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**REPORTS OF THE
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**No. 21.—Atmospheric Conditions in
Cotton Weaving.**

(Textile Series No. 6.)

By S. WYATT, M.Sc.



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PREFACE.

The present report, dealing with the atmospheric conditions in weaving sheds, has an important bearing on a question which has long been the subject of controversy in the cotton industry.

For the weaving of certain classes of cotton cloth, moisture (in the form either of steam or of water) is introduced into the air of the sheds, in order to maintain the degree of humidity desirable for successful weaving. This practice, which has always been strongly objected to on the part of the operatives, has for many years been controlled by statutory regulations, the requirements of which have been changed from time to time. The question has always been recognised as a complex one, chiefly because the physiological effects of humidity, temperature, and ventilation on the comfort and health of the operatives, must be considered in conjunction with their physical effects on the yarn in manufacturing. It may be of interest, therefore, to trace briefly the successive stages in legislation from the beginning up to the present time.

The first protest against the artificial humidification of weaving sheds appears to have been made in 1882 by the Parliamentary Committee of the Trade Union Congress, in consequence of which an official inquiry was held by Dr. J. H. Bridges and Mr. E. H. Osborn [1], who arrived at the conclusion that the principal defect in weaving sheds at that time was lack of efficient ventilation and made recommendations for ensuring a sufficient standard.

In 1889, following some local inquiries in Lancashire, an Act* was passed, in which for the first time the maximum limits of the humidity permissible in the atmosphere for different temperatures were tabulated, and effect was given to the recommendations as to ventilation contained in the Report of 1882 by prescribing for the admission of at least 600 cub. ft. of fresh air per hour for every person employed.

These restrictions, however, failed to satisfy the operatives, and in 1896 the Weavers' Associations again approached the Home Office with a demand for the total abolition of "steaming." A Departmental Committee, under the Chairmanship of Sir Henry Roscoe, was thereupon appointed by the Secretary of State to inquire into the working of the Act of 1889. Their Report [2] made in 1897 contained certain recommendations, most of which were embodied in a Statutory Order of the Secretary of State*

* Cotton Cloth Factories Act, 1889. (52 & 53 Vict. chap. 62).

under powers conferred on him by a special Act.† In this Order the permissible limits of humidity were retained unchanged, but important provisions were introduced relating to temperature and ventilation. Thus, in order to reduce the rise of temperature within the sheds, the white-washing of the roofs of the sheds in summer and the lagging of the steam-pipes were made compulsory, whilst as regards ventilation a chemical standard of purity was introduced for the first time and sufficient means were required to prevent the accumulation of more than nine volumes of carbon dioxide in 10,000 volumes of air.

In 1906, protest from the operative weavers was renewed, a ballot taken showing a large majority in favour of abolition of steaming. Another Departmental Committee was then appointed with Sir Hamilton Freer-Smith, R.N., C.S.I., as Chairman, with more detailed terms of reference as follows :—

- (1) What temperature and humidity are necessary in each case for the manufacture of different classes of cotton fabrics ;
- (2) At what degrees of heat and humidity combined definite bodily discomfort arises, under the conditions of work carried on by the operatives, and what, if any, danger to health is involved by continuous work at those degrees ;
- (3) What means of cooling humid sheds (where necessary) exist, whether combined with the means of humidifying or otherwise, which are both efficient and practicable, having regard to the conditions required for the manufacture of the several classes of goods ;
- (4) What special arrangements, if any, are necessary in order to admit of the proper ventilation of dry weaving sheds without prejudice to the process of manufacture.

The principal recommendations contained in the final report of this Committee [6] may be summarised as follows :—

- (a) The permissible relative humidity is defined in terms of the difference between the dry and wet bulb temperature. Below 70° F. this is limited to two degrees, and above 70° F. to an increased amount on a graduated scale.
- (b) The introduction of humidity is prohibited when the dry bulb temperature is below 50° F. or the wet bulb temperature is above 75° F.

† Cotton Cloth Factories Act, 1897. (61 & 62 Vict. chap. 58). The Order was subsequently incorporated with slight modifications in the Factory & Workshop Act, 1901. (1 Ed. 7, chap. 22, Sec. 90-96).

- (c) A standard of efficiency is prescribed for the material to be used for the lagging of steam pipes.
- (d) With the object of lessening the quantity of steam introduced into the air, the standard of ventilation is relaxed from 9 volumes of carbon dioxide per 10,000 volumes to 8 volumes in excess of the outside air (roughly equivalent to 12 volumes absolute).

On the submission of this report, the same procedure was adopted as with the earlier Committee. A special Act was passed*, and under it the recommendations of the Committee were incorporated in a Statutory Order†, which is still operative.

This legislative action, however, like the previous statutes, failed to effect a complete settlement, and in 1914 Sir Hamilton Freer-Smith was engaged, on behalf of the Home Office in further discussions with the employers and operatives until postponement was brought about by the outbreak of war.

An interesting feature in the history of this question is the different aspects from which the factors of humidity, temperature and ventilation have been successively regarded. The earliest report [1], as is natural, is practically silent on the modern physiological views as to the effects of humidity and temperature, and it would appear that the recommendation as to increased ventilation was made solely with a view to replacing vitiated air by fresh, the aspect from which ventilation questions in those days were always regarded. Similarly, in the report [2] of Sir H. Roscoe's Committee, humidity is discussed chiefly from the point of view of deposit of moisture (on the clothing, etc.), and not from its physiological aspect. This is clearly indicated by the schedule of humidity recommended, in which wet-bulb temperatures up to 91° F. are specified, with the implication that work would be possible under those conditions. The report suggests, in short, that atmospheric humidity was regarded as of secondary importance compared with other matters, such as dust, purity of water and ventilation.

At the time when the third inquiry was held, more recent physiological work on the subject was available. Not only was general evidence given before them by Drs. J. S. Haldane, L. Hill, A. E. Boycott and M. S. Pembrey [5²²¹], but two important series of observations were made on behalf of the Committee on weavers actually at work. In the former of these [6¹⁵], which was carried out by Dr. T. M. Legge in co-operation with the Medical Officers of Health of certain Lancashire Boroughs, a large number of mouth

* The Factory and Workshop (Cotton Cloth Factories Act, 1911)² (1 and 2 Geo. 5, chap. 21).

† Regulations for Cotton Cloth Factories, dated December 21, 1911.

temperatures were taken in weaving sheds, in which the wet-bulb temperature was 75° and over, both before the weaver had begun work and after he had been exposed to shed conditions for some hours. The two series, on being compared, clearly indicated that a rise in mouth temperature occurred in the later observations as compared with the earlier*. Dr. Legge's conclusion is as follows :—

" The general conclusion I have formed from the detailed study of the observation is that a rise of mouth temperature makes itself distinctly felt when the temperature of the wet bulb exceeds 75° F. ; in other words, that weavers are likely to be working under adverse physiological conditions."

The second inquiry, conducted by Drs. M. S. Pembrey and E. L. Collis [6²⁴], was of a more intensive character, and was based on detailed observations of mouth, rectal and skin temperatures, pulse rate, and blood pressure, made on the authors themselves and on certain weavers working under ordinary conditions. The inquiry led them to the following general conclusions :—

" Our observations show that the influence of the warm, moist atmosphere is to diminish the difference between the internal temperature of the body and that of the peripheral parts. The tendency is to establish a more uniform temperature of the body as a whole, and to throw a tax upon the powers of accommodation, which is indicated by the low blood pressure, notwithstanding the rapid rate of the pulse. This is exactly the condition which would explain the discomfort and low state of health of which many of the weavers complain. . . .

" In a weaving shed the machine sets the pace, and the worker must neglect the dictates of his sensations, which are the natural guardians of his health and well-being. He must strive, as far as possible, to accommodate himself to the adverse conditions of heat and moisture. Some workers can respond to the demand better than others, but all must have their powers of accommodation taxed when the temperature of the wet bulb rises much above 70° F. It is not surprising, therefore, that at the end of a day's work many of the weavers complain that they have no energy left, have no great desire for food, and need only drink and rest."

With this evidence before them, the Committee accepted the principle that of all the different factors operating, the most important is the wet-bulb temperature. Not only was their main recommendation concerned with definite limitation of wet-bulb temperature, but with the avowed object of retarding its rise, a relaxed standard of ventilation was put forward, thus reflecting the present views that wet-bulb temperature is of greater physiological importance than change of air.

* In an inquiry on similar lines carried out by Legge in certain *linen* weaving sheds, in which the wet-bulb temperatures were higher, the rise in mouth temperature following exposures to shed conditions was found to be still more marked [7⁴¹].

Such then was the position at the time when the Board was appointed (July, 1918), and amongst the earliest suggestions received by the Board was one from the Home Office calling attention to the need for further investigation into the conditions in weaving sheds in the cotton industry [8¹⁵]. The Board thereupon decided to pay special attention to this industry, and since their inception investigations have been in progress (under the supervision of Mr. S. Wyatt) into various problems arising in the weaving section. The results of these investigations are only now available, and the present report, which deals with the atmospheric conditions in weaving sheds, is in some sense the logical continuation of the previous inquiries that have been held.

In effect, the report introduces for the first time into the study of this question in cotton weaving, a new and important factor in environment, namely, air *movement*. In recent years, largely through the work of Dr. Leonard Hill, it has gradually become realised that neither the dry nor the wet-bulb thermometer is *per se* an accurate criterion of the physiological effects of environment, but that, in addition to these, the rate of *movement* of the air must be taken into account. For instance, a (wet-bulb) temperature, which will prove insupportable in still air, may be borne without discomfort if the air in contact with the body is kept in a state of movement. An instrument (the kata-thermometer) has been devised by Hill, by which the total cooling effect of the air (depending on the dry and wet bulb temperatures and the air movement) can be measured directly, and the present inquiry is based on a large number of observations which have been made in this way.

The Board desire to direct special attention to certain important points which emerge from this investigation.

In the first place, it appears (so far as conclusions can be drawn from the investigation of sample factories), that in humid cotton weaving sheds the physical conditions of the workers' environment do not reach the standard which ought to exist, and which is, in fact, attained in other, though not in all, industries. The physiological effects of these conditions have already been explored in previous inquiries, the results of which go to show that long continued exposure may produce discomfort, and tend to a low state of health.

Further, in another report dealing with linen weaving [9], some evidence has been recently adduced which suggests that similar environmental conditions when sufficiently pronounced, may react upon the operative in such a way as to impair his productive efficiency. This is shown by the fact that when the wet bulb temperature reaches 73° F., efficiency falls, and since

the high temperature has physically a beneficial effect on the yarn, this can only be ascribed to the bodily discomfort felt and to the fatigue induced by working under such conditions. Similar evidence also has been recently obtained in the case of cotton weaving [10].

The present Report does not touch on the vexed question that has been so frequently raised but never finally disposed of, namely, whether these conditions, which undoubtedly cause discomfort, are productive of actual ill-health. No conclusive evidence on the subject has ever been obtained, and indeed the lack of any real information relating to it is emphasised by each of the Departmental Committees which have successively dealt with humidity in weaving. The possibility of studying this question by a determination of the actual sickness incidence in humid and dry sheds has already been before the Board, in consultation with the Home Office and the Trade, and at a conference with employers and operatives, held in Manchester in July, 1920, under the Chairmanship of Sir Hamilton Freer-Smith, the action contemplated was unanimously approved by those present. In view of this approval, the Board have made preliminary inquiry into the matter, and have arrived at the conclusion on the advice of the Committee on Industrial Health Statistics that owing to the absence of certain necessary information and to the abnormal conditions prevailing during the war, the use of existing sickness records for this purpose will not be practicable, and that an investigation therefore must be based on records kept in the future. Quite recently, further progress has been made and definite lines of inquiry which seem to offer the most promising prospects are now under consideration. Whilst it appears that actual investigation cannot usefully be started at the present time, the Board hope that when trade conditions again become normal the industry may be disposed to collaborate with them in future work on this subject, for which the expert advice of the Committee on Industrial Health Statistics will be available.

