quadruple its original value. Moreover, however this standard of work is set it may be, though it is not necessarily, entirely a neurological affair. The operator may know nothing about it. He may assert that his skill is exactly as it was, and if he is stopped and his threshold of discrimination measured he may appear to be right. For a genuine measure of his skill he needs to have both these thresholds determined within the operation itself.

Results of These Experimental Studies

Let me now try to sum up the main results of these developing experimental studies of skill so far as the linkage of receptor and effector functions is concerned. By far the most important one is that no measure of isolated function can throw any light upon skill or immediate skill potentiality. The crucial point in the linkage with which we are concerned is the accurate timing of the constituent items within their series. So far as the sensorimotor characteristics of the process go it seems that the important thing is the determination of the overall response times—including the recovery time—in the march from interpretation to action and from action to interpretation. There is a tendency for effector response time to lag and for action to get out of step with signals for action. This can be arrested within limits by increased objective urgency, by volition, and by anticipation, provided it does not run very far ahead. It will be facilitated, unless special precautions are taken, by a rapid fall of immediate recall and by the automatic increase of indifference threshold. Looking at the whole matter from the point of view of classical psychological experiment, the field is now set for a thorough reorientation of the traditional study of reaction times and of the functions of latent after-impulses.

[The second lecture will appear in our next issue.]

A CONCEPTION OF INDUSTRIAL HEALTH*

BY

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At any moment of time, and especially in a relatively free-thinking community, the volume of public support lent to an idea is often as important as the intrinsic novelty of the idea itself, and when the pressure of opinion surpasses a certain critical value action leaps from latency to life. The conception of industrial health now has reached this point. It is, however, always a salutary exercise, on starting a new venture, to consider whether its aims and outlook are really original, whether they represent a step in a process of thought which started long ago, or whether they are merely the return of a cyclical fashion.

Some Preliminary Thoughts

It is also appropriate now to put forward some preliminary thoughts about this new Nuffield Department in King's College, and about the methods of approach which it is intended to adopt in order to study some of the facets of this very wide problem of industrial health. But first, perhaps, the very word "health" itself requires some consideration, as we must remember that the classical conception, which the Greeks called *εὐξ*, had in their day a

limited application, usually to the soundness of the body only, and now, like so many other words of like derivation, it has lost caste and become our English "hygiene" with its stereotyped suggestion of soap and water, teeth and tooth-brushes, forms and files, strictly departmental thinking, and rather dull courses of lectures.

But health surely means, among other things, freedom from disease, good performance at the job, whether of mind or hand, the right rate of growth, and the happiness born of a satisfactory wholeness of existence. Moreover, in their wisdom the founders of this Chair intended to indicate a breadth of interest, especially in the direction of the causation and prevention of disease, which would not have been clearly shown by the use of any other word. It is, then, worth while taking trouble to define what is meant by health, because when a new subject or a new attitude towards an old subject comes into view it is only too easy to be under a misconception about what is meant, or even to say that there is no such thing; and, indeed, the most recent attitude towards medicine, which is often thoughtlessly criticized along these lines, is that of social medicine, which some people deny exists at all, and which others even think is medicine in relation to the State.

It may, therefore, be suggested now that the field of study of our new department here may be considered to be the reciprocal and triple relation between job and health and social state, and it is worth while noting at this point that this contrasts somewhat with a conception based upon industrial *medicine* or *disease* as usually conceived, because there is, of course, no true dividing line between industrial and non-industrial illness.

Foundations of Industrial Health

As long ago as 1670 the Italian doctor Ramazzini laid the foundation stone of industrial health with his book *De Morbis Artificum Diatriba: A Dissertation on the Diseases of Workmen*. Ramazzini was not only a bedside doctor but spent much of his time visiting workshops and mines, noting especially the conditions of work, and his conception of industrial health was wide, as shown by the later editions of his book, which included chapters not only upon the diseases of learned men but even upon the health of nuns—an investigation which we may well imagine to have taxed his ingenuity to a high degree and to have involved secret methods, perhaps including even personal disguise.

