PHYSICS

Air—Breath of Life

10,000,000,000,000,000,000 Molecules in Each Cubic Centimeter—Simple Mixture With Minute Impurities

ABOUT ONCE every five seconds man fills his lungs with a simple mixture of gases—air.

If this unconscious process ceases for very long, the life of any land-dwelling creature is at an end. Existence on this planet is possible only because there is a superabundance everywhere of nitrogen and oxygen in the proper proportions.

"As free as the air" is a common figure of speech. Only water has a comparable significance to living things. The more minutely air is analyzed, the more complex it seems, and today physicists and chemists recognize that they still have far to go before they can present an adequate picture of the "breath of life." There are many things in it whose existence, to say nothing of whose significance, is just beginning to be recognized.

The ancients spoke of four elements—earth, air, fire and water. Quite naturally they considered the all-encompassing atmosphere as a distinct substance which could not be split up into other constituents. By the beginning of the nineteenth century, however, this concept had been generally abandoned and air was recognized as primarily a mixture of the gases oxygen and nitrogen with various impurities.

Research at Carnegie

Further steps now are being taken in laboratories all over the world, and some of the most notable work is carried on at the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. A clear understanding of the composition of the atmosphere is essential to explain its electrical conductivity, but the investigations seem to be yielding results significant in far-removed fields, such as the ventilation of buildings and possible explanations of air-borne diseases. Hardly anything could be discovered about air which would not be of potential significance.

In a cubic centimer of air there are approximately 10,000,000,000,000,000,000 molecules. This shows strikingly how small a molecule really is.

About 500 cubic centimeters are inhaled in a single breath.

Nearly 80 percent of these molecules consist of two atoms of the heavy gas nitrogen. About one-fifth are double atoms of oxygen. There are a few single atoms of the rare gases argon and helium. Roughly half of one percent are particles of the gas carbon dioxide, from which plants, by the process of photosynthesis, extract the carbon which constitutes the major part of their structure—the starches and sugars which are the fuel of animal life.

These gases are not chemically combined. They are simply mixed together, each retaining its identity.

Very Little Impurity

Mingled with them are extremely minute amounts of impurities—particles of water vapor, of dust, of smoke, of gaseous forms of other elements which leak from the earth, of bacteria, of the giant molecules of viruses which are the carriers of deadly diseases, of plant pollen which brings hay fever.

At their worst, the impurities constitute a very small percentage of the whole. The air may seem to be all dust to a person caught in a dust storm. Actually, in comparison with the number of molecules present, the number of particles is small indeed. In the thickest sort of fog, it has been estimated, there are only about 1200 water droplets, each about 10 ten-thousandths of a centimeter in diameter, in a cubic centimeter.

Now each molecule of air might be considered normally as electrically neutral. Yet many of them, tests show, actually carry positive or negative electrical charges. One or more atoms of such a particle has an outer electron too few, or too many. Something has been introduced to disturb the balance—some radiation capable of stripping away electrons. There are only three major possibilities in the lower atmosphere, physicists have determined.

First is the radiation from the radioactive elements in the crust of the earth itself. This contains everywhere minute quantities of radium and thorium, on an average two or three parts in a trillion. These exploding elements constantly are emitting powerful radiations—alpha particles, beta and gamma rays. They hit the gas molecules of the atmosphere, strip electrons from them, and thus create positively charged particles.

This accounts, Carnegie physicists believe, for about three-tenths of the "ions," or electrically unbalanced atmospheric particles. Most of this is due, in turn, to the penetrating gamma, or X, rays from the radium and thorium. The beta rays, single electrons, and the alpha rays, nucleii of helium atoms, hardly can get into the air from more than a fraction of an inch below the surface of the soil. The gamma rays, however, can go into the air from depths of several feet.

By far the most important ion-makers close to the surface are the radio-active gases—radon, thoron, and their progeny—which leak from the soil. These are the decay products of radium and thorium. Quite short-lived, they are being formed constantly by the break-down of these elements in the surface rocks. They escape and form part of the atmosphere itself. Probably in each breath one gets nearly a thousand particles of the exploding gases—never enough, however, to have the slightest physiological effect on a higher animal. Their radiations, it is calculated, are responsible for at least half the ions in the air adjacent to land.

Most Penetrating

The other producer of ions in the lower atmosphere is the cosmic ray, most penetrating of known radiations. These rays, originating somewhere in outer space, constantly are bombarding the earth and creating ionizing showers in the upper atmosphere which, in turn, make charged particles near sea level. This is the preponderant ionizer over the oceans and polar regions.

From all these radiations combined are formed approximately nine ions per cubic centimeter of atmosphere per second. They are all, at the start, negatively charged; that is, a molecule lacks one or more electrons, or negative electrical units. This ordinarily lasts only an instant. The freed electrons are joined either to neutral molecules, giving them negative charges, or to other positive ions, which are rendered neutral again. At any one time there is probably close to a balance of positive and negative ions in the atmosphere.

These all are known as "small ions," two or three atoms in size. They make the atmosphere an electrical conductor, however poor at the best.

Otherwise, it would seem, they have no effect. Certain Russian and German experimenters have claimed that very large concentrations of negative small ions in the atmosphere are exhilarating while positive ions are depressing. A few years ago there developed in Russia a system of "aerionotherapy," and remarkable cures of about 30 different maladies, from stomach ulcers to tuberculosis, were claimed. The claims have not been fully substantiated by American investigators, and their validity is open to serious question.