Secondly, the present report suggests two important methods by which improvement in the working conditions can perhaps be brought about. One of these is the use of more suitable clothing on the part of the operatives. Perhaps the most definite feature of the observations on weavers made by Dr. Legge and by Drs. Pembrey and Collis [6] is the consistently higher mouth temperature on the part of women as compared with that of men, and this is ascribed by the authors to the less suitable clothing worn by the former. The great importance of the kind of clothing worn on its bearing on comfort is perhaps not generally realised, and the attention of the industry is accordingly invited to the section in the present report dealing with this subject.

The other method is the introduction of some means for artificially increasing the air movement in the neighbourhood of

the operatives, on the lines of the experiments described on p. 30. The practical adoption of some such method was in fact foreshadowed in 1914 by a Departmental Committee dealing with the kindred process of linen weaving [7]. Referring to Dr. L. Hill's observations with the kata-thermometer, they state :—

“ He urges that in heated atmospheres, whether moist or dry, greater comfort can be secured by the use of appliances which will keep the air in continual motion, even where circumstances render it inexpedient to admit more than a limited amount of fresh air. In our opinion manufacturers might with possible advantage, and at little cost, give efficient trial to Dr. Hill's suggestion. This might be done by small fans placed on the heddle-bars of looms, or by fixing blades in suitable places on the revolving shafting.”

A similar suggestion is contained in the Annual Report of the Chief Inspector of Factories for 1914 (p. 62), from which it even appears that appliances for increasing air movement have already been tried on a practical scale :—

“ Air samples taken when investigating complaints of impure air or of bad ventilation often gave quite satisfactory results upon analysis, and Mr. Crabtree (Burnley) suggests that the cause of complaint is stagnant air, and not excess of carbon dioxide. As a remedy for this he suggests that agitators in the shape of flat boards (about 14 in. wide and 10 in. long) should be fitted to the overhead shafting, so that the air is made to circulate with their revolutions. This plan has been successfully tried in three sheds in this district.”

The Board are advised that the application of this principle is not free from practical difficulties. They understand, for instance, that the actual device described in the report is open to objection on the grounds that it interferes with the free movements of the weavers, and that other appliances suggested (such as the agitators already mentioned) could not be widely adopted without extensive structural alterations. Nevertheless, in view of the suggestive results embodied in this report, the Board think that unless and until it is found possible to dispense with artificial humidification through technical modifications in methods of manufacture (such as sizing), a solution of this question may be found in the control of air-movement. They accordingly hope that textile engineers and all concerned in the industry will bring their practical knowledge to bear on the subject, with the object of devising some means of improving the conditions physiologically without interfering with the process of manufacture, and of ascertaining, through experiments conducted on a larger scale than those described, how far such means are capable of general application.

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ATMOSPHERIC CONDITIONS IN COTTON WEAVING.

By S. WYATT, M.Sc., *Investigator to the Board.*

CONTENTS.

	PAGE.
1. INTRODUCTION	2
2. METHODS OF OBSERVATION	4
3. DESCRIPTION OF SHEDS	4
4. RESULTS OBTAINED	5
A. <i>Winter Observations</i>	5
(a) <i>Intermittent Series</i>	5
(b) <i>Continuous Series</i>	7
(c) <i>Extended Series</i>	13
B. <i>Summer Observations</i>	15
(a) <i>Intermittent Series</i>	15
(b) <i>Continuous Series</i>	17
(c) <i>Extended Series</i>	19
5. COMPARISON BETWEEN COTTON WEAVING SHEDS AND OTHER PLACES	20
6. MISCELLANEOUS OBSERVATIONS	22
A. <i>The Influence of Machinery and Belting and of other Factors on Air Movement</i>	22
B. <i>Comparison between Head and Floor Level</i>	24
C. <i>The Effect of Moving Air upon Skin Temperature</i>	24
D. <i>Notes on Clothing</i>	26
7. SUMMARY	29
APPENDIX I.— <i>An Experiment on increasing the Cooling Power of Air in a Humid Weaving Shed</i>	30
APPENDIX II.— <i>Instructions for using the Kata-Thermometer</i>	34

1. Introduction.

The practical study of human fatigue and efficiency must often depend to a large extent on technical considerations. For example, in a clothing factory the temperature of the air is a matter of small importance as regards manufacture, and attention can therefore be concentrated on securing ideal conditions for the workers. Again, in a steel works, although the high temperature required inside the furnace affects the environment of the worker, outside the furnace technique demands no special thermal conditions, and it is accordingly open to an investigator to consider every possible method of overcoming such effects of the manufacturing process as are physiologically undesirable. In other words, in both cases the investigator has a "free hand."

The textile industries, on the other hand (and particularly cotton), comprise certain processes in which the operatives during their work are continuously exposed to exactly the same extrinsic conditions as the material demands for successful manipulation. In dealing with such conditions, therefore, the exigencies of manufacture have to be taken into account and practical suggestions confined to those which will result in some physiological improvement without any seriously harmful technical effects.

The nature of the atmospheric conditions which prevail in cotton weaving sheds has up to the present been determined chiefly by means of wet and dry bulb thermometers. The Factory and Workshop (Cotton Cloth Factories) Act, 1911, gives the permissible maximum limits of humidity of the atmosphere for different temperatures, and the manager of a humid shed regulates the amount of artificial moisture entering the shed according to the readings indicated by these instruments.

The wet and dry bulb thermometers, however, fail to give a complete indication of the qualities of the air in the shed which affect the bodily comfort and efficiency of the operatives. Thus the temperature and humidity of still and moving air may be the same, but the "*cooling power*" will be very different in the two cases. A person who on a hot day in summer may be unpleasantly warm, can gain relief by a ride on the top of an open tram or bus. In the same way the unpleasant effects of a moist tropical climate can be greatly reduced by artificially creating air movement.

The bodily comfort of individuals is partially dependent upon the relations between the rates of heat production and heat loss, for if the former is in excess, discomfort is caused by the resulting accumulation of heat. A knowledge of the cooling effect of shed conditions upon the operatives is therefore important since unfavourable conditions probably accelerate the onset of fatigue and impair efficiency.

The human body may lose heat by the processes of convection, radiation, and evaporation. Normally, the first two processes are largely responsible for the maintenance of equilibrium between heat produced and heat lost, but during periods of bodily exertion, or under unfavourable atmospheric conditions, the mechanism subserving the last process is frequently brought into play in the form of sweating, whereby a considerable cooling effect is produced by the evaporation of superficial moisture, a fact which finds frequent application in the treatment of fever patients.

The cooling power of the air is most conveniently determined by the *kata*-thermometer,* a special form of thermometer so designed as to enable the time required for it to fall from one temperature to another to be accurately observed. From the time so required the rate of cooling of the bulb per unit area per second can be calculated by the use of a simple factor (the so-called "*kata factor*", depending on the size and shape of the bulb and marked on each instrument), and this in turn gives a direct indication of the cooling power of the surrounding air. By suitable adjustment of conditions the instrument can be made to measure its own rate of cooling (and accordingly the cooling power of the air) when its temperature approximates to that of the human body. Under such conditions the rate of cooling of the *kata*-thermometer gives an approximate indication of the rate at which the exposed surface of the human body loses heat. The instrument can be used either as a dry or wet bulb thermometer; in the former case it indicates the rate of heat loss due to the processes of radiation and convection (analogous to the state of the body when there is no visible perspiration), and in the latter it measures in addition the rate of heat loss due to evaporation (similar to the conditions when the body is visibly perspiring).

The cooling power of the air as measured by the dry *kata* (usually abbreviated into *dry kata cooling power*) depends upon:—

- (a) The difference in temperature between the thermometer and the surrounding air.
- (b) The rate of movement of air ("air velocity").

* This instrument is the invention of Dr. Leonard Hill, F.R.S., and is fully described in his book on "The Science of Ventilation and Open-Air Treatment, Part I" (*Medical Research Council; Special Report Series No. 32*). Most of the above remarks are based upon the contents of this book.

A description of the nature and use of the instrument is given in "Preliminary Notes on Atmospheric Conditions in Boot and Shoe Factories," by W. D. Hambly and T. Bedford (*Industrial Fatigue Research Board, Report No. 11*), and in the Appendix to this Report. (p. 34.)

A full account of the method of determining cooling power and air velocity is given in the Appendix to this Report. (p. 34.)

The cooling power of the air as measured by the wet kata (or *wet kata cooling power*) is a function not only of the temperature and air velocity, but also of the difference between the vapour pressure of the air saturated at body temperature (97.7° F.), and that of the air at the observed temperature.

According to Hill, the minimum cooling powers required for the comfort of those engaged in sedentary work are 6 for the dry kata and 18 for the wet; for weaving the values would be a little higher. These are henceforth referred to in the report as "*cooling standards*."

2. Methods of Observation.

Kata readings were taken during summer and winter in a number of humid sheds. The observations were spread over a number of days in each shed, since in the English climate the weather usually associated with the different seasons is notoriously uncertain. Although precautions were taken to secure typical seasonal readings, the summer was unusually cool and wet and the shed temperatures did not reach the usual level.

To avoid any preponderance of readings at any given hour, the observations were evenly distributed throughout the working day. Variations in method will be mentioned as they arise.

3. Description of Sheds.

The chief features of the sheds included in this investigation are given in Table I.

TABLE I.—*Description of sheds investigated.*

Shed.	Looms.	Operatives.	Capacity (cub. ft.).			Class of Work.	Method of Humidifying.	Method of Ventilation.
			Total.	Per Loom.	Per Operative.			
A ..	1,134	320	838,890	740	2,621	Dhooties ..	Vortex ..	Vortex.
B ..	300	90	214,728	716	2,386	Shirtings ..	Steam Jet..	Gregson's Fans..
C ..	609	250	288,458	474	1,154	Bleaching Goods.	Vortex ..	Vortex.
D ..	2,020	886	1,236,704	612	1,396	Shirtings ..	Harts ..	Roof Doors.
E ..	417	118	308,890	741	2,618	Shirtings ..	Harts ..	Windows.
F ..	894	135	794,474	889	5,895	Printers and Sheetings.	Hall and Kay.	Hall and Kay and Grids.
G ..	1,058	150	731,808	691	4,879	Printers and Twills.	Hall and Kay.	Hall and Kay.
J ..	835	260	453,096	543	1,743	Drills ..	None ..	Gregson's Fans..

4. Results Obtained.*

A.—WINTER OBSERVATIONS.

(a) Intermittent Series.

In order to obtain results representative of the atmospheric conditions in humid weaving sheds during the winter months, observations of the cooling power of the air at head level were made in several sheds at different times of the day on different days. The results are given in Table II.

TABLE II.—*Atmospheric observations made in weaving sheds during winter.*

Shed.	Ob- serva- tions.	Temperature (° F.).				Cooling Power.				Cool- ing due to Evap- ora- tion.†	Air Velo- city (ft. per min.).
		Dry Bulb.	* M.V.	Wet Bulb.	* M.V.	Dry Kata.	* M.V.	Wet Kata.	* M.V.		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
A	40	70.7	2.5	65.8	2.5	5.4	0.6	15.8	1.2	10.4	32
B	27	65.5	2.3	62.2	1.7	6.2	0.5	17.7	1.3	11.5	26
C	43	72.9	1.9	68.7	1.8	4.7	0.4	14.9	1.1	10.2	24
D	18	69.1	2.0	63.7	1.5	5.4	0.3	13.3	0.9	7.9	24
E	30	70.9	1.6	65.5	1.6	5.2	0.4	13.1	1.0	7.9	28
Av.† A-E	—	69.8	—	65.2	—	5.4	—	15.0	—	9.6	27
F	44	71.6	2.2	64.6	3.2	4.9	0.5	16.3	1.3	11.4	23
G	45	74.3	1.4	71.1	1.3	4.3	0.3	13.2	0.6	8.9	21

* The mean variation (M.V.) (cols. 4, 6, 8, 10) is the average of the deviations of the individual determinations from their average, and is a measure of the degree of "scatter" of the individual measurements about their mean.

† Sheds A to E are averaged separately for comparison with Table V later.

‡ The "cooling power of the air due to evaporation" (col. 11) is obtained by finding the difference between col. 9 and col. 7. Recent experiment has shown that this difference is only an approximate measure, since under similar external conditions the surface temperatures of the dry and wet kata are not the same.

The average dry bulb temperature ranges from 65.5° F. in Shed B to 74.3° F. in Shed G.

