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IV.—Industrial Psychology in Relation to Coal Mining.

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In this very brief introduction to Mr. Farmer's account of the details of a recent psychological investigation in a Coal Mine, I propose to present in broad outline the aspects of industrial psychology which are of most obvious and special interest to those engaged in the coal industry.

May I be allowed at the outset to observe that the application of experimental psychology to the problems of industry and commerce affords the most recent example of the value of applied science. Experimental psychology is the youngest of the biological sciences. The problems of industrial importance with which, as a pure science, it deals are those relating to sensation, perception, memory, emotion, instinct, muscular and mental work, and the devising of tests to afford an estimate of various mental and motor abilities. The applied science of industrial psychology marks a new phase in industrial history. It stresses the importance of considering industrial conditions from the *human* aspect. The last century was the age of the evolution and introduction of *machinery*. Machines were designed with little regard to the requirements of the human organism; the engineer was not equipped with the knowledge necessary to decide, say, the best position of the levers or treadles which the worker had to manipulate, or to take into consideration the optimum rate of his movements, or the optimum load which he should move. The worker had to adapt himself as best he could to the machine at which he was set to work. He was, to all intents and purposes, part of the machine; indeed he was himself regarded as a machine. No one knew, or appreciated the importance of investigating, the principles of the least fatiguing movements of the worker. No one knew, or appreciated the importance of investigating, the output of the worker at different hours of the working day in different kinds of work, mental, rhythmical, dexterous, light or heavy muscular work. The relative efficiency of before-breakfast work, overtime, etc., and their effects on the total day's output were unconsidered. The longer the working day, the greater it was supposed must be the worker's output. When a

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reduction from a twelve to a ten hours' day was first proposed, it was publicly claimed that it was only the last two hours' work of the twelve-hour day that provided the employer with his profit. We have now data systematically collected during the war which definitely prove in a number of instances that not only is the output per hour considerably greater in a ten-hour than in a twelve-hour day, but that the total daily output may also be greater in the shorter day's work. We have now available for study the hourly recorded output curves in a number of widely different varieties of work, showing how the curve of the day's output changes in form according to the nature of the work, according to the length of the spell, and according to the expertness and fatigability of the worker. Not only the total daily output but the form of the daily work curve has been unquestionably improved by shortening the length of the shift (*e.g.*, in the tinplate industry) or by systematically interpolating a brief period of rest at a favourable point in a 4-5 hours' working spell.

Valuable results have likewise attended an inquiry into the best methods of movement in manual labour. An uninterrupted sweeping movement has proved more effective than several shorter broken movements between which the direction is suddenly changed. After a short course of instruction by Mr. Farmer in the new methods based on this principle, a group of workers engaged in sweet-dipping showed an increased output amounting to 27 per cent. In the process of removing scratches from spoons and forks, Mr. Farmer and Mr. Brookes obtained from twelve workers an increase of over 36 per cent. in average earnings after a period of training in labour-saving methods, the average time being reduced from 126 minutes before instruction to 89 minutes after instruction, and the number of strokes made being reduced from 119 to 83. In the packing of chocolates, working with Miss Bevington, he obtained an increased output of over 35 per cent., and the packers spontaneously thanked him because they went home feeling so much less tired at the end of the day. In another factory Messrs. Muscio and Brooke obtained an increase of 27 per cent. after applying a systematized course of training to certain less efficient workers.

The worker acquires his habits of movement by imitation, by accident or by experience. But by none of these methods can the adoption of the most effective forms of movement be guaranteed. Tradition is all-powerful and important; but even many generations of workers may perpetuate and stereotype relatively inefficient methods of work. The principles

of psychology and physiology are now being applied to the study of movements,—not only of their direction and extent, but of their rhythm. Just as a longer sweeping movement may prove less tiring than a shorter broken movement, so a slower rhythm may prove more efficient than a faster one which tradition or environment may enforce on the worker.

Similar scientific inquiries have been conducted into the effects of humidity, temperature and illumination on human output. Weston found that in fine linen weaving the efficiency falls by about 11 per cent. as the result of artificial lighting, and Elton obtained a closely similar result in the process of silk weaving, which entails correspondingly delicate work. In coarser operations, *e.g.*, in cotton weaving, Wyatt obtained in one shed a reduction of 5 per cent. in efficiency due to artificial light. The far-reaching importance of adequate illumination can hardly be over-estimated. The feeble lamp of the miner not only restricts his output but is also partly responsible for his mental atmosphere, and is perhaps wholly responsible for the development of miner's nystagmus, which involves the industry in enormous expense.