In any event, however, they refer to concentrations of small ions enormously greater than would ever be found in the atmosphere—about one to every 10,000,000,000,000 gas molecules. In a year the average human being doubtless absorbs less than a few million-million atmospheric ions, scarcely enough to make up a body as large as a rain drop. This amount could hardly be expected to have any effect whatsoever, per se. It might, however, serve as an activator of some chemical process within the body. As to this, there is no evidence, one way or another. Here is at least an interesting field for investigation by physiologists.

Large Ions More Abundant

Far more abundant in the atmosphere, and perhaps of greater biological significance, are the so-called "large ions." One of these may be a thousand times the size of a small ion and in some places they are at least 1,000 times more abundant.

An ionized molecule tends to give up its charge to any foreign particle in the atmosphere—a water droplet, a speck of dust, a grain of pollen. Thus is constituted a relatively enormous charged body. It is likely to build itself up by the addition of other ions and may end as either a charged or neutral particle.

The number of these large ions varies enormously from place to place, and from time to time. Lighting of fires in the autumn causes a very large increase around towns and villages. These particles are generally least numerous in the air over the ocean.

An interesting recent discovery of Dr. G. R. Wait, physicist of the Department of Terrestrial Magnetism of the Carnegie Institution, is that the number of these particles in the atmosphere of a room is enormously increased by the presence of human beings. It is difficult to explain the phenomenon. One possible deduction is that there are approximately 200,000,000 particles nearly 100 times the diameter of air molecules in every exhaled breath. Where do they come from? One theory is that they are the "smoke" of the fires of life—the constant burning of carbohydrates which maintains the temperature of the body.

Much further investigation is needed for an entirely acceptable explanation. The exhaled particles—many of them either positively or negatively electrified—may play a role, as yet unknown, as carriers of disease-causing microorganisms, such as filterable virus molecules. They probably explain, Dr. Wait believes, why one is able to see one's breath on a frosty morning even in an exceptionally clear, and consequently relatively pure, atmosphere.

When the breath is exhaled its moisture condenses around large particles in the atmosphere. If the air were free of them, it would be expected that the breath would be invisible, but it never is. This can be explained by the finding of particles in the exhalation itself.

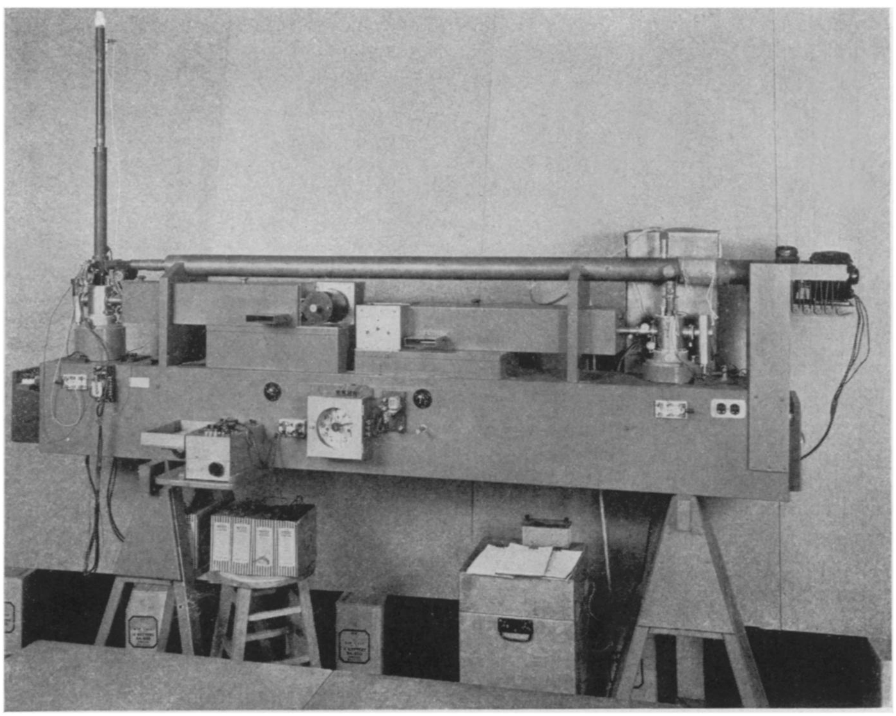
This finer structure of the atmosphere is far too elusive to be studied by chemical methods. There are two ways of counting the ions, however, both of which give approximately the same results. One is an adaptation and a forerunner of the so-called Wilson cloud chamber, by means of which the existence of the atmospheric particles first was demonstrated. Air condenses on particles in much the same way as clouds are formed in the sky. The droplets which fall in a dark field can be counted.

This is a convenient device which can be carried in the pocket. It sometimes is referred to as an "electric nose," since by means of it one can track down a source of large ions, such as smoke from a chimney, decaying vegetable matter in a swamp, or a spray of water. The particles which are counted, however, need not necessarily carry electric charges.

The other method requires the use of a device for counting electrical particles—measuring the concentration of the several types of ions in a locality.

Both methods are being used in the Carnegie Institution studies. At present special efforts are being made to determine the rate of formation of the various types of ions. Accurate information on this is essential to the understanding of various aspects of electrical conduction through atmosphere.

Science News Letter, October 4, 1941



AUTOMATIC

This apparatus counts automatically the electrically charged condensation nuclei in the atmosphere. It is in the laboratories of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington.