MODERN TRENDS
IN
OCCUPATIONAL HEALTH

Edited by

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LONDON

BUTTERWORTH & CO. (PUBLISHERS) LTD.

1960

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PRINTED IN GREAT BRITAIN BY R. J. ACFORD LTD., CHICHESTER, SUSSEX

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INTRODUCTION

OCCUPATIONAL HEALTH is expanding so rapidly that it is not possible to cover all its recent developments in one book. We have, therefore, attempted to give an account of the more important general trends, particularly the broadening of the scope of occupational health beyond the boundaries of medicine and of the development of scientific methods for measuring the working environment and its effects on health. Occupational diseases have been well covered by Dr. Donald Hunter in his classic work *Diseases of Occupations*, so we have dealt only with those diseases in which there has been a notable advance in knowledge in the last few years.

One aim has been to show that with doctors and nurses, the occupational hygienist or health engineer, the physicist, chemist, psychologist and sociologist are all playing an increasingly important part in protecting people from the hazards of their work.

The subjects of occupational skin disease, heating, ventilation and lighting have not been included and with the limited space it has been possible to deal with only a few of the important techniques used for the measurement and control of the working environment. For these subjects, the reader should refer to other books and the generous lists of references given at the end of the chapters.

While this book is written primarily for industrial medical officers, research workers and students of industrial medicine, it is hoped that it may also be of value to others concerned with occupational health. This includes factory inspectors, personnel safety officers, nurses, and the managers and representatives of workers on whom so much depends in promoting the health of people at work.

I am indebted to the collaborators for their contributions and for their assistance in planning this book. For the latter, I am especially indebted to Dr. J. M. Barnes and Dr. J. C. Gilson. I am grateful to many others and particularly to the members of the Department of Occupational Health, London School of Hygiene and Tropical Medicine—Dr. C. H. Wood, Mr. S. A. Roach, Miss S. H. Meadows, Mrs. B. Gurney and Miss V. Follenfant—for their help in many ways.

April, 1960 R. S. F. SCHILLING.

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CHAPTER 1

THE MEASUREMENT OF HEALTH

R. S. F. SCHILLING

INTRODUCTION

IN THE last two decades occupational health has developed rapidly as a scientific discipline. Governments and private industries now employ many more medical officers and hygienists, and have created institutes for research into occupational hazards and laboratories for routine measurements (World Health Organization, 1957). This may be a reflection of a general trend to introduce measurement into medicine. But at the same time the purpose of occupational health services has changed. At first they had the limited objectives of providing treatment and controlling the more obvious toxic hazards. They were often inspired by employers who sought protection from claims for compensation (Meiklejohn, 1956). In countries which are highly industrialized, the employers' motives for providing health services now stem from more powerful forces—a desire to raise the standards of human efficiency and a growing awareness of their moral and legal obligations to protect employees from the hazards of their work (*see* Chapter 20 by Mansfield Cooper). In countries undergoing rapid industrialization, the highest priority is being given to the development of occupational health services because national prosperity depends fundamentally on transforming peasants, ignorant of the hazards of industrial life, into healthy and effective workers.

Thus, industrial medical officers, hygienists and research workers have had to turn their attention to a much wider range of problems than the treatment and prevention of injuries and the more blatant toxic hazards. The growing demand by industry and the armed services for more precise knowledge of their health hazards, and the need to solve new and complex problems in a variety of occupations, have especially stimulated the development of occupational health as a scientific discipline.

This chapter outlines methods which may be used for measuring health at work—usually the first step in the detection and subsequent control of occupational hazards. In this context health may be defined as competency of body and mind at work. It includes physical, mental and social well-being. But these qualities usually defy reliable measurement and in promoting health we are still mainly concerned with preventing disease. Health is measured more reliably and effectively in terms of injury, disease and physiological dysfunction than in terms of well-being. Nevertheless, more positive indices of health, such as work performance and satisfaction, may be used.

