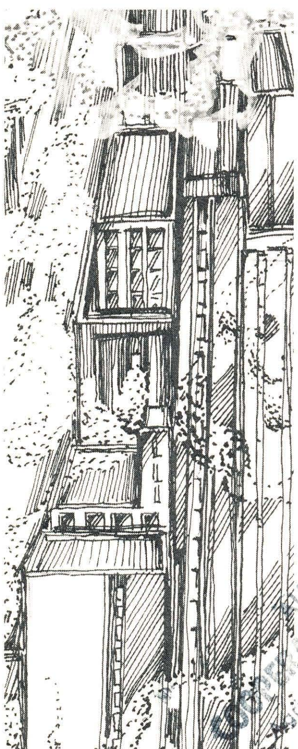
Air Pollution
Michigan State University Cooperative Extension Service
4-H Club Bulletin
Weather Project Unit 5
Norton Strommen, NOAA
Issued N.D.
28 pages

254

UNIT 5 4-H WEATHER PROJECT

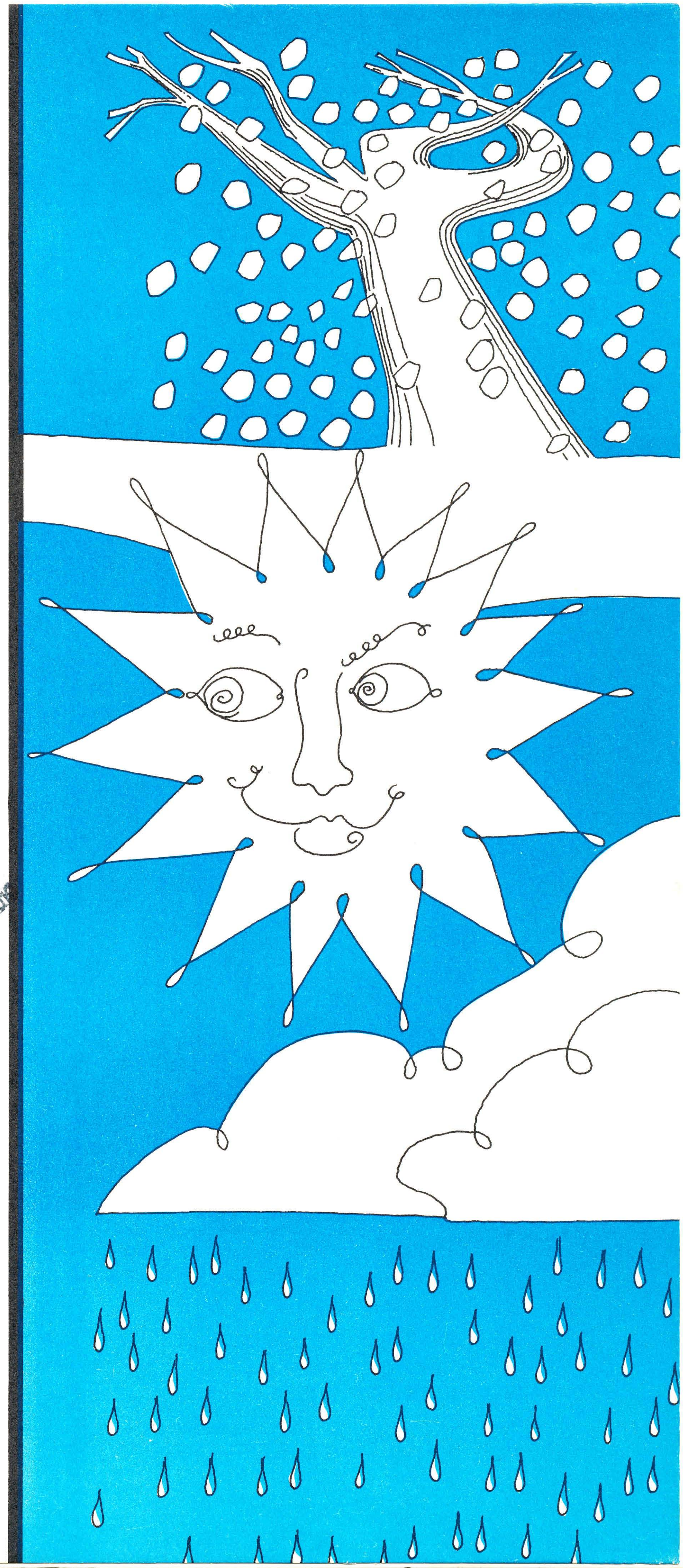
AIR POLLUTION

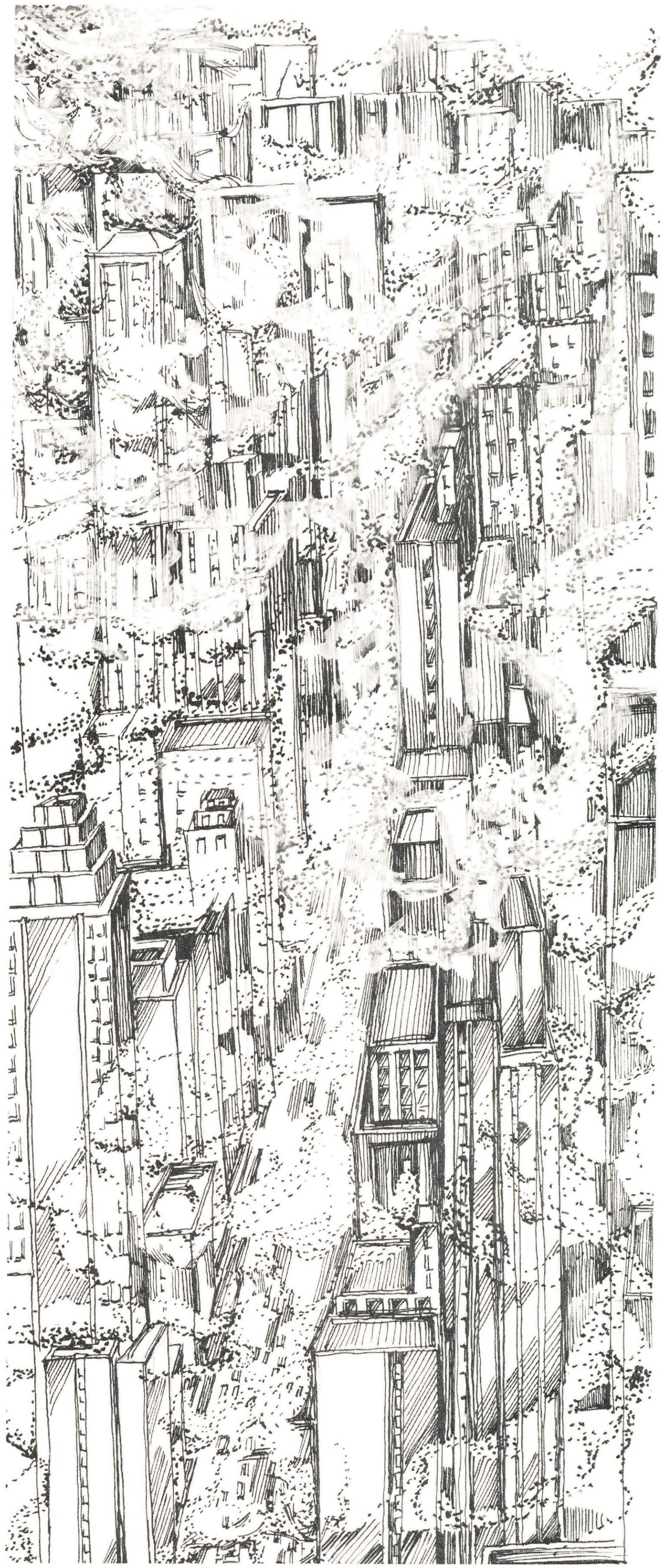


4-H Bulletin 150.2E
Member's Guide

4-H—Youth Programs
and
Agricultural Engineering Department

Cooperative Extension Service
Michigan State University





Technical Consultant for the
4-H Weather Project
Norton Strommen
State Climatologist ESSA
East Lansing, Michigan

INTRODUCTION

The most serious threats which man faces today are those he has brought upon himself.

Air pollution endangers the well-being of every person driving a car on a crowded expressway, or living within any large, modern city or industrial area, anywhere in the world. Polluted air can kill — sometimes swiftly as it has in several prolonged smogs, but more often in a slow, crippling kind of a way. The lungs of persons who live in heavily industrialized cities may turn black from their steady diet of dirty air. The long-time city dweller is more apt to cough a lot, be short of breath, and may die eventually of emphysema or lung cancer.

We cannot live without air, and we must breathe whatever is available. When our lungs cannot filter out impurities and clog up from particles of ash, dirt, unburned substances like rubber — all of which are carried in polluted air — then heart and lungs alike are strained and weakened. When the air our bodies need for life is inhaled in some harmful form, such as carbon monoxide from auto exhaust, our body cells starve and cannot function properly. This is the biological price of pollution.

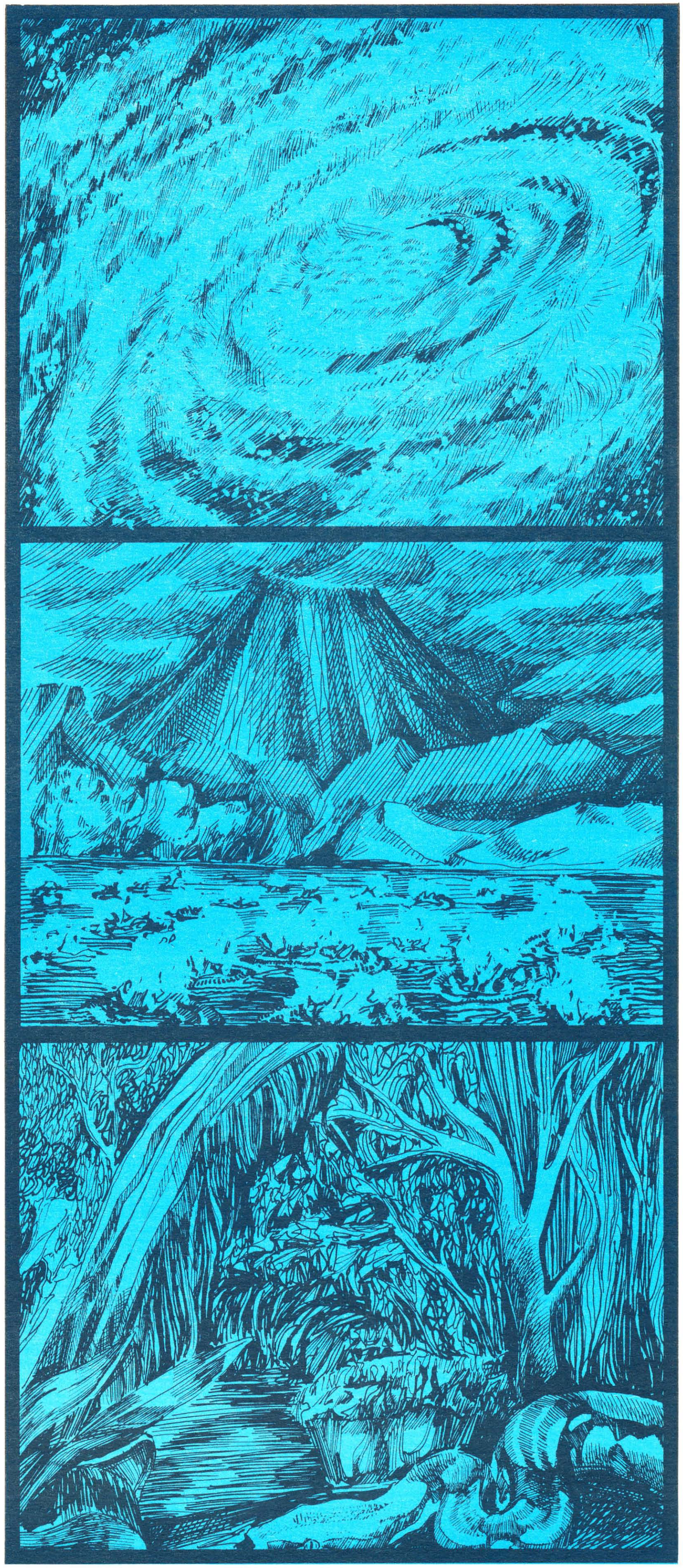
The economic price is also high. Pollution costs us, in the United States alone, billions of dollars each year. Pollutants damage everything they touch. Vegetation is killed, clothing is soiled, paint is discolored, metal work is corroded, and buildings are defaced.

Most pollution at least warns of its presence, however. We can detect the murky air, feel it sting our eyes or scratch our throats. Most obnoxious of all, we can smell pollution. But a far greater threat comes from the air too, and we cannot sense it at all. Deadly radio active fallout, the debris that returns to earth from a ground-level nuclear blast, is also the direct result of man's activity. Just one nuclear explosion, whether by plan or accident, could kill or seriously injure thousands, perhaps millions of people.

In this unit, we explore what makes up the air and how pollution and fallout endanger our lives, our families and our communities. The unit does not pretend to cover either subject completely; it is merely an introduction. It does, however, provide you with basic knowledge whereby you can better prepare to limit or control the danger of pollution, or protect yourself against the threat of fallout.

Air pollution and fallout will probably become even more threatening in the modern world. In any event, with growing technology, population booms, and increasing use of nuclear energy, the dangers will not grow less. Your experience and interest in weather uniquely prepare you to understand the nature of these modern threats and to act to lessen their effects.

CONTENTS



OUR ATMOSPHERE -HOW IT BEGAN

The air we breathe is probably the third distinctive atmosphere our earth has had.