After a long interval this work was followed, in the middle of the eighteenth century, by a most brilliant practical demonstration of preventive medicine applied to a small community by the naval captain James Cook, who, on a voyage which lasted more than three years, which stretched from latitude 52° N. to 71° S., and which meant, therefore, going through the Tropics, lost through illness but one out of his crew of 118 men. The Royal Society appropriately marked this feat by awarding him the Copley medal for his paper entitled "The Method taken for Preserving the Health of the Crew of His Majesty's Ship, the *Resolution*, during her late voyage round the world." Now Cook's outstanding demonstration, the more notable because he was a layman, was not so much due to his having made any new discoveries in the science of preventive medicine, but can be ascribed almost entirely to his making the fullest application of the principles which were known at the time, to his attention to detail, and to the fact that he had complete charge of a small and isolated community.

The next step forward in this subject came in 1831 with the publication of a book entitled the *Effects of the Arts*,

* An inaugural lecture delivered at King's College on Feb. 24, 1947.

Trades, and Professions and Habits of Living on Health and Longevity, with Suggestions for the removal of many of the agents which produce Disease and shorten the duration of Life, by that famous Leeds clinical surgeon Charles Turner Thackrah. This publication went into two editions in two successive years, but unfortunately the writer died at an early age, long before his prime.

The next figure in this field, who towers, moreover, above all others before or since, is that of the great lay sociological sanitarian Edwin Chadwick. In the nineteenth century it was Edwin Chadwick who laid the foundations of what we now call social and industrial health. In conjunction with his colleague, Dr. Southwood Smith, he undertook an inquiry into the effects of labour in factories upon the general condition of the operative classes, and carried out an investigation upon the employees of the East India Company. Chadwick pointed out that the recording of the incidence of sickness is the first step necessary to indicate its origin, and he suggested that all records be related to the job, wages, price of food, and, indeed, to any and every change in the material circumstances which affect the workpeople. Moreover, this great man was also interested in the effect of an abnormal environment upon the human being, and he therefore undertook a research to find out how tailors reacted to the hot and humid atmosphere in which they worked.

Set this work against that being done and the outlook which prevails to-day, when we see new departments of social medicine and public health using the morbidity or sickness survey as one of their chief weapons of inquiry, and when recently the Medical Research Council and the Royal Navy have together intensively investigated the action of hot and humid atmospheres upon a man's performance. Notice that we are only now beginning to give effect to ideas first put forward by Chadwick nearly 100 years ago.

In the outlook of three of these pioneers—Ramazzini, Thackrah, and Chadwick, a physician, a surgeon, and a non-medical sociologist—can be seen three of the four essential methods of approach for any new department of industrial health—namely, the bedside or clinical, the outdoor or field, and the statistical, for in those days the laboratory had not attained its present eminence. It may incidentally be noted here that Chadwick's point of view demonstrates the artificiality of dividing social from industrial health, since he emphasized that health is related not only to job alone but to every circumstance which surrounds the working man.

Recent Trends in Industrial Medicine

The last 50 years have not, perhaps, produced any such outstanding individual figures as these, but they have been notable for the development of a number of important trends in this branch of knowledge. *Pari passu* with the Industrial Revolution, which of course is still taking place, and with the introduction of more and more machinery, came a volume of preventive legislation, and with it the setting up of both mechanical and medical inspectorates directly responsible to the Government, for bringing about compliance with the law. With the increase in the complexity of industry comes the widening of the range of chemical substances which are used, and we have therefore seen a great rise in preventive toxicology, associated in the past with the name of Sir Thomas Legge; and indeed, until recently, this approach to the subject has been almost synonymous with what is meant by industrial health. Likewise, too, with increasing mechanization has come the rise and fall of the conception of fatigue as a scientific

entity, with the subsequent realization that its study is merely another way of looking at all the different environmental influences acting upon the working man or woman.

We have also seen in the last 30 years a great increase in research by committees, sometimes sitting at a distance from where the problem lies; and we have witnessed an attempt, with the various Compensation Acts, to equate money with injury and illness, together with an only partially successful realization that a physical token cannot replace even that which is physical in a human being, and still less can it replace that which is psychological, which indeed money may make worse. These are important points to keep before us, because every illness of the body affects the mind, and many of the mind the body too. This attempted false equation produces also the attitude of mind which, though perhaps rightly, pays a man more for doing a dangerous job, then wrongly stops at that point and forgets to make it safer.