The individual and the group

The basic aims of an occupational health service are to help people to choose jobs within their capacity (*see* Chapter 12 by Elliott), to observe departures from health, to treat sickness and injury (*see* Chapter 11 by Bull), and to find their causes and eliminate or control them (*see* Chapter 10 by Bramley-Harker). Sometimes the causes of ill health are obvious as in a workman suffering from lead poisoning, injury, heat exhaustion, or fatigue from excessively long hours. But occupational health is concerned with more complex diseases, the causes of which cannot be elucidated by investigating the individual. For example, lung cancer and deafness are diseases which may or may not be caused by work. There are others, such as chronic bronchitis, coronary heart disease, rheumatism and mental illness, in whose aetiology work may play a part in association with other influences such as the environment outside the factory, heredity and personal habits. By using the methods of epidemiology to study groups rather than individuals, it may be possible to discover the influence that work may have in the aetiology of disease, to measure the extent of occupational hazards and to define that aetiology with more precision.

Occupational mortality rates have long been used to detect the hazards of work. More recently indices of morbidity, derived from sickness records, accident records, and field surveys, have been developed for this purpose.

OCCUPATIONAL MORTALITY

National records

A century ago mortality rates were used in England and Wales by William Farr of the General Register Office to study the relation between health and occupation (Registrar General, 1855). His methods are still used today in Great Britain but they have not been applied generally to the study of occupational mortality in other countries.

Farr's successors enhanced the value of occupational mortality studies in Great Britain. They used purer occupational groupings and calculated the mortality rates of wives and infants of occupied men to distinguish between occupational and socio-economic hazards; but these data have quite serious limitations.

In calculating death rates, the populations at risk are obtained from the national census, and the number dying from death certificates. The latter record the deceased's last occupation, which may not be the one which influenced his death. A sustained period of full employment, which has given more opportunities to the disabled and the retired to find new jobs, seems to have increased this source of unreliability.

In England and Wales during the quinquennium 1949–53, 22 warehousemen, 16 clerks, 11 company secretaries, 7 publicans and many others, doing what is believed to be non-dusty work, were recorded as dying of pneumoconiosis (Registrar General, 1958). Among cotton workers the respiratory death rates for 1949–53 show that those employed in dusty trades had apparently lower death rates than those in much less dusty occupations (Schilling, 1960). If it were not for the contrary evidence from field surveys, and that in the period 1956–58 nearly 700 cotton workers were awarded pensions for byssinosis under the National Insurance Industrial Injuries Act, it might be concluded from mortality rates that this hazard had been successfully controlled. The most likely explanation for this anomaly is that the English cotton industry has contracted very much in the last 20 years, and that many of the older cotton workers, disabled with respiratory disease, have found other occupations to which their deaths have been ascribed.

Heasman, Liddell and Reid (1958) have produced evidence which strongly suggests that among coalminers the death rates for hewers and getters, reported by the Registrar General, are quite considerably inflated by inaccurate job descriptions on death certificates and by arbitrary coding conventions.

The Registrar General's data, or any other, based on national rates are not sufficiently detailed to indicate hazards of small groups, as, for example, the risk of chemical workers exposed to benzol and its compounds dying of anaemia and liver necrosis. Nor are they relevant to the investigation of diseases like rheumatism and neurotic illness which have high morbidity but low fatality rates.

Nevertheless, the Registrar General brings new occupational risks to our notice and reminds us that old ones still exist. What other sources of information could reveal so readily the excessive mortality from cancer of the lip among male agricultural workers (Logan, 1959) or the relatively high mortality from coronary heart disease in radio and telegraph operators (Registrar General, 1958)?

Records from firms and localities

Existing records of death collected by firms or trades unions for pension funds or funeral benefits have been used to measure occupational risks of cancer. Doll (1952) found that such data were sufficient to demonstrate a hazard of lung cancer in the gas-producing industry. The official records of death in the locality in which an industry is situated have also been used to investigate the risk of cancer in a factory making inorganic arsenicals (Hill and Faning, 1948).

Following case reports by the industrial medical officer (*see* Chapter 5 by Browning), Doll (1958) investigated a hazard of lung and nasal cancer in nickel workers from data held by medical officers of health.