The results show that with the exception of Shed B the average never reaches the dry kata cooling power standard of six, even during the winter months when the shed temperatures are comparatively low. The conditions in Shed G are particularly unfavourable, the relatively high temperature and slight movement of the air producing an average dry kata cooling power of only 4.3. Similarly, the average wet kata cooling power never reaches the standard (18) considered necessary for sedentary workers, though it approaches it very closely in Shed B (average 17.7). In this respect Shed G is again one of the most unsatisfactory (average 13.2). Here the investigator experienced great discomfort and on several occasions perspired freely. Similar

* The writer is indebted to Miss P. M. Vickers, Miss B. S. McFie, Mr. H. C. Weston and Mr. A. D. Ogden for the collection of the data contained in this report.

signs were also noticeable in the case of the operatives, whilst in Sheds A, B, C and F the skin of the weavers did not show visible perspiration.

The effect of different degrees of humidity is seen in a comparison of the results of Shed G with those of Shed F. The higher wet kata cooling power and evaporative power in the latter shed are due almost entirely to the lower humidity as indicated by the greater difference between the wet and dry bulb thermometer readings.

A dry kata cooling power of five and a wet kata cooling power of 15 are apparently sufficient to prevent sweating on the part of weavers employed under normal conditions, but the air under these conditions is rather stagnant and lacks the stimulating effect usually associated with pleasant external conditions, and higher values are undoubtedly desirable.

In general, the results obtained in the different sheds show that the cooling power of the air becomes distinctly unsatisfactory when the shed temperature exceeds 70° F. For higher temperatures, a satisfactory cooling power can only be obtained by increasing the rate of air movement.

Considerable differences in cooling power exist in the different sheds. Since all the sheds are exposed to fairly similar outside atmospheric conditions, the shed temperatures and humidities, and consequently the cooling power of the air in the sheds, are, within limits, under the control of the management, and the differences observed are largely due to the different quantities of steam admitted into sheds for humidification purposes.

The dry kata observations have been also arranged according to the frequency with which the values fall within certain limits, although it must be admitted that the number of observations comprised within each class interval is generally small. Fig. 1 shows the distribution of the dry kata observations according to cooling power values. Thus in Shed A, the number of readings for successive increases of 0.5 were :—

From	Number.
3.5 — 4.0 ..	1
4.0 — 4.5 ..	3
4.5 — 5.0 ..	8
5.0 — 5.5 ..	13
5.5 — 6.0 ..	5
6.0 — 6.5 ..	6
6.5 — 7.0 ..	3
7.0 — 7.5 ..	1

A broad flat curve means that the readings cover a wide range and that the number of readings at one part of the curve is not very different from the number at any other part. A narrow tall curve (*e.g.*, Shed G) indicates a small range and a tendency for most of the readings to cluster around the average.

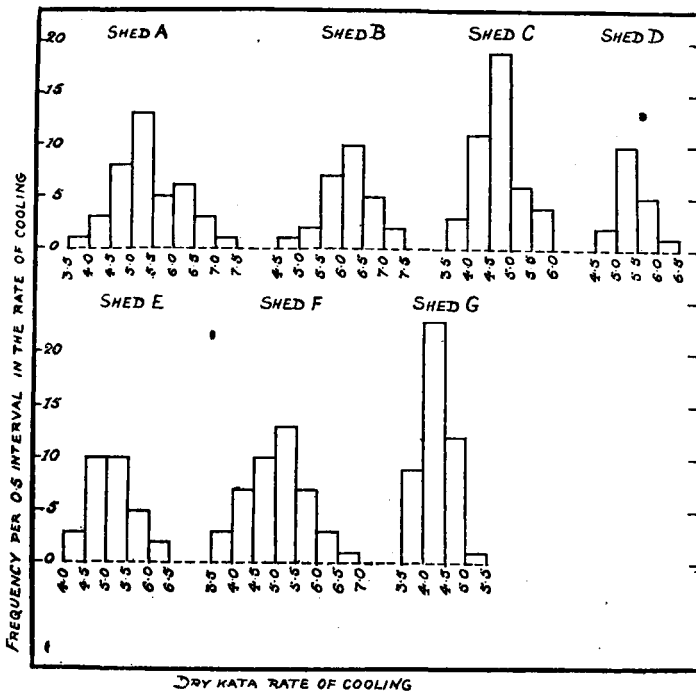


FIG. 1.—DISTRIBUTION OF DRY KATA READINGS ACCORDING TO COOLING POWER (WINTER RESULTS).

The curves in general show that the individual readings are fairly regularly distributed about a point which approximates to the average values given in Table II. A larger number of readings in each shed would give curves which approximate to the normal curve of distribution. The deviation of the results from the average is given numerically in Table II by the mean variation (M.V.), and the curves show that this quantity is not unduly influenced by unusually high or low readings. The uniformity of the results obtained in Shed G is largely due to the unusually uniform temperature which prevails in this shed during the working week.

(b) *Continuous Series.*

In order to determine the variations in cooling power during the hours of work, continuous observations were made in three sheds on different days. In each shed a representative position at head level was chosen for the observations and maintained throughout each series of readings. The results obtained are given in Table III.

TABLE III.—Record of observations made at approximately hourly intervals during hours of work.

Approximate Hour.	Shed A. (Average for 4 days.)										Shed D. (Average for 2 days.)						Shed E. (Average for 3 days.)					
	Temperature.				Cooling Power.				Cooling due to evaporation.	Air velocity (feet per min.).	Temperature.		Cooling Power.		Cooling due to evaporation.	Air velocity (feet per min.).	Temperature		Cooling Power.		Cooling due to evaporation.	Air velocity (feet per min.).
	Dry Bulb.	M. V.	Wet Bulb.	M.V.	Dry Kata.	M.V.	Wet Kata.	M.V.			Dry Bulb.	Wet Bulb.	Dry Kata.	Wet Kata.			Dry Bulb.	Wet Bulb.	Dry Kata.	Wet Kata.		
8.0	58.5	3.8	56.1	3.2	7.7	0.8	19.2	1.2	11.5	28	61.0	56.9	7.2	17.1	9.9	29	60.4	55.3	7.2	18.7	11.5	26
9.0	62.8	2.7	59.0	2.9	6.8	0.7	16.9	0.7	10.1	28	63.5	59.7	6.5	16.0	9.5	25	64.9	60.8	6.2	15.4	9.2	25
10.0	65.6	1.4	62.1	1.1	6.1	0.3	16.1	0.5	10.0	27	65.4	61.8	5.8	15.4	9.6	19	67.1	62.7	5.6	15.1	9.5	21
11.0	66.9	0.5	62.5	1.3	5.8	0.3	15.7	0.1	9.9	24	66.7	62.4	5.5	15.1	9.6	18	68.9	64.5	5.4	14.9	9.5	23
12.0	67.6	0.9	62.7	0.9	6.0	0.5	16.4	0.4	10.4	31	68.2	63.4	5.2	14.7	9.5	17	71.0	66.2	4.9	15.1	10.2	21
12.30	66.9	0.9	61.7	1.4	5.9	0.5	16.4	0.4	10.5	26	67.8	61.3	5.5	16.0	10.4	21	69.1	63.0	5.8	17.3	11.5	34
1.0	65.1	0.7	60.1	1.4	6.2	0.5	17.6	0.3	11.4	25	65.5	59.9	5.7	15.7	10.0	18	67.1	61.4	6.6	17.3	10.7	44
1.30	65.5	0.5	61.4	2.0	6.3	0.4	17.1	0.6	10.8	29	66.9	62.0	5.4	15.8	10.4	17	—	—	—	—	—	—
2.0	—	—	—	—	—	—	—	—	—	—	68.9	64.5	5.1	14.5	9.4	18	70.9	65.5	5.0	14.1	9.1	23
2.30	66.4	1.6	61.9	1.4	6.1	0.3	16.3	0.2	10.2	28	—	—	—	—	—	—	—	—	—	—	—	—
3.0	—	—	—	—	—	—	—	—	—	—	70.5	66.0	4.7	13.8	9.1	16	73.0	68.1	4.5	13.3	8.8	20
3.30	67.4	1.6	63.5	0.9	6.1	0.4	16.7	0.3	10.6	32	—	—	—	—	—	—	—	—	—	—	—	—
4.0	—	—	—	—	—	—	—	—	—	—	71.0	66.6	4.5	14.1	9.6	14	74.2	68.4	4.5	13.7	9.2	25
4.30	66.9	1.4	62.8	0.9	6.1	0.3	16.2	0.4	10.1	30	—	—	—	—	—	—	—	—	—	—	—	—
5.0	—	—	—	—	—	—	—	—	—	—	72.3	67.4	4.4	13.8	9.4	16	75.1	68.9	4.4	13.6	9.2	28
5.30	66.4	1.4	61.4	1.4	6.4	0.5	16.2	0.9	10.2	38	—	—	—	—	—	—	—	—	—	—	—	—

The mean variations for Sheds D and E are not given, but they are of the same magnitude as those for Shed A.

The general tendency of these results is seen more clearly in Figs. 2, 3 and 4. Usually, the dry kata cooling power decreases during the morning spell, rapidly at first but more slowly afterwards. With the cessation of work at 12.15 p.m., a rise takes place, which continues during the dinner hour, but after the resumption of work at 1.15 p.m., there is a gradual fall throughout the afternoon spell, until preparations for departure are made just before 5.30 p.m.