Two world wars have greatly accelerated the winning of knowledge in this field, but some of the early effort in the late war was either a repetition of former work or it was designed to re-emphasize principles which were already known, and we observed the melancholy but understandable spectacle in the stress of 1940 and early 1941 of industry attempting to run in almost complete ignorance of much of what had already been discovered by the Industrial Fatigue Research Board of the Medical Research Committee in the previous war.

During the recent struggle, however, a type of research with a rather different emphasis began to appear in each of the three armed Forces, the so-called personnel research, which was aimed largely at attempting to fit more closely to his needs the many and often very complex mechanical situations in which the modern fighting man finds himself—to use, in other words, the principles of anatomy and physiology to modify the mechanical *milieu*.

The New Nuffield Department

How, then, in the light of this brief historical survey should the new department here set about its job? It is intended to direct the effort about equally into three interconnected spheres—the outdoor field of industry, the hospital, and the laboratory. In the field, man will be considered socially, in his group or herd; and here an attempt will be made to assess his liability to disease and accident, and, in certain cases perhaps, his performance at the job, and to set these against the conditions in which he lives and works. The methods of statistical survey will be used here. The experiment, as it were, is already going on, and we have therefore to devise the best methods of sifting out the answers to our questions and, indeed, to consider carefully what questions should be posed. We hope to undertake such a survey in some representative parts of industry in this area. The problems here are not the major illness or the dramatic fatal accident, but the short-term illness and, in some industries, the enormous number of small accidents and injuries, some of which become infected and leave much greater disability. Our thinking about accidents often tends to be clouded by too much disapproving attention as to whose fault it was, or whether there was carelessness or not; it is not taken up enough with improving what may be an unsatisfactory relationship between a man and his machine, and, by attention to fundamental mechanical design, with making it impossible for an accident to happen to even the biggest fool.

The design of any piece of apparatus which comes into contact with the human being must be conceived upon a basis broad enough to include not only the aesthetic

approach but also some simple principles of anatomy and physiology. These do not, of course, compete with the aesthetic point of view, but supplement it, because surely a thing purposely designed to fit the healthy human body is no less beautiful than one which does not do so. If, for example, a machine is needed, it is necessary to make it fit the sizes of the range of men or women working it. It must be the right width and height, and attention must be given to the method of control; the handles must be so placed that smooth direction can be obtained, and they must turn in the most natural way so as not to be too easy or too stiff. Thus, examples of the type of questions which arise are: Is it better to have a push-pull lever or a turning handle?; and, How must the controls themselves be shaped so that they do not rub the hands and cause breaches in the skin surface which may afterwards become infected? If the machine has indicators to tell the man or woman working it whether it is on or off, whether it is going too fast or slow or in what direction, then these too must be designed and placed for easy reading; and this at once raises the whole problem of the best way to display a piece of information to the human being. Many points here come to mind: What information is it necessary to display at all? Is it better to combine a system giving information both to eyes and to ears? Should the display be round like a clock face, or should it go up and down or from side to side? Is it better to use coloured lights, remembering that about 8% of men cannot distinguish red from green by colour alone, and that therefore indicator lights must have another clue, perhaps in their position or their spacing?

One of the great problems of interest in this whole field of the relationship of functional physiology to industrial design is how to plan and perfect experiments to give objective methods of assessment, and how to use the human being experimentally as a yardstick against which to measure the machine.

Service experience during the war was in advance of present civilian practice on this subject, and machines, like aircraft, were designed by a number of small committees composed of engineers, manufacturers, pilots, anatomists, and physiologists, so that at least an attempt was made to fit machine and man together. It may be thought at first that this method may be cumbersome and slow, but it is surely clear that if it was efficient enough to work in a war of such rapid evolution as the last it is efficient enough to serve civilian uses now.

The results of this type of work in the department, all of which is fairly long-term, with the year as a unit of time, will of course be made generally available to all concerned, and I should like to feel that it will represent the joint co-operation of employer, working man, and college—in short, of Tyneside as a whole.

