populated country as England. But the overloading of the country with people past work, or, at any rate, not equal to exerting the energy expected of the middle-aged, has no advantage at all.

These calculations would give a date for the attainment of the maximum population some time between 1951 and 1961. An unofficial estimate made in 1927 gave the year of the maximum as between 1949 and 1953. Dr. Enid Charles's estimates, published in 1935, based upon three different assumptions, and very carefully worked out, gave the year of the maximum as 1940, 1944 or 1960. All that we can say is that the maximum has not yet (1942) been reached, and that all estimates have been upset by the War.

We cannot tell how long the War will last, or how many of our young and middle-aged men will be killed or permanently disabled. But we do know that there is the certainty of the War's disturbing effect on the birth-rate, which has already dropped from the recent pre-war average of 15·1 to 14·2 in 1941. Moreover, war takes its chief toll from the young men, and the result must be that the disparity between the numbers of males and females will be still further accentuated, as also will be the ageing of the population as a whole.

To take a long view then, it would appear that, while we need fear no serious diminution of our numbers for the next generation, the population will grow steadily older, and if we wish eventually to attain a happy condition of equilibrium, with a satisfactory age distribution, and thus avoid dangerous decreases of population in the times of our grandchildren and great-grandchildren, we should take steps as a nation, now, to encourage an improvement in the birth-rate.

THE HUMAN FACTOR IN PRODUCTION*

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THE word 'production', like its fellow 'output', is an uninspiring word. Those of us who must use it for convenience need to remind ourselves at intervals that it is a general term and really stands for concrete things. Behind each article is an innumerable company of human beings, each with his hopes and fears, dreams and realities. This may be a machine age; industry may be mechanized, but personally I have never met the mechanized human being.

The work of any human being, like any other activity, can be affected positively or negatively by numerous causes, and a complicated web has to be unwoven if these causes are to be sorted out. Nor are all of them equally operative all the time; now one, now the other is thrown into relief with the others in the background.

Output is affected by the material and the psychological environments and by the physical and mental make-up of the individual.

* Substance of a paper read on June 6 before a conference on "Social Biology in Relation to the War" arranged by the British Social Hygiene Council.

Factors in the Material Environment

(*a*) *Lighting*. Natural lighting (daylight) is ideal when there is plenty of it. Since it is not available for night work, and for the ordinary hours of work in winter, and since the black-out has interfered still further, a satisfactory substitute has to be found. With inadequate illumination, output is reduced by a slower rate of working and by an increase of spoilt work. The liability to experience eye strain, 'nervous trouble' (probably irritability) and accidents is increased.

(*b*) *Heating*. Lack of warmth on one hand, and overheating on the other, cause discomfort. Experience gained during the War of 1914–18, and by investigations made since, has shown that efficiency falls when the temperature rises unduly—particularly in heavy industries. In industries such as iron and steel, tin plate and glass manufacture, output is lowest in the hot summer months and highest in the winter. Even in the lighter work of textile operatives, the work deteriorates as the temperature rises above the comfort zone. On the other hand, low temperatures adversely affect manual dexterity. Broadly speaking, those atmospheric conditions which are generally found to be comfortable are also those which are best from the point of view of efficiency and safety.

(*c*) *Ventilation*. The first requirement is an adequate supply of chemically pure fresh air. After that, attention has to be paid to the temperature, humidity and rate of movement of the air. War-time lighting restrictions interfere considerably with ventilation arrangements. When a night shift is worked, arrangements for securing adequate ventilation are even more imperative. The problem of obtaining this adequate ventilation is not a purely mechanical one; there is also a psychological factor.

(*d*) *Hours*. Within limits, an increase of hours will increase the output. The human being is not a machine, and this being so, he can by force of will drive himself to perform far more than he considered his maximum. There were endless examples of this in industry after the Dunkirk period. To do this, however, reserve energy has been used; he has as it were used his reserve energy; and such activity can only be carried on for a limited time, after which considerable reduction occurs. The result is that after a continuous period of overwork, improvement in output does not take place for a considerable time after the return to normal hours. The Health of Munition Workers' Committee of the 1914–18 War summed up thus: "Misguided efforts to stimulate workers to feverish activity in the supposed interests of output are as useless as would be the cheers of partisans encouraging a long distance runner to a futile sprint early in the race."

Even with normal hours of work, the long spells of four and a half or five hours should be broken up preferably by organized rest pauses and not by accidental interruptions due to waiting for materials, etc. Most people can face with equanimity work of about two hours' duration and can keep a steady pace, but the prospect of five hours' unbroken work often exerts a retarding influence on speed. The effect of any continuous activity, whether physical or mental, is associated with a gradually diminishing success in that activity. The stages at which full success is replaced by partial success and eventually by failure are not the same for everyone, or constant for the same person. Anything that reduces the available energy of the worker, or his interest, will affect the stage at which reduction of effective work begins to take place.

Fatigue is therefore a relationship between the amount of available energy, the nature of the work, and the attitude of the worker towards it. The remedy for fatigue is rest, and if work has been within reasonable limits, a night's rest will restore energy. If, however, in addition to the effects of hard or prolonged work, rest has to be taken in an air-raid shelter, or rest is impossible on account of the competing roar of guns and bombers, energy is expended instead of being renewed.

