampler collects particles on two filters separated by size. The size separation is done by an aerodynamic technique that utilizes the higher intertia-to-drag ration of the larger particles. The air sampled is accelerated to high speed and split into two flows. The majority of the air makes a sharp turn to split away from the remainder. The large particles have too much inertia to make the turn, and therefore go with the minor flow. The fine particles are dragged along by whatever air they are with, so most of them turn with the majority air flow, but some go with the coarse particles.

The dicotomous sampler uses membrane filters (often Teflon) with a pore size of 2 microns or smaller. The aerodynamics of flow through the filters is such that they may be regarded as absolute filters, capturing nearly all particles larger than about 0.01 micron. The sampler collects in the size ranges 0.01 to 2.5 and 2.5 to 15.0.



INTERIOR LAYOUT OF THE HIGH VOLUME SAMPLER



Telescope E.F.L. 508 mm
Filter Turret
Focusing Eyepiece
Altitude Adjustment
Objective Lens
54mm Dia. - F/10.0
3½ Digit LCD
1999
Electronic
Circuit Bo.
Beam Diverter
Flip Mirror
On-Off
Gain Control
Ratio-Direct
Tripod Adapter