In addition to the interesting problems already mentioned it is important to think of health, or lack of it, as a personal and individual state to be studied at the bedside in that relationship between doctor and patient which still contains all that is best in medicine; for when a sick person comes to see a doctor, what he wants is help, and not a learned statistical analysis of his condition. It follows, therefore, that one of the fundamental difficulties to be faced in a department of this sort is how to combine the coldly critical scientific outlook of the laboratory with warm humanitarianism at the patient's bedside.

The Social Aspect

In the present way of practice in a hospital there tend to be two big gaps in our information which cannot adequately be filled by merely questioning the patient, and

they can perhaps be indicated here by asking: What social influences have been acting on him in the past before he came, and what is going to happen to him when he leaves? In other words, we usually have little detailed knowledge about his home or job, or about his progress on return. To provide this knowledge, a special type of visitor is needed, based upon the hospital and operating as a member of a team from a self-contained unit which has male and female patients, medical, nursing, and social staff all in one small area and under unified control.

The duties of this visitor or social worker will be to bring information about the patient's home surroundings and economic background, and, if possible, about his industrial environment as well, and to follow him up on his recovery and return to work. But it may be that we must have a visiting team of two—one for the home and the other for the job.

There are a number of possible trainings which fit a woman for this job of social visiting—those of almoner, psychiatric social worker, or health visitor come at once to mind—but the ideal perhaps would be an almoner with a factory inspector's training in addition. Here personality precedes training in importance, and it is essential that she should work as a member of a team and consider the social information gained objectively under a number of defined headings. There is a tendency for some types of this work to become wordy, diffuse, and sentimental; it is proposed, therefore, that the worker in this outlined department shall spend part of her time upon a specific problem which will provide as a basis something concrete and scientifically planned.

Indeed, the time is now passing when the social work of a large hospital can be adequately performed by an autonomous department functioning without a well-marked chain of responsibility, either to the patient or to the patient's doctor. Moreover, this type of work at its best is time-consuming and personal to the patient or his relatives; surely the social worker should undertake it in direct co-operation with the physician or surgeon who is in charge, and she should act as a full liaison officer between the patient's hospital and home, and in addition should take her share in teaching.

Some of the patients will be suffering from industrial disease within the narrow meaning of the term, which will demonstrate the effect of job on health; but a small proportion will have general medical illnesses, thus linking our specialty closely to the main subject—medicine—and, at the same time, allowing us to study the relationship between returning health and the job.

The Ward as a Co-ordinating Point

The ward, then, will be the co-ordinating point where information from the patient's home and from his work is welded on to the impression gained by the usual bedside methods. This synthesis may well take the form of a small conference attended by representatives of the four groups of people having contact with the patient—the medical, nursing, and social staff and students—because each will have something to add, and, in exchange, something to learn.

When, therefore, the patient arrives in hospital he or she will be examined by the doctor in the usual way, but in addition permission will be sought by the social visitor to go to the home, and also to the patient's job; information from both these will be added to his notes, which will also contain a statement on the progress made after he has left, with special reference to such things as how long he

takes to return to his full job, and whether he maintains it or changes to another. In this way it is hoped to link together the technical excellence of the teaching hospital with the social slant of the family physician and with the industrial slant which only the factory doctor on the spot usually can have, and so to permit the passing of knowledge from one medical compartment to another. This means three diagnoses—home, job, and patient—instead of one, together with a follow-up, in one set of patients' notes.

There will also be an out-patient department, working closely in conjunction with the ward, where people will be seen who are not ill enough to be in bed, and where they and their doctors can be advised about their illnesses. It is most important that a department which spends the greater part of its time upon research should keep its feet firmly on the ground of everyday medicine, and it should therefore share, even if only to a small extent, the hospital's daily work.

From time to time students and assistant doctors will accompany the social worker on visits to gain first-hand knowledge of home and working life, because it is clearly illogical that the first time that a medical student sees a patient in his own home (with the exception of a brief training in midwifery) is as a general practitioner after he is qualified; and the same is true of seeing the patient at his work, which he may never do unless he becomes an industrial doctor. It must never be forgotten that a man is the same man whether at his work or in his home, and, ideally, the same doctor should know about both parts of his life. It is important, moreover, that a university department such as this should attempt to practise and to preach that which is biologically true rather than that which seems at the moment to be administratively expedient, and that it should also try to do something to offset the increasing compartmentation which is spreading so quickly through medicine as a subject.