The method Doll used is of particular interest. It was impossible to calculate specific death rates because the numbers of men employed were not known. There were more than 15,000 death certificates of males aged 15 years and over from the area in which the nickel workers had lived. The certificates were sorted into five occupational groups—the nickel industry, three other industries which might carry a risk of lung cancer, and all other occupations. They were then classified by three causes of death—lung cancer, nasal cancer and other causes, for thirteen age-groups. Using the group of men in all other occupations as a standard, Doll estimated the number of deaths expected to be due to lung cancer in the nickel workers by assuming that the ratio between the number due to lung cancer and the number due to causes other than cancer of the lung and nose should be the same at each age, as in the standard group. Thus, it was estimated that the risk of nickel workers dying of lung cancer was about 5 times the normal risk (Table I). It was also estimated that the risk of nasal cancer was 150 times the normal. Perhaps equally interesting was the finding of a low lung-cancer rate in coalminers.

Morgan (1958), the industrial medical officer to a nickel refinery, showed from the firm's records that the hazard has been greatly reduced, if not eliminated, since working conditions were improved some 30 years ago. One may wonder how many epidemiological pearls lie buried in the records of public health departments and of industry.

Firms or an industry with a suspected cancer risk may make a special effort to collect records of deaths. Such records have revealed a risk of lung cancer in the asbestos and chromate industries (Doll, 1955; Bidstrup and Case, 1956) and

TABLE I

NUMBER OF DEATHS FROM CANCER OF THE LUNG AND OTHER CAUSES[1]
(From Doll, 1958)

Age at death (years)	*Nickel industry*			*All other occupations*[2]	
	Other causes	*Cancer of the lung*		*Other causes*	*Cancer of the lung*
		Observed	*Expected*		
15–24	1	0	—	141	0
25–34	4	0	0·093	214	5
35–44	6	0	0·225	373	14
45–49	3	1	0·329	365	40
50–54	16	11	2·133	510	68
55–59	22	11	2·460	778	87
60–64	13	15	1·324	1,041	106
65–69	28	8	1·982	1,328	94
70–74	19	2	0·813	1,378	59
75–79	21	0	0·368	1,314	23
80–84	6	0	0·039	916	6
85 and over	0	0	—	525	1
Not stated	0	0	—	11	0
All ages 15 and over	139	48	9·766[3]	8,894	503

Expected rates are calculated as follows:
Age-group 55— $22 \times \frac{87}{778} = 2{\cdot}46$

[1] Excluding cancer of the nose among men in the nickel industry.
[2] Excluding men in the steel industry, coalmining and other selected occupations.
[3] The expected figure of 9·766 for lung cancer deaths differs slightly from that given by Doll. Since he made his calculations there have been minor changes in the age distribution of the nickel workers.

bladder tumours in the dyestuffs and rubber industries (*see* Chapter 7 by Walpole and Williams).

Raffle (1957) used a combination of mortality and morbidity experience (deaths, retirements and transfers for ill health) to indicate the absence of an occupational hazard of lung cancer in garage men exposed to exhaust fumes from petrol and diesel engines.

OCCUPATIONAL MORBIDITY

In measuring the morbidity of occupational groups, recent trends have been to make more use of records of hospital patients, and to increase the usefulness of sickness absence data for medical research.

Hospital patients

Breslow and his colleagues (1954) emphasized the inaccuracies entailed in using death certificates which give only one occupation, often incorrectly, without any records of duration. This may blur the identification of suspected occupations.

In Californian hospitals 500 patients with lung cancer were interviewed and detailed histories taken of their occupations and smoking habits. Identical information was recorded for a control group admitted to the same hospitals and matched for age, sex and race. In addition to confirming the association between cigarette smoking and lung cancer, several occupations occurred with much greater frequency among the case series than in the control group. These included: welding; painting; lead, zinc and copper mining; commercial cooking; marine engine-room work; steam fitting; and electric bridge-crane operations. Breslow then defined large populations engaged in the suspect occupations in order to observe prospectively the occurrence of lung cancer among them, compared with non-suspect groups and the population at large. Their method of first using patients and matched controls to discover suspect occupations might well be more widely applied to the study of other risks.

Sickness absence

During World War II, when the health and efficiency of workers became especially important, industry was encouraged to record sickness absence, to assess the effects of sickness on the availability of manpower. In the hands of medical and personnel officers, inexperienced in statistical methods, much of this data was useless as an instrument for health research.