But industrial psychology does not only study the most efficient movements and environment of the worker, the most effective methods of systematic training of the worker, the best arrangement of his materials, the optimal distribution of hours of work and rest, and the psychology of advertisement and design. It is also concerned with the selection of the workers best fitted for a given occupation and with the guidance of the young workers towards the occupation for which they are best fitted. Vocational psychology, as it is called, after ascertaining the abilities required for success in any given occupation, seeks to establish and to apply standardised tests for those abilities. Thus, for successful telephone exchange work it is evident that a good memory for numbers and names, a quick reaction in response to a given signal, and an accurate aim are essential. A series of nine tests of those abilities applied by Fontègne to 27 operators of the Geneva Central Telephone Exchange gave the following ranking, which was then compared with the independent official ranking of the operators by the exchange supervisor :—

				(a)		(b)						
Ranking by supervisor	1	2	3	4	5	6	7	8	9	10	11	12
" " tests ...	3	2	1	17	4	18	15	5	8	13	7	12

			(c)	(d)							(e)			
13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
9.5	14	11	6	27	24	16	23	19.5	26	21	9.5	22	19.5	25

With few exceptions, the correspondence or correlation is seen to be very close. Of the five cases of bad correlation, one (*e*) the administrative staff admitted, "would make an excellent telephonist if she chose," and another (*a*) appeared to take no interest in the tests. The three remaining exceptions may be due to the inadequacy of the tests or to defective ranking on the part of the supervisor.

The importance of such tests in guiding the young worker towards the available occupation for which he is best fitted, or in electing the best available worker for a given occupation, is self-evident. The round peg in the square hole in such an exacting occupation as telephone work is especially liable to nervous breakdown. Whereas loyalty, honesty, responsibility and the like can be best discovered at the interview, the interview needs to be supplemented by scientifically constructed and standardised tests of general and special abilities. The National Institute of Industrial Psychology has now standardised tests of general intelligence and of shorthand and type-writing ability. On similar lines its research workers, under Mr. Cyril Burt, are now formulating tests of the abilities required in the various branches of engineering and of dressmaking. A series of tests has also been successfully devised in this country by Professor Muscio, when investigator to the Industrial Fatigue Research Board, in regard to compositors. Among the tests he used for this purpose was one in which the speed of picking up matches and placing them in a series of holes (as on a cribbage board) was determined, and one in which wedge-shaped wooden blocks had to be selected to fit into a number of spaces on a board, which were of varying size corresponding to the size of the blocks.

The importance of vocational tests is fast becoming realised on the Continent. Barcelona and Brussels have each one or more rate-supported institutions devoted to this object, at which medical, anthropometric, as well as physiological and psychological tests are applied to those seeking advice. Similar work is being carried out at the Institut Rousseau at Geneva, at the Institute of Applied Psychology, the Charlottenburg School of Technology, and at other Institutions in Berlin, at the Masaryk Academy of Labour in Prague, and in the Department of Industrial Psychology in Tokio endowed with approximately £800,000, of which two-thirds has been contributed by industrial and commercial firms, and the remaining third by the Japanese Government. In the United States the Institutes devoted to such work are too many to

enumerate individually, but special mention must be made of the work of the Carnegie Institute of Technology, Pittsburgh, U.S.A., where vocational tests are being extensively applied and to which a number of leading industrial and commercial firms have granted a subvention, obtaining in return valuable information concerning the selection, training and organization of their personnel. In Germany, as in America, various public and private bodies are also engaged in applying vocational tests within their offices and works, *e.g.*, the Berlin Post Office, the German State Railways, Siemens and Halske, the Osram Company, the A.E.G., etc. In Great Britain, pioneer work in industrial psychology has been conducted by the Industrial Fatigue Research Board and the National Institute of Industrial Psychology. The former is a branch of the Medical Research Council, derives its present income almost wholly from the public funds and necessarily confines its investigations to the problems of each industry considered as a whole. The National Institute of Industrial Psychology, on the other hand, investigates the conditions of individual works and offices (which differ as widely as the constitutions of individual patients) and it is financially dependent solely on voluntary support. Its profits are devoted solely to research in industrial psychology, and its income is derived largely from payments for the investigations which it is asked to undertake by commercial and industrial firms. The detailed results of such an investigation in a Lancashire Coal Mine are described in the paper which follows, written by Mr. Farmer, who, with the permission of the Industrial Fatigue Research Board, has acted as a Senior Investigator to the National Institute of Industrial Psychology for this purpose, the work being carried out for twelve months by two University graduates, Mr. Adams and Mr. Stephenson, who during much of this time lived the life and worked the hours of a coal miner while engaged in this investigation, and during the rest of their time made use of the Manchester University Psychological Laboratory for the basis of their experimental work.