This conception is, of course, entirely experimental, and there are clearly a number of potentially weak points which will need watching: for example, the proportion of time spent travelling to homes and factories may prove too great; patients or their wives may resent a visitor intruding into houses already somewhat over-visited, and the same may happen at the places where they work; but these are only stimulating difficulties, to be overcome with tact and the right approach.

The New Department and the Student

The laboratory in the new department will be used as a tool in the investigation of the more intricate and the more fundamental relationship between man and machine, and here also will be studied those problems in mechanical design already mentioned. This has a practical as well as an academic interest, because it is directed towards better mechanical control, less fatigue, and fewer accidents.

Now health, like charity, should begin at home, and in the future it may well be that the college student's health becomes the responsibility of this department. But care must be taken to distinguish between the detection of a disease and its prevention. One of the most important functions of any students' doctor will be to act as health adviser to the college. He must consider it as an industrial organization, have a good knowledge of the physical and psychological conditions of each faculty, and thus know something about the educational and other loads which press upon the various groups of men and women. He will then in time be able to advise upon such things. On the whole, good organization of work, play, food, and lodgings will prevent more disease than detective methods working relatively late; routine medical examination must of course

be done only after it has been decided to admit the student, and the dulling effect upon the doctor of examining large numbers of normal young people must be considered. We know little about the liability of young men and women to disease, or how they spend their money or their time, and surely there is here an opportunity to combine both prevention and research.

You will no doubt have noticed that, apart from a few passing references, little has yet been said about teaching, and this is because from our departmental terms of reference it must stand second to research. Nowadays the layman rightly expects the doctor to have a wide intellectual horizon and more knowledge of the cause and prevention of disease, and a better appreciation of what is common and important and of what is uncommon and unimportant, however technically interesting the uncommon state may be; yet it may well be doubted in this case whether the customer really is getting what he needs. Mental flexibility is not encouraged by an overcrowded course which teaches too many facts that are of little use, and which does not stress enough the scientific method of their collection, and still less their orderly arrangement and rearrangement in logical argument. Reflective thought flourishes only when there is leisure and free informal discussion among small groups of people—and the medical student is at present allowed too little of either. Indeed, sooner or later the present method must be left behind whereby students are given a course in what is really gross clinical pathology of the museum type and then an attempt is made to undo the wrong with some sort of postgraduate technical diploma. The aim should be to produce the type of mind which can design a way of life instead of merely prescribing physic, which knows something about what is inside and what is outside the normal environmental range, and which thinks in terms of prevention rather than of so-called cure. Industrial health is not a specialty within the usual meaning of the term, but is a reorientation of the general subject, and it is highly doubtful whether in the future it will be wise to organize it as a narrow-minded special service. After all, most places of employment are small and could, and should, be looked after by the general practitioners in the area, with advantage both to doctor and to patient, since the doctor will have a wider type of interest and the patient will be cared for by a man who has a better chance of knowing both his job and his home.

How, then, in the light of these considerations should industrial health be taught? It is surely clear that it may perhaps one day replace in the general medical course some dead wood which must be cut away, and that it must not be made an additional subject to be loaded on the already groaning student. A game is learned best by those who play it, and it is proposed, therefore, that students should be allowed to co-operate in the experimental work, when they will learn something about the scientific method and about the application of physiological principles to practical problems. Again, visits to workplace and home should rank as part of the usual course in medicine, and it may well be that it should be compulsory for every student to attend a number of the small case conferences and clinical discussions already mentioned, so that he can see an attempt being made to paint the whole picture of a patient's health. The formal lecture will not rank high in our teaching plans, because in a course like this the need is not for facts but for food for thought, and this is best imparted informally to the smallest number possible. Much of the teaching of this subject will be oblique, using visual methods of display by photographs and other changing demonstrations. For example, there

may well be staged, in some convenient place, a selection of protective industrial clothing. A miner, after all, wears a hat, a lamp, and sometimes knee-pads; but few students know exactly why, and still less do they realize that these represent elementary steps in preventive medicine.

