FILE NAME: Trade Publications (TR)

DATE: 1973 May

DOC#: TR063

DOCUMENT DESCRIPTION: Article from Mechanical Engineering

MEchanical engineering

VOLUME 95 NUMBER 5 MAY 1973

Published by The American Society of Mechanical Engineers

THE COVER

ENGINEERING FOR HEALTH

A notorious lack of communication between the medical and engineering communities has undoubtedly deprived mankind of vast areas of potential benefit. Although our recent space programs have done much to develop channels of cooperation between these important professions, it appears that it will be left largely to the engineer to show the way. The need is not so much for new developments as it is for simply the application of existing engineering technology and methods to medicine and public health. It's a real challenge for the engineer. Our cover this month symbolizes engineering in medicine. Read about it in an article beginning on page 18.

FEATURE ARTICLES

GUIDELINES TO PROFESSIONAL EMPLOYMENT FOR ENGINEERS AND SCIENTISTS 14

A guide proposed by the engineering societies for mutually satisfying relationships between professional employees and their employers.

ENGINEERING AND PUBLIC HEALTH ..... William J. Nicholson 18

While engineers and technology have had an impact on some areas of medicine, there is an "open sesame" for more transfer to be accomplished.

TECHNOLOGY AND COST OF COAL GASIFICATION ..... H. M. Siegel and T. Kalina 23

Economical coal gasification is possible, but extensive development work will be required to advance any of the new processes to the commercial stage.

ELECTRONIC PIG INSPECTS PIPELINES IN PLACE ..... Harold W. Bredin 29

There's a nondestructive quality-assurance inspection technique for determining the condition of in-service gas, oil, or crude-product pipelines.

WATER REUSE IN INDUSTRY

Part 2—Transport Water ..... E. H. Pavia and A. D. Tyagi 32

An example of the reuse and recycling of waste water that both protects the environment and recovers usable raw material.

DEPARTMENTS

EDITOR'S PAGE 13
BRIEFING THE RECORD 35
PHOTO BRIEFS 42
INTERNATIONAL FOCUS 44
ASME TECHNICAL DIGEST 46
LETTERS AND COMMENT 58
CURRENT BOOKS 59
ASME BOILER CODE 61
ME NEWS ROUNDUP 65
NEWS BRIEFS 68
EDUCATION NEWS 70
EDUCATION CALENDAR 72
MEETINGS CALENDAR 73
THE ASME NEWS 74
WOMAN'S AUXILIARY 81
EXECUTIVE COMMITTEE ACTIONS 83
CALL FOR PAPERS 83
PEOPLE IN THE NEWS 84
ELECTIONS TO FELLOW GRADE 85
DECEASED 86
WASHINGTON WINDOW 88
KEEP INFORMED 92
EMPLOYMENT OPPORTUNITIES 105
CONSULTANTS 112
ADVERTISING INDEX 113
CHANGE OF ADDRESS 114

NEXT MONTH

Long-Range Approaches for Resolving the Energy Crisis
Transporting Gas by Airship
Noise Control: A Common-Sense Approach

EDITORIAL STAFF

J. J. JAKLITSCH, JR., Editor
HAROLD BREDIN, Associate Editor
SAMUEL WALTERS, Staff Editor
ELIZ. CALVELLI, Assistant Editor
JANET KOTEL, News Editor
GALINA SAZONOV, Art Editor
GEO. SAMERJAN, Art Director
JIM MOBLEY, Editorial Production

POLICY BOARD, COMMUNICATIONS

Chairman and Vice-President
JAMES O. STEPHENS

Members-at-large
P. G. HODGE, JR., W. G. CORNELL, S. P. KEZIOS, D. F. WILCOCK

Policy Board Representatives
J. W. HOLL, Basic Engineering
S. P. ROGACKI, General Engineering
G. P. ESCHENBRENNER, Industry
G. P. COOPER, Power
G. C. WIEDERSUM, JR., Research
W. H. BYRNE, Codes and Stds.
G. P. ESCHENBRENNER, Nom. Com. Rep.
C. O. SANDERSON, Mng. Dir., Com.