Earth's First Atmosphere:

Hydrogen and Helium. Most scientists today believe that our entire solar system was born at the same time, billions of years ago, in a great gathering together of cosmic dust and gases, chiefly hydrogen and helium. Pressure exerted on the gases at the center of the mass triggered a thermonuclear chain reaction. From this has grown our sun. The planets emerged as the cosmic dust consolidated. Each planet was surrounded by thick, swirling masses of hydrogen, helium and a few other gases left over from the formation of the sun. These gases, none of which support life, formed earth's first atmosphere.

Earth's Second Atmosphere:

Carbon Dioxide, Water Vapor, Nitrogen. In time, this atmosphere of light gases disappeared, probably scattered by intense radiation from the sun. The gases had served as an insulating blanket, trapping heat generated by the earth's creation. As these gases were lost, the heat escaped and the earth began to cool and contract. This put a tremendous squeeze on the other gases trapped within the planet. These gases, predominantly nitrogen, carbon dioxide and water vapor, forced their way outward through huge eruptions all over the earth's surface. It was these first volcanoes that gave the earth her second atmosphere.

Earth's Third Atmosphere:

Oxygen and Nitrogen. After many *eons,* the earth cooled and cooled, finally reaching a point where the water vapor in the air could condense and fall to the earth as rain. Along with the rain came lightning, the electrical spark needed to generate new reactions between elements. Finally signs of primitive life began to appear, probably one-celled organisms which used the gases available and gave off oxygen. From this simplest form of life developed the lush, massive plants of the *Carboniferous* period, all exuding oxygen in such enormous quantities that they changed the makeup of the air into its present form.

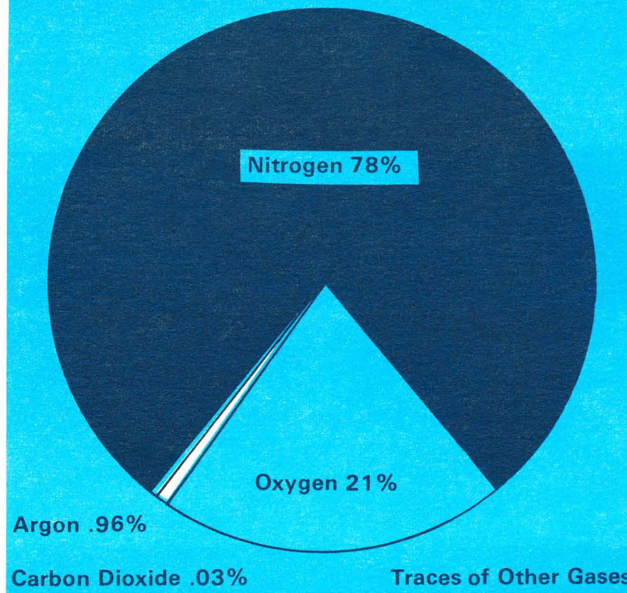


Fig. 1 Composition of Air

WHAT'S IN THE AIR?

Our atmosphere is a mixture of gases, water vapor and particles, or dust, of almost every conceivable kind of matter.

The percentage of gases remain nearly constant in volume. Oxygen makes up about one-fifth (a little less than 21%) of our atmosphere. Four-fifths (78%) of the air we breathe is nitrogen. Another 1% or so is composed of carbon dioxide, argon, neon and many other gases.

OXYGEN

Plant life is essential for our existence. Plants take in carbon dioxide and give off oxygen. Animals, on the other hand, use oxygen and exhale carbon dioxide.

Experiment 1: Demonstrating That Plants Give Off Oxygen

You'll need an aquarium or wide-mouth gallon jar filled with water and water plants; a funnel; test tube or long, narrow bottle; and a painted coat hanger. The entire experiment is submerged.

From the coat hanger, form a stand that will hold an inverted funnel over the aquatic plants. Fill the test tube with water and then invert it over the funnel. Check the experiment periodically, but leave it long enough (possibly a week) for a sizeable amount of gas to collect in the test tube. Is the gas oxygen? Oxygen is the only gas that will support a flame. Remove the test tube and see what happens when you insert a small lighted candle.

Experiment 2: Demonstrating That All Animals Exhale Carbon Dioxide

You'll need a glass of limewater and a straw. To make limewater, dissolve a spoonful of lime (the kind used to mark ballfields) in a quart of water. Stir until the liquid is clear.

Using a straw, blow into the limewater. If your breath contains carbon dioxide, the water will soon turn milky. What happens is this: the calcium (Ca) in the lime combines with the carbon dioxide (CO_2) to form calcium carbonate ($CaCO_2$), a white chalky substance (actually particles of limestone).

We inhale only a small portion of the oxygen produced. A much larger amount is used up by combustion and other processes in which oxygen combines with other chemicals. Rust, which is an *oxide*, is the result of one of these combinations. Try this:

Experiment 3: Oxidation

You'll need a test tube or pill bottle, iron filings and a shallow bowl of water.

Moisten your finger and rub it around the inside of the tube. Now sprinkle iron filings into the tube. The filings will cling to the moistened sides. Turn the tube upside down in a bowl of water and leave it for a day. Is there water in the tube when you begin? What do you observe at the end of the experiment? What has happened to the filings? Why? What else do you observe within the tube? Why? What gas remains in the tube?

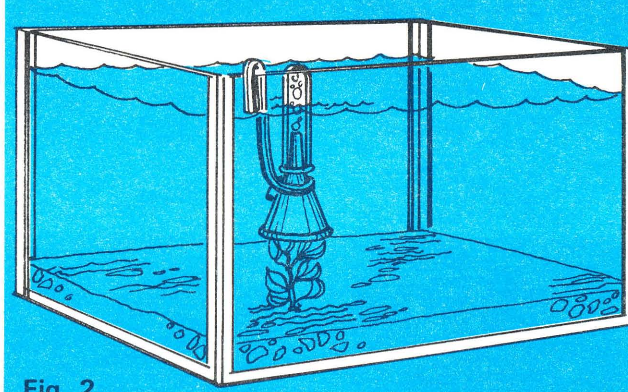


Fig. 2
Demonstrating that Plants Give Off Oxygen

NITROGEN

All living matter contains nitrogen. As plant and animal matter decays, nitrogen is released into the air, thereby helping to maintain a near constant supply. Nitrogen is also released when volcanoes erupt and when fuels containing nitrogen are burned.

Plants need nitrogen for growth. Many obtain their nitrogen directly from compounds within the soil. Others rely instead on nitrogen-fixing bacteria to change free nitrogen into useable chemical compounds. Some of these bacteria live in the soil. Others attach themselves directly to the roots of plants. If you examine the roots of certain plants, such as peas, beans and clover, you'll find many tiny nodules which have been produced by nitrogen-fixing bacteria.

Fig. 3 Roots of Peas Showing Nodules

CARBON DIOXIDE

While the amount of nitrogen and oxygen in the air remains fairly constant, that of carbon dioxide is increasing. The main reason is probably our greater use of fossil fuels (gas, coal and oil). Carbon dioxide is given off whenever these are burned. Can you suggest how our tremendous world-wide growth in population might also be affecting the CO_2 level?

Carbon dioxide makes up only 3/10ths of 1% of the gases in the atmosphere. Yet even a slight increase in this amount concerns scientists. Carbon dioxide helps regulate the earth's heat balance. Too much carbon dioxide might permit overheating of the earth and the consequences could be disastrous. Glaciers and polar ice would melt, which would raise the level of oceans enough to submerge vast areas of the earth.

NATURAL DUST IN THE AIR

If man and his machines were not around to contaminate the atmosphere, would the air be "clean"? Not entirely. Nature adds many kinds of particles or "dust".

VOLCANIC ASH

An erupting volcano can blast enough ash into the air to black out the sun in surrounding areas. When Indonesia's Krakatoa erupted in 1883, the blackout lasted for 2-1/2 days. Krakatoa threw into the air almost *five cubic miles of* pulverized rock. The most violent explosion hurled ash upward for 50 miles. The whole world felt the effects of Krakatoa's eruption. Volcanic dust in the stratosphere produced spectacular red sunsets for many weeks all over the world. Can you find out why?

Is Krakatoa still active? See what you can learn. What other volcanoes are active today?

SALT

Most salt in the air comes from ocean spray. Although the particles are microscopic in size, their presence can easily be detected near any seashore. Salt corrodes the finish on cars. (Cars in Michigan and other northern climates are similarly affected by the salt spread on streets to melt snow.)

Salt particles serve an important weather function. In Unit I, we learned that water vapor must collect on or cling to solid particles before it will condense and grow into rain droplets. Salt particles are among the most favored of these *condensation nuclei*. High in the atmosphere and in laboratory experiments where condensation nuclei are lacking, air containing water vapor can be cooled far below the point of saturation without condensation occurring.

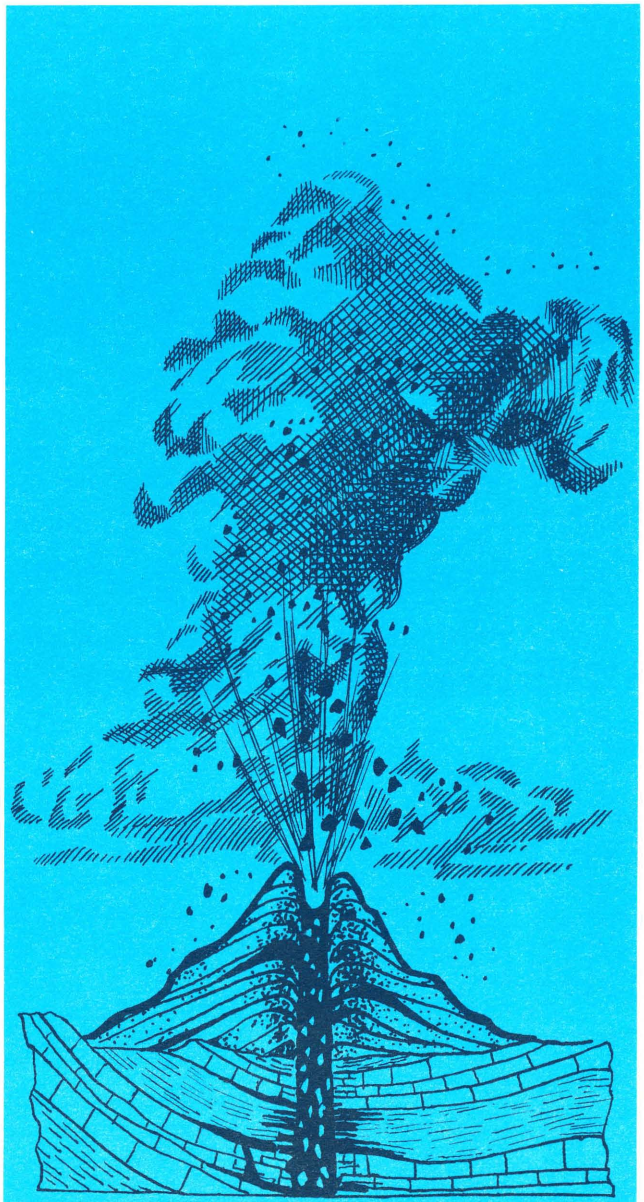


Fig. 4

Fig. 5
How Particles Look Under a Microscope

POLLEN

Pollen is the reproductive yellow powder found on the *stamen* of flowers. Its presence in the air might not concern us at all if so many people were not allergic to it. Man is partially responsible for the atmosphere's most objectionable pollen content. Ragweed, the bane of "hayfever" sufferers, thrives only in cultivated soil. Wheezing victims, doctors, public health officials, botanists and many others are vitally interested in knowing when and where the pollen content of the air is greatest. The ragweed sampling project (Experiment 4) is a highly accurate technique used to take a pollen count. The directions below show you how to collect the pollen. Your leader can explain how to take a count.

What you are about to make is a tiny flag of sticky tape, mounted in a small glass vase

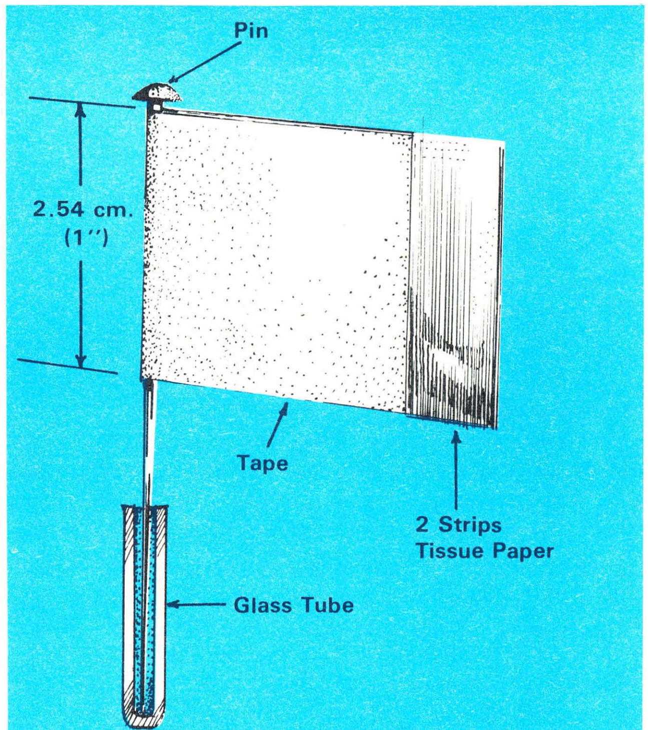


Fig. 6 Assembling a Pollen Sampler

or bearing (see Fig. 6). The mounted flag always keeps its leading edge to the wind. You won't be interested in what collects on the flag itself, but rather, the deposit on the back side of the pin. Particles the size of ragweed pollen (20 microns or so) fly into or "impinge" on this edge of the pin. When you remove the tape flag from the pin and attach it to a glass slide, you can study the pollen under a microscope and even take a count. The ragweed pollen content of the air reaches its peak in late summer and early autumn.

