

Service facilities, 11 per cent in facilities of other federal agencies (Bureau of Mines, National Bureau of Standards, Weather Bureau), 18 per cent by contract research outside the government (universities, industries, etc.) and 36 per cent in research grants, the largest share of which went to universities.

Medical-Biological Research

Medical-biological research specifically related to air pollution has been carried on extensively only since the inauguration of the federal air pollution program in 1955. Extensive background data, a good deal of which are directly transferable to the air pollution field, are available from previous studies specifically related to other areas of interest, principally industrial hygiene or occupational health. Current medical-biological studies may be divided into two major areas: controlled biological experimentation and epidemiological investigations.

The former is confined mainly to the laboratory and uses as experimental subjects for measurement of effects the gamut of biological systems ranging from microorganisms, biochemical systems, such as enzymes and tissue cultures, to plants, animals and humans. Exposure studies also have been carried to the field to avail the researcher of actual polluted atmospheres rather than laboratory simulations. The extensive animal studies under way at several locations in Los Angeles and the citrus studies at Uplands, California, are examples of the latter.

Epidemiological investigations may be subdivided into two major areas. The first of these comprises field investigations, in which mortality, gross morbidity, or some indicator of health status, vegetation damage, corrosion, and the like, are measured and correlated with current air pollution levels. Since the main avenue of insult of air pollution

to the human is through the respiratory system, these studies have stressed and continue to emphasize respiratory illnesses of many types or respiratory function testing. The second area of epidemiology encompasses studies of mortality and morbidity records and their correlation with existing demographic, socio-economic, meteorological, and air-quality information. As one might expect, such statistical studies tend to provide leads for further intensive field investigations rather than definitively indicating cause-effect relationships.

Today's areas of emphasis for medical effect research in air pollution are veering considerably from traditional investigations of the past. Because of the low-concentration, long-term nature of air pollution exposures, present investigations center on the evaluation of and search for functional changes in both epidemiological and laboratory studies in contrast to previous studies that used mortality, gross morbidity, gross lung damage, and the like, as indicators of biological stress.

In the epidemiological field, research now encompasses the more subtle techniques, such as lung function testing or investigation of illnesses restricted to sensitive portions of the population, e.g., asthmatics, or to those considered to be of less serious clinical significance, e.g., the common cold. The emphasis is on uncovering biological indicators of resulting chronic diseases, particularly those involving or related to the respiratory system. Because of the low concentrations of the exposures, laboratory studies are being extended to investigations of the more subtle effects of exposure, such as reaction time, color perception, learning rates, spontaneous activity, fertility, mutations in the cells of exposed animals, and biochemical studies.

The second area of divergence of present-day medical research in air pollution from the traditional practices