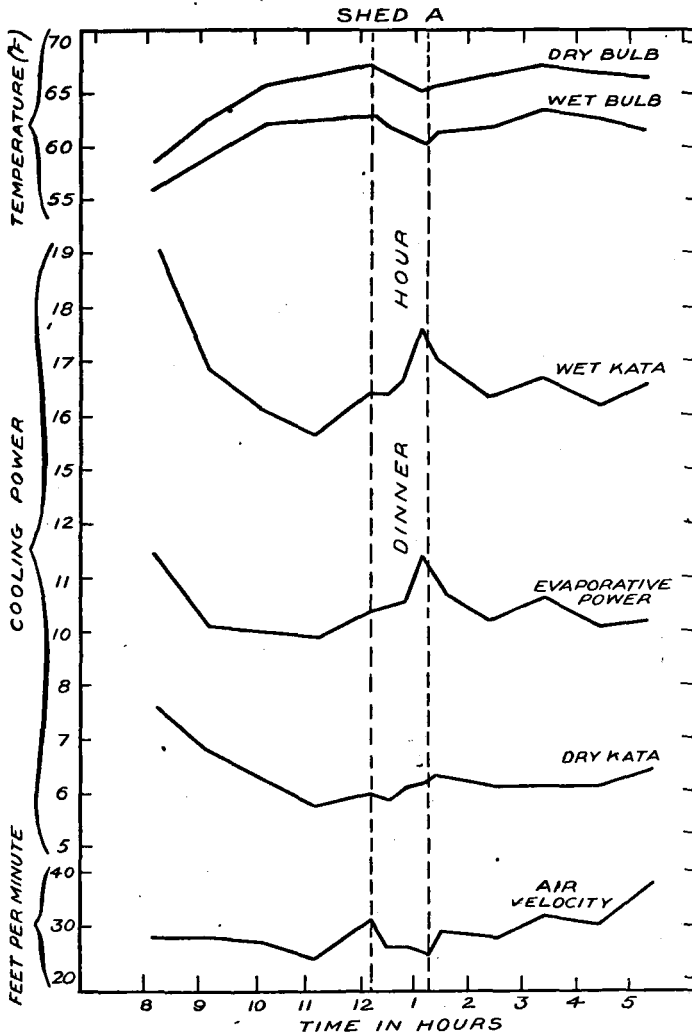


FIG 2. VARIATIONS IN TEMPERATURE AND COOLING POWER OF AIR

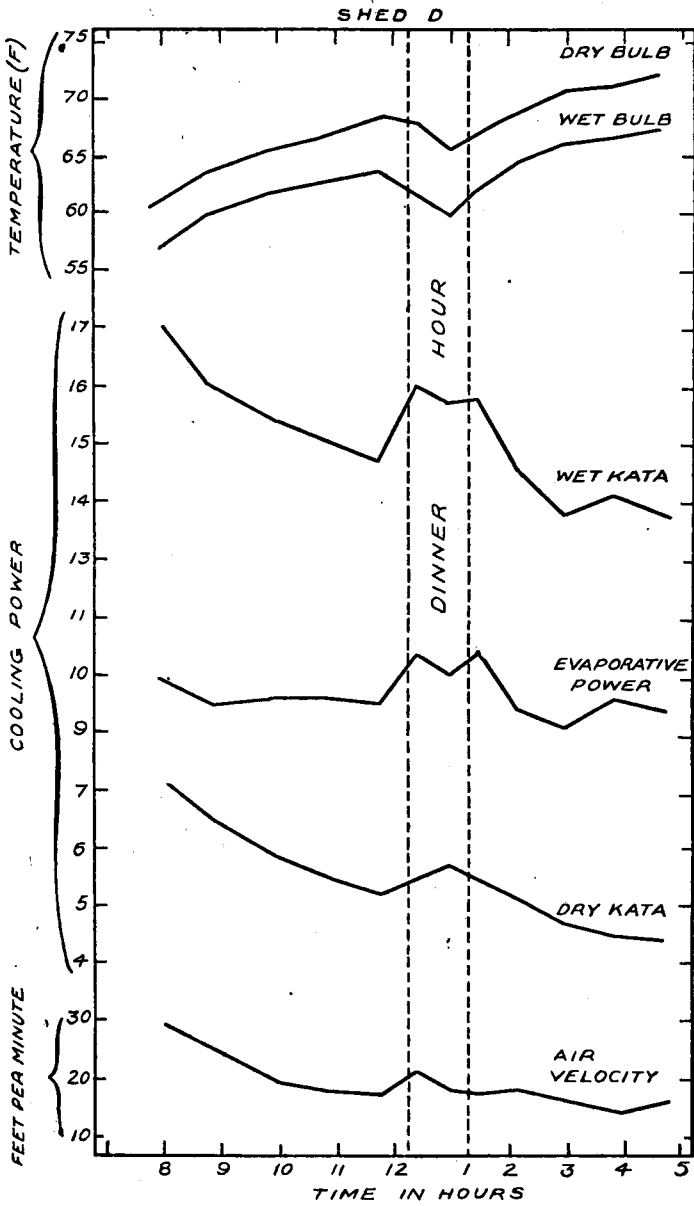


FIG 3. VARIATIONS IN TEMPERATURE AND COOLING POWER OF AIR

SHED E

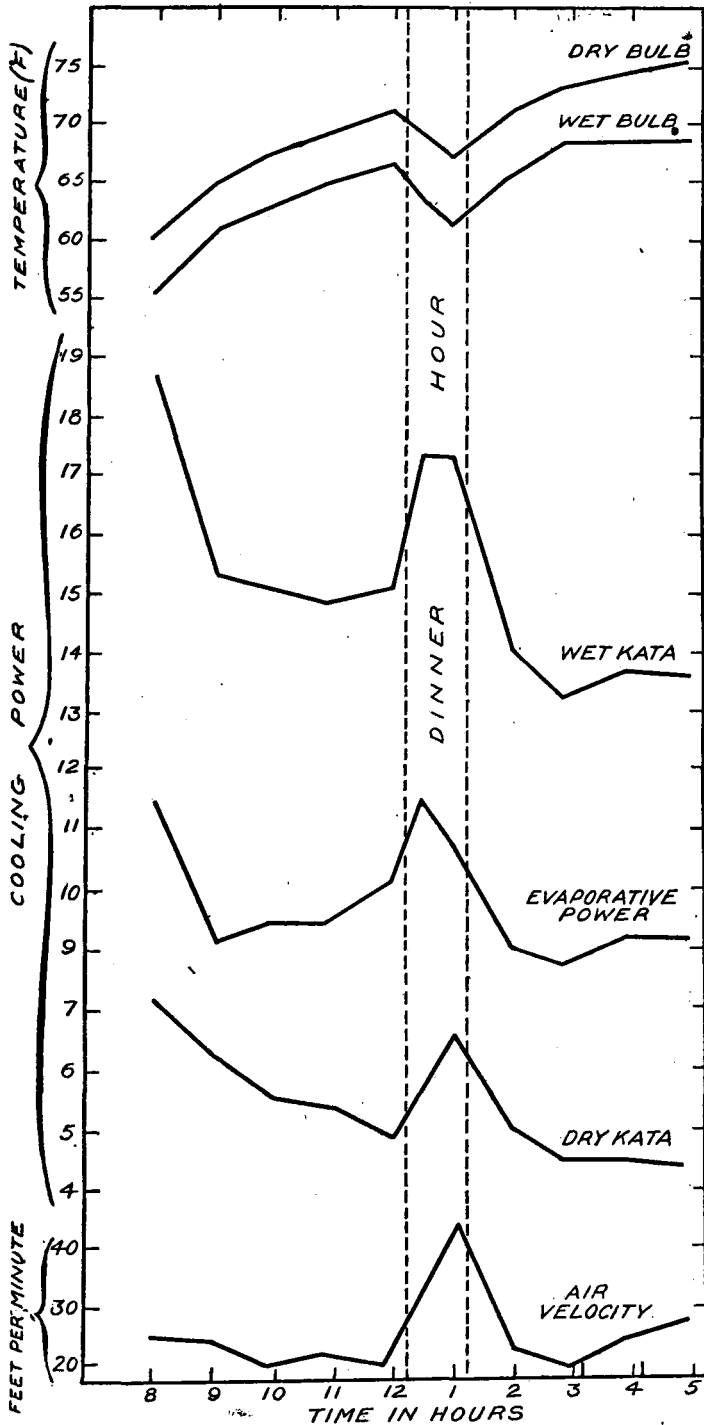


FIG. 4. VARIATIONS IN TEMPERATURE AND COOLING POWER OF AIR

In explaining the above tendency, we must remember that the rate of cooling of the dry kata is dependent upon (1) the temperature of the air, and (2) the rate of air movement. During the normal period of work (*i.e.*, omitting the first and last observations and the meal hour), the temperature rises steadily throughout the day. On the other hand, for a given shed the air velocity remains remarkably constant, hence we should expect the continuous decrease in cooling power that actually occurs in most sheds, since the rise in temperature is not counteracted by an adequate increase in air velocity. The only exception is the afternoon spell of Shed A, in which the cooling power remains virtually constant corresponding with a nearly constant temperature, due probably to adjustment of the heating appliance in the shed, since in winter the sheds are artificially heated by steam pipes, so that the control of the inside temperature is to some extent in the hands of the management.

During the meal hour, other factors come into operation, for instance :—

- (a) the machinery is stopped and most of the operatives are absent. The mechanical energy used and the bodily heat of the operatives are responsible for most of the heat produced and the consequent rise in temperature. With the removal of these two sources of heat, the temperature rapidly falls ;
- (b) the ventilating system is stopped, which with the absence of moving machinery, *reduces* the rate of air movement ;
- (c) doors are continuously being opened whereby the rate of air movement is *increased*.

All of these are reflected in the curves. In each shed there is an abrupt drop in temperature. The extent to which this influences the dry kata cooling power depends on the relative importance of the second and third factors. In the large Sheds A and D, the third has a very small effect, so that the air velocity actually diminishes and the increase in cooling power is due entirely to the fall in temperature. In the small Shed E, however, the opening of doors causes an appreciable increase in air velocity, and the rise in dry kata cooling power is much greater. Similar considerations hold in regard to the beginning and the end of the day's work,

In regard to the properties affected by humidity, the wet bulb temperature follows a course closely parallel with the dry bulb temperature, indicating an almost constant difference between the two, though this difference is increased during the meal hour and generally at the beginning of work as well. Similarly, the wet kata cooling power follows a course similar to that of the dry kata cooling power, but the gradients are steeper. The evaporative

cooling power is more constant, except at the beginning of the day, and during the meal hour, when the amount of humidity in the shed atmosphere is below its normal level.

The data for the three sheds show certain differences. A dry kata cooling power of six is attained and maintained only in Shed A. In Sheds D and E it falls as low as 4.5 in the afternoon period. A cooling power of five did not appear to make the operatives sweat visibly. Thus in this respect winter conditions in weaving sheds cannot be said to overtax the body by the continuous use of the sweating mechanism. Greater bodily comfort would, however, result from the maintenance of atmospheric conditions having a higher cooling power; moreover, the body heat production is promoted by higher cooling powers and this is accompanied by better appetite and improved vigour and health.

The conditions in Shed D are less variable than those in Shed E. This is probably due to the fact that Shed D is one of the largest in the cotton industry, while Shed E is comparatively small. Shed A is intermediate in size between D and E. An external force acting upon large masses has much less effect than upon small, and a current of air entering large and small sheds will have a similar influence. Thus movements of the operatives and doors which modify air movements in the small Shed E fail to have any appreciable effect upon the air in the large Shed D.

Except during the first hour of the day the wet kata cooling power (like the dry kata) is much below the standard of 18 recommended for sedentary workers.

Again, in comparing the air velocities, we find considerable differences in the three sheds. During the normal period of work, A has an air velocity of about 28 feet per minute, D of 18, and E of about 23. This suggests that A is better ventilated than E, and E than D.

A general comparison of the sheds investigated shows in fact that the conditions prevailing in Shed A are the most favourable and in Shed D the least. The decreased cooling power in the latter is due almost entirely to the stagnant nature of the air, and this again is the result of the exceptionally large dimensions of this shed. Some means of increasing the air movement in large sheds seems to be specially needed in the interests of the bodily comfort of the operatives.

(c) *Extended Series.*

At one of the mills included in this investigation (Shed A), kata readings were taken in the same position at the middle of the morning and afternoon spells (*i.e.*, at 10 a.m. and 3.15 p.m.)

on every working day during the winter months. The morning and afternoon averages for each week are given in the following table :—

TABLE IV.—*Record of atmospheric conditions in a weaving shed during consecutive weeks in winter.*

Week Ending.	Temperature (° F.).				Cooling Power.				Cooling due to Evaporation.		Air Velocity (ft. per min.).	
	Dry Bulb.		Wet Bulb.		Dry Kata.		Wet Kata.		a.m.	p.m.	a.m.	p.m.
	a.m.	p.m.	a.m.	p.m.	a.m.	p.m.	a.m.	p.m.				
Nov. 1 ..	67.2	69.6	65.5	67.6	5.9	5.4	15.2	14.1	9.3	8.7	27	26
Nov. 8 ..	66.4	68.6	64.7	66.6	6.2	5.4	14.7	14.7	8.5	9.3	30	22
Nov. 15 ..	62.6	66.5	61.2	64.3	7.0	6.4	16.4	15.9	9.4	9.5	31	36
Nov. 22 ..	66.9	67.8	65.6	65.5	5.9	5.6	15.5	15.8	9.6	10.2	26	23
Nov. 29 ..	66.1	68.4	64.7	66.1	6.3	5.8	15.5	15.4	9.2	9.6	31	30
Dec. 6 ..	66.7	68.1	65.0	65.6	6.0	5.6	15.2	14.6	9.2	9.0	28	24
Dec. 13 ..	64.7	68.2	63.2	65.6	6.5	6.1	15.7	15.2	9.2	9.1	29	36
Jan. 10 ..	65.2	68.2	63.9	66.6	6.2	5.7	15.8	15.6	9.6	9.9	25	27
Jan. 17 ..	66.7	68.2	64.9	65.7	5.9	5.8	15.3	15.1	9.4	9.3	25	29
Jan. 24 ..	65.9	68.1	64.1	65.5	6.5	6.0	16.7	15.6	10.2	9.6	33	33
Jan. 31 ..	63.6	66.7	61.1	63.9	6.5	6.3	16.7	16.4	10.2	10.1	25	34
Feb. 7 ..	67.0	68.7	64.6	64.5	5.8	5.7	16.1	16.1	10.3	10.4	24	30
Feb. 14 ..	66.2	67.2	64.1	64.5	5.9	5.5	15.9	15.7	10.0	10.2	21	20
Average ..	66.8	68.0	64.0	65.5	6.2	5.8	15.7	15.4	9.6	9.6	28	28
M.V... ..	1.1	0.6	0.9	0.8	0.3	0.2	0.5	0.5	0.4	0.4	—	—

In cooling power of the air this shed is one of the best of those investigated, and the dry kata cooling power at the times stated is approximately equal to the standard of six. The wet kata cooling power is evidently affected by the high humidity of the air caused by the introduction of steam and falls short of the standard (18) by approximately 2.5.