Experiment 4: Ragweed Pollen Sampling

You'll need a length of 1/8th inch glass tubing; a 2-inch straight pin (known as a bank pin, available from stationery stores); a 2-inch length of double-coated transparent tape; 2 strips of tissue or lens paper, 1/4 inch by 1 inch; and diluted rubber cement (1 part rubber cement to at least 3 parts rubber cement thinner).

Break off the glass tubing to a 3/4 inch length. Seal one end in a Bunsen burner, then pass the other end through the flame just enough to polish the glass edge. This will lower the friction. Attach a strip of tissue paper to each end of the tape (on the surface facing you). Then fold the tape over the pin, bringing the tissue pieces together. (The tissue permits you to separate the tape easily when your experiment is over.) If the flag does not stand erect, crease it back along the pin. Coat the tape at the back edge of the pin with diluted rubber cement. Now your sampler is waterproof and can be placed outside whenever you want to take a count.

SAND AND SOIL

Sand and dust storms account for millions of tons of airborne dust which settle out over the United States every year. Loose dry topsoil, not held in place by sufficient vegetation, may be carried off by the winds, sometimes settling out thousands of miles away. During the drought and great dust storms of 1933, loose topsoil picked up by the winds over the Great Plains was blown as far as the Atlantic Ocean. Some of this dust, falling in New England as discolored snow, averaged 25 tons per square mile.

Experiment 5: How "Clean" is Rain or Snow?

Collect rain water or snow and either: Pass the sample through a filter (paper coffee filter without a center hole, or two thicknesses of wet-strength paper towelling); or evaporate the water.

Examine the residue under a microscope.

RADIOACTIVE PARTICLES

When we think of radioactive particles in the air, we tend to think only of man-made fallout (see page 9). Actually, some radioactive particles have always been in the atmosphere.

One of these naturally existing radioactive particles is Carbon 14, or radiocarbon. Carbon 14 is produced in nature by the interraction of cosmic rays with the atmosphere's nitrogen. This radioactive form of carbon unites with oxygen to form radioactive carbon dioxide, which, along with regular CO_2 is taken in by all living cells. The normal carbon content remains in the cells, but the less stable radiocarbon begins to "decay". We say it has a *half-life* of about 5,700 years.

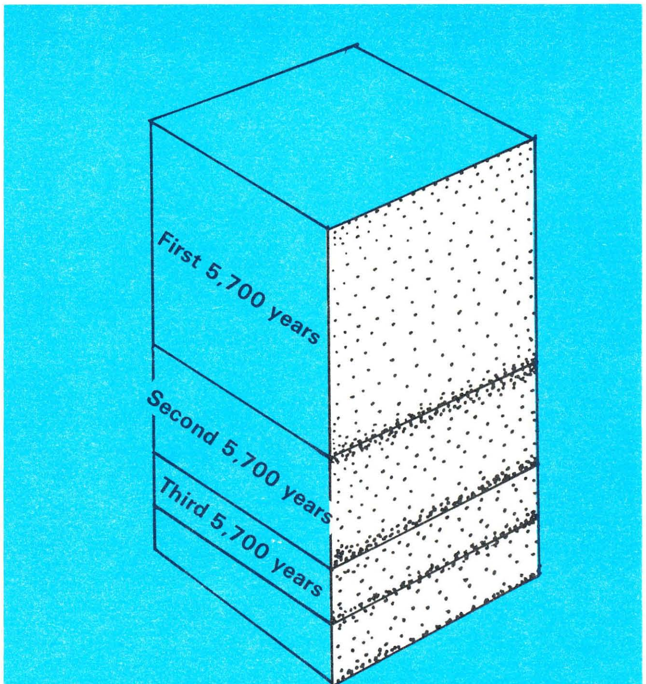


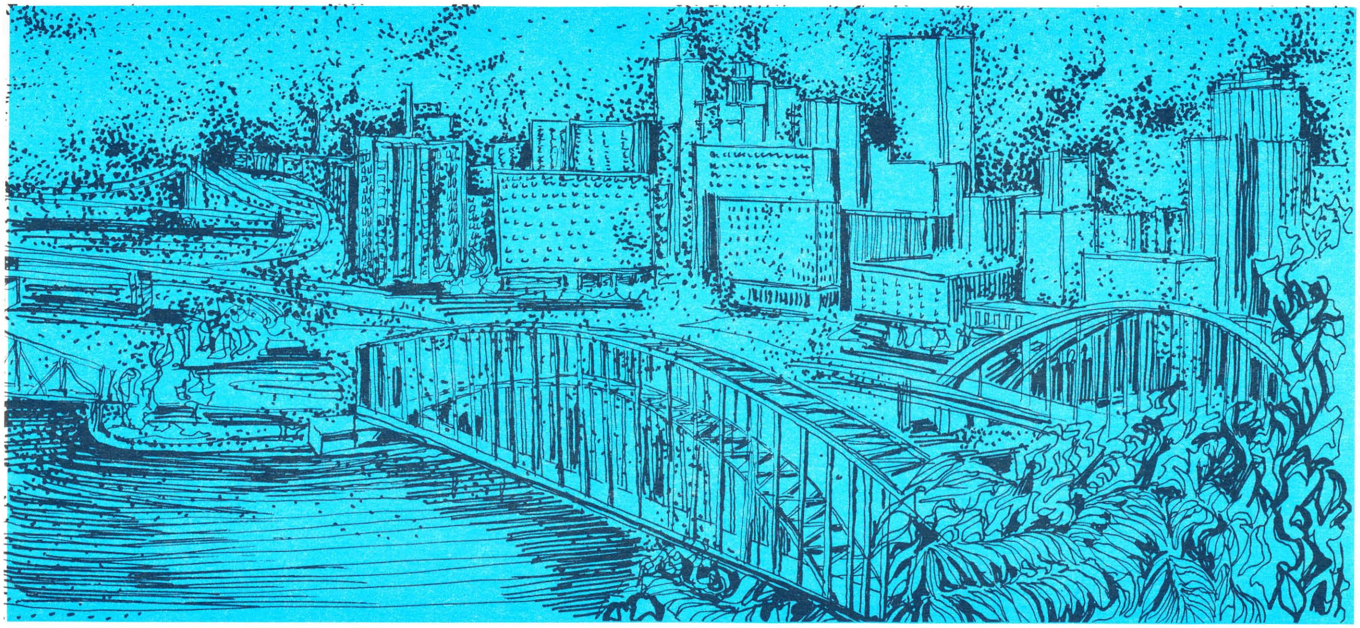
Fig. 7 Rate of Carbon 14 Change or "Decay"

In that length of time, one-half of the radioactive carbon will have changed to a more stable element. In another 5,700 years, one-half of the remainder will have changed. All radioactive materials change or *decay* in this manner, each with a different half-life. In the case of radiocarbon, whatever remains is reduced by one-half every 5,700 years.

This long half-life has led to a fascinating scientific development: the dating of archeological finds by the amount of radiocarbon present. If the radiocarbon content of a mummy, for example, has diminished by 1/2, scientists know that the mummy must be about 5,700 years old. If the radiocarbon has diminished by 3/4ths, they know another 5,700 years have elapsed.

Radioactivity cannot be seen, but the presence of radioactive particles can be detected in other ways. Their radiations can be picked up by a *Geiger counter* or similar device. Also, as we shall see in Experiment 14, the radiations will darken a photographic film.

You might want to invite your civil defense director or a state police officer to a meeting to talk about *radiological monitoring.* Ask him to bring along a Geiger counter. He will show you how radio activity is detected and measured. What do you hear after a Geiger counter has warmed up? Why?



MAN-MADE POLLUTION

Although nature can do a pretty good job at times of dirtying the air, pollution as we know it, is man's work. For the most part, it's the work of man's machines. Engines of all kinds suck in billions more tons of air than man himself does, then spew out obnoxious fumes, poisonous gases and particles that soil, contaminate and corrode.

AUTO EXHAUST

The car is the worst offender. Cars in the United States in one year consume about 4 *billion* tons of air, and replace it with carbon monoxide, nitrogen oxides, sulfur oxides and other poisonous and corrosive substances. On a crowded expressway the level of carbon monoxide can be high enough to dull a driver's reflexes or make him unconscious. Public health officials wonder how many city and expressway accidents might have been caused by carbon monoxide poisoning.

When air circulation is poor and sunlight is strong, auto exhaust reacts *photochemically* with the sun to produce two different and extremely harmful substances: ozone and PAN (peroxyactyl nitrate). Los Angeles is the classic example of this situation. High concentrations of both ozone and PAN are found in a typical Los Angeles smog. Ozone damages plant life; PAN is exceedingly irritating to the eyes.

Experiment 6:
Ozone Effect on Plants and Rubber

Ozone may also be produced by an electric spark. For this experiment you'll need a spark-producing induction coil or ozone producing lamp ("steri-lamp"). Since the most readily available induction coil will probably be found in a general science class or high school physics lab, you might want to carry out this experiment in school.

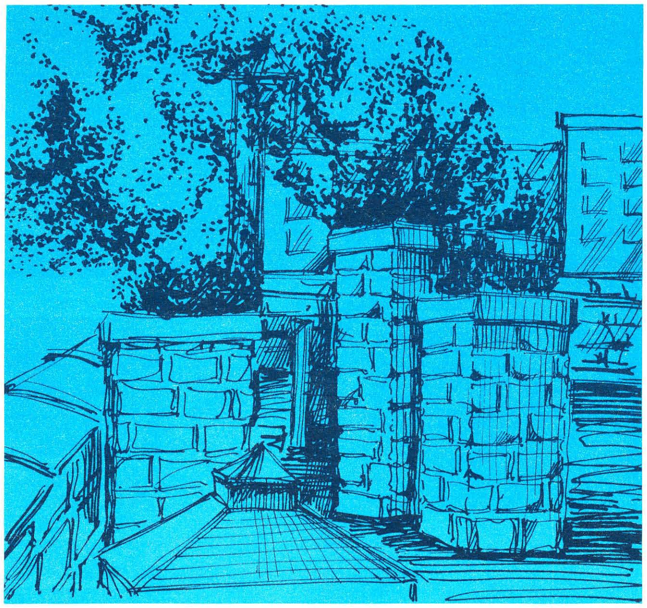
In one corner of an empty aquarium set up the coil or lamp. On the opposite side of the aquarium place a potted plant. If you also want to test the effect of ozone on rubber, include an inflated toy balloon. Cover the aquarium, plug in the spark producer, leave for a day and observe the results. For scientific control, place a similar plant and inflated balloon outside the aquarium.

SMOKE

Auto exhaust is only one part of the pollution picture. Much more visible and offensive to the nose and throat is smoke belching out of chimneys of all kinds and smouldering rubbish heaps. Smoke, like auto exhaust, results whenever a fossil fuel (coal, oil or gasoline) does not burn completely. Smoke scratches the throat, stings the eyes, damages plants, reduces visibility and everywhere lays down a cover of soot and grime.

Smoke can also kill.

Let's look back to London, 1952. The time is late November. A wave of cold air has just settled in over the city. The accompanying high-pressure system is the beginning of a long-lasting temperature inversion. This meteorological condition does not mean much to the average Londoner; he is more concerned about the sudden chill as he rushes home to stoke his coal furnace. Before long, smoke is pouring out of chimneys all over the city.



Trapped by the inversion, the pollutants cannot escape. A dense cloud begins to envelop the city. Day by day as the cold spell continues, more coal is shoveled on the fires and the cloud grows more thick and foul. Soon the old, the young, and those of every age with respiratory ailments begin to gasp. Many die.

After the inversion had broken two weeks later, the records showed that over 4000 people had died from the effects of the smoke-filled fog, or "smog".

This is the worst smog disaster that has ever occurred. But other cities have also had killer smogs, among them New York City and Donora, Pennsylvania. What can you find out about these? What is being done on a national, state and local level to reduce the concentration of smoke in the air? Does your community have a smoke abatement law or plan?

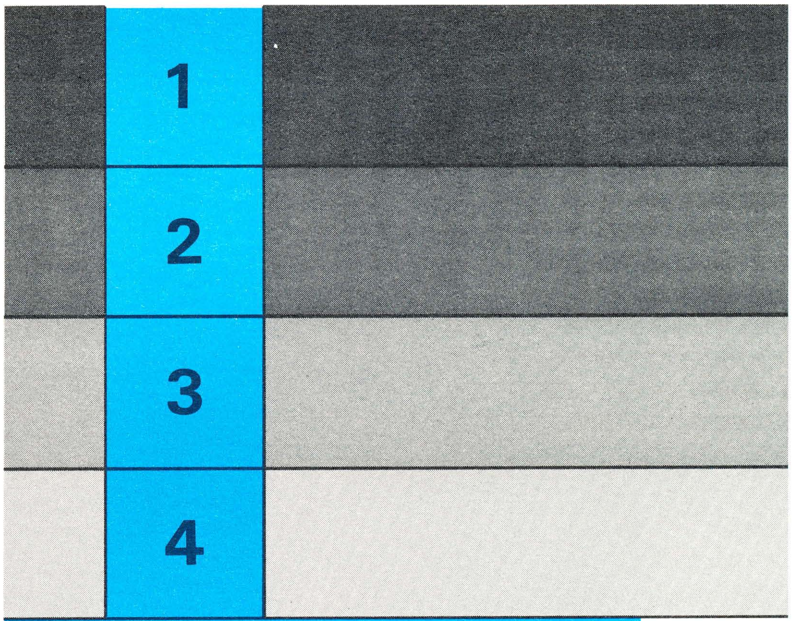


Fig. 8 Smoke Chart. Hold at eye level. Select shade of gray closest to smoke color. Record the number.

MEASURING SMOKE

Wherever enough smoke is present to interfere with man's well being and comfort or the full enjoyment of his property, an air pollution problem can be said to exist. The thicker and blacker the smoke, the greater is the quantity of undesirable particles and gases being emitted. Above is a chart used by meteorologists and air pollution control officials to measure the intensity of black smoke.