There are several reasons why sickness absence has limitations as an index of sickness and why care is needed in their interpretation. Absence is not solely dependent upon sickness. The nature of employment is important. A clerk with a fractured arm can work, but a bus driver with a similar injury cannot. The payment of wages during absence has variable effects upon the readiness with which a worker absents himself (Denerley, 1952; Buzzard and Shaw, 1952). Sickness absence varies substantially with age, sex, and with marital status, and is sometimes higher in occupations with least responsibility and vice versa (Gordon, Emerson and Pugh, 1959). Absence may also be affected by the human relationships of working groups (*see* Chapter 13 by Revans).

For every occupation there is a process of self-selection, in the sense that people do not seek employment in it unless they feel able to meet the minimum requirements. Nor do they remain in it if they find other employment which they consider preferable. Superimposed on this self-selection are the selective processes of the employer and the industrial medical department, designed to admit and to retain only those who satisfy physical standards and standards of proficiency appropriate to the particular occupation.

With an increasing awareness of the many pitfalls associated with sickness absence statistics, some firms have abandoned them, but others, notably the London Transport Executive (1956), have developed methods of recording and analysis which can be of value in occupational health research.

The London Transport Executive use three indices and calculate specific rates for twenty groups of diseases based on an international classification of disease (World Health Organization, 1949):

(1) The average annual duration per person, which is the average number of calendar days of sickness absence per employee per annum.

(2) The annual inception rate (spells) which is the average number of spells commencing in a year per employee.

(3) The average length of spells in days.

Rates are calculated separately for males and females in five 5-year age-groups, 15–19, 20–24, and so on, and those aged 65 years and over. The number exposed to risk is calculated for each age-group by taking the average of the numbers at the beginning and at the end of the defined period.

With such techniques it is possible to indicate occupational hazards. Hill (1930, 1937) used the records of sick-benefit societies of trades unions which showed that there was a hazard of chronic respiratory disease in cotton card-room workers exposed to dust, and suggested that London bus drivers and conductors had an excess of gastric illness compared with tramway drivers and conductors.

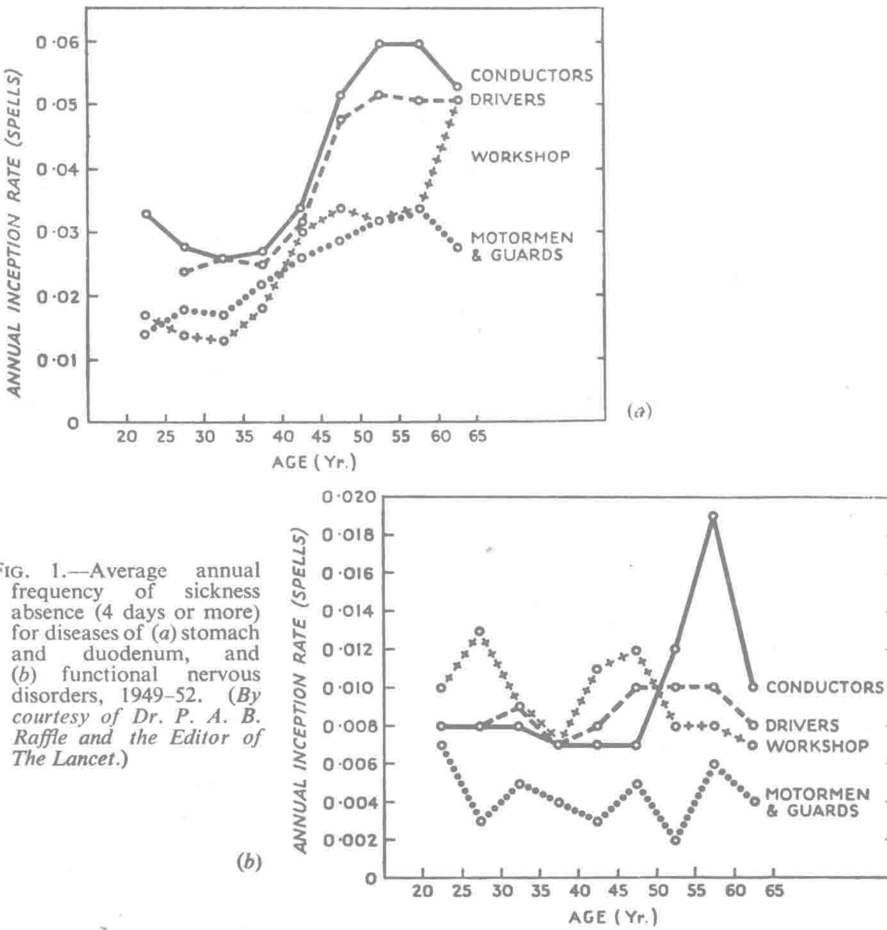

FIG. 1.—Average annual frequency of sickness absence (4 days or more) for diseases of (*a*) stomach and duodenum, and (*b*) functional nervous disorders, 1949–52. (*By courtesy of Dr. P. A. B. Raffle and the Editor of The Lancet.*)