OFFICERS OF THE ASME

RICHARD G. FOLSOM, President
ROGERS B. FINCH, Exec. Dir. & Sec'y
HENRY N. MULLER, JR., Treasurer
Vice-Presidents, **R. A. Bennett, C. T. Carley, Jr., D. H. Cornell, N. R. Johanson, C. H. Long, J. W. McKiernan, A. R. Machell, Jr., G. F. Maruska, R. W. Mills, R. M. Nee, D. E. Ott, J. D. Paulus, R. Plunkett, J. D. Quinn, W. T. Reid, R. E. Roberts, W. A. Shearer, Jr., J. O. Stephens, J. A. Talbott, F. A. Thomas, Jr., D. Zwelp**

EDITED AND PUBLISHED monthly at the offices of The American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, N. Y. 10017. Cable address, "Mechaneer," New York. Second-class postage paid at New York, N. Y., and at additional mailing offices.

PRICES: to members, annually $5.00 for initial membership subscription, $8.00 for additional subscriptions, single copy 80 cents; to nonmembers annually $10.00, single copy $1.00. Add $2.00 for postage to countries outside the U. S. and Canada

STATEMENT from By-Laws. The Society shall not be responsible for statements or opinions advanced in papers or . . . printed in its publications (B7, Par. 3).

COPYRIGHT 1973 by The American Society of Mechanical Engineers. Reprints from this publication may be made on condition that full credit be given MECHANICAL ENGINEERING and the author and date of publication be stated.

INDEXED by the Engineering Index, Inc., and the Applied Science and Technology Index.

MOVING?

Please Use Form on Last Page

74,000 copies of this issue printed

AUDITED PAID CIRCULATION

AN OPPORTUNITIES IN ENGINEERING FEATURE

ENGINEE
AND PUBLIC

Existing and potential developments in engineering skills and technology can be put to good use in various areas of public health. Although significant contributions have been made by engineers to clinical and diagnostic medicine, many other areas could benefit from the application of existing technology and from engineering approaches.

WILLIAM J. NICHOLSON[1]

Mount Sinai School of Medicine of the City University of New York

The adaptation of engineering techniques and the transfer of engineering technology to the solution of medical problems is an especially appealing concept. When one considers the impact on medicine of engineering expertise and technology that has already taken place, such devices as heart–lung machines, kidney dialysis units, or improved diagnostic instruments immediately come to mind. The space program, especially, has contributed to physiological-monitoring instrumentation and signal processing, as well as to a fuller understanding of certain body processes. An entire subprofession, bioengineering, with over 3500 members, now functions as part of both the engineering and medical communities.

The channels of communication that have developed between the engineering and medical communities have followed naturally from activities of this type. A wide variety of conferences and symposia are held annually with such topics as instrumentation, artificial organs, and patient-monitoring systems dominating the discussion sessions. Several journals specializing in bioengineering, with an emphasis on similar topics, now exist. Many universities have standing committees of engineering and medical faculty to consider these areas of mutual cooperation and interest.

These developments are important, and the contribution of engineering to these area of medicine will continue to expand. So far, however, their overall impact on health has been limited. This can be demonstrated, in part, by a survey recently taken at Mount Sinai Hospital in New York City. The courses of treatment of all 1038 patients in wards and semiprivate and private rooms during one day were reviewed to determine the use of electronic diagnostic or monitoring equipment (excluding x-ray machines, electrocardiographs, or routine laboratory equipment for the analysis of blood specimens, tissue biopsies, etc.). The results appear in Table 1 [1].[2] During the 24-hr period of Jan. 15, 1970, only 3.8 percent of the patients required treatment utilizing various electronic gear, and only 14.3 percent received such treatment at any time during their hospitalization. If one also excludes electroencephalographs, used extensively in the neuro-psychiatric department, and hardly a new device, these percentages drop to 2 and 6 percent, respectively. Additionally, Table 1, which also lists the electronic equipment used, shows only three devices that were developed in the last decade.

This limited use was not from unawareness on the part of the clinical staff nor from unavailability in the hospital. *Fortune* magazine of January, 1970, the very month of this survey, stated that Mount Sinai Hospital was "one of the most extensively automated big hospitals in the nation." What this limited use does show is that much of biomedical engineering is irrelevant to the everyday problems of patient care.

Additional evidence of the lack of impact of technology on the nation's health can be obtained from an analysis of the life expectancy of the U. S. population over a period of time. An infant born today has a life expectancy 20 years longer than a child born in 1900. Antibiotics and vaccines, which have virtually wiped out childhood and infectious diseases, have been the major factors in this increased life expectancy. However, the attempts of medicine and technology to prolong life in adulthood have been, to date, singularly unsuccessful. Figure 1 shows that the life expectancy of U. S. white males, *at age 60,* has not improved in the last 200 years [2].