Apart from the diminished accuracy and speed consequent upon a fatigued state, there are well-known fatigue sensations, namely, a feeling of weariness, disinclination to make an effort, inco-ordinated movements, organic disturbances, irritability, listlessness. Consciousness of these sensations can distract a worker's attention from the work to himself. Since some of these symptoms are associated with certain diseases, it is not difficult for a fatigued person to think he is ill; the step to being ill is short.

The Psychological Environment

(*a*) *The mental atmosphere.* Diminished efficiency, weariness and an appearance of listlessness *may* still be present when the work is light and hours normal. These pseudo-fatigue effects are due not to the using up of reserve energy but to lack of interest, and are associated with repetitive work, of which there is a great deal; the sufferer is bored.

It must not be assumed that all workers find all repetitive processes boring. One worker will stigmatize a process as boring and find another interesting, whereas to the observer there was nothing to choose between them. It has been found that on the average about 26 per cent of workers experience considerable boredom at repetitive work. An investigation was made into filament winding, soap wrapping, chocolate packing and tobacco weighing, from the point of view of the relation of output and boredom. Results showed that the more intelligent suffered more from boredom than those of inferior intelligence, but there were individual differences, even among the intelligent. It is worth noting that one can be fatigued without knowing it, but not bored.

There are compensations, however, even in repetitive processes, if we consider the worker as a human being and not merely as the performer of a repetition process. Some workers, for example, experience a sense of power when operating a large or delicate machine, and where a machine is a unit there is often a strong sense of possession: "my machine", it is called. Some people find considerable relief in day-dreaming and declare that it makes the time pass quite pleasantly.

Repetitive movements must either be studied as such, in which case they belong to the psychology of habit formation, or else put in their complete setting, including at least the opinions of fellow-workers and authorities about the work, physiological changes, emotional changes, and the general collective life of the place. The total reaction at any one time will be a reaction to a composite situation which constantly changes and of a personality that changes.

(*b*) *Personality of the Authority.* By far the most important factor in the mental environment is the personality of those in authority. There is no correlation between being able to do a job oneself, and being able to superintend others doing it. The effect of power on many people is to let loose a number of qualities otherwise held in check and usually unsuspected; in some occupations it has proved possible to demonstrate the effects of people in authority whose childish emotional development has counteracted their intellectual and practical ability.

There is a price to be paid for inadequate ruling and that price may be the unhappiness of subordinates. Unhappiness, however, does not remain merely a mental state; it receives expression, and in the industrial world this can sometimes be measured, the usual means of expression being an inferior output, high sickness rate or high labour turnover.

In one investigation, four groups of clerical workers were specially selected for experimental purposes to be comparable so far as possible; detailed output records for the six months preceding the experiments were available. Each group was in charge of a departmental head new to the group. Daily records were kept for the next two years. Hence it was possible to compare each person's record during the periods preceding and following the selection. The immediate effect of one head was to increase not only the average output of her group by 10·3 per cent, but also the output of each worker, whereas another decreased it by 5·5 per cent. The work was similar, and the chief difference between the two extremes lay in the temperament of the heads, one being a particularly 'vital' person, the other a person who 'enjoyed' ill-health.

Selection of People for the Right Work

A certain amount of negative selection takes place in most occupations; for example, a thin, weedy man would be unlikely to apply for a dock labourer's job, and a boy with little mathematical ability would scarcely seek to be an accountant. What is less obvious is the need for a much better selection for the majority, and the most important mental characteristic to test for is intelligence. It is now possible, within a very narrow margin of error, to test for general intelligence; it is also possible to differentiate between jobs needing intelligence and those needing little. To allow a person of great intelligence to do a job requiring little is wasteful, both to the individual and to the community; to use a person of lower intelligence than the job requires is to reduce output and cause unhappiness to the individual.

Since the War of 1914–18, when the United States produced the group intelligence test, much work has been done. In addition, a better adjustment of the worker to the work can be obtained by testing for various special skills and by systematic training. Experience in such varying trades as silk-weaving, chocolate covering, metal-polishing, folding and calender work in laundries, has shown that by systematizing movements and by training the novice a saving generally results. If a novice is allowed to pick up his job merely by watching proficients, he frequently adopts uncritically many unnecessary movements, which sometimes interfere with his possible speed and in some cases result in muscular habits harmful to him.

Those who are responsible for the teaching of beginners ought to have made a special study both of the technique of the movements and of teaching. Ability to perform an activity is no guarantee of an ability to teach it.

Time and motion study are a necessary part of the scientific study of skilled movement, and both are as necessary in industrial processes as in sport. If they are used merely to 'speed up' regardless of the individual, they are being used illegitimately and will have serious consequences. Any speed that results in a worker feeling flurried stands condemned. It is one of the anomalies of applied psychology that the earliest attempts to study skilled movement were made by two engineers, Taylor and Gilbreth, whose aim in studying the movements was to reduce the waste of human effort and by so doing to reduce the cost of production and enable the worker to earn more.