If you would like to measure pollution sources in your own community, clip the chart, mount it on a card and follow the directions below:

Experiment 7: Reading a Ringlemann-Type Smoke Chart

Stand between 100 feet and 1/4 mile away from the smoke plume. Then hold or hang the chart at eye level, as nearly as possible in line with the chimney, preferably with the sun to your back. Find the shade of gray on the chart closest to the smoke and record the number. To get a more accurate reading, rate the smoke level every 1/2 minute for a half hour or so. Record each reading and then find the average rating and average density. Number 1 smoke (20% density) is the standard.

SULFUR DIOXIDE IN THE AIR

Among the most objectionable substances in smoke is sulfur dioxide. Oxides of sulfur are given off in large quantities whenever coal containing sulfur is burned. Since sulfur reacts with water to produce sulfuric acid, droplets of this highly corrosive acid may fall through a polluted atmosphere as rain, or float through the air as fog. Sulfuric acid eats away metal, paint and even stone. To the dismay of women in industrial areas, very tiny droplets of sulfuric acid in the air will pop the threads of nylon hosiery, leaving them in shreds.

Experiment 8: Determining the Presence of Sulfur Dioxide in the Air

This experiment should be conducted in a city or industrial area where a reasonably high level of sulfur dioxide might be expected. You'll need a basketball inflating pump* with a hose attached to the inflating end; a jar or pail of water, and blue litmus paper.

Drop the hose into the water and pump air for at least 10 minutes, preferably longer. Then test for acid. If sulfur dioxide is present in the air in a sufficient quantity, it will react with water to form sulfurous acid, which will turn blue litmus paper red.

*Some bicycle tire pumps may work. Others may suck the water up into the pump.

ANALYZING THE AIR

Following are several more experiments for analyzing the contents of the air. By enlarging the sampling (either the area or time involved) you can make several of these experiments as elaborate as you like.

Experiment 9: How Much Dust is in the Atmosphere of Your Community

This is based on an actual sampling technique used for pollution control.

You'll need one or more wide-mouth gallon jars, one-third full of distilled water. If more than one jar is used, place them in different parts of your community, or use them to compare rural and urban air; or place them within a given distance (100 feet, 200 feet, etc. or 1/4 mile, 1/2 mile, etc.) of a known pollution source. Leave the jars exposed to the air for 30 days. Add water during this period as necessary to maintain the proper level. At the end of 30 days, evaporate most of the water away. Transfer the remainder, including sludge, to a previously weighed dish and then finish evaporating the deposit to dryness. Weigh the residue. Then measure the area of the opening of the jar and from that calculate the dustfall in tons per square mile per 30 days. If you need help with the calculation, ask your math or science teacher.

Experiment 10: Analyzing the Air in Your Home

Before a used furnace filter is discarded, cut out a small square and drop it in a beaker of distilled water. Remove as much of the dust as possible in the water. Then test the water for acidity (see Experiment 8). Evaporate the water and notice the amount of residue. Examine the residue under a microscope. Black irregular particles will be pieces of soot. White particles will be other types of dust. Do you notice any crystal formations? Any cellular structures such as pollen?

Experiment 11: In What Direction Lies the Major Source of Pollution? (Fig. 9)

You'll need a piece of board with compass points marked (N, E, S, W); a tall jar with a screw top; two nails and gummed paper or tape, coated with vaseline or diluted rubber cement.

Nail the cap, top side down, to the board. Then screw on the jar. Form a band around the jar with the tape. Place the board so that the N marking faces north. Leave it in an exposed position out of doors for a period of time (a week or more) and then observe.

Experiment 12: Small Particles in the Air

Spider webs capture extremely small particles in the air. You might want to look at a piece of spider web under a microscope and examine these captured particles.

SMOKE CONTROL

Many devices are now available which, in one way or another, trap a pollutant before it leaves the smokestack. One of the most effective is the electrostatic precipitator.

This process requires a discharge electrode (usually negative) and a collecting electrode (usually positive). A high voltage electric field

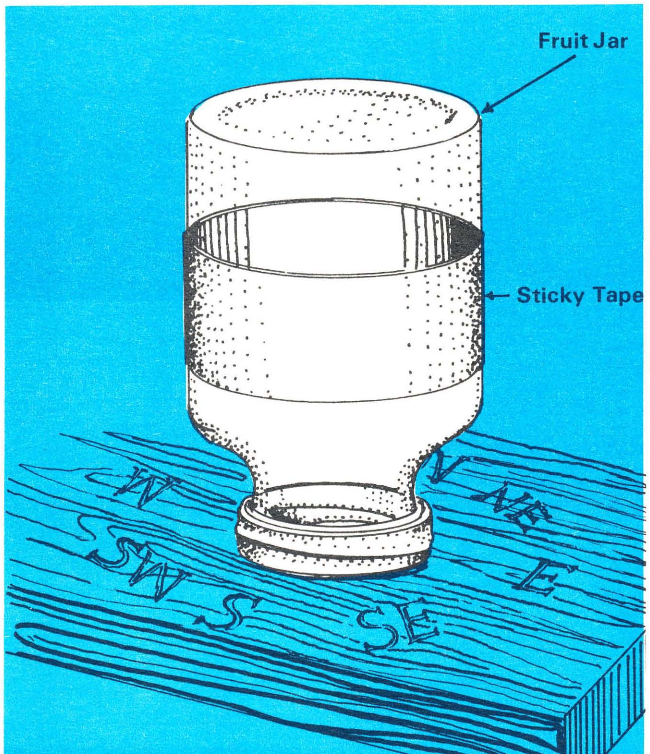


Fig. 9 Finding Direction of Pollution Source

is set up between the electrodes. Gas to be cleaned flows between these electrodes. The air molecules *ionize*—that is, break down into negative and positive particles or *ions*. Since opposite charges attract, the negative ions move toward the positive collecting surface and the positive ions move toward the discharge electrode. These charged particles attach themselves to neutral particles in the smoke and carry them along to the electrodes. The electrostatic filter is set up so that the negative ions have a much greater distance to travel before reaching the collecting electrode. Thus they contact many more particles than the positive ions and leave a large deposit on the collecting electrode. The deposited particles neutralize and can easily be washed or shaken off.

Let's demonstrate what happens in this electrostatic process.

Experiment 13: Precipitating Smoke

You'll need an induction coil, 2 narrow strips of wire screening, toothpicks and a glass tube.

Suspend the screening strips in the tube and hold them apart with toothpicks. Wires from the induction coil are attached, one each, to the screening. Now fill the tube with smoke and activate the coil. What happens to the smoke? Can you explain why?

FALLOUT

Fallout is the radioactive debris which falls back to earth when a nuclear explosion takes place at or near ground level. Fallout may resemble fine ash. Often it cannot be seen. Yet it gives off rays and particles which are able to penetrate and destroy living cells. If the concentration is high enough, radioactive fallout can seriously injure and even kill human beings and animals. Farmlands and crops which have been contaminated by fallout may be too dangerous to use.

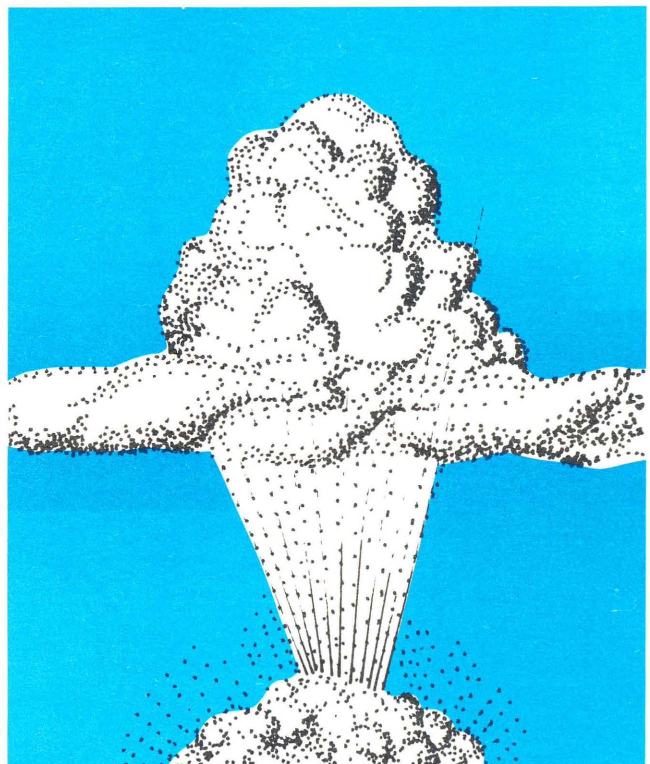


Fig. 10 Nuclear Explosion at Ground Level

Fallout in the atmosphere reached its highest levels in the 1950's when Russia, Great Britain and the United States were all conducting nuclear bomb tests on a large scale. The fallout level became so alarming that the three nations agreed, in 1958, to stop further testing in the atmosphere. Two emerging nuclear nations—China and France—did not sign the treaty and have conducted limited atmospheric tests. Although the level of man-made fallout has declined considerably since the 1950's, some can still be detected in the atmosphere in addition to the natural radioactivity that has always been present.

SULFUR DIOXIDE IN THE AIR

Among the most objectionable substances in smoke is sulfur dioxide. Oxides of sulfur are given off in large quantities whenever coal containing sulfur is burned. Since sulfur reacts with water to produce sulfuric acid, droplets of this highly corrosive acid may fall through a polluted atmosphere as rain, or float through the air as fog. Sulfuric acid eats away metal, paint and even stone. To the dismay of women in industrial areas, very tiny droplets of sulfuric acid in the air will pop the threads of nylon hosiery, leaving them in shreds.

Experiment 8: Determining the Presence of Sulfur Dioxide in the Air

This experiment should be conducted in a city or industrial area where a reasonably high level of sulfur dioxide might be expected. You'll need a basketball inflating pump* with a hose attached to the inflating end; a jar or pail of water, and blue litmus paper.

Drop the hose into the water and pump air for at least 10 minutes, preferably longer. Then test for acid. If sulfur dioxide is present in the air in a sufficient quantity, it will react with water to form sulfurous acid, which will turn blue litmus paper red.

*Some bicycle tire pumps may work. Others may suck the water up into the pump.

ANALYZING THE AIR

Following are several more experiments for analyzing the contents of the air. By enlarging the sampling (either the area or time involved) you can make several of these experiments as elaborate as you like.

Experiment 9: How Much Dust is in the Atmosphere of Your Community

This is based on an actual sampling technique used for pollution control.

You'll need one or more wide-mouth gallon jars, one-third full of distilled water. If more than one jar is used, place them in different parts of your community, or use them to compare rural and urban air; or place them within a given distance (100 feet, 200 feet, etc. or 1/4 mile, 1/2 mile, etc.) of a known pollution source. Leave the jars exposed to the air for 30 days. Add water during this period as necessary to maintain the proper level. At the end of 30 days, evaporate most of the water away. Transfer the remainder, including sludge, to a previously weighed dish and then finish evaporating the deposit to dryness. Weigh the residue. Then measure the area of the opening of the jar and from that calculate the dustfall in tons per square mile per 30 days. If you need help with the calculation, ask your math or science teacher.

Experiment 10: Analyzing the Air in Your Home

Before a used furnace filter is discarded, cut out a small square and drop it in a beaker of distilled water. Remove as much of the dust as possible in the water. Then test the water for acidity (see Experiment 8). Evaporate the water and notice the amount of residue. Examine the residue under a microscope. Black irregular particles will be pieces of soot. White particles will be other types of dust. Do you notice any crystal formations? Any cellular structures such as pollen?

Experiment 11: In What Direction Lies the Major Source of Pollution? (Fig. 9)

You'll need a piece of board with compass points marked (N, E, S, W); a tall jar with a screw top; two nails and gummed paper or tape, coated with vaseline or diluted rubber cement.

Nail the cap, top side down, to the board. Then screw on the jar. Form a band around the jar with the tape. Place the board so that the N marking faces north. Leave it in an exposed position out of doors for a period of time (a week or more) and then observe.

Experiment 12: Small Particles in the Air

Spider webs capture extremely small particles in the air. You might want to look at a piece of spider web under a microscope and examine these captured particles.

SMOKE CONTROL

Many devices are now available which, in one way or another, trap a pollutant before it leaves the smokestack. One of the most effective is the electrostatic precipitator.

This process requires a discharge electrode (usually negative) and a collecting electrode (usually positive). A high voltage electric field

Experiment 14: Detecting the Presence of Radioactive Particles in the Air

You'll need a 6-inch piece of used furnace filter with its collection of dust, and a sheet of cut photographic film or X-ray film*, wrapped in thin black paper. Lay the section of furnace filter over the wrapped film. Leave for 24 to 48 hours. Then develop the film. If radioactive particles are present in the furnace filter, their radiation will penetrate the wrapper, leaving dark spots on the developed negative or white spots on the print.

*Ordinary roll film may be used if it is unwrapped in a dark room (an unlighted closet at night is best), cut into a piece about 6 inches long and then wrapped with thin black construction paper. Do not expose any of the unwrapped, undeveloped film to light.

THE ROLE OF THE ATOM

Chemical change . . . ionization . . . radioactivity. All occur in the atmosphere and you've observed the effects of each in your experiments. But have you any idea what exactly happened and why?

—Why can two elements (for example, hydrogen and oxygen) combine to form another that is totally different (for example, water)?

—What is ionization and how can it make smoke disappear?

—Why does fallout kill?

To answer such questions, we have to understand first the very nature of matter.

AT THE HEART OF MATTER: THE ATOM

Early Greek philosophers first suggested that if any piece of matter could be divided and subdivided, eventually one piece, the smallest possible would remain. They called this smallest particle an *atom*, meaning "indivisible."

The Greek philosophers were partly right. The atom is the smallest unit of an element that bears all the characteristics of the element. But the atom itself is made up of many, even smaller parts.