For engineering and technology to achieve a maxi-

[1] Assistant Professor, Department of Community Medicine.
Based on a paper contributed by the ASME Aerospace Division.

[2] Numbers in brackets designate References at end of article.

RING HEALTH

mum impact on public health, it will be necessary to look beyond the operating rooms and the research laboratories of the major medical centers to the departments of community medicine, to regional medical facilities, and to the municipal departments of health. Preventive medicine, occupational health, delivery of medical care, accident prevention, and the health aspects of inner-city ghetto living all offer problems of immense scope to challenge the engineering community, problems whose solutions can have a dramatic impact on public health. We have been able to send a man to the moon in an environment clean enough to perform major surgery, yet a large number of America's workers labor in dust conditions that would be considered intolerable even by nineteenth-century standards. In other circumstances, a patient can await replacement of a mitral valve in a $150-a-day room while a few blocks away a child is doomed to a life of impairment as a result of permanent brain damage suffered from eating leaded paint falling from the ceiling into his crib.

For a significant impact to be made in many of these broad areas of community health, it is not necessary that new, sophisticated technology or elaborate gadgetry be developed. What is needed is the application of existing technology to this relatively neglected class of medical problems. Of equal importance is the need for an engineering systems approach to such large-scale health issues. In many areas of community health, models can be developed, system components and their interactions defined quantitatively, and changes and their consequences simulated as part of a comprehensive approach to the solution of urban health problems. A consideration in detail of a specific example of these broad problems—that of the health effects associated with the commercial and industrial uses of asbestos—will illustrate the role of the engineer in their solution.

Asbestos-associated Disease

Knowledge of a deleterious health effect from occupational exposure to asbestos dates from 1907, when Montague Murray, a physician at London's Charing Cross Hospital, described the severe lung scarring found in a 1900 autopsy performed on a 33-year-old former asbestos-textile worker who had been the sole survivor of a group of 10 individuals em-

TABLE 1

Utilization of Electronic Equipment* by Patients at Mount Sinai Hospital, January, 1970, at Any Time during Their Hospitalization

	Number	Percent
Patients surveyed	1038	100.0
Patients using electronic device:	149	14.3
on day of survey	40	3.8
during admission prior to day of survey	128	12.3

*Excluding ECG, x-ray, and service laboratories, but including EEG, isotope scanning, electromyography, audiometry, artificial kidney, pacemakers, etc.

Electronic Equipment Used on Day of Survey or during Admission

Device	Frequency of use
Artificial kidney	2
Audiometer	2
EEG	86
EMG	3
Electronic transducer	3
Emmerson chest suction	2
Hypothermic mattress*	3
Monitoring system	30
Pacemaker*	11
Pulsemeter	1
Radioisotope scanner	21
Respirator (Bennet)	9
Rotating tourniquets*	5
Ultrasonic nebulizer	10
Total	188

*Developed in the last decade.

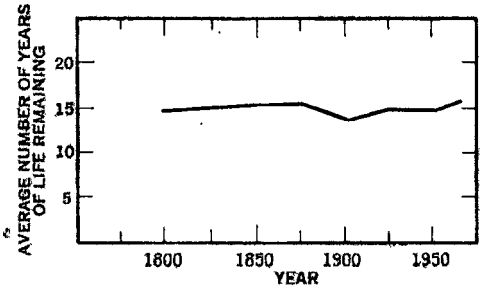


Fig. 1 Life expectancy of U. S. white males, at age 60, has not improved in the last 200 years.

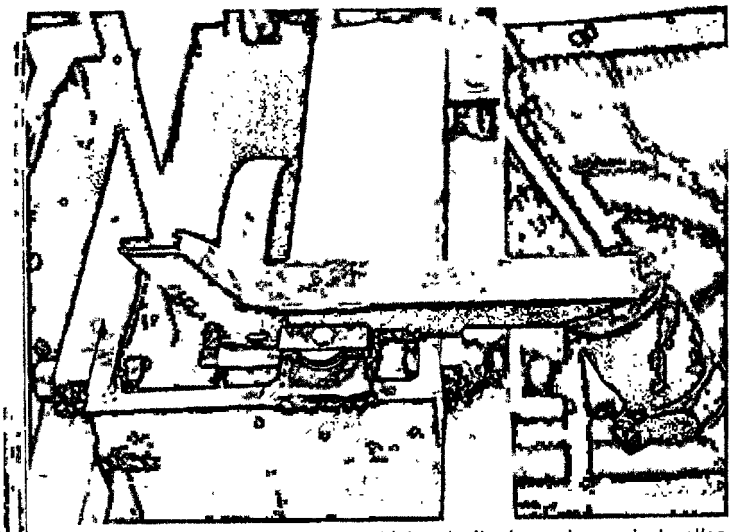


Fig. 2 Entrance port of a high-velocity low-volume dust-collection system for a band saw. The port is located directly under the cutting table, which has been moved aside in this photograph. Air velocities in excess of 10,000 ft/sec, three times typical blade velocities, are generated.