Staffing the Department

I have dealt to some extent with what this department has to do, and now can outline briefly the staff needed to undertake the task. In the early stages of the bedside work full clinical responsibility should be borne by the departmental head; but later, as the work increases and plans mature, a competent clinician capable, if necessary, of bearing the full load must be employed. He should, moreover, have another interest in some investigation of his own. Under him would come two junior assistants, spending part of their time on clinical work and part on fundamental research, and part again in helping with the routine departmental teaching. These men or women will be at the stage of deciding whether, or how, they intend to advance themselves, and, if so, in which of the branches of activity displayed before them in the department; and one of them will join the social worker as a small combined team of two. Finally will come a house-physician of some previous medical experience who may one day become an assistant in his turn.

On the laboratory side it is most necessary to have a man who combines a knowledge of statistics with a social or biological outlook and who will perhaps in time develop a small subdepartment of his own; there are needed, too, a physicist or engineer who can plan and make machinery to study our problems of design, and a non-medical but biological assistant to use this machinery as a tool to answer the questions posed. Occasionally, but very rarely, one man can do both of these; but usually the purer type of scientist has difficulty in dealing with the variability of response of human beings, and, vice versa, few biologists have the necessary technical knowledge to design the apparatus used. Finally there must be, of course, ample help in computation and secretarial work, because otherwise much time will be wasted.

The "foreign policy" of a department such as this should be to maintain the closest contact with both employer and employed, to eschew politics and compensation questions like the plague, and to avoid the role of expert witness. It should, moreover, work in close connexion with the local department of public health, and with the sister—perhaps one should say the elder sister—Nuffield Department of Child Health.

Conclusion

To summarize the story, it can perhaps be said that an organization such as this should have five main duties: (1) to its patients, which it must treat as persons as well as members of an industrial or social group; (2) to its subject, which it may advance a little, chiefly by affording a seed-bed for the germination of potential workers in this field; (3) to the students, by reorientating their medical horizon; (4) to its college, by concentrating mostly upon research, and only slightly upon teaching; and (5) to employer and employed by maintaining a tactful, fair, and independent attitude in its outside work.

May I now conclude with some words of John Dryden's which do, I think, foreshadow this new spirit in preventive medicine?

"Better to hunt in fields for health unbought,
Than fee the doctor for a nauseous draught,
The wise, for cure, on exercise depend;
God never made his work for man to mend."

SURGICAL EMPHYSEMA DUE TO COMPRESSED AIR

BY

A. M. DESMOND, F.R.C.S.

In the last twenty years compressed air has been employed in industry on an increasing scale, and the hazards associated with its careless use are now well recognized. Emphasis has been placed particularly on injuries of the rectum and colon, and Wyllys Andrews (1911) and others have given excellent surveys of this aspect of the subject. One feels, however, that the occurrence of tissue emphysema in the presence of even the smallest wounds has not been sufficiently brought to notice, and for this reason the following case is considered worth recording.

Case Report

A metal miller aged 16 years was working on the "miller," and a small piece of metal shaving (referred to in the trade as "swarf") punctured the ulnar side of the palm of his left hand about 1 in. (2.5 cm.) proximally to the base of the little finger. He removed it, and the minute pin-point wound bled a little. He then, in an attempt to remove the remainder of the "swarf," directed the nozzle of a powerful air compressor pump on to his hand, which instantaneously became ballooned and painful. He was examined within two hours, and complained only of the swelling and pain.

The ulnar side of the palm was diffusely swollen and tender, the swelling roughly conforming to the size and shape of the palmar space, with ballooning of the webs between index, middle, ring, and little fingers (see Fig.). The palmar creases

Showing the ballooning of the palmar tissues. The puncture wound is indicated by arrows.

over the area involved were almost obliterated. No crepitus was elicited. The remainder of the hand, the fingers, and the forearm were normal; there was no swelling of the dorsum. There was a pin-point puncture wound in the position described above, and scattered over the surface of the hand were multiple cuticular abrasions. An x-ray photograph showed air in the