breathing problems would be confined to underwater or to travel in high altitudes. Unfortunately, pure air is a relatively rare commodity, and is much harder to obtain pure than many chemical elements and compounds.

Some variations of the air are caused by natural forces (such as moisture from rain or dust from winds on dry earth), while some are due to man (such as combustion products, unburned or incompletely burned fuels, solvents, vapors, dusts, fumes, inert and toxic gases). When these variations are small, we say that the air is "pure," but when the variations, either alone or in combination, exceed our ability to adapt to them, or our ability to tolerate them, we say the air is "bad."

AIR POLLUTION

No simple yardstick has yet been devised to tell us when air ceases to be "pure," although numerous air pollution studies are underway, and threshold limit values (maximum allowable concentrations for industrial exposures) are available as a guide. We have just begun to realize that air pollution control may be even more important than stream pollution control. When extreme conditions exist, as in London, Meuse, Donora or Los Angeles, we know that human life is more difficult than other times when smog is not present.

On a minor scale, every year a serious problem exists from dust or pollen (such as rose fever, hay fever, or ragweed fever) for allergic persons, and we have found that respirators are frequently considered a a welcome supplement to medication for the relief of such conditions.

Most breathing air supply problems can be controlled with adequate ventilation. If air could be properly treated to remove *particulate matter, noxious vapors, and toxic gases, heated or cooled, and then distributed as required, breathing can be reduced to a minor problem insofar as purity of air is concerned. Unfortunately, adequate ventila-*tion and air treatment is sometimes impossible or impractical where emergency action must be taken to preserve life and property.

Therefore, we must provide man with respiratory protection if we expect him to survive. A glance at the case histories of incidents collected at random from many sources and appended to this paper shows that respiratory problems have occurred in many diverse activities. Specialized knowledge and action in advance is essential if such injuries are to be prevented.

It is sometimes glamorous or unusual incidents which produce serious results; failure of a pressure system in an airplane at high altitudes will cause blackouts in seconds; above 43,000 feet, even breathing pure oxygen is not adequate— a pressure suit or a pressurized cabin is essential. On the other hand, no less serious are the problems when commonplace materials, such as a few sausages overheating and burning on a frying pan on a kitchen range produced sufficient smoke and toxic gases to overcome the occupants; firemen required respiratory protective apparatus to effect a rescue of the unconscious victims.

Gases and smokes resulting from fires have been studied for years, and excellent reports are available, but it is impossible to predict what gases may be encountered or in what concentrations in a given fire. A large number of different flammable chemical compositions or chemical combinations that change with heat, such as plastics, fabrics, insulation, refrigerants, solvents, paints, insecticides and building materials, play important roles in our daily lives.

VARIETY OF GASES IN FIRES

In addition to carbon monoxide, carbon dioxide, and water (present in nearly all fires), one may expect ammonia from burning wool, cyanogen from burning silk, acrolein from burning fats, sulfur-containing gases from burning rubber and leather, and chlorine-containing gases from burning or smouldering chlorinated plastics. From piled newspapers smouldering in limited oxygen, 41 per cent of the total gases given off was found to be carbon monoxide, and 43 per cent was carbon dioxide.

A pile of newspapers in a large open hallway would give an entirely different concentration of carbon monoxide and carbon dioxide within the breathing zone than the same pile burning in a small enclosed basement. Determinations ranging from two per cent to four per cent carbon monoxide have been made using recognized CO detectors in the smoke of building fires in the same room in which firemen were engaged in extinguishment, by a medical doctor

wearing self-contained breathing apparatus. A vigorous movement is now underway to encourage fire and other rescue services to use adequate respiratory protection more effectively.

AIR CONTAMINANTS

The conventional classification of air contaminants follows:

A. Aerosols (dispersoids) (particulate contaminants)—dusts, fumes and mists.

A better classification of aerosols is based on physiological effects:

- A. Nuisance and Inert: produce no known injuries: calcium carbonate, magnesium carbonate, gypsum
- B. Inert pulmonary reactions: produce non-specific pulmonary reactions: silicates, carbon, aluminum
- C. Minimal pulmonary fibrosis-producing barium compounds, tin, iron oxides
- D. Extensive pulmonary fibrous-producing silica, asbestos
- E. Chemical Irritants: produce inflammation or ulceration alkaline reactions: acids, fluorides, chromates
- F. Toxic systemic poisons: produce pathological reactions: lead, manganese, antimony, arsenic (not more toxic than Pb), arsenates, organic-phosphates, *cadmium, radioactive, beryllium (more toxic than lead)*
- G. Allergic manifestations: produce allergic reactions: pollens.
- H. Fever-producing reaction: action unknown or allergen: metal fumes, certain textile dust, (hemp, cotton, jute, bagasse)

A. *AEROSOLS*

Formerly called dispersoids or particulate *contaminants, these are substances present in the air as minute particles (such as dusts), as fumes (such as metal fumes), or as mists (such as chromic-acid mists). In grouping these together, it is recognized that they* may be physically filtered, screened, or adsorbed from the air with properly designed filters. Aerosols may range in size from 150 microns to a thousandth of a micron in size (1 micron equals 39.37 millionths of an inch or 1 x 10-4 centimeter). Many dusts are also fire and explosion hazards.

Pneumonokonioses (Greek for lung dust) or pneumoconioses are a group of lung conditions which result from the inhalation of dust. Silicosis is one of the most common types of pneumoconiosis, and is caused by the inhalation of "free" or "uncombined" silica, such as quartz, opal flint and crystobalite. Many other dusts may produce lung involvement such as absestos, talc, the silicates, carbon, iron and barium.

Other dusts cause chemical irritation, such as the acids, alkali substances, fluorides and chromates. Allergic reactions may be caused by common dusts such as pollens, synthetic resins, plastics, felt, fur, gums, spices, tobacco, paper, rubber, wood, starch, flour, and wool. The Bureau of Mines groups all the above dusts as "Pneumoconiosis-Producing and Nuisance Dusts."

TOXIC DUSTS

Another classification of dusts refers to "Toxic Dusts." Some have a lower threshold limit or maximum allowable concentration than does lead, although the Bureau of Mines classification uses lead as a reference. Among aerosols more toxic than lead are: cadmium oxide fume, chromic acid and chromates, mercury, mercury (organic), yellow phosphorus, picric acid, selenium, tellurium, calcium arsenate.

Respirators approved for all the above dusts (both toxic and pneumoconiosis-producing and nuisance dusts) are called "dust" respirators. A few substances, such as beryllium and radioactive substances, are not currently covered by Bureau of Mines schedules.

"Fumes" include aerosols formed by the condensation of vapors from heated metals. Melting, cutting, and welding of zinc, lead, cadmium and other metals produce such fumes.

"Mists" and "Sprays" include liquid droplets formed when liquids are carried into the air or are formed by a reaction with the moisture in the air. An interesting example is 0.3 parts per million sulfur dioxide, with sunlight, forms 20,000 particles per c.c. of sulfuric acid mist.

The availability of filters with pore sizes from 10 millimicrons (approximately the size of the polio virus) to five microns (the size of common contaminants in liquids) has greatly improved and speeded up analyses