choose parallel lung-cancer and non-lung-cancer patients for comparison whose other differences have been cancelled out with the exception of one variable, namely, smoking or non-smoking. This Doll and Hill did: they studied 1,357 men who had contracted lung cancer and the same number of men free of lung cancer as controls, together with 108 women suffering from lung cancer and 108 women controls. The patients and their controls were in the same hospitals in London, Birmingham, Cambridge, Leeds and Newcastle and in rural areas of Dorset and Wiltshire; they belonged to the same age group, had been in hospital for the same length of time, and the controls even had the same disease (cancer) of some other part of the body. It would be difficult to imagine a more carefully worked out scheme of matched controls. The results of the Doll–Hill investigation are now too well known to need reiteration.

The report develops the argument that modern therapeutic methods have allowed age groups liable to lung cancer to survive which would previously have had large losses by death at a less advanced age. Let us then assume that the steep fall in the tuberculosis death-rate since the latter part of the past century has saved susceptible groups for a later death from lung cancer. But what of the women? Their death rate from lung cancer is much below that of the men. It will be necessary then to postulate a second hypothesis, that lung cancer is sex-linked. But our difficulties are not over, for the lung-cancer rate for women has been rising quite rapidly. For the moment, this line of argument is better abandoned.

I. HIEGER

THE NATIONAL COAL BOARD'S PNEUMOCONIOSIS FIELD RESEARCH

By DR. J. W. J. FAY
Chief Scientist of the Research

PNEUMOCONIOSIS is a condition which starts almost imperceptibly with the fixation of a small amount of dust in the lung, and as the period of exposure increases more and more dust is accumulated. So long as the condition remains as 'simple' pneumoconiosis, it is believed that it will not progress if the subject is removed from the dusty environment, and disability is absent or comparatively slight. The rarer but more serious form is known as 'complicated' pneumoconiosis, or progressive massive fibrosis. In this form of the disease the patient's condition deteriorates even if he is removed from the dusty environment. Progressive massive fibrosis is thought to be caused by the superposition of an extraneous infection, probably tubercular, on a background of simple pneumoconiosis usually in its more advanced stages. Hence, if pneumoconiosis is halted at the earlier stages of the simple form, the results are not serious. Both forms of the condition are recognizable by X-ray examination of the lungs.

In spite of the work which has already been done, pneumoconiosis still presents a serious problem in the coal-mining industry, about five thousand new cases being certified every year. The National Coal Board has therefore undertaken a field research to study the effect of the dust breathed by coal-miners in the course of their work. As the result of long-term field studies it is hoped to obtain accurate data on which to base safe levels of dust concentrations which miners will be able to tolerate throughout their working lives without suffering any considerable disability.

The research, which was started in 1953, is being conducted at twenty-five collieries in England, Scotland and Wales. The selection of collieries is designed to provide a reasonable cross-section of mining practices, conditions and types of dust, in order to investigate the effect of composition as well as quantity of dust. These twenty-five collieries employ about 35,000 men, approximately 5 per cent of the coal-miners in the United Kingdom.

Medical Studies

There are two mobile medical units, each equipped with the most up-to-date X-ray machines for taking full-size chest X-rays of the population at each colliery every three years or so. Each unit is in charge of a senior medical officer and includes a qualified physiologist, a radiographer and clerks, technicians and ancillary staff to a total complement of nine.

The films are classified into categories of pneumoconiosis according to the international (I.L.O.) classification, which recognizes four stages of simple pneumoconiosis and four of progressive massive fibrosis.

The reading of the films is done by the senior medical officers. Due precautions are taken to estimate the accuracy and consistency, including the application of cross-checks and a continuous statistical control on the reading levels. By this means a uniform and satisfactory standard of reading is maintained.

The first round of X-ray surveys has been completed, and the results have shown a wide range of prevalence of significant pneumoconiosis at the different collieries.

At the time of the X-ray survey, details have been recorded of the past working histories of all the men examined. There is thus available a record of the prevalence of pneumoconiosis on an individual basis among the present populations at the collieries, together with a record of the environmental history which has contributed to the prevalence revealed. This information enables an estimate of the prevalence throughout the coalfields to be made.

The examination is voluntary, but the co-operation of the men has been extremely good, the overall response being about 95 per cent. The lapses have been analysed in terms of age and occupation and they do not appear to be significant in either respect. Thus the population examined is considered to be representative of all the men working at the collieries at the time of the surveys.