Since in this shed the average dry kata cooling power of six corresponds with an average dry bulb temperature of 66.9° F, it follows that for the maintenance of the standard of six either the temperature of the shed must never exceed 66.9° F, or the movement of the air must be increased. In the same way the corresponding limits of temperature for other sheds can be determined.

The results also show that in the morning conditions are slightly more favourable than in the afternoon, a fact which is due chiefly to the lower morning temperature.

The variability in the weekly averages as shown by the mean variation, is remarkably small, and emphasises the uniformity of the atmospheric conditions prevailing at the same time of the day in a humid weaving shed during the winter months.

The air movement was quite imperceptible, and failed to produce the stimulating effect which is noticeable under more pleasant conditions outside. Though the operatives appeared to be content and showed no signs of bodily discomfort, beneficial results would probably be obtained if the cooling power and stimulating effects of the air were increased by air movement.

B. SUMMER OBSERVATIONS.

(a) Intermittent Series.

Observations on the rate of cooling of the kata thermometer were made at different times on different days during the summer months and the results obtained are given in Table V.

TABLE V.—Record of atmospheric conditions in weaving sheds during the summer months.

Shed.	Ob- serva- tions.	Temperature (° F.).				Cooling Power.				Cool- ing due to Eva- pora- tion.	Air Velo- city (ft. per min.)
		Dry Bulb.	M.V.	Wet Bulb.	M.V.	Dry Kata.	M.V.	Wet Kata.	M.V.		
A	33	72.7	2.8	68.7	2.6	4.7	0.6	14.2	1.1	9.5	24
B	22	77.5	2.1	73.4	1.4	3.8	0.5	12.7	0.9	8.9	24
C	33	76.1	2.2	71.8	1.6	3.9	0.4	13.4	0.8	9.5	19
D	24	75.3	2.9	67.8	2.4	4.7	0.7	13.6	1.3	9.3	39
E	20	71.3	3.0	64.8	1.9	4.7	0.6	14.1	0.8	9.4	18
Av. A-E	—	74.6	—	69.3	—	4.4	—	13.6	—	9.3	25
X	31	75.5	1.5	73.3	1.2	4.3	0.3	12.0	0.9	7.7	27
J	24	72.1	2.1	62.8	1.3	5.0	0.5	17.3	1.2	12.3	28

In considering these results it must be remembered that the summer of 1920 was unusually cool and wet, so that the shed temperatures were lower and the rates of cooling of the dry kata correspondingly higher than the average. From this point of view the observations were made under exceptionally favourable summer conditions and must be interpreted accordingly.

Taking Sheds A to E, for which both winter and summer readings are available, the results show that the average dry bulb temperature at the time of the observations was 74.6° F. in summer, or 4.8 degrees higher than the corresponding temperature for the winter months. The average wet bulb temperature was 69.3° F., or 4.1 degrees higher than the average for the winter months. Thus the difference between the wet and dry bulb temperatures for the winter readings was slightly less than for the summer, though well outside the limit specified (3.5 degrees at a dry-bulb temperature of 75°) in the Cotton Cloth Factory Act of 1911.

The effect of the higher summer temperature upon the rate of cooling of the dry kata is distinctly noticeable; this varies from 3.8 in Shed B to 4.7 in Sheds A, D and E, and the average for Sheds A to E is 4.4, or 1.0 less than the corresponding value

for the winter months. Thus the rate of cooling of the dry kata during the summer months is considerably below the standard (6.0) suggested by Hill.

The average rate of cooling of the wet kata in the same sheds is 13.6, as compared with 15.0 for the winter months. This again is much below the standard suggested (18.0), an indication that the normal rate of evaporation of moisture from the body is retarded by the atmospheric conditions in the shed. Air with such low evaporative power is slow to absorb superficial moisture caused by sweating, with the result that the operatives tend to become overheated and decidedly uncomfortable.

During the hot summer months complaints about the high shed temperatures are very numerous and the appearance of the operatives together with the kata readings fully justify these complaints. In another report the effect of atmospheric shed conditions upon efficiency will be considered, but the more important question of their relation to the general health and physical fitness of the operatives, in spite of the work already carried out on the subject, still calls for further study. At this stage it is sufficient to point out that during the summer months the operatives in humid weaving sheds are working under decidedly unnatural and unfavourable conditions, and any devices which will reduce the effects of a high temperature and degree of humidity without seriously impairing productive efficiency should be given a trial, and adopted whenever possible.

Shed J differed from the other sheds in the fact that it was "dry"; *i.e.*, the air in it was not humidified by artificial means. This difference is reflected in the higher wet kata cooling power (17.3) and evaporative power (12.3), as compared with 13.6 and 9.3 for the humid sheds. The temperature also is moderate and the rate of cooling of the dry kata in consequence greater than the corresponding results obtained in the other sheds, but the greatest difference is in the evaporative power.

The higher cooling power in Shed J means that the operatives in this shed will lose heat more readily than those in the other sheds. Sweating will not be so active, since the superficial body moisture will evaporate more rapidly and consequently produce a greater cooling effect. In this respect a "dry" shed is more conducive to bodily comfort than one in which additional moisture is introduced, though the beneficial effects of a greater rate of cooling may be partially neutralised by the effects of atmospheric dust, which is a prominent feature in many dry sheds.

The frequency of occurrence curves (Fig. 5) are constructed in the same way as those for the winter readings, but since they are based upon comparatively few readings they give only an approximate indication of the distribution of the observations obtained from each shed. This distribution appears to approach the normal or symmetrical curve in every case, and a larger number of observations would undoubtedly give such a curve.

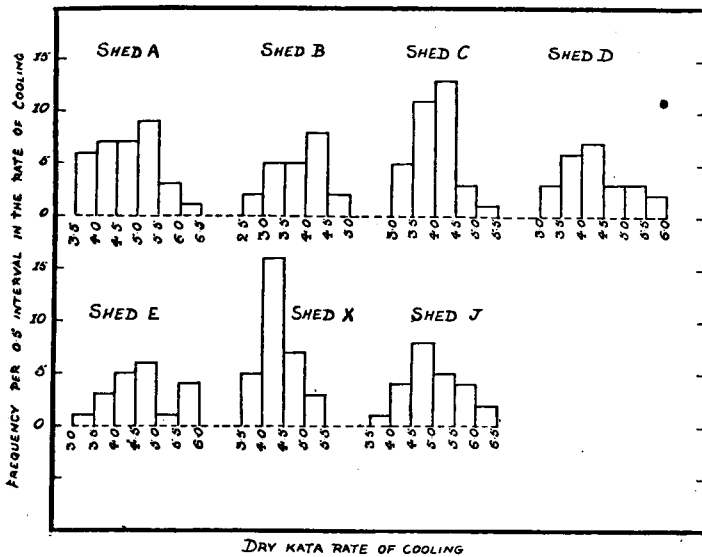


FIG. 5.—DISTRIBUTION OF DRY KATA READINGS ACCORDING TO COOLING POWER (SUMMER RESULTS).

(b) Continuous Series.

Kata readings were taken at approximately hourly intervals on four successive days in shed X and the averages of the results obtained at corresponding times are given in the following table :—

TABLE VI.—Record of atmospheric observations made at approximately hourly intervals during the hours of work in Shed X (Summer.)

Mean Time.	Temperature (° F).		Cooling Power.		Cooling due to Evaporation.	Air Velocity (ft. per min.).
	Dry Bulb.	Wet Bulb.	Dry Kata.	Wet Kata.		
9.25	72.9	71.6	5.1	13.8	8.7	38
10.18	73.9	72.2	4.7	13.1	8.4	29
11.15	74.5	72.3	4.4	12.3	7.9	25
12.2	75.0	72.8	4.3	12.0	7.7	25
1.55	75.3	73.2	4.4	11.8	7.4	29
2.53	76.7	74.3	4.2	11.1	6.9	31
3.51	77.5	75.0	4.0	10.9	6.9	30
4.50	77.9	75.1	4.0	11.2	7.2	31

The above results are represented graphically in Fig. 6.

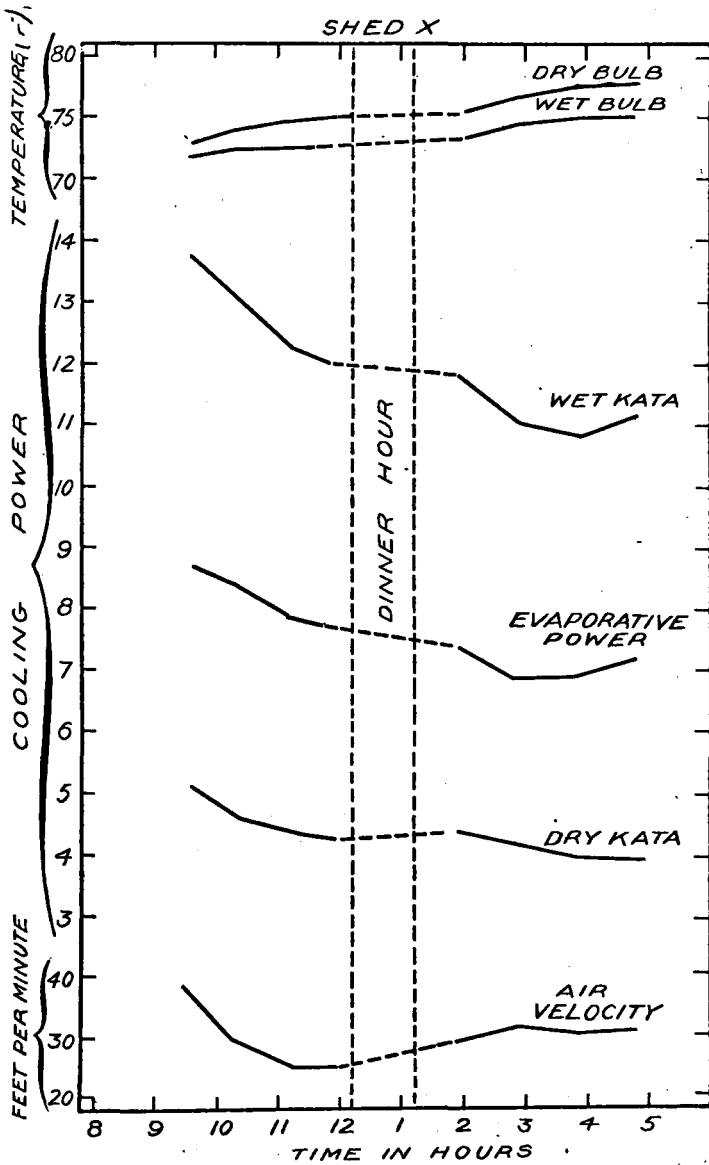


FIG. 6. VARIATIONS IN TEMPERATURE AND COOLING POWER OF AIR.

The general direction of the above curves is very similar to those obtained for the winter months, but the rise in cooling power during the dinner hour, which is characteristic of the winter readings, is not shown because observations were not taken at that time. Thus the wet and dry bulb temperatures rise steadily throughout the working day and corresponding falls are seen in the wet and dry kata readings.

These results show that as regards rate of cooling, the atmospheric conditions are unsatisfactory when work is begun and become progressively worse as the day proceeds. Such conditions may be favourable to the yarn used in the weaving process, but they are unfavourable to the operatives, for they throw a strain on the heat-regulating mechanism of the body and so undoubtedly accelerate the onset of fatigue. In this shed, also the degree of humidity is exceptionally high and the wet kata cooling power is accordingly less than usual. For the same reason the evaporative power of the air is comparatively low, a state of affairs which will accentuate the effects upon the warp and the weaver just mentioned.

(c) *Extended Series.*

Kata readings were taken at 10.30 a.m. and 3.0. p.m. on consecutive working days for a period of nine weeks in Shed A, and the averages for each week are given in Table VII. All the readings were taken in the same position and they are typical of the atmospheric conditions prevailing in this shed during the earlier part of the summer of 1920.