Fig. 3 The cutting of asbestos-containing pipe covering with a band saw equipped with a high-velocity dust-collection system.

Fig. 4 Three single-use respirators, especially suitable for use in construction sites, manufactured by the Welsh Manufacturing Co., the 3M Co., and American Optical Co.



ployed in a factory since 1886 [3]. A 1930 British study [4] further documented the pervasive presence of asbestosis (the term applied to the pulmonary fibrosis and scarring resulting from the inhalation of significant quantities of asbestos) in factory workers. This led to the imposition of what were thought to be stringent control measures in British factories producing asbestos products. Later research uncovered the existence of an additional problem. Lung cancer was suggested as being causally associated with an asbestos exposure in 1933 [5], and the association was fully confirmed in 1948 [6] and 1955 [7] studies.

In spite of this long history of disease, studies of Selikoff, Hammond, and Churg [8] demonstrated that an extensive health problem still exists in the U. S. asbestos industry. From observations made on the 1943 membership of the New York and New Jersey locals of the asbestos insulation workers union, a catastrophic health experience has been documented. Table 2 describes the mortality experience of this group of workers through 1971. One in five of the deaths of these workers was from lung cancer; nearly one in 10 from mesothelioma, a disease so rare in the general population that perhaps only one in 10,000 deaths are from this cause; one in 10 from cancer of the gastrointestinal tract, three times that expected; one in 10 from other cancers; and almost one in 10 from asbestosis, an occupational disease identified over 70 years ago. Nearly 40 percent of these workers' deaths can be attributed to their occupational exposure to asbestos. Moreover, recent studies of an asbestos-products manufacturing facility point to the existence of an even greater health problem in factories [9].

In addition to the extent of the disease experience,

TABLE 2

Deaths among 625 N.Y.–N.J. Insulation Workers Observed Prospectively 1943–1971, after Reaching 20 Years from Onset of Work

	Expected	Observed	Percent
Total workers, 625	—	—	—
Total deaths, all causes	288.5	423	100.0
Lung cancer	11.2	84	19.8
Pleural mesothelioma	—	8	1.9
Peritoneal mesothelioma	—	20	4.7
Cancer: stomach, colon, rectum	12.5	41	9.7
Cancer: all other sites	28.2	37	8.8
Asbestosis	—	32	7.6
All other causes	236.6	201	47.5

two other important concepts were revealed in these studies: the problems introduced by the long lapse between onset of asbestos exposure and the incidence of disease and the effects of co-factors on the intensity of disease. In virtually all cases, the occupationally related deaths from asbestos exposure came only after 20, 30, 40, or more years since onset of exposure. This, of course, has presented considerable difficulties in attempting to apply proper control measures based on information of disease experience produced by inadequately evaluated environmental exposures of past decades. In short, there is excessive time lag in the feedback loop.

The other problem demonstrated by the mortality experience of these workers is that a synergistic effect exists between occupational asbestos exposure and cigarette smoking in the development of lung cancer. From a study of the mortality experience of individuals whose smoking habits were known, it was found that 42 of 136 deaths of 283 smoking asbestos workers were from lung cancer, whereas only one of 32 deaths of 87 nonsmokers was of lung cancer. Thus, while an asbestos exposure alone may give rise to some increased risk of lung cancer, the combination of asbestos exposure and cigarette smoking is especially deleterious to health. A cigarette-smoking asbestos worker has approximately a 90 times increased risk of dying of lung cancer as an individual who neither smokes nor works with asbestos. Here, as in many other medical problems, we are dealing with nonlinear systems.