The second round of medical surveys will be started this year, and a number of simple anthropometric and physiological measurements will be made in addition to the X-ray examinations. This is in order to investigate the relationship between X-ray classification and disability. In addition to the physiological tests, which are primarily intended to investigate respiratory function, a questionnaire will be used for eliciting information regarding other chest conditions which may complicate the investigation of pneumoconiosis.

Environmental Measurements

The environmental sampling programmes are designed to measure the environments of the men, particularly dust concentrations, for the purpose of correlating the attack and progression of pneumoconiosis as revealed by the follow-up X-ray surveys with the intervening dust exposure which has caused it.

An individual record of dust exposure is required for each man under observation, to match against his X-ray record. The system adopted to accumulate the necessary data has been to stratify into occupational groups the population of each colliery and to get a measure of the environment of each group. Each occupational group consists of men doing the same work, at the same time, in the same place, so that the environment within any one group can be expected to be reasonably uniform. The sampling procedure is to select representatives randomly by name from each of the groups and to measure their exposure throughout a working shift. Different representatives are covered on successive shifts of sampling and, by a suitable choice of sampling fractions, occupational group exposure indices are built up with increasing accuracy as time goes on. These occupational group exposure indices are attributed to each man in the group for the period he spent in the group, and in this way an individual exposure index is cumulatively recorded for each man under observation.

The dust concentrations are measured by investigators based at the collieries who accompany the representatives throughout their working shift. The thermal precipitator is used as the standard instrument, and the dust concentrations are evaluated in terms of the 1–5 micron particle counts, as representing the best practical method of assessing the respirable dust. There are sixteen senior investigators (scientists) engaged in these field studies, each being responsible for the work at one or two collieries. They are assisted by thirty-nine junior investigators (scientific technical officers), giving a total field team of fifty-five, an average of just over two investigators at each colliery. The actual distribution of staff depends upon the size of the colliery. The environment of the whole colliery population is measured, and a picture is built up of the dust exposures of all the occupational groups on all shifts.

The sampling procedures are standardized and the performance of the investigators in evaluating their samples is subject to continuous check. In this way satisfactory counting levels have been attained and maintained by the team as a whole throughout the investigation.

The success of the system of sampling by occupational groups depends upon maintaining an accurate record of each man's working history. At any one time there are about 1,400 occupational groups altogether, with considerable movement of men from one group to another. Records must therefore be kept of changes in occupation, and the methods for doing this have been successively refined as the investigation has proceeded. The system which has finally been developed involves the use of individual mark-sense Hollerith cards which are prepared by a clerk at each colliery. The cards are mechanically punched, sorted and summarized on a Hollerith machine at headquarters in London to provide a detailed record of environmental exposure, due allowance being made for the man's time at risk.

The emphasis so far has been on the measurement of dust concentrations in terms of total particles of respirable dust, but the question of composition is covered in two ways. The thermal precipitator slides are evaluated regularly in terms of coal and non-coal particles in order to record what proportion of the 1–5 micron dust is mineral. In addition, work has been started on the collection of gravimetric samples of the various dusts for composition analysis, inuding an estimate of the free silica content.

Correlation of the Medical and Environmental Data

The ultimate object is to correlate the observed progression of pneumoconiosis with measured dust exposure. In the first place, the hypothesis to be tested will be that radiological pneumoconiosis is related to dust exposure expressed in terms of the number of 1–5 micron particles per unit volume of air. Alternative hypotheses will have to be investigated if this simple hypothesis is disproved. For example, it may be necessary to take account of the composition and size distribution of the dusts, as well as to investigate the effect of very high intermittent, or 'peak', concentrations. It is, however, impossible to undertake any analysis based solely on the observed progression and measured dust concentrations until at least one follow-up X-ray survey has been made and some progression measured.

Hence the analysis is limited for the time being to an examination of the present prevalence in terms of past occupations. The past working histories taken during the first X-ray surveys have been summarized and analysed in terms of prevalence of pneumoconiosis and period of exposure in the different occupations and places of work. In this way it is possible to obtain information about the relative hazards of different occupations at the various collieries in the past, which will provide a useful background of knowledge for the quantitative correlations later in the investigation.

The planning and supervision of the environmental sampling programmes and of the medical/environmental correlations, as well as the development of new techniques and methods of analysis, are carried out by a headquarters unit consisting of eighteen scientists and technologists and twenty-four clerical and ancillary staff—a total complement of forty-two. With the eighteen people associated with the medical units and the fifty-five investigators in the field, there are thus 115 people engaged full time on the investigation.