In 1911, Sir Ernest Rutherford made some interesting observations about the atom and came up with a description that won him the Nobel Prize. He suggested that the atom is composed of positively and negatively charged particles which balance each other electrically. The positively charged particle, called a *proton,* is contained in a dense, heavy *nucleus.* The balancing negative charge is found in the *electron,* an extremely light and fast-moving particle which orbits around the nucleus at a tremendous distance. Imagine this: If the nucleus were the size of a pea, the electron would be in orbit a football field away!

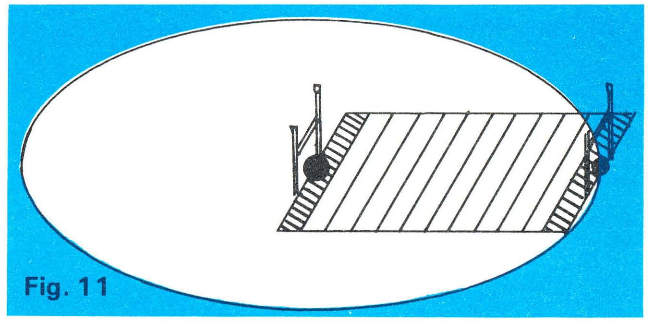


Fig. 11

To remain electrically neutral, an atom with one proton in its nucleus must have one electron in orbit around it. This, in fact, is the normal atomic composition of hydrogen, lightest of all elements. Helium, next lightest, has two protons and two electrons. Oxygen has eight protons and eight electrons. Uranium, heaviest of all natural elements, has 92 protons and 92 electrons.

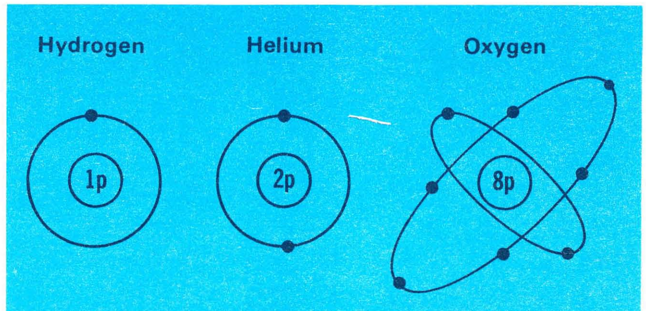


Fig. 12

IONIZATION

What happens then if an electrical spark or some other jolt of energy knocks an electron out of orbit? The atom is no longer electrically neutral. It has a surplus of positive charge. We say it is a *positive ion.* The loose electron carries a negative charge and is called a *negative ion.* A basic law of electrical charges is that like charges repel and opposite charges attract each other. The positive ion will be attracted to a negative ion, or, as in the electrostatic precipitator, to a negative surface. The negative ion, or electron will be attracted to a positive charge. You can show this with an *electroscope.*

Experiment 15: Demonstrating Ionization with an Electroscope

You'll need a small clean, dry bottle; a rubber stopper to fit the bottle; a nail with a head; two strips of thin aluminum foil, about 1/4 inch by 1 inch, and nail polish.

Drive the nail through the stopper so that the point will extend into the bottle. Place a drop of polish on each side of the nail and use this as glue to hold the foil strips. Since humidity could spoil your experiment, make sure all parts are thoroughly dry. Insert the stopper. Now approach the nailhead with a charged item and see what happens.

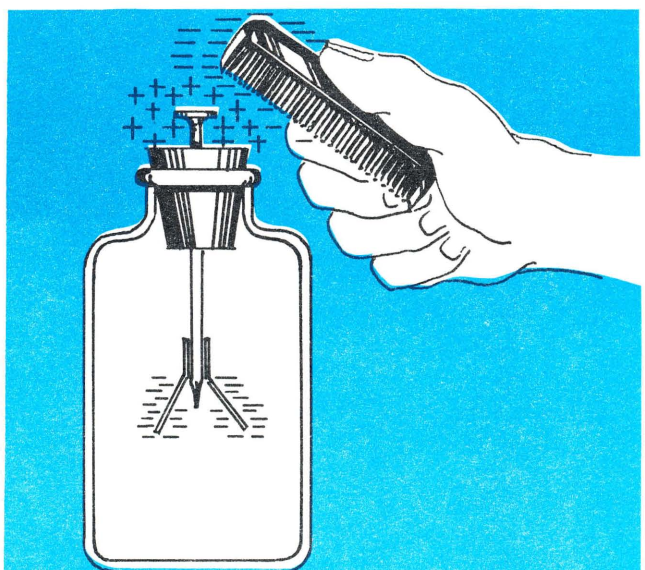


Fig. 13 Using an Electroscope

Example: Vigorously rub a plastic pen with wool or fur, or run a comb through your hair. The pen or comb will gain a surplus of electrons. As you move either of them toward the nailhead, positive charges within the nail will be attracted and move up into the nailhead. The nail's electrons will be repelled and driven into the foil pieces. Now the foil pieces are both negatively charged. What happens?

Touch the nailhead. What happens?

To produce a positive charge, rub a glass or lucite rod with a piece of silk. Repeat the experiment and explain what happens.

CHEMICAL CHANGE

The electrons follow a very definite arrangement in their orbit around an atom's nucleus. Scientists call their orbit paths *shells.* The first orbit path, or K shell, is closest to the nucleus and can hold no more than 2 electrons. The next, or L shell, can hold a total of 8 electrons; the M shell, 18; the N shell, 32 etc.

Any element whose atoms have a complete outer shell will not unite chemically with another element. Only six such elements are known. They are the inert gases and include helium, argon and neon. However, if the outer shell is incomplete, one atom will unite with one or more others. The combined atoms form a *molecule* of a new substance which may be totally unlike the separate atoms. Such a change can come about by ionization, in which a positive ion (an atom which has a shortage of electrons) combines with a negative ion (an atom which has a surplus of electrons). Or atoms may combine by sharing electrons.

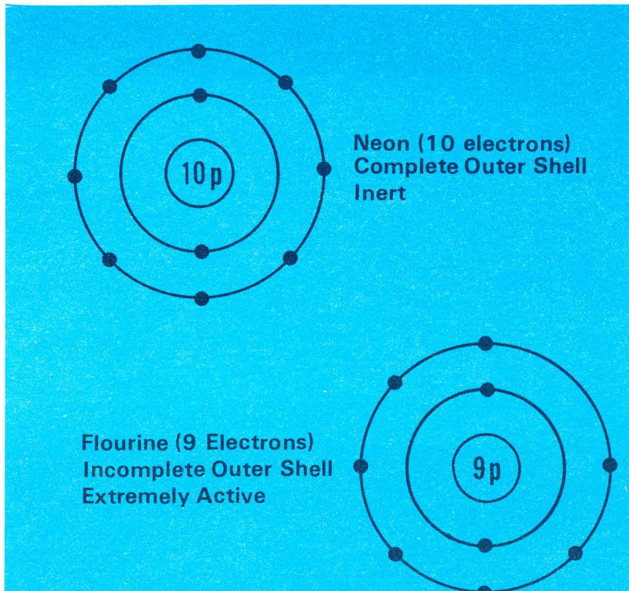


Fig. 14 Flourine and Neon

We learned that oxygen forms many chemical combinations. Let's see why. Oxygen has 8 electrons. Two are in the first shell, and six in the second. An atom of oxygen, then, has room for two more electrons. Perhaps two hydrogen atoms will share electrons with her. We can illustrate this as shown, or write it H_2O which is the chemical formula for water.

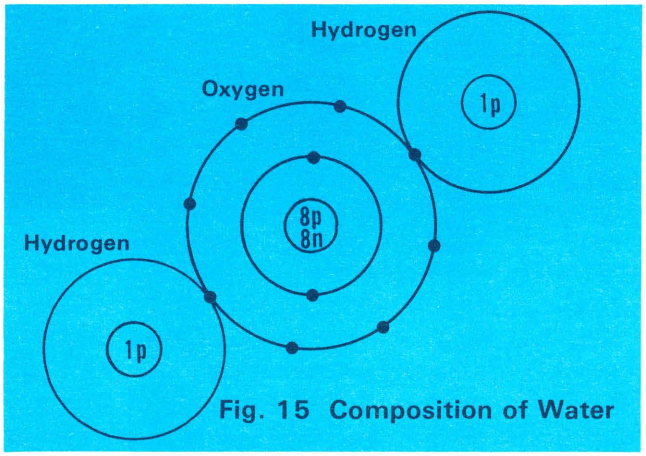


Fig. 15 Composition of Water

One oxygen atom may even unite with one or two others. The oxygen we breathe is actually O_2, or two atoms joined together. Should three oxygen atoms join, the result is O_3, or pungent, caustic ozone.

Nitrogen and oxygen unite to form many oxides. Nitrogen has 7 electrons, two in the first shell, and 5 in the second. Two nitrogen atoms and one oxygen (N_2O) give us nitrous oxide or laughing gas. Small amounts of nitrous oxide can be used as an anaesthetic, but a large dose causes death.

Two other nitrogen oxides, nitric oxide (NO) and nitrogen dioxide (NO_2) are extremely poisonous. These are among the gases most commonly found in auto exhaust. Whenever a fossil fuel is burned without an adequate supply of oxygen, atoms of carbon, oxygen, sulfur, hydrogen and nitrogen may unite in harmful ways.

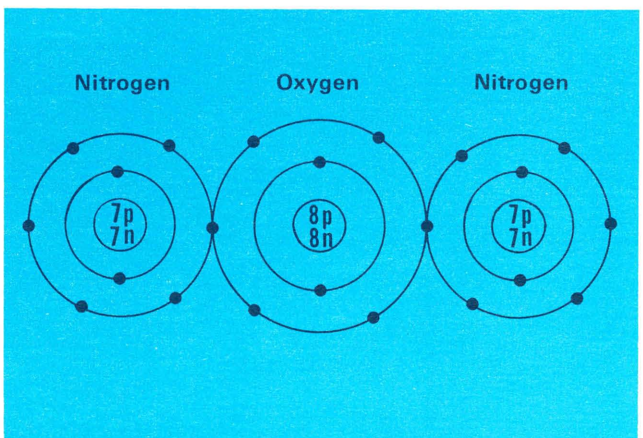


Fig. 16 Composition of Nitrous Oxide

INSIDE THE ATOM'S NUCLEUS

The discovery that the atom contains protons, electrons and lots of empty space was a giant step forward. Scientists soon realized that the number of protons determines the element. An atom with eight protons is always oxygen; an atom with 79 protons is always gold.

Then a puzzling observation was made. Atoms of the same element did not always weigh the same. For example, some hydrogen atoms weigh three times as much as others. This led to the discovery of *neutrons*, neutral particles as heavy as protons and, like protons, located in the nucleus. Neutrons stabilize an atom. They help keep protons and electrons, with their opposite charges, from smashing together. Lighter atoms generally need one neutron for each proton for stability. Heavier atoms need more. Atoms of the same element with varying numbers of neutrons are called *isotopes*, which means "atomic brother".

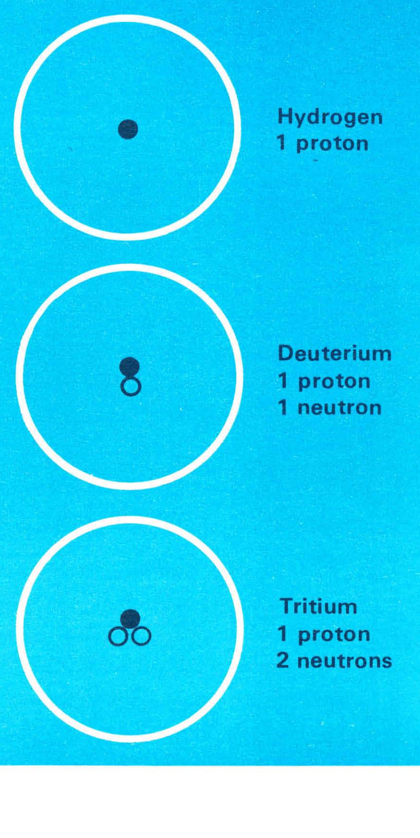


Fig. 17 Three Isotopes of Hydrogen

RADIOACTIVITY

When a nucleus contains too many neutrons—and many isotopes do, the atom becomes unstable. In an attempt to stabilize, the atom may throw off pieces of itself along with excess energy thereby reducing its mass. These pieces of matter might be *alpha particles, beta particles,* or neutrons. The thrown-off energy most often takes the form of *gamma rays.* Atoms in the process of breaking down to stabilize are said to be radioactive.

ALPHA PARTICLES

Heavier atoms may balance themselves by giving off two protons and two neutrons, identical to the nucleus of a helium atom. These are called *alpha particles* and are relatively large and heavy. As soon as they rob two electrons each from other surrounding atoms, they stabilize as helium. Alpha particles can be stopped by a piece of paper, outer skin, or one or two inches of air. Alpha particles are dangerous to man if taken internally for then they take electrons from the atoms of living cells which kills the cell.

Experiment 16: Observing Alpha Particle Activity with a Spinthariscope

A spinthariscope is easy and fun to make. With one you can watch the sparks of light which are given off by certain chemical compounds when bombarded by alpha particles.

You'll need 2 cardboard tubes (about the size of toilet tissue tubes) which fit together like a telescope—make them if necessary; a magnifying lens (double convex) to fit the smaller tube; dull black paint; scrapings from a radium dial clock or watch; and a pinch of zinc sulfide, if obtainable. (Experiment will work with radium scraping alone.)

Paint the inside of the cardboard tubes dull black. With model glue or household cement, mount the lens to one end of the smaller tube.

Cut a circle of cardboard to fit an end of the larger tube. Paint it black. To the center, attach a small piece of glass (even a splinter will do). Mix together a small amount of radium scraping and zinc sulfide. Try not to get any of the radium on your hands. Wash them carefully when you're through. Can you explain why?