Unfortunately, the health problems associated with asbestos extend beyond those individuals directly exposed to those exposed only by virtue of working in the vicinity of the application of asbestos products, to the families of asbestos-factory workers, and to people who simply live in the neighborhood of mines or factories. Mesothelioma has been shown to occur in excess in shipyard employees such as welders, carpenters, electricians, and others only indirectly exposed to asbestos [10]. Exposures at lower than occupational levels have also been linked to mesothelioma found in family and neighborhood exposures in London [11] and Pennsylvania [12]. Here we are concerned with a problem of entirely different dimensions. The asbestos exposures that produced such disease were much lower than those of the insulation workers previously discussed, and the risk of asbestos-related disease was concomitantly reduced. However, the number of individuals potentially exposed is numbered in the tens of millions. Of special concern in this context is the widespread dissemination in recent years of asbestos into the environment through the spray fireproofing of high-rise office buildings, a process now banned in several cities.

Engineering Approaches to Environmental Control

Having identified the scope of the health problems associated with the use of asbestos and asbestos products, a cooperative effort was initiated at Mount Sinai School of Medicine to control human exposures to asbestos. Here the clinical and epidemiological staff was supplemented by engineers, industrial hygienists, physicists, and even mineralogists to evaluate all aspects of the health problem and to develop and implement various control solutions. Data were obtained on the variety of products incorporating asbestos and the potential dust exposures that might occur during their manufacture and use. Studies utilizing optical and electron microscopy and electron microprobe analysis documented the air levels and tissue burdens of asbestos from occupational and environmental exposure. Research on control strategies was mounted to reduce asbestos exposures to all segments of the population.

In the initial efforts to develop control measures to protect workers on construction sites and shipyards who cut, fit, and apply asbestos-containing thermal insulation, it was found that much existing technology had never been applied in this industry.

An especially easy solution for the control of dust generated by mixing asbestos cements was accomplished by requiring the manufacturer to ship these cements in plastic bags to which water can be added and mixing accomplished without generation of dust.

Severe inconsistencies in the area of respiratory protection were quickly revealed. Although insulation contractors would supply workers with half-face-mask, replaceable-filter respirators approved by the Bureau of Mines, they were completely ineffective in protecting the workers. As no respirator maintenance program existed on any construction site, the respirators soon became contaminated inside and out and often were in a state of disrepair. Additionally, their use by individuals with impaired breathing ability was precluded by the relatively high air resistance of the filter. A three-year effort involving safety-equipment manufacturers, the Bureau of Mines, industrial-hygiene engineers from Mount Sinai School of Medicine, and Johns-Manville Corp. has finally culminated in the availability of three economical, approved, comfortable respirators having minimum breathing resistance.

One area now under development that offers the opportunity for technological transfer specifically from space technology is that of room air-cleaning systems. As yet, no effective portable room air-cleaning system is available for use in the asbestos-insulation industry. While dust control directly at the source of generation is the most desirable, occasionally widespread dissemination occurs that requires different control concepts. In cooperation with engineers at Florida Institute of Technology, room cleaning systems are now being developed and tested. In this study, such procedures as air curtains and directed air-cleaning systems are under consideration.

Problems of Implementation

As in all problems having significant impact on various groups in society, implementation of identified solutions to problems can be slow, difficult, and frustrating. Many of the solutions forthcoming from the M.S.S.M. Insulation Industry Research Program were not immediately implemented, although they could have reduced dust exposures to one-tenth that which existed in the past. While their cost was modest in terms of the total expense for insulation work, in the absence of assurance of "across the

board" implementation by industry, no single contractor wished to be placed at even a slight economic disadvantage. Thus action by the federal government was necessary, and an improved, but still inadequate, asbestos standard was promulgated by the Department of Labor on June 7, 1972, which incorporated some of the foregoing procedures [13].

It is important that engineering input be available for such implementation processes, especially to individuals proposing courses of action or budgetary commitments by the government. Without such input, political or economic considerations will dominate the governmental decision-making process. Thus many research results and much technical development may be wasted without the commitment of engineers to the full process of development *and* implementation of the work.

Occupational Health

Asbestos was described in detail to illustrate the full scope of a health problem and the different aspects where the approach and the knowledge of engineers proved of benefit. An engineering systems analysis of the commercial and industrial uses of asbestos defined the scope of the medical problem. Engineering expertise was utilized in the instrumentation developed to assess occupational and environmental exposures, engineering technology was identified or developed to control the excessive asbestos exposures found, and finally, engineering input into the regulatory process was of benefit in the initial steps taken by government to control the uses of asbestos.