More recently, sickness absence records have shed some light on the aetiology of chronic bronchitis in gas workers (Gregory, 1955) and postmen (Fairbairn and Reid, 1958). Reid (1957) has also compared the incidence of mental illness and disorders of the digestive tract (long suspected of being associated with psychological disturbance) among postmen in towns of varying population densities. There is a clear relationship between the postman's environment in the more densely populated towns and his liability to sickness absence from these causes. Raffle (1959) found that male bus conductors and drivers have appreciably more absence from the same causes than do workshop employees and motormen and guards on the underground railways (Fig. 1). The differences among the postmen may reflect the effects of the general stress of life in a big town, but the differences between the various occupational groups of transport workers, who all live in the same city, may reflect the effects of occupation on mental health—a subject more fully discussed by Carstairs in Chapter 15.

Treatment records

Treatment records in industry have been used to measure accident proneness in individual workers and accident and minor sickness rates for various occupations; but recently their value has been doubted. Williams and Capel (1945) showed that the proportion of injured factory workers who attend for treatment varies considerably. It may be as high as 25 per cent or as low as 9 per cent. Whether or not they report depends on many factors. Some make light of minor ailments. Others make the most of them. Distances from the treatment centre, the personality of the nurse and possible loss of wages may all influence the worker's decision to attend for treatment. Only if such factors are controlled can jobs or departments with high injury rates or sickness rates be detected in this way.

As a preliminary to a clinical survey of pulmonary disease, Stott (1958) examined the attendance rates of sisal workers for chest complaints and found that these were more than twice as high for workers in the dusty card rooms as in other rooms.

Attendance rates at sick bays in ships and shore stations of the Royal Navy indicate the effects of climatic temperature on health (Smith, 1958). When the temperature was about 60°F, 3 per cent of the ship's company were on the attending list. This proportion increased to 9 per cent when the temperature was above 90°F. In ships in the Persian Gulf, where temperatures were particularly high, the attendance rates fell from 11 per cent to 7 per cent when the living spaces were air-conditioned.

International morbidity indices

In an attempt to develop international comparability of morbidity measurement, a Committee on Health Statistics (World Health Organization, 1959) has recommended four basic indices. They include those adopted by the London Transport Executive, and those recommended by the Permanent Committee and International Association on Occupational Health.

Incidence.—Frequency of illnesses commencing during a defined period.

Period prevalence.—Frequency of illness in existence at any time during a defined period.

Point prevalence.—Frequency of illness in existence at a particular point in time.

Duration of illness.—Measured as an average or as a frequency distribution.

Industries using these indices may enhance the value of their own data, but it is questionable whether international comparisons will be of much value because of the overriding influences of different customs, economies and systems of social security.

FIELD SURVEYS

The field survey is another way of collecting data about the occurrence of disease. Much of this information, which cannot be obtained from other sources, may give a more precise measure of the health of workers than can routine records of mortality and morbidity. Nevertheless, the field survey has a limited value in investigating diseases of low prevalence. Lung cancer is now a common cause of death, but its prevalence is so low that even in the presence of a relatively high risk, the examination of as many as 1,000 workers may fail to reveal any cases at all (Doll, 1959a). The hazard of lung cancer in the chromate industry was not revealed by a field survey (Bidstrup, 1951).

In the nineteenth and early twentieth centuries, British pioneers of industrial medicine usually undertook field surveys merely to detect occupational disease. The field survey has since been developed as a more precise research instrument to measure prevalence, severity and progression of disease, notably by the United States Public Health Service (Bloomfield and his colleagues, 1935) and by the Pneumoconiosis Research Unit in South Wales. The clinical findings may be related to personal and environmental factors to determine causes and to define acceptable limits of exposure.