Varnish the glass, then shake the radioactive mixture over the wet varnish. Tape the assembled cardboard disc to one end of the large tube, sealing the joined edges. Insert the smaller tube, lens inward. Now your spinthariscope is ready to use.

A spinthariscope works best in a dark room. After your eyes have become accustomed to the darkness, (about 10 minutes) slide the tubes in and out until the radioactive material is well focused—then watch the show!

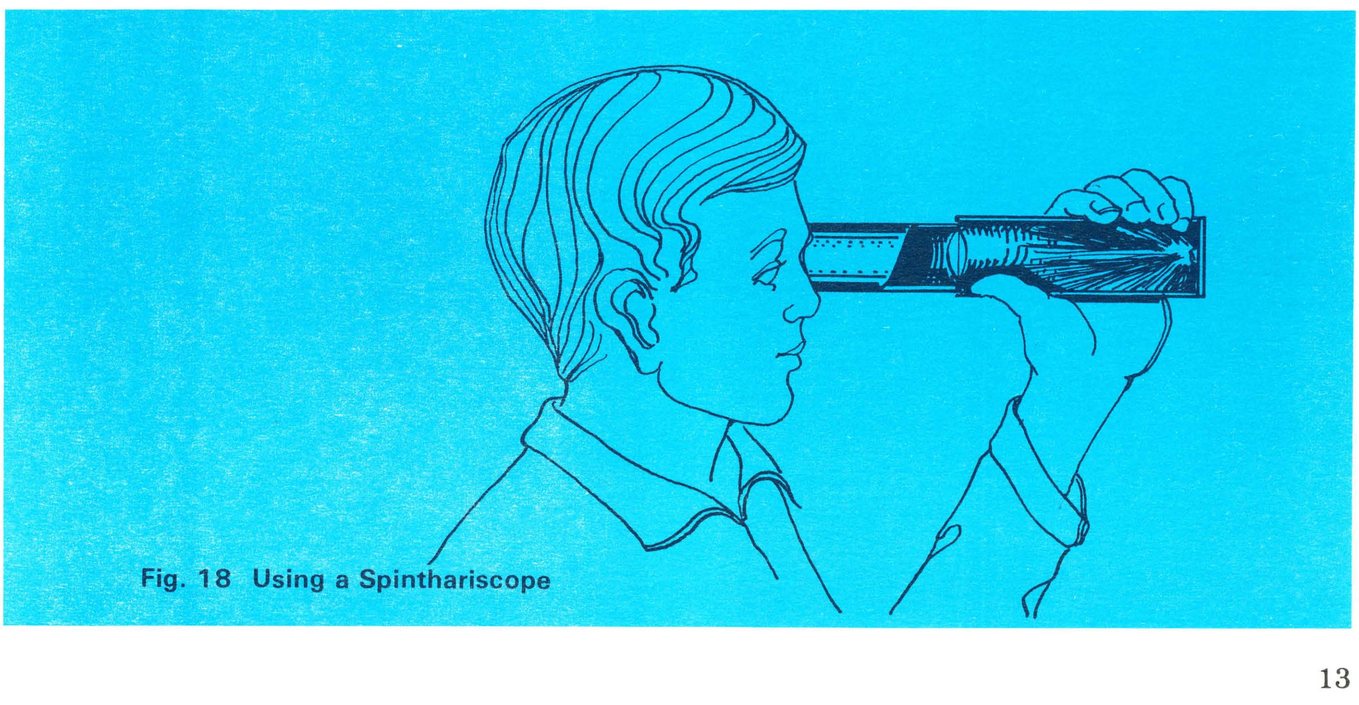


Fig. 18 Using a Spinthariscope

BETA PARTICLES

Sometimes to stabilize itself, a nucleus needs another proton. In this case, a neutron in the nucleus splits into a proton and electron. The proton remains, and the electron is ejected as a *beta particle.* This electron from the nucleus is about 7,500 times smaller than an alpha particle. It is extremely fast moving and more penetrating. Heavy clothing, or the equivalent of a half-inch thickness of wood are needed to stop a beta particle. However, should the particles be left on the skin, severe burns result. Like alpha particles, beta particles can cause serious cell damage if taken internally.

GAMMA RAYS

A nucleus in the process of breaking down releases much of the binding force or energy that formerly held its protons and neutrons together. The excess energy is thrown off as *gamma rays.* Like visible light, ultra-violet light and X-rays, gamma rays are electromagnetic waves of energy.

Their extremely short wave length and high frequency make them the most destructive and penetrating force man has ever encountered. Gamma rays invade cells, break up delicate chemical balances and disrupt a cell's normal function. Gamma rays can only be stopped by dense, massive materials, such as 4 or 5 inches of lead or a foot of concrete.

Experiment 17: Demonstrating Shielding with an Electroscope

This experiment is for a meeting with your civil defense director or a state police officer, both of whom would have access to radioactive materials.

Alpha particles, beta particles and gamma rays ionize the air. If radioactive materials are brought near a charged electroscope, the ionized air allows the charges on the foils to leak off. The foil strips come together. Observe what happens when a radioactive source and a charged electroscope are brought together. Now observe what happens when they are separated by materials of differing densities such as paper, a piece of wood, a sheet of steel, or lead. What do you conclude?

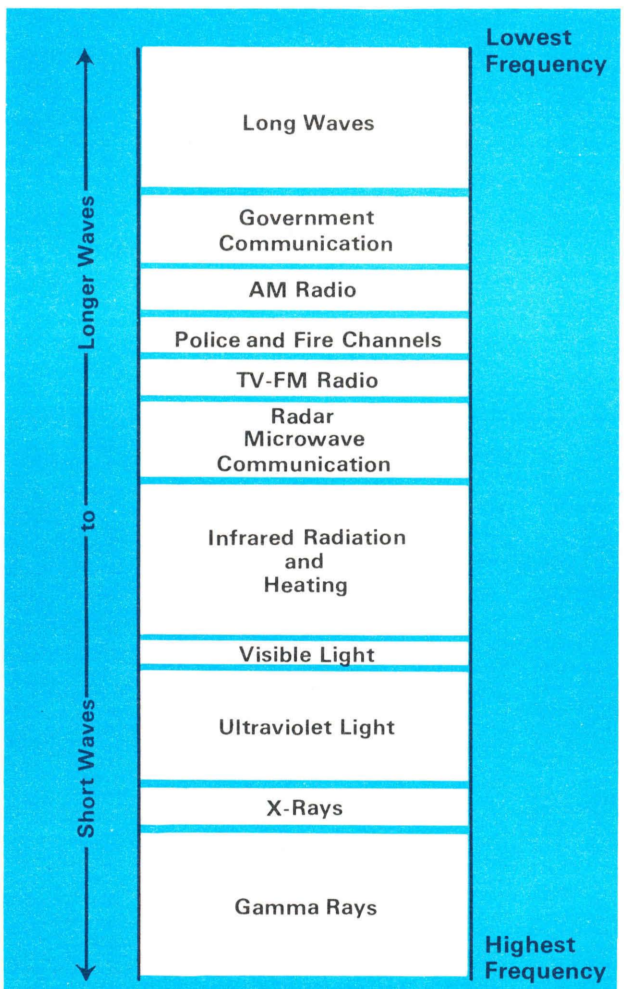


Fig. 19 Electromagnetic Spectrum

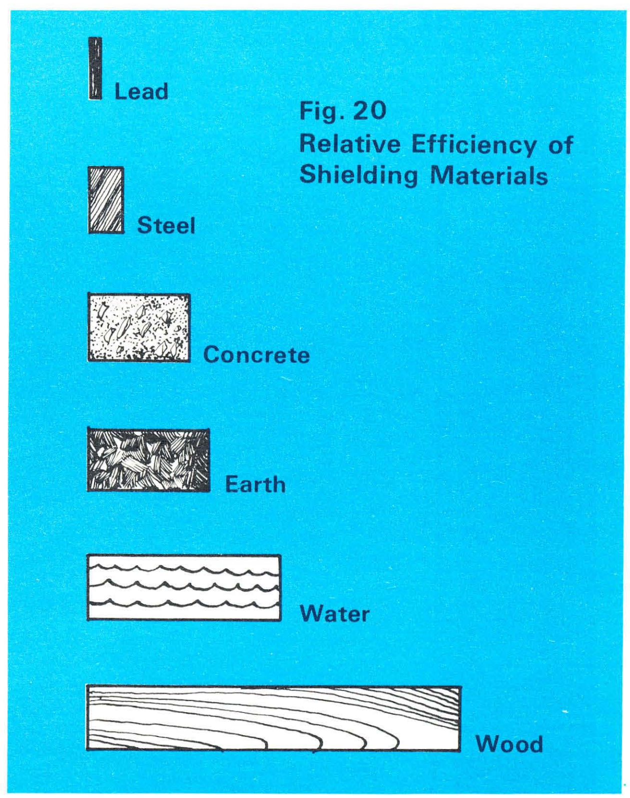


Fig. 20 Relative Efficiency of Shielding Materials

THE DANGER OF FALLOUT

When a nuclear explosion takes place at or near ground level, thousands of tons of dirt and other materials are sucked up into a mushroom cloud. The intense heat generated by the explosion vaporizes bomb particles and earth and mixes them together. These particles then condense and fall back to earth as lethal radioactive "fallout".

A large amount of fallout, including the heaviest debris, falls immediately near the impact area. If the bomb is large enough, much of the fallout may be forced into the stratosphere, where it might remain suspended for years before falling back to earth. The rest—an enormous quantity of minute particles—is carried away by the winds to fall downwind, hours or days or weeks later. This wind-borne fallout could affect so many people that it is called the greatest threat the world faces today.

Radiation is most intense at the time of the explosion, but drops sharply as the radioactive isotopes with short half-lives decay. By the end of seven hours, the overall radiation level will have decreased to 1/10th of the original. At the end of two days, the overall radiation intensity will be 1/100th of the original. At the end of two weeks, the radiation level will have decreased to 1/1000ths.

FALLOUT PROTECTION

From all that we have learned about the nature of radiation, it becomes clear that protecting ourselves against fallout is possible. We can lessen the danger—and very possibly save our lives—in three ways:

First—by *shielding,* surrounding ourselves with dense, heavy materials that even gamma rays cannot penetrate;

Second—by *time,* remaining shielded until the level of radio-activity has diminished and the greatest danger is over; and

Third—by *distance* avoiding or evacuating those areas where fallout is most likely to be concentrated.

Should a nuclear explosion at or near ground level occur, two questions immediately arise and need to be answered: "What areas will be affected?" and "How soon?" This leads us back to weather.

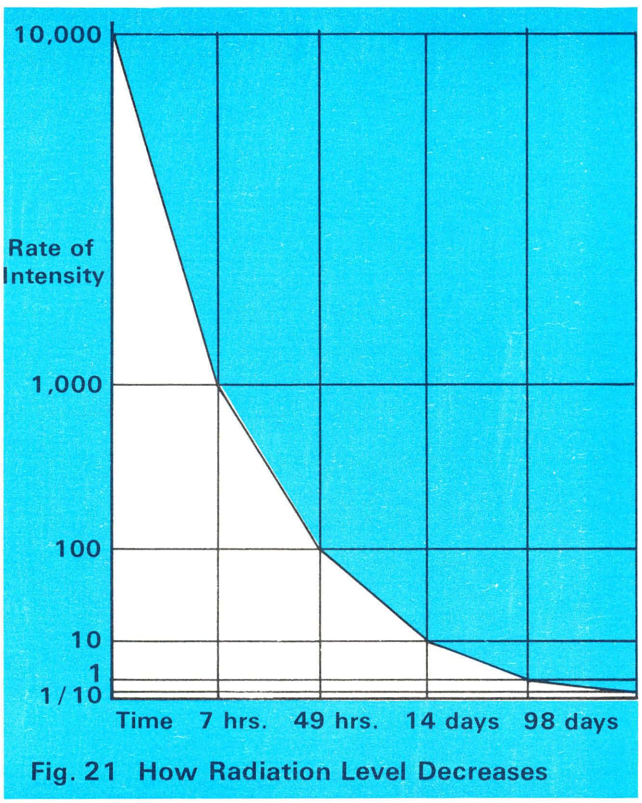


Fig. 21 How Radiation Level Decreases

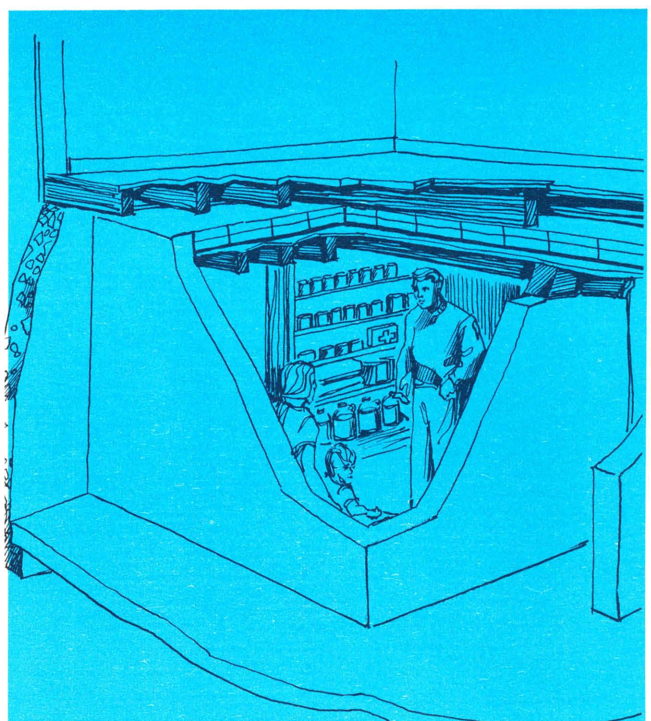


Fig. 22 Basement Shelter of Concrete Block

THE ROLE OF WEATHER

How much we are affected by fallout or pollution depends upon the weather, and especially the speed and direction of the winds. Winds increase the threat of fallout. A shift in the winds could carry the deadly particles to an area that might otherwise be safe. But with pollution, air on the move — either flowing outward as wind or upward as currents in an unstable atmosphere — has an enormous capacity to disperse and diffuse pollutants, thereby reducing the danger.