TABLE VII.—*Atmospheric conditions during consecutive weeks in summer in a weaving shed.*

Week Ending.	Temperature (° F.).				Cooling Power.				Cooling due to Evaporation.		Air Velocity (ft. per min.).	
	Dry Bulb.		Wet Bulb.		Dry Kata.		Wet Kata.		a.m.	p.m.	a.m.	p.m.
	a.m.	p.m.	a.m.	p.m.	a.m.	p.m.	a.m.	p.m.				
April 24 ..	64.4	68.3	61.9	65.6	5.9	5.1	18.1	16.0	12.2	10.9	19	15
May 1 ..	63.4	68.9	60.9	66.3	6.0	4.9	17.4	14.9	11.4	10.0	17	14
May 8 ..	66.7	69.3	64.4	66.7	5.8	5.0	16.9	16.3	11.1	11.3	23	15
May 15 ..	67.5	73.9	64.3	71.2	5.6	4.4	16.8	15.1	11.2	10.7	22	22
June 5 ..	67.0	74.5	64.9	71.9	5.5	4.0	16.4	14.0	10.9	10.0	19	15
June 12 ..	68.5	74.2	66.7	70.8	5.4	4.2	16.9	15.1	11.5	10.9	23	19
June 19 ..	71.8	77.4	68.3	71.8	4.6	3.5	14.6	13.6	10.0	10.1	18	15
June 26 ..	72.7	78.6	68.8	74.2	4.4	3.0	14.6	12.1	10.2	9.1	17	16
July 3 ..	72.1	77.5	68.2	72.9	4.3	3.6	14.6	13.6	10.3	10.0	13	18
<i>Average</i> ..	68.2	73.6	65.3	70.1	5.3	4.2	16.2	14.5	10.9	10.3	16	16
<i>M.V...</i> ..	2.7	3.2	2.3	2.6	0.6	0.6	1.1	1.1	0.6	0.5	—	—

These figures show the general decrease in the dry kata cooling power during the successive weeks. This decrease is, of course, caused almost entirely by the corresponding increase in the temperature of the shed. During the earlier part of the period under consideration, the rate of cooling of the dry kata in the morning spells approximates to the standard suggested (6), but later it falls much below this value. The rate of cooling in the afternoon is much lower than in the morning spells—a result which again is largely due to the higher afternoon temperature. During the afternoons of the last three weeks the cooling power is especially low (average 3.4), and in a typical summer it would be still less.

The variations in the wet kata cooling power are very similar and emphasise the fact that the evaporative power of the air is unable to give the relief which is advantageous to operatives exposed to high dry bulb temperatures. Under ordinary atmospheric conditions a rise of dry bulb temperature is usually accompanied by an increase in the difference between the wet and dry bulb readings, but in humid weaving sheds a nearly constant difference between these readings is maintained with the result that the heat lost by the body through the processes of radiation and convection is considerably reduced, and the additional cooling effect produced by the effects of evaporation is impaired because of the high degree of humidity in the shed. Thus all the physical factors appear to conspire to produce unsatisfactory shed conditions during the summer months.

5. Comparison between cotton weaving sheds and other places.

In order to give a clearer conception of the precise significance of the results described in the previous sections of the report, it is of interest to show how the atmospheric conditions in humid weaving sheds compare with the conditions found elsewhere.

TABLE VIII.—*Summary of observations taken in different places.**

Place of Observations.	Temperature (°F).		Cooling Power.		Air Velocity (ft. per min.)
	Dry Bulb.	Wet Bulb.	Dry Kata.	Wet Kata.	
Out of Doors (bright, pleasant day in May)	68	60	7.5	27.2	79
Brass Foundry (good)	72	60	7.3	24.0	119
Machine Shop (bad)	72	61	4.6	15.0	18
Cartridge Annealing and Cleaning (bad)	80.5	64.5	3.0	17.5	16
Cartridge Annealing and Cleaning (good)	60.0	54.5	9.0	24.0	64
Boot Factories (Summer) :—					
Clicking Rooms	67.0	—	6.2	16.8	33
Closing Rooms	66.0	—	6.5	18.3	33
Press Rooms	65.5	—	6.7	17.0	38
Lasting Rooms	67.0	—	6.3	17.5	35
Finishing Rooms	67.0	—	6.5	18.5	41
Shoe Rooms	66.4	—	6.7	18.0	42
Clicking Rooms	61.2	—	7.5	20.2	36
Closing Rooms	64.0	—	7.0	19.9	38
Boot Factories (Winter) :—					
Press Rooms	61.3	—	7.4	20.2	34
Lasting Rooms	62.0	—	7.5	19.8	39
Finishing Rooms	62.3	—	7.7	20.9	46
Shoe Rooms	59.0	—	7.7	19.7	31
Humid Weaving Sheds :—					
Summer	74.6	69.3	4.4	13.6	25
Winter	69.8	65.2	5.4	15.0	27

* "Preliminary Notes on Atmospheric Conditions in Boot and Shoe Factories." (Industrial Fatigue Research Board, Report No. 11, p. 33).

The cooling power of the air in humid weaving sheds (even during the winter months) compares unfavourably with that observed in the other industries given in the table. This is due to the higher temperature and humidity found in humid sheds and indicates that the operatives in these sheds are exposed to adverse physiological conditions which may impair their general health and physical fitness.

A further comparison between cotton weaving sheds and certain other workrooms is given in Table IX. To enable an accurate comparison to be made between summer and winter readings, only the data relating to the sheds investigated over both periods (i.e., sheds A, B, C, D, E) have been included.

TABLE IX.—*Cooling power of air in cotton weaving sheds, potters' shops,* boot and shoe factories,† and laundries.‡ (Percentage frequencies.)*

Dry Kata Cooling Power.	Cotton Weaving Sheds.		Potters' Shops.		Boot Factories.		Laundries.
	Winter.	Summer.	Winter.	Summer.	Winter.	Summer.	
Below 2 ..	0	0	0	0	0	0	19
2 to 2.9 ..	0	1.5	0	6	0	0	17
3 to 3.9 ..	2.5	33.3	3	23 *	0	8	21
4 to 4.9 ..	36.1	45.2	18	34	1	10	19
5 to 5.9 ..	42.4	19.3	40	26	4	19	12
6 to 6.9 ..	17.1	0.7	24	8	28	28	7
7 to 7.9 ..	1.9	0	12	2	35	20	4
8 to 8.9 ..	0	0	3	1	18	9	0.7
9 or more ..	0	0	0	0	14	6	0.3
Total Observa- tions ..	158	135	289	463	377	276	300

* "Two Investigations in Potters' Shops" by H. M. Vernon, M.D. (*Industrial Fatigue Research Board, Report No. 18.*)

† "Preliminary Notes on Atmospheric Conditions in Boot and Shoe Factories," by W. D. Hambly, B.Sc., and T. Bedford. (*Ibid.*, Report No. 11.)

‡ "Some Studies in the Laundry Trade," by May Smith, M.A. (*Ibid.*, Report No. 22.)

Although the number of observations taken in cotton weaving sheds is rather small, they serve to indicate that the conditions in cotton weaving compare very unfavourably with those in boot and shoe factories, and are slightly worse than those in potters' shops, but that they are much superior to those in laundries.

The average air velocity in weaving sheds is 26 feet per minute, while the corresponding values for potters' shops, boot and shoe factories, and laundries, are approximately 19, 36, and 45 feet per minute. The average temperature in weaving sheds is higher than that of potters' shops and much higher than that of boot and shoe factories, consequently temperature is responsible for the lower cooling power of the air in weaving sheds as compared with potters' shops, but in boot and shoe factories a higher rate

of air movement, in addition to a lower temperature, makes the conditions more satisfactory. The temperature in laundries is higher than in weaving sheds, and although the air movement in laundries is about twice that of weaving sheds, it is unable to raise the cooling power to that observed in the latter industry.

6. Miscellaneous Observations.

A. THE INFLUENCE OF MACHINERY AND BELTING AND OF OTHER FACTORS ON AIR MOVEMENT.

As has been already stated, a dry kata cooling power of six is considered to be the minimum standard for workers engaged in sedentary occupations. Since the dry kata cooling power is a function of, (a) the temperature of the air, and (b) the rate of air movement, it can be increased either (a) by lowering the temperature of the shed or (b) by increasing the rate of air movement. The former method has already received much attention from the industry, but the latter has been comparatively neglected. It seemed desirable, therefore, to pay special attention to the subject of air movement, by investigating some of the factors producing it. In addition, a small-scale experiment designed to increase the air velocity in the vicinity of the loom (see Appendix I, p. 30) has been carried out.

In a weaving shed the air is disturbed by the action of the machinery. An attempt was made to determine the effect of the machinery movements upon atmospheric conditions by taking readings during the dinner hour when the machinery was stopped and comparing them with those recorded when the machinery was in motion. In the absence of other disturbing factors, one would expect to find a decrease in the rate of air movement during the dinner hour, but in several instances this theoretical expectation was not realised because of the admission of outside air due to the frequent opening of the shed doors.

Some additional results were obtained during the working period in head level position between looms which were alternately stopped and in motion. The averages of the observations, made in the same position on eight different days are given in Table X.

TABLE X.—*Showing effect of machinery movements on cooling power of air.*

Looms.	Observations.	Temperature (°F).				Cooling Power.				Air Velocity (ft. per min.).
		Dry Bulb.	M.V.	Wet Bulb.	M.V.	Dry Kata.	M.V.	Wet Kata.	M.V.	
Working	8	68.0	1.4	64.6	1.4	6.0	0.3	17.7	0.6	33
Stopped	8	68.2	1.4	64.6	1.4	5.5	0.3	16.7	0.9	22

The results indicate that at the head level of the weaver, the motion of the looms increases the air velocity by 50 per cent., and so brings about an appreciable increase (approximately 9 per cent.) in the cooling power of the air. The rate of cooling of the wet kata is also increased from 16.7 to 17.7, or 6 per cent. These increases were due chiefly to the movement of the sley which moves backwards and forwards a distance of approximately one foot in a horizontal plane at a rate of 100 complete oscillations per minute.

In the shed in which these observations were made the looms had the individual form of electric drive and the belting which usually forms such a conspicuous feature of a weaving shed was absent. In most weaving sheds steam power is used and the power is transmitted from overhead line-shafts to each loom by means of belting. It appeared probable that the movement of the belting would affect the cooling power of the air in its vicinity and an attempt was made to determine the nature and extent of this effect by taking readings in positions at varying distances from the belting. Six observations were made on different days in each position and the averages of the results obtained are given in Table XI.

TABLE XI.—*Showing effect of belting on cooling power of air.*

Distance from Belt.	Temperature (°F.).				Cooling Power.				Air Velo- city (ft. per min.).
	Dry Bulb.	M.V.	Wet Bulb.	M.V.	Dry Kata.	M.V.	Wet Kata.	M.V.	
3 ins.	66.2	1.7	62.8	1.2	7.0	0.7	20.1	1.6	49
6 ins.	66.6	1.6	62.8	0.8	6.9	0.6	19.5	1.1	49
9 ins.	66.6	1.5	63.3	1.1	6.7	0.7	18.8	1.5	44
12 ins.	66.9	1.7	63.5	1.4	6.4	0.7	17.6	1.1	37
10 ft.	67.1	1.7	63.7	1.5	5.7	0.4	16.3	0.8	23

Thus the cooling power of the air increases as the distance from the belting diminishes, and since the temperature remains almost constant, this increase is due to the increased air velocity.

The effective range of the air disturbances caused by the belting is considerably greater than one foot, since at that distance the air velocity is still 65 per cent. greater than that in a position ten feet from the belting and entirely outside its influence. In a position three inches from the belting the increase in air velocity is about 100 per cent., causing an increase in cooling power of 20 per cent. In this respect a steam-driven shed appears to have, a slight advantage over one having the individual electric drive, though this may be easily neutralised by other factors.

Another possible method of improving the atmospheric conditions in humid weaving sheds consists in a system of ventilation in which conditioned air is used. By means of suitable apparatus the temperature and humidity of the incoming air can be controlled and its velocity regulated. An apparatus which is said to *maintain* a dry bulb temperature of 72.5 and a relative humidity of 80 per cent. throughout the summer months is now on the market. This apparatus also controls the velocity of the incoming air, and consequently seems worthy of consideration.

The cooling power of the air in the vicinity of the looms has also been increased by attaching a strip of canvas to the heald roller. The method adopted and the results obtained are fully described in Appendix I (page 30).