The investigation is still in its comparatively early stages and much of the effort to date has inevitably been devoted to the design and application of the long-term procedures. This account has therefore

been largely limited to a description of the background and planning of the investigation. The results so far available are preliminary ones, but those which are of general interest will be published from time to time.

It is impossible to acknowledge in detail the help and encouragement which are forthcoming from so many people. Without this co-operation, however, it would obviously be impossible to conduct the investigation, which can safely be said to represent a good example of a large-scale, co-operative experiment in the field of occupational hygiene.

This short statement of the programme of research is published by permission of the National Coal Board.

NUCLEAR RADIATION MEASUREMENTS DURING THE INTERNATIONAL GEOPHYSICAL YEAR

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THE development in the field of nuclear physics in recent years has indeed been remarkable. Not only has our understanding of the principles of nuclear reactions been vastly increased, but refined techniques for identifying and measuring radioactive isotopes in exceedingly small amounts have also been developed. These latter methods have been of great use in biological and medical studies; of late they have been applied to geochemistry, and are now finding their way into geophysics. A new and powerful tool for studies of our environment has thus been placed at the disposal of the Earth scientists, the ultimate possibilities of which we cannot judge to-day. It is highly desirable that the great promise of this field be realized and a global observational programme formulated, particularly in view of the intimate world-wide co-operation in all fields of geophysics during the International Geophysical Year 1957–58.

A number of natural radioactive elements are found in Nature, the existence of which has told us interesting facts about, for example, the history of the Earth, the exchange processes in the atmosphere and the sea as well as through the interfaces between these media. Thus determinations of beryllium-10 in deep-sea sediments may be of importance for studying the chronology of the bottom floor; the distribution of the much more rapidly decaying isotope beryllium-7 might yield interesting information about the horizontal large-scale mixing in the atmosphere. Determinations of carbon-14 in the sea and atmosphere have given much more precise knowledge about the exchange of carbon dioxide between the atmosphere and the ocean, and may very likely tell us something about the speed of circulation of the deep ocean. Similarly, studies of the radium and ionium content of the deep sea throw some light on the water motions in the bottom strata of the deep sea. A number of investigations of radium and thorium and their daughter products have given us better knowledge of exchange processes in the surface layers of the atmosphere.

In the past twelve years an increasing number of radioactive elements have been introduced into the atmosphere through nuclear weapon tests. In a thermo-nuclear explosion more than one hundred different radioactive isotopes are formed directly or indirectly. Most of these isotopes were previously not present in measurable amounts in Nature, while in other cases this new source means a contamination of the natural reservoirs of radioactive elements. Thus the amount of tritium in the atmosphere, sea and lake waters has significantly changed due to these experiments. It may, therefore, now be difficult to determine precisely the amount of tritium on the Earth that is of natural origin. On the other hand, the variable input of tritium by man into the atmosphere, and its propagation in the water-cycle, will probably yield interesting information about this cycle itself, that might have been difficult to find using only the naturally formed tritium. Other radioactive isotopes produced by nuclear weapon tests are strontium-90 and cæsium-137, the distribution of which has already revised our ideas about the vertical exchange in the stratosphere, and most likely will be of great importance for the study of the general circulation of the atmosphere.

Already measurements of the total amounts of man-made radioactivity deposited on the ground have shown remarkable variations. Meteorologists might earlier have thought of the motion of the atmosphere as a large-scale turbulent process, but observations of the radioactivity of the air reveal details that would have been very difficult to obtain by any other method.

In view of the large observational programme in all fields of geophysics during the International Geophysical Year 1957–58 it seems highly desirable also to organize a programme for observations of radioactive elements in Nature. Quite a large observational network for measuring the radioactivity of the air and the deposited radioactivity has been reported to the United Nations, but the question of health hazard has been the main objective in the organization of these observations. It seems that the purely geophysical and geochemical aspects of the problem deserve a much more detailed examination. Recognizing this the Special Committee for the International Geophysical Year (CSAGI) in September 1956 endorsed a recommendation that a programme be formulated for measuring, on a world-wide basis, the nuclear radiation of air and precipitation and of solid particles deposited on the ground. Based on this recommendation a Working Group on Nuclear Radiation met at Utrecht during January 22–26.

The programme adopted by the Special Committee for the International Geophysical Year should be looked upon as a minimum programme. In view of