By studying the speed and direction of the winds we should be able to tell how fast and how far fallout would be carried or how quickly some obnoxious fume, such as smoke from a smokestack, would be dispersed. Complications arise when we realize that both the wind's speed and direction change with height. Winds aloft may be entirely unlike those at the surface, and winds at various levels in between may also differ. The change in direction is generally most rapid in the lower levels where pollutants are most concentrated. In an extreme example, the wind at ground level might be coming from the southeast; at the top of a tall smoke stack the direction might be northeast, while at a higher altitude the wind might be from the northwest.

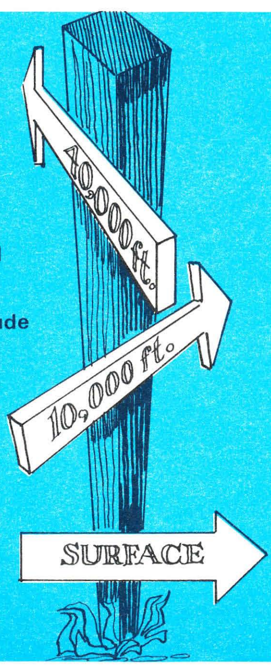


Fig. 23
How Wind Direction Changes with Altitude

Measuring the Wind

To make a reasonably accurate prediction of which areas might be affected by a source of pollution, wind direction at all levels must be determined. Meteorologists do this by tracking the path of a small balloon with a theodolite. You can do the same with two homemade theodolites and the help of three club members. The following project will give you the wind's speed as well as direction.

Experiment 18: Assembling the Theodolite:

Drive two posts into the ground at a given distance apart, preferably 100 feet. On each of the posts assemble a theodolite as illustrated in Fig. 24.

The base can be of metal, masonite, plastic or any other stiff, durable material. It can either be circular or have a circle drawn upon it and is calibrated into degrees. The 360° mark must be in a line with true north as determined by a compass.

Attach base to post. Base must be level. Drill a hole, then insert a peg, through the center of base and post to serve as a pivot for the holder.

The holder is a piece of wood of any desired length and thickness (possibly a 1 x 1, 5 inches long). Drill a hole in the bottom of the holder to fit over the peg. To the top of the holder, hinge a similar piece of wood (the arm) to serve as a sight. You may have to attach a weight at B for balance. Attach a protractor to the arm so the 90° mark is level with the bottom of the arm and the 0° mark is at the edge of the holder. Cut off any part of the protractor that extends above the arm.

Drive in two nails, approximately at A and B, for sights, and another nail at the bottom of the holder, parallel to the B end of the arm, as a pointer.

To Take Readings: Release a helium-filled balloon at one of the sites. One person at each post tracks the balloon by sighting along the nails at A and B. The other takes readings every 30 seconds of the *direction* (as indicated by the pointer) and the *angle of elevation* (the degree mark shown on the protractor at the edge of the holder). Record readings in a log similar to the one illustrated in Fig. 25.

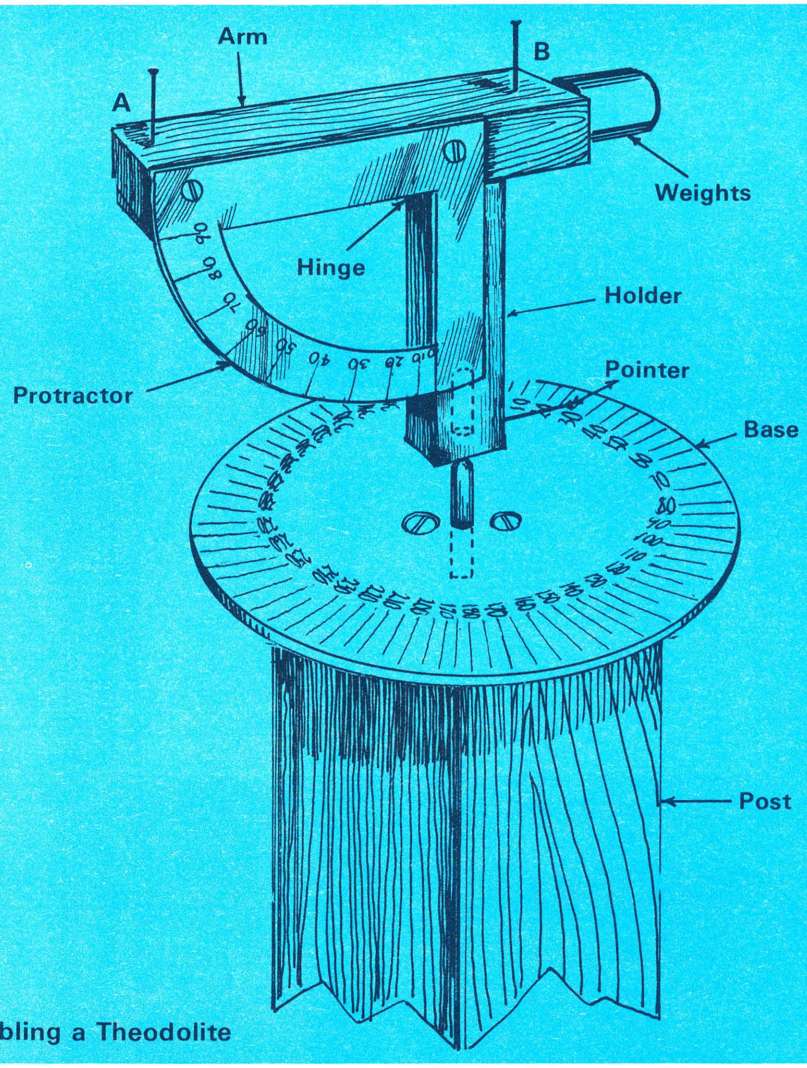


Fig. 24 Assembling a Theodolite

Observer at Post #1 Time of Launch 2pm Date 4/17

Distance from Observer #1 to #2 100 Feet

Readings from Launch Time	Direction as Shown on Base	Angle of Elevation From Protractor
30 seconds	120°	30°
1 minute	95°	45°
1½ minutes	90°	55°
2 minutes	82°	60°
2½ minutes	78°	60°
3 minutes	75°	62°
3½ minutes	70°	65°
4 minutes	65°	70°

Fig. 25 Sample Log for Recording Theodolite Readings

For the Wind's Speed: On a chart, draw to scale a line (AB in Fig. 26) that corresponds to the ground distance between the two posts. If the posts are 100 feet apart, the length of AB would be equivalent to 100 feet. Use the same scale to mark the vertical line of your chart. This will represent altitude. For each 30 seconds of lapsed time, draw at A the angle of elevation observed at post 1, and at B the angle of elevation observed at post 2. The point at which the angle lines intersect will be the height and distance the balloon has traveled since its launch. By correlating ground distance to the time elapsed, you can get the speed of the wind.

For the Wind's Direction: On a similar chart, plot the direction recorded by each observer. Mark the intersection of the angle lines with dots and connect the dots. This will give you the path of the balloon as steered by the winds —in other words, the wind's direction.

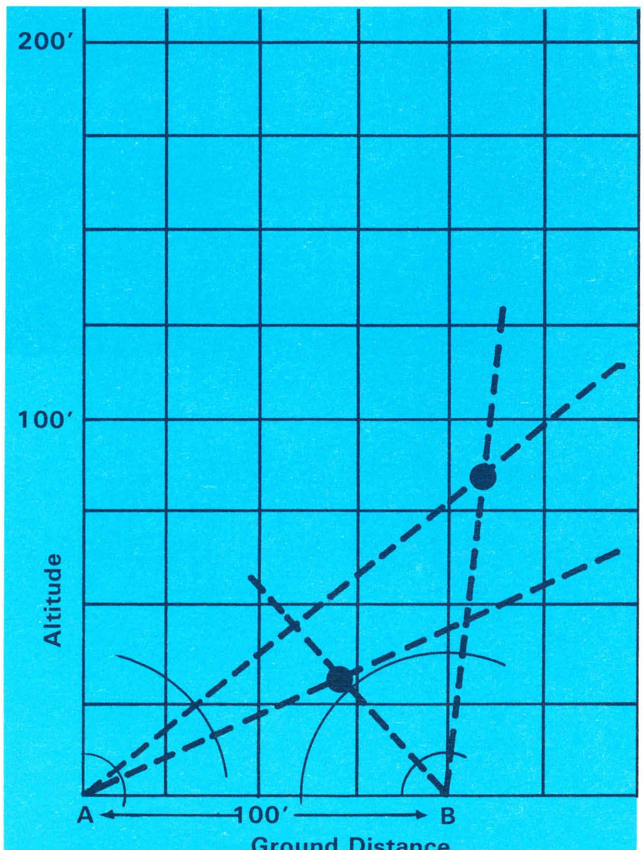


Fig. 26 Plotting Angles of Elevation for Wind Speed

Wind Speed

Smoke and other polluted air is diluted in proportion to the wind speed. A greater speed brings in more fresh air to mix with the smoke. Aloft, where wind speed is greater, the concentration of pollutants is much weaker than at the surface. In the project just completed, did you find an increase in wind speed as the balloon moved higher? This is very significant for air pollution control. Very often, pollution of city industrial air can be sharply reduced if the offending smokestacks are raised higher. This permits the smoke to be carried away by faster winds.

Wind speed also determines how soon air from a source of pollution will reach a specific area downwind. For example, if the place is one mile away, and the wind is traveling at 5 miles per hour, the polluted air will arrive in 1/5th of an hour, or 12 minutes.

Stability

The less stable the atmosphere—that is, the more freely air currents can move up and down, the greater will be the mixing of the air. Pollutants do not accumulate easily when the air is unstable. The contaminated air moves upward and is quickly dispersed.

A stable atmosphere, on the other hand, inhibits the air's vertical movement. Although the air can still move horizontally, the pollutants may remain at a level where people must live with them. A plume of smoke from a stack shows very graphically what happens to polluted air under different conditions of stability.

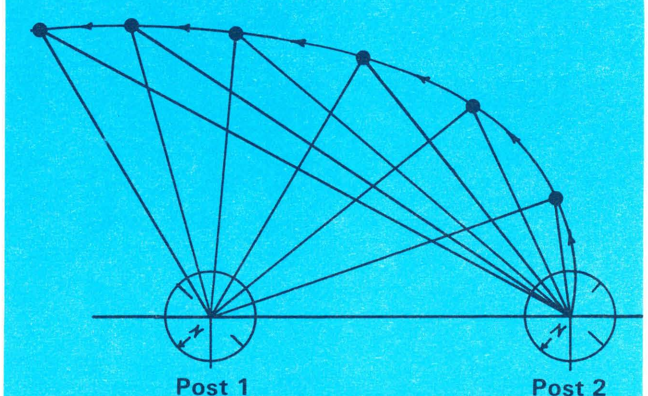


Fig. 27 Plotting the Wind's Direction

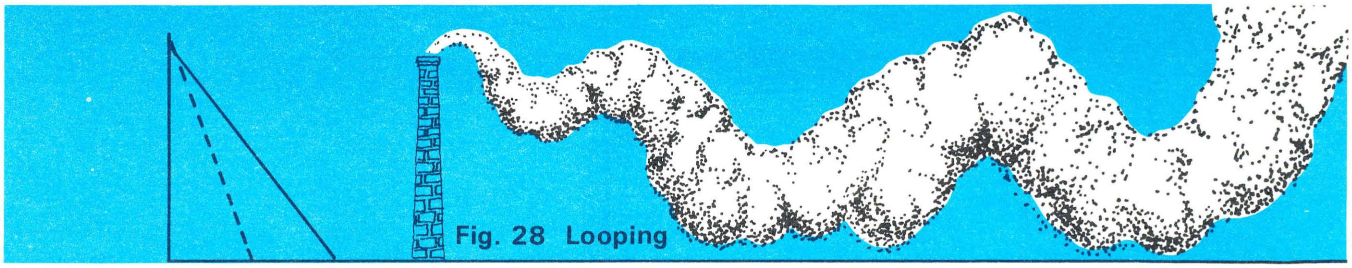


Fig. 28 Looping

Looping occurs in a highly unstable atmosphere, when the sun is shining brightly and winds are light. Eddies of turbulent air may cause the smoke to dip toward the ground, but, on the whole, diffusion is good.

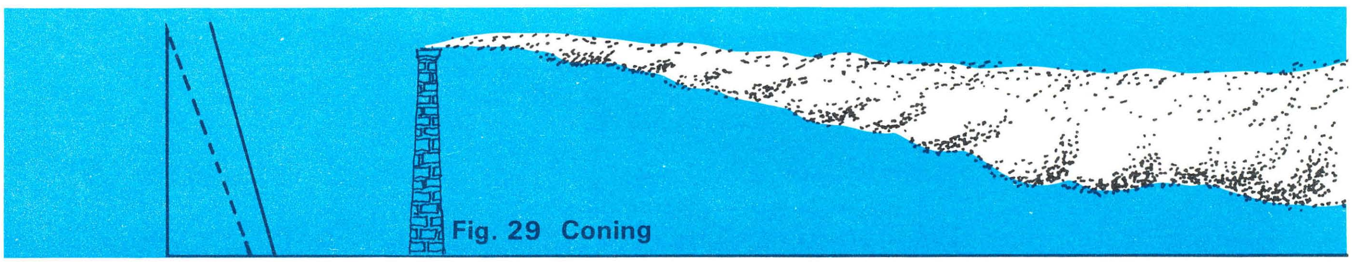


Fig. 29 Coning

Coning indicates a slightly unstable condition and is more apt to occur on windy or cloudy days or nights. The distance at which the smoke first reaches the surface is greater than with looping since thermal eddies are absent.