B.—COMPARISON BETWEEN HEAD AND FLOOR LEVEL.

In one of the sheds mentioned in this report (Shed A) observations on the cooling power of the air were made at floor level. A comparison of these with others obtained at head level in the same shed is given in Table XII.

TABLE XII.—*Cooling power of air at head and floor levels.*

Level.	Ob- serva- tions.	Temperature (° F.).				Cooling Power.				Air Velo- city.
		Dry Bulb.	M. V.	Wet Bulb.	M. V.	Dry Kata.	M. V.	Wet Kata.	M. V.	
Head ..	40	70.7	2.5	65.8	2.5	5.4	0.6	14.8	1.2	31
Floor ..	16	69.3	2.1	65.7	1.7	5.9	0.5	15.0	1.1	37

It will be seen that the dry kata cooling power is greater at floor level than at head level. This difference is due both to the increased movement of the air and to the slightly lower temperature at floor level.

These results show that the feet tend to be cooled more rapidly than the head. Normally, the head should be slightly cooler than the feet, and in this respect the heating and humidifying arrangements in humid weaving sheds probably act adversely upon bodily comfort and efficiency. A higher temperature and degree of humidity at floor level would also be more in accordance with the technical requirements of weaving.

C.—THE EFFECT OF MOVING AIR UPON SKIN TEMPERATURE.

A few experiments were made in a closed laboratory in order to illustrate the effects of moving air upon the temperature of the cheek. The subject was seated three feet from a small fan

and had one cheek exposed to the current of air created by the fan. The temperatures of both cheeks were taken simultaneously at intervals of two minutes by means of maximum reading surface temperature thermometers, and the following are typical of the results obtained.

TABLE XIII.—*The effect of air movement upon skin temperature.*

Series 1.					Series 2.				
Temperature (° C.).			Fan.	Air Velocity (ft. per min.).	Temperature (° C.).			Fan.	Air Velocity (ft. per min.).
Room.	L. Cheek (Exposed).	R. Cheek.			Room.	L. Cheek (Exposed).	R. Cheek.		
20.2	34.3	34.6	Stopped	—	20.4	34.3	34.5	Stopped	—
"	33.4	34.4	Running	39	"	32.3	34.3	Running	70
"	32.8	34.6	"	"	"	31.8	34.3	"	"
"	33.0	34.5	"	"	"	31.8	34.4	"	"
"	32.8	34.6	"	"	"	32.0	34.0	"	"
"	32.8	34.5	"	"	"	31.7	34.3	"	"
"	32.3	34.6	"	"	"	32.1	34.2	"	"
"	32.4	34.5	"	"	"	31.3	34.2	"	"
"	32.3	34.3	"	"	"	31.5	34.2	"	"

The increased movement of the air causes an appreciable decrease in the temperature of the exposed cheek, which is maintained throughout the duration of the experiment (about 20 minutes), whereas the temperature of the protected cheek remains nearly constant. A velocity of approximately 70 ft. per minute produces a slightly greater decrease than one of 39 ft. per minute, but in both cases the effect of the increased velocity is very quickly seen.

These results are merely suggestive, and a more extensive and varied series is necessary in order to show the effect of prolonged exposure to air movement and the probable reaction which takes place when the fan is stopped.

The maintained difference in temperature between the two cheeks indicates that within the limited duration of the experiment the increased cooling effect is restricted to the area of the skin exposed to the current of air, and that this difference in local temperature is chiefly responsible for the perception of air movement.

Observations on the body temperature of weavers in humid weaving sheds by Legge,* and Pembrey and Collis,† show that the effect of a warm moist atmosphere is to "diminish the difference between the internal temperature of the body and that of the

* Second Report of the Departmental Committee on Humidity and Ventilation in Cotton Weaving Sheds, 1911, p. 15.

† *Ibid.* p. 24.

peripheral parts." In other words, the surface temperature of the body is increased until it approximates to the internal temperature. Such a condition maintained over a long period is physiologically harmful, and consequently an arrangement which will counteract the rising tendency of the surface temperature of the body will probably have a beneficial effect. The above results show that an increase in the rate of air movement will secure this effect, and the practical application of this principle to humid weaving sheds deserves consideration.

D.—NOTES ON CLOTHING.*

The question of the most suitable kind of clothing for operatives in weaving sheds does not appear to have received the attention it deserves. Since the maintenance of a state of equilibrium between the rates at which the body produces and loses heat is of vital importance, it becomes necessary to consider all the factors which tend to modify this state. Clothing is undoubtedly one of the most important of these, and the miscellaneous assortment worn by operatives in weaving sheds suggests that some clothes are much more suitable than others in their effect upon bodily comfort and efficiency.

Hill has shown that a naked man loses heat twice as rapidly as one clothed, but in the latter case the rate of heat loss depends upon the nature and amount of clothing worn. Thus, if the radiant heat emitted from the naked skin in a room at 59° F. is taken as 100, it is reduced by:—

a wool vest to 73,
a wool vest and linen shirt to 60,
a wool vest, linen shirt and waistcoat to 46.†

Further, the dry kata cooling power when the bulb of the kata was covered with the following materials was found to be—‡

			Knitted Wool.	Silk.	Open Cotton Mesh.	Close Cotton Mesh.	Naked.	Temp. (°F.)
In room	..	..	4.8	6.0	6.1	5.7	6.1	60-63
In wind§	..	..	7.0	11.1	12.0	11.1	10.8	64-65

Thus the rate of heat loss is appreciably affected by the material used, and the superiority of a fabric with open mesh is clearly shown. The properties of a garment have been found to depend almost wholly upon the manner of its weaving, and not upon the kind of material. Experiments by Flack and Hill|| have led them

* This section of the report is an attempt to apply some of the facts given in "The Science of Ventilation and Open-Air Treatment," Parts I & II, by Leonard Hill, M.D., F.R.S. (*Medical Research Council, Special Report Series, Nos. 32 and 52*). The footnotes refer to the pages in these books.

† Part II, p. 226.

‡ Part II, p. 239.

§ Velocity 3 ft. per second approximately.

|| Part II, p. 244.

to state that "It made little difference whether the shirt was cellular cotton or flannel or flannelette, the protection from cooling depending on the restriction of ventilation, not on the nature of the material."

In weaving sheds, especially during the summer months, the temperature frequently exceeds 80° F. The human body strives to maintain itself at a temperature of 98·4° F. As the shed temperature rises, heat lost by radiation and convection becomes proportionately reduced, and in the case of very high temperatures, almost all the heat lost is by the process of evaporation. To promote evaporation, the rate of movement of the air in contact with the body must be increased, but in weaving sheds air movement is comparatively slight. As a result the air in the meshes of the clothing and between the clothing and the surface of the body, tends to approximate to body temperature and becomes saturated with moisture. In this respect it resembles the atmosphere of a moist, tropical climate, and retards very considerably the rate of heat loss from the body. "Every hindrance to heat loss either reduces bodily exertion or causes the exertion to be done under a feeling of oppression and a burden of weariness,"* hence it seems highly probable that the bodily comfort and efficiency of the weavers is impaired, especially during the summer months, by the unsuitability of the clothing worn in many cases. "There are hot, moist mines where the day's working power of the white is reduced by the strain on his heat losing mechanism to no more than the equivalent of two hours' labour performed out of doors."† Although the nature of the work in a weaving shed is very different from that performed in a mine, the effect upon the operatives will be similar in kind but different in degree.

In the case of male operatives, a certain amount of relief is obtained by exposing the arms and chest to the air, but in the case of the women this is not done to the same extent. Inadequate heat loss involves the use of the sweating mechanism, the prolonged operation of which throws a definite strain on the circulation, *i.e.*, on the heart. For use in weaving sheds, light clothing, permeable to air, which promotes evaporation, is the most suitable, such as loose cotton garments and material having a cellular structure. Before passing into the outside air, thicker and warmer clothing should be added. This additional garment should be kept in a suitable cloakroom and not in the weaving shed as is frequently the case. When kept in the shed it becomes humidified by the steam used for humidification purposes, and although at the temperature of the shed it may appear to be fairly dry, when exposed to the cooler outside air the water vapour absorbed by the material condenses and the garment becomes damp. The evaporation of this moisture lowers the temperature,

* Part I, p. 56.

† Part I, p. 59.

of the parts in contact with it, and the cooling effect thus produced causes chilling which is prevented by an outer dry garment. In the matter of keeping warm wool has an advantage over other textiles while wet, since it does not cling to the body and entangles air under its elastic fibres. The clothing question is an important part of the field of industrial hygiene, and the operatives should receive advice and instruction in this connection. In the near future it will probably form an important feature in the welfare scheme, but whatever organisation eventually becomes responsible for its development, the importance of this aspect of industrial life cannot be denied.

The rate of heat production varies in different individuals, and in the same individual under different conditions. Weavers accustomed to working in hot moist atmospheres have their rate of heat production reduced, and when outside the shed feel the cold more than the average person. The paleness of the skin usually associated with weavers is largely due to the same cause. Under fairly uniform atmospheric conditions, the body tends to become adapted to its physical environment, and although the exposed parts of the body may be at a lower temperature than those which are clothed, the difference is not perceived by the individual. The changes experienced in passing from the street to the weaving shed illustrate this point. Prolonged exposure to the shed conditions causes a readaptation in body temperature, and if the shed is not uncomfortably hot, the body temperature again appears to be uniform and the differences perceived on entering disappear. It seems probable that the weavers become better adapted to the higher temperature, humidity, and uniformity of air movement which usually prevail in humid weaving sheds, and conditions which cause discomfort to the new arrival are borne with equanimity by the experienced weaver. Adaptation to abnormal atmospheric conditions does not necessarily imply the existence of a normal state of health, and it is hoped that a study of sickness records will yield conclusive evidence in this connection.

"Monotony of the atmospheric conditions and the reduction of the body metabolism by diminished rate of cooling, with the consequent loss of nervous tone and disordered digestion, are, we believe, the chief causes of the ill-effects of confined sedentary occupations."*

Hill states that in order to work comfortably at 77° F. with a relative humidity of 47 per cent., a man requires a wind of 0.5 to 1.0 metres per second.† In humid weaving sheds in which the humidity is much higher, the air velocity is generally about

* "The Measurement of the Rate of Heat Loss at Body Temperature by Convection, Radiation and Evaporation," by L. Hill, F.R.S., C. W. Griffith and Martin Flack. *Phil. Trans. of the Royal Society, B.* Vol. 207, 1916, p. 184.

† Part I, p. 137.

one-third of this value. The body is also stimulated by temperature changes, but in weaving sheds the variations in temperature are slow and gradual. As a result a state of equilibrium is established between body temperature and the atmospheric conditions in the shed, and the stimulating effect of variations in temperature is entirely lost. "The adequate movement of the air makes a high wet-bulb temperature much less oppressive, and thus by ensuring sufficient movement a humidity can be secured for trade purposes which otherwise would be uncomfortable and deleterious to work-people."* The experiments with the strips of canvas attached to the heald rollers (*see* p. 30), produced variations in the surface temperature of the body by modifying the rate of air movement in its vicinity, and the principle involved is worthy of further development and application.

7. Summary.

1. For workers engaged in sedentary occupations, a dry kata rate of cooling of 6 and a wet kata rate of cooling of 18 are considered to be the desirable minima. In humid weaving sheds these standards are seldom reached. (pp. 5, 8, 14, 15, 17, 19.)

2. During the winter months, when the shed temperatures are comparatively low, the average dry and wet kata readings are approximately 5 and 15 respectively. These conditions appear to be sufficient to prevent visible sweating in the case of the operatives, yet the air is fairly stagnant and fails to have the effect usually associated with pleasant conditions in the open air. (pp. 5, 6.)

3. During the summer months the cooling power of the air in the sheds is considerably reduced, and is much below the standards given above. The operatives are exposed to atmospheric conditions which are physiologically unsatisfactory and devices which will protect them from the effects of the prevailing high temperatures and humidities should be adopted whenever possible. (p. 15 to 20.)