An estimated 250,000 workers are directly exposed to asbestos. Another 4,000,000 are exposed indirectly by virtue of their jobs. The effect on health achieved by adequately controlling the occupational use of this substance alone could result in a saving of over 5000 lives annually. Additionally, proper control of the work environment can significantly reduce the exposure and risk to the general public. However, asbestos is only one substance found in the occupational workplace. Silica, talc, and other dusts are ubiquitous in the work environment; 8000 chemicals are on the toxic-substances list of the National Institute for Occupational Safety and Health—workers in refineries, chemical plants, and other factories are often exposed excessively to many of these substances. Fewer than 450 of these have established occupational standards of exposure. In many cases, the full scope of the health aspects of these substances has not been established, especially the long-term effects and the effects of different combinations of materials. A multitude of urgent challenges await both the medical and engineering communities here.

Summary

While engineering and technology have had an impact on some areas of medicine, many additional areas exist where a transfer of engineering skills and technology can have a significant impact on the solution of major health problems. These lie in areas where the need for new developments is far less than the need for an analytical engineering approach and the application of existing technology. Many areas of health could benefit, but it will be necessary for the medical community to be educated as to what the potential contributions of engineers might be. While it is the medical community that requires the education, the initiative for this process must come from the engineering community. However, in bridging the communications gap that exists between parts of these two communities, engineers must reach out beyond the departments of medicine or physiology to the departments of community medicine or occupational health. Epidemiologists and sociologists as well as surgeons and biophysicists must be contacted. Speak also to psychologists concerned with the mental health of workers confined to the drudgery of a single task on a massive assembly line and those concerned with making the workplace, the home, or the automobile safer.

However, as important as communication between engineers and the medical community is, it is only a first step. Dialogues at long range are singularly unproductive. Also of limited productivity is the procedure of engineers coming to medicine with a gadget, a technique, or a material and asking for a use. What is productive is for engineers and health professionals to *work* together, on a daily basis, to solve the problems confronting us. The engineer must still retain his contact with the engineering community. He must stay current with new information and new technology, but for full effectiveness in the field of public health he must become totally immersed in its activities. It might be appropriate to close by suggesting that engineers apply "Sutton's law" to their search for an involvement in public health. Willie Sutton, when asked why he robbed banks, replied "because that's where the money is." If engineers wish to make an impact on public health, they must go where the problems are.

References

1 Gonda, I., and Richter, E., "Use of Electronic Equipment in a Medical Center," *Medical Research Engineering*, Vol. 10, 1971, pp. 21–24.

2 Bjorksten, J., "Approaches and Prospects for the Control of Age-Dependent Deterioration," *Annual, N. Y. Academy of Science*, Vol. 184, 1971, pp. 95–102.

3 Report of the Departmental Committee on Compensation for Industrial Disease, 4076, HMSO, London, England, 1907.

4 Merewether, E. R. A., "A Memorandum on Asbestosis," *Tubercle*, Vol. 15, 1933–1934, pp. 69–81, 109–118, 152–159

5 Lynch, K. M., and Smith, W. A., "Pulmonary Asbestosis III: Carcinoma of the Lung in Asbesto-Silicosis," *American Journal of Cancer*, Vol. 24, 1935, pp. 56–64.

6 Annual Report of the Chief Inspector of Factories for the Year 1946, HMSO, London, England, 1947.

7 Doll, R., "Mortality from Lung Cancer in Asbestos Workers," *British Journal of Industrial Medicine*, Vol. 12, 1955, pp. 81–86.

8 Selikoff, I. J., Hammond, E. C., and Churg, J., "Asbestos Exposure, Smoking and Neoplasia," *Journal of the American Medical Association*, Vol. 204, 1968, pp. 106–112; Selikoff, I. J., Churg, J., and Hammond, E. C., "Asbestos Exposure and Neoplasia," *Journal of the American Medical Association*, Vol. 188, 1964, pp. 22–26.

9 Nicholson, W. J., Selikoff, I. J., and Hammond, E. C. (to be published).

10 Stumphius, J., "Epidemiology of Mesothelioma on Walcheren Island," *British Journal of Industrial Medicine*, Vol. 28, 1971, pp. 59–66; McEwen, J., et al., "Mesothelioma in Scotland," *British Medical Journal*, Vol. 4, 1970, pp. 575–578.

11 Newhouse, M. L., and Thompson, H., "Mesothelioma of Pleura and Peritoneum Following Exposure to Asbestos in the London Area," *British Journal of Industrial Medicine*, Vol. 22, 1965, pp. 261–269.

12 Lieben, Jr., and Pistawka, H., "Mesothelioma and Asbestos Exposure," *Arch. Environ. Health*, Vol. 14, Apr. 1967, pp. 559–563.

13 *Federal Register*, Vol. 37, June 7, 1972, pp. 11318–11322.