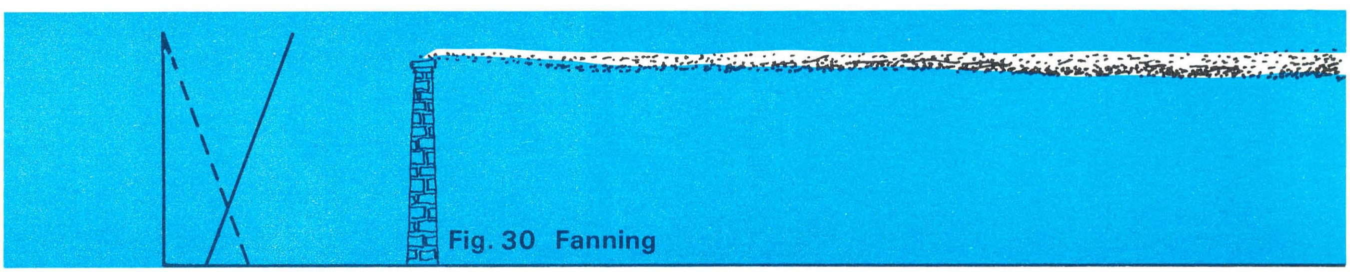


Fig. 30 Fanning

Fanning is most apt to be noted at night with clear skies and light winds. Rapid cooling of the earth's surface increases stability and may bring about an inversion. Upward motion of the air is suppressed, but the air still moves horizontally. A fanning smokestack isn't always unfavorable. If the smoke remains high enough, our comfort won't be affected.

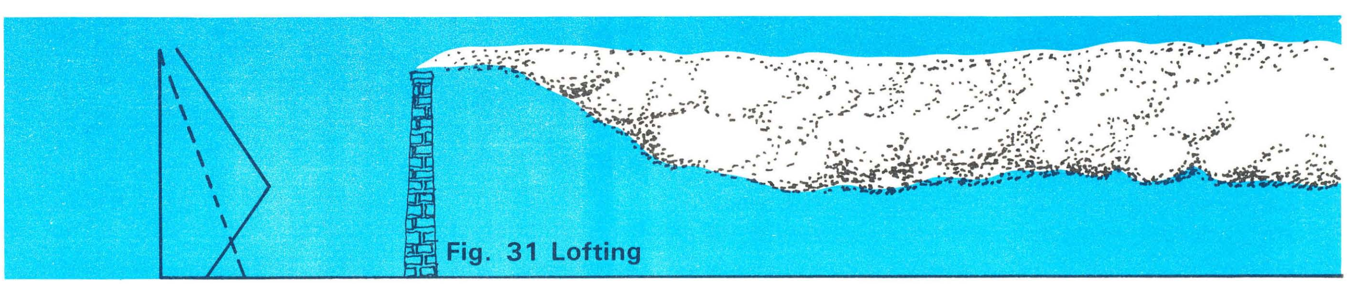
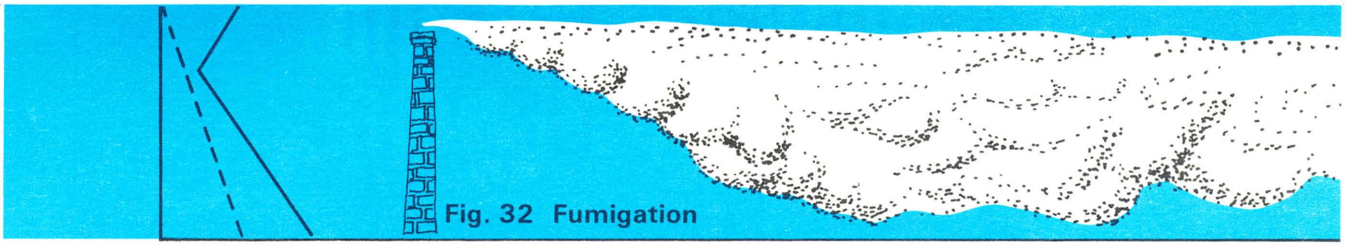
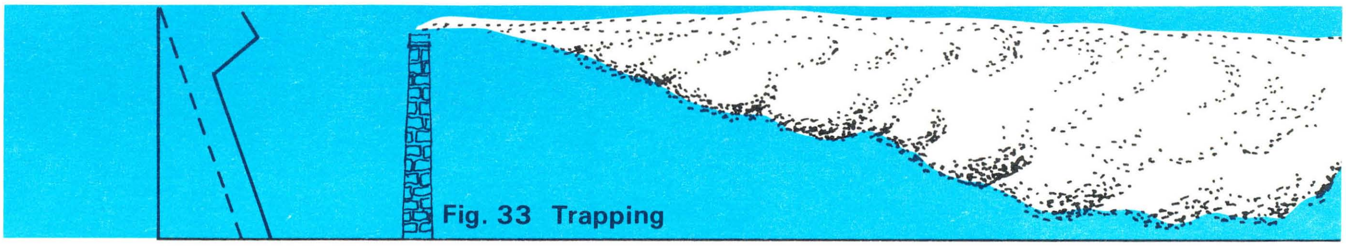


Fig. 31 Lofting

Lofting indicates a temperature inversion at the surface under a highly unstable layer. This atmospheric condition is most apt to happen near sunset on a clear evening, when the ground has started to cool. Fortunately, the objectionable gases do not reach the surface under these conditions. They diffuse upwards very rapidly.



Fumigation is a sign that a surface inversion has been replaced by a highly unstable condition. The resulting turbulence may bring high concentrations of pollutants in the smoke to the ground. Fortunately such a condition usually does not last too long.



Trapping takes place when an inversion aloft stops the upward diffusion of air. No matter how favorable the lapse rate is for upward movement below the inversion layer, the pollutants can only rise so far. Trapping is most apt to occur where air is settling, as in a high pressure area. Trapping is a common occurrence in Los Angeles. Not only does the city lie in a basin, hemmed in by mountains to the east and north, it is also located at the eastern edge of a semi-permanent high pressure cell which spreads over the eastern Pacific Ocean. The result for the third largest city of the United States is smog.

Smog

How is smoke trapped to produce smog? The experiment below will show you.

Experiment 19: Demonstrating a Temperature Inversion

Build a temperature inversion box (12 inches by 12 inches by 24 inches high) using 3/4 inch plywood, as illustrated. The front panel, of glass or plastic, should be mounted in a groove so that it can slide up and down. Paint the inside of the box dull black. A sliding masonite partition separates the box into upper and lower chambers. You'll also need a hair dryer and about 3 flashlights.

With the partition in place, blow warm air from the dryer into the upper chamber. Room temperature air is in the bottom section. Gently remove the masonite partition and introduce smoke into the lower section (possibly from a burning piece of incense). Observe what happens.

Now heat and illuminate the lower section with flashlights. Observe again.

How do you explain your results?

What you have demonstrated in the previous experiment is that a temperature inversion, or warming of the air aloft, puts a lid on the upward movement of air below. In a full-scale inversion, condensation often forms at the base of the inversion, where warm and cold air come together. This may appear as a low stratus cloud or fog. If the trapped air is full of smoke and other pollutants, a deadly smog can result.

All Kinds of Inversions

A temperature inversion may develop in a number of ways:

—On a clear night, when the ground loses its heat by radiation, the lower layer of air also cools. This type of inversion doesn't occur in the presence of cloudy skies or high winds. Do you remember why?

—In the fall, warm ocean air moving over a cooler land surface can also create an in-

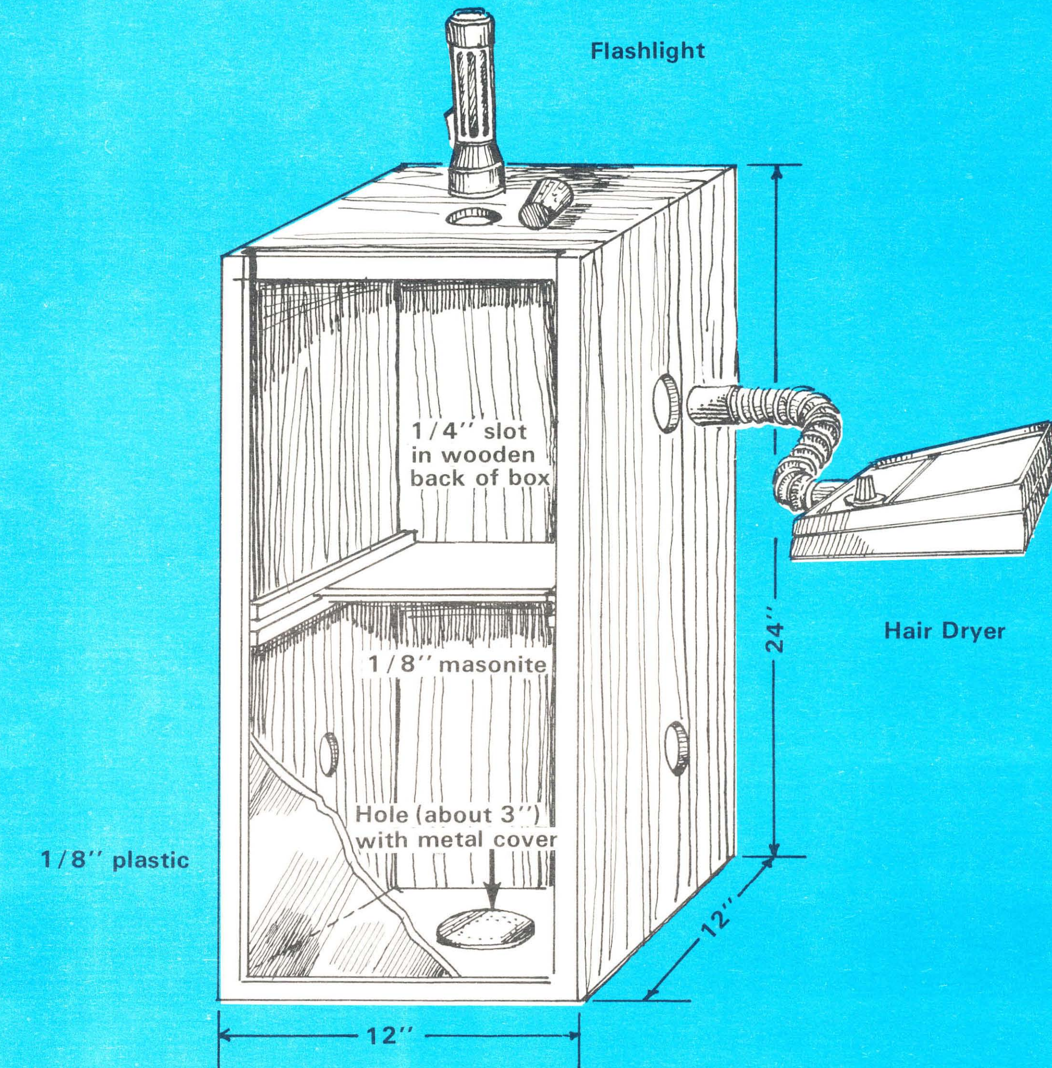


Fig. 34 Assembling a Temperature Inversion Box

version. New York owes its fall and early winter smogs to this situation.

—A stagnant high pressure system or a valley location, where air is sinking and warming adiabatically and winds are light, can set up the most persistent inversion—and the worst smogs of all.

Certain parts of the United States are more susceptible than others to stagnating high pressure systems. As we have seen, Los Angeles is one. On the East coast, the Bermuda High often spreads over Georgia, South Carolina and the western part of North Carolina, resulting in long periods of temperature inversions and weak winds. If this area were more populated or industrialized, a serious smog condition could be anticipated.

Michigan has been fortunate. Because of its location about the 45th parallel of latitude, Michigan weather is alternately affected by the polar front and the Bermuda High. As a result, the air is frequently changed and cleansed. Prolonged smog-producing inversions are rare, seldom lasting longer than six to ten days.

SUMMING UP

What man has done, he cannot entirely undo. A certain amount of pollution is the price we must pay for the benefits of an advanced civilization. Fallout is also a "by product" of our expanding knowledge and technology. We do not care to give up our cars and other machines; neither can we forget what we have learned about the atom.

At the same time, our survival may depend on how effectively we can control pollution and learn to live with the dangers of radiation. At the Federal level, our government is deeply involved in many programs to clear the air and limit the threat of fallout. You might want to learn more about these. States also have pollution control laws and civil defense programs. Find out what you can about Michigan. None of these programs, however, can really be effective unless each of us, as individuals and as members of families and communities, becomes concerned and *acts* to help solve these problems.

What You Can Do

1. *Smoke control is everyone's job.* Overall, the major sources of pollution are private cars, homes and factories. How well do you rate on pollution control? How do you and your family dispose of leaves? get rid of trash? heat your home? If you live on a farm, how do you remove stubble from a field? How well is your family car maintained? Does it have noticeable exhaust?

2. *Be concerned about your community's efforts to curb air pollution.* Does your community have smoke control ordinances covering industries? leaf burning? car exhaust? open incinerators? Do public utilities practice smoke control? How does your community dispose of trash? Give your support to programs that would help clear the air.

3. *Make sure your family would be protected in a nuclear emergency.* Is there an area in your home or nearby that would shield them even from gamma rays? How well prepared would they be to spend a week, if necessary, in a sheltered area? You can make many preparations now, such as keeping on hand a week's supply of canned food and water.

4. *Become involved in civil defense.* In this unit you've had a chance to meet persons in your community who have civil defense responsibilities. Learn more about their role in natural as well as nuclear disaster. Do what you can to support local civil defense programs. With the knowledge you have gained in this project you are better prepared than most people to help yourself, your family and your community to a safer world.

CORRECTION

THE LAST LINE ON PAGE 7 SHOULD READ: Number 4 (not No. 1) smoke (20% density) is the standard.