Choice of populations

Patients attending hospitals and workers applying for disability pensions have been studied epidemiologically, but the fallacies in using such selected populations to obtain prevalence rates are very great. For field surveys, the choice usually lies between a population in an industry or the community in which the industry is situated. It has to be remembered that a factory or mine population is always a survivor population, particularly so where there is a special risk of disabling disease. For this reason, Cochrane and his colleagues (1956) used communities in mining areas for their investigations of coalworkers' pneumoconiosis.

The community survey is the most accurate method of estimating the prevalence of disease and progression rates. In follow-up studies it is important to examine those who have left the industry as well as those who remain. A community survey is also preferable for investigating diseases like chronic bronchitis in which conditions within and outside the workplace may both be aetiologically important. For example, to find out the aetiological significance of coalmining in chronic bronchitis, which is endemic in industrial populations in Great Britain, the prevalence and severity of this disease should be measured in miners, ex-miners and also members of the community living around mines.

However, the community survey is a laborious and expensive method of research and certainly not one which can be easily undertaken by industrial medical officers; also, if there is substantial movement of people out of the community, the whole object of the community survey may be lost.

If a community survey cannot be made, the less expensive and less laborious method of surveying industrial populations should be used. The latter may be preferable for investigating mildly disabling conditions and for determining acceptable environmental levels of exposure, such as dust ; in the latter the main concern will be in the relationship between prevalence of early manifestations of disease and dust exposure. This should not be affected by those who leave because of disease, for they are more likely to have advanced disease.

The defined population may be the whole population, a random or selected sample. If the population is very large, a random sample is preferable to avoid fatigue in the investigators or even failure to complete the survey. If the disease occurs only in the middle-aged and older people—as, for example, coronary heart disease—there may be little point in examining the younger workers. And those in industrial populations who are over the normal age of retirement are so highly selected that they are of little value in any epidemiological inquiry.

Co-operation of workers

The importance of achieving low lapse rates cannot be overstressed. For it is now known from the experience of several field surveys that those who readily respond are different from those who are reluctant to be examined. In a 100 per cent survey of a colliery population, the prevalence of pneumoconiosis was highest in those attending early and that of pulmonary tuberculosis was highest in those who attended late (Miall and Cochrane, 1956). Morris (1957) has quoted other examples to show the differences between co-operators and non-co-operators in surveys.

Low lapse rates are usually achieved only by hard and painstaking preparation, to gain the support and interest of employers, foremen and workers. It is necessary to explain to representatives of managements, and workers, the object of the survey, the examinations to be made, and to emphasize that individual findings are not disclosed to anyone but the worker; and to his doctor only with his consent. A preliminary discussion with employers' organizations and trades unions is also desirable, especially where a large-scale investigation is to be made. In a survey, doctors have to treat subjects with more consideration than is sometimes given to outpatients in hospitals and clinics. They must be ready to spend much of their time persuading, but never compelling, the reluctant to be examined. Even industrial medical officers, who are well known to their communities, need to pay attention to these details.

Several research workers have demonstrated that in field surveys it is possible to get more than 95 per cent of the defined populations to be examined or interviewed (Cochrane and his colleagues, 1956; Doll and Avery Jones, 1951; Schilling, 1960).

Reliability of clinical measurements

In field surveys, clinical symptoms and signs may be used as indices of disease. If they are to be of real value, it is necessary to define these indices more precisely than is often the case in hospital practice. In the field, prevalence and progression rates of disease are measured at single examinations and many people examined are normal or have only early manifestations of disease. In hospital the majority of patients have unequivocal evidence of disease, and diagnosis and treatment seldom depend on single examinations.

In developing epidemiological techniques for studying pneumoconiosis, Fletcher and his colleagues measured the reliability of the clinical history in respiratory disease and of the usual methods of diagnosing and classifying chest radiographs of pneumoconiosis (Fletcher, 1952; Fletcher and Oldham, 1951). They demonstrated large disagreement between different observers, and between the same observers at different times in the recording of signs and symptoms. Having become aware of observer error, it is essential to minimize it so that diagnostic indices are suitable for survey work. This has been made possible by various processes of standardization, such as the use of standard radiographs, standard