Suppose, however, that we know the requirements for a particular activity and that we have tests that are scientifically sound and practicable, and that the people in charge are adequate for the work of supervision. We have even then considered only part of the problem, for no account has been taken of temperamental or emotional differences, and the evidence shows that differences of this nature play an important part in many problems of industrial efficiency, sickness absence and labour wastage. In popular speech, 'temperamental' implies some lack of emotional stability. A healthy minded, well-poised person would scarcely be considered to have any temperament, whereas an emotional, erratic, irresponsible person is generally called 'temperamental'. In practical life, we hear more about temperamental failure than temperamental success. This is due to the nature of temperamental failure, which causes suffering, or at least mild discomfort, to those who come in contact with it.

Throughout history there runs a recognition of the importance of the general emotional make-up of individuals, for health, efficiency and happiness. Many observers, chiefly medical men and Fathers of the Church, that is, those whose work brought them into intimate responsible contact with human beings, have recorded as a fact of observation that there are considerable differences of an emotional nature between people, expressed very clearly in their susceptibility to, and behaviour in the face of, sickness and death, and also in their relation to other people, and as long as we have written records we have attempts at classification. The oldest and best-known comes to us from Galen in the second century, namely, the sanguine, the choleric, the phlegmatic and the melancholic. A more quantitative classification is : (1) those who are emotionally well balanced ; (2) those whose temperamental organization is adequate for the duties required, but not altogether perfect ; (3) those who are somewhat unbalanced, but within the limits of health, for example, persons rather too liable to be afraid or too easily stirred to anger but not thereby prevented from carrying on ; their efficiency and happiness may be impaired but not seriously interfered with ; (4) those whose temperamental lack of balance interferes with health.

The 'unbalanced' temperament is the so-called 'nervous' temperament. As a mode of behaviour it has been known for centuries, although not by that name. The name was given in the late eighteenth century and has stuck, though it has long since lost any meaning ; the name refers to a mistaken belief that the symptoms characteristic of it were related to the organic 'nerves'. There are no tests for the 'nervous' temperament, and its assessment has to be made by a competent interviewer.

On the whole, after an examination of about a thousand people, there was some evidence showing that the nervous person tended to be less efficient in some environments than others, and also to be more difficult to get on with, to be less satisfied with his work and to have a somewhat higher sickness absence rate. Some environments, particularly those characterized by rigidity of organization and an arbitrary personal criterion of efficiency, are difficult for many nervous people.

The incidence of nervous symptoms varies considerably from one group to another. Those with serious maladjustment ranged from 1·2 per cent in a group of factory workers to 7 per cent in a group of clerical workers.

ABSORPTION AND EMISSION OF RADIATION IN THE ATMOSPHERE

THE radiation traversing the atmosphere is in part radiation coming from the sun, and in part radiation emitted by the earth and its atmosphere. The first is mainly in wave-lengths between 0 25 μ and 2·5 μ ($1\,\mu = 10^{-4}$ cm. $= 10^4$ A.) : the second is chiefly confined to wave-lengths greater than 5 μ, and may therefore be called long-wave radiation.

The passage of either kind of radiation through the atmosphere is impeded by Rayleigh scattering, by diffuse reflection from cloud particles, and by true absorption : we are concerned here only with the third of these. The major atmospheric gases, diatomic oxygen and nitrogen, do not contribute appreciably to the absorption, which is due to the presence of small quantities of certain polyatomic gases. Of these, the most important are water vapour (which is responsible for the major part of the absorption), carbon dioxide and ozone. Other gases, such as hydrocarbons, nitrogen oxides, cyanogen and sulphuretted hydrogen, may also contribute to the absorption ; their total absorption is, however, small.

Ozone is largely confined to the upper atmosphere ; if it were concentrated in a horizontal layer at atmospheric pressure at the ground, the thickness of this layer would be only 3 mm. Carbon dioxide, which is fairly uniformly distributed throughout the atmosphere, would form a similar layer about 2 m. thick. Water vapour is largely confined to the lowest few kilometres of the atmosphere. Its amount is very variable : if precipitated on the earth as liquid water, it would form a layer the thickness of which would range from less than 1 mm. on a cold dry day to a few centimetres on a warm, humid day.

Radiation from the sun is absorbed chiefly by ozone in the ultra-violet, between 0·2 μ and 0·3 μ, and in the visible region, between 0·45 μ and 0·65 μ ; and by water vapour in the infra-red, especially between 0·8 μ and 2·2 μ. The ozone absorption results in a hot layer in the upper atmosphere, at a height of about 60 km. Apart from its effect in producing this layer, atmospheric absorption of solar radiation is relatively unimportant ; with the sun at the zenith it reduces the intensity of the incident radiation only by 6–8 per cent.

Atmospheric absorption of long-wave radiation is much more important. A layer of damp air one metre thick can absorb one tenth of the radiation emitted from the surface of the earth. Successive layers of the same thickness do not increase the absorption proportionately ; the atmosphere is fairly opaque in certain wave-lengths, but nearly transparent in