4. Whenever the cooling power of the air is insufficient to prevent visible sweating on the part of the operatives, the low evaporative power, produced by the admission of steam, is unable to give the relief needed by operatives exposed to high dry bulb temperatures. Under more ordinary conditions an increase in the dry bulb temperature is usually accompanied by an increase in the difference between wet and dry bulb readings, but in humid weaving sheds a constant difference between these readings is maintained, with the result that the heat lost by the body through the processes of radiation and convection is considerably reduced, and the additional cooling effect produced by evaporation is impaired because of the high degree of humidity in the shed. (pp. 16, 20.)

* *Phil. Trans.*, op. cit., p. 213.

5. In general, the results obtained in the different sheds show that the cooling power of the air becomes distinctly unsatisfactory when the shed temperature exceeds 70° F. For higher temperatures, a satisfactory cooling power can only be obtained by increasing the rate of air movement. (pp. 5, 8, 15, 17, 30.)

6. Considerable differences in the cooling power of the air exist in the different sheds. Since all the sheds are exposed to fairly similar outside atmospheric conditions, the shed temperatures and humidities, and consequently the cooling power of the air in the sheds, are, within limits, under the control of the management, and the differences observed are largely due to the different quantities of steam which are forced into the sheds for humidification purposes. (pp. 5, 15.)

7. Hourly observations show that the cooling power of the air in the sheds decreases during the morning spell, rapidly at first but more slowly afterwards. During the dinner hour an increase is noticeable which is followed by a gradual fall during the afternoon spell. Thus atmospheric conditions which may be favourable at the beginning of the working day become more unfavourable as the day proceeds. (pp. 8, 17.)

8. Machinery movements cause an appreciable increase in the cooling power of the air in the vicinity of the operatives. The increase, even though imperceptible, yet cannot fail to have a beneficial physiological effect. (pp. 22, 23.)

9. The cooling power of the air in humid weaving sheds compares unfavourably with the rate of cooling observed in the other industries mentioned in this report. (pp. 20, 21.)

10. The air movement in the vicinity of the weaver can be increased by attaching a three-inch strip of canvas to the heald roller on the loom. This device is inexpensive and easily attached, and is able to maintain a cooling power above the necessary standards for high shed temperatures. Owing however to the fact that the weaver when examining the warp sometimes places her head near the heald roller, the device described would probably have to be modified in practice. (pp. 30, *et seq.*)

APPENDIX I

AN EXPERIMENT IN INCREASING THE COOLING POWER OF AIR IN A HUMID WEAVING SHED.

In this experiment an attempt was made to apply the principles already described to the conditions at present existing in humid weaving sheds. For this purpose the rate of air movement, and consequently the cooling power of the air in the vicinity of the weaver was increased by attaching strips of material of various widths to the heald roller, as shown in Figs. A and B.

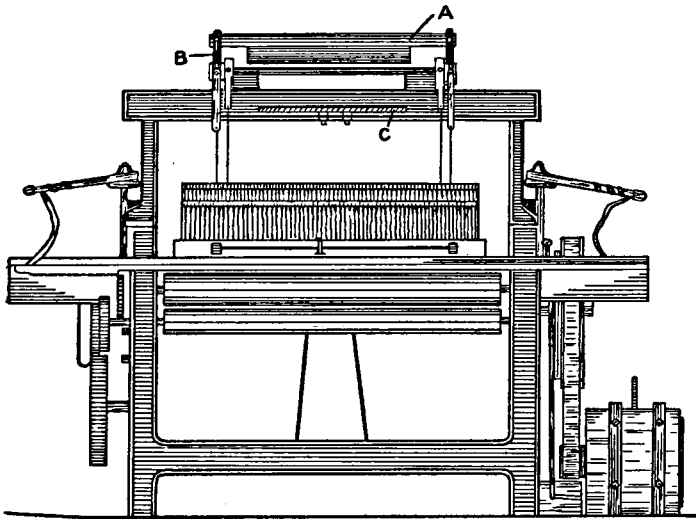


FIG. A.

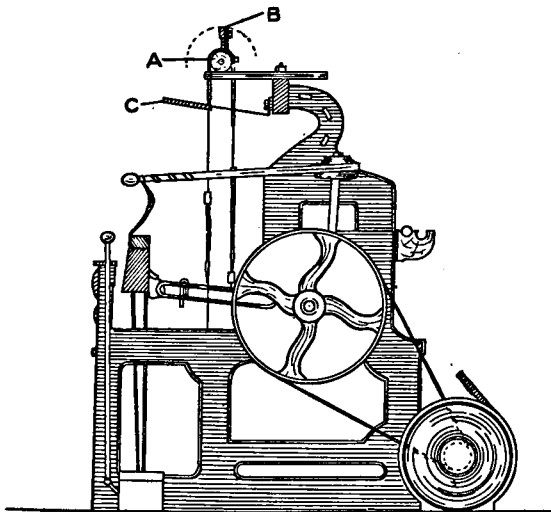


FIG. B.

The boards (B) used were $2\frac{1}{2}$ feet long and when the loom was in motion oscillated through an angle of 180° at a rate of 100 complete oscillations per minute. A fixed board (C) deflected the air towards the weaver and at the same time protected the warp. Such an arrangement was attached to opposite looms and observations on the cooling power of the air were made in different positions between the looms.

The results, based on eight observations in each position, are given in Table A :—

TABLE A.—*Showing effect on cooling power of air of device for increasing air movement (Boards).*

Conditions.	Temperature (°F.).		Cooling Power.		Air Velocity (ft. per min.).
	Dry Bulb.	Wet Bulb.	Dry Kata.	Wet Kata.	
Between Looms :					
Looms stopped	68·2	64·6	5·5	16·7	23
Looms working	68·0	64·6	6·0	17·7	33
3-in. Board on Looms ..	68·0	64·6	6·9	20·2	58
Three inches from Board C :					
3-in. Board on Looms ..	68·2	64·6	9·3	25·9	164

It will be seen that although the temperature remains constant, a large increase in the rate of cooling takes place, due to the greatly increased air velocity. Even at a point midway between the looms where the effect of the boards on the weaver is at a minimum, the air velocity is nearly doubled and the dry kata rate of cooling is raised from 6·0 to 6·9 (15 per cent.) by means of the three-inch board.

Frequently the weaver is much nearer the moving strips, especially when she is stooping over the warp in order to repair breakages. In such cases the proximity of the source of air movement causes an increased cooling effect, as will be seen from a comparison of the above results with those obtained at a distance of three inches from the fixed board C. The wet kata cooling rate is also favourably affected by the increased air movement, though the rate of increase is not quite as great as in the case of the dry kata.

During the tests, the air movement produced by the three-inch board was distinctly pleasant and much to be preferred to the comparatively warm, stagnant feeling which was noticeable when the looms stopped.

Although a three-inch strip will not raise the dry kata cooling rate to 6 during the very high temperatures which prevail in weaving sheds during the summer months, it will materially increase the cooling power, and therefore add to the comfort of the operatives.

Since there is a possibility of the three-inch board striking the weaver, experiments were made with a protective device attached to the loom (*see* Figs. C and D), consisting of a semi-circular tin shield (D) which entirely covered the moving board with the exception of an opening two inches wide at the front end of the shield. The air was driven through the opening by the moving board and deflected towards the weaver by a horizontal board (C) placed under the shield and projecting about two inches in front of it.

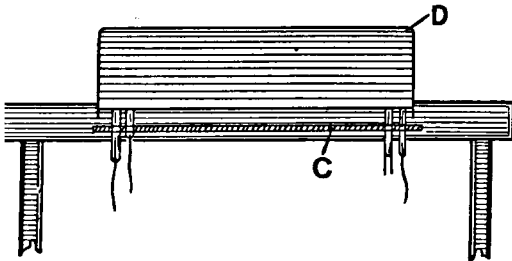


FIG. C

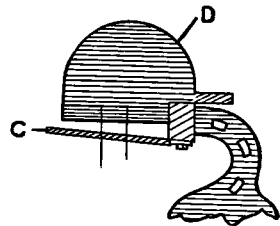


FIG. D.

The results obtained in this experiment are given in Table B.

TABLE B.—*Showing effect on cooling power of air of device for increasing air movement. (Board and shield).*

Conditions.	Temperature (°F.)		Cooling Power.		Air Velocity (ft. per min.).
	Dry Bulb.	Wet Bulb.	Dry Kata.	Wet Kata.	
Looms stopped	71.8	68.5	4.7	14.4	20
Looms working	71.8	68.5	5.3	16.1	34
3-in. Board on Looms.. ..	72.2	68.5	5.6	19.1	47
3-in. Board 3 in. from Looms	72.3	68.7	7.4	22.2	123

The general effect of these conditions is similar to that observed in the previous table, but the rate of cooling does not increase at the same rate as in the last experiment. The protective device appears to reduce the rate of the air current deflected towards the weaver, and a noticeable increase in the cooling power of the air was observed when the cover was removed. The metal shield also looked somewhat unwieldy, and it was thought advisable to dispense with this arrangement.

An experiment was then tried with a stiff canvas about three inches wide attached at the ends to two metal supports on the heald roller; the horizontal board being still retained to deflect the air towards the weaver. The following are the results obtained with this arrangement :—

TABLE C.—*Showing effect on cooling power of air of device for increasing air movement. (Canvas strips).*

Conditions.	Temperature (°F.).		Cooling Power.		Air Velocity (ft. per min.).
	Dry Bulb.	Wet Bulb.	Dry Kata.	Wet Kata.	
Looms stopped.. ..	72.7	68.7	4.6	13.4	21
3-in. canvas on: Looms working	73.3	68.2	9.0	25.9	243
3-in. canvas 3 in. from Loom..	72.5	68.4	10.7	30.3	346
Cover on: Looms working ..	73.0	68.7	5.4	16.0	46
Cover on: 3 in. from opening	73.0	69.8	8.2	25.2	193

The above results indicate the increased cooling effect produced by the exposed strip of canvas. The rate of cooling of both the wet and dry kata is raised well above the standards recommended for persons engaged in sedentary occupations, and even with a shed temperature of 80° F. the rate of cooling of the dry kata would still be about 6.4 in a position midway between the looms. The effect of enclosing the canvas in the metal shield is clearly seen in the results and confirms the advisability of dispensing with the shield arrangement. The exposed strip of canvas seems to be the best arrangement yet tried and has the additional advantage of being simple, cheap, and easily attached to the looms. Owing, however, to the fact that the weaver when examining the warp sometimes places his head near the heald roller, the device described would probably have to be modified in practice.

APPENDIX II.

INSTRUCTIONS FOR USING THE KATA-THERMOMETER.

The observations dealt with in this report were taken by means of the kata-thermometer, an instrument designed to measure its own rate of cooling at a temperature approximately that of the human body. The kata-thermometer has an alcohol reservoir in the form of a cylindrical bulb about 1½ in. long, and ¾ in. in diameter. The stem, which is graduated in tenths of a degree from 95° to 100° Fahrenheit, has at the top a small bulb which acts as a safety overflow when the thermometer is heated.

Readings are taken with the kata used both as a dry bulb and as a wet bulb thermometer. Dry readings are taken by immersing the large bulb of the kata-thermometer in water having a temperature of about 180° F., until an unbroken column of the spirit has risen half way up the safety bulb. The alcohol rises slowly when first the reservoir is immersed in hot water, but this slow movement is followed by a sudden rise, and care is necessary in order to avoid fracture of the safety bulb. The instrument is cooled for a minute so as to enable the glass to get into equilibrium. Then the thermometer is re-heated, and after bulb and stem have been wiped quite dry, the kata is placed in the desired position, preferably suspended from a stand. The time in seconds which is occupied by the thermometric liquid in falling from 100° to 95° F., *i.e.*, through a range of temperature approximating to that of the human body, is noted by means of a stop watch. From three to five readings are, as a rule, sufficient for calculating an average rate of fall, from which the rate of cooling is estimated, though a larger number of observations of rates of fall is advisable when the kata-thermometer is used in positions where puffs of wind alternate with calm intervals. The same procedure is followed when "wet readings" are taken, excepting that a tightly fitting cover of Lisle silk knitted glove is stretched over the reservoir of the kata-thermometer. Excess of moisture is jerked off before the instrument is suspended for observation.

The average time of fall thus obtained gives an indication of the rapidity with which heat is lost by the particular instrument used, but owing to such variables as the thickness of the glass, and slight variations in surface area, two different instruments would give different times of fall, even under identical circumstances and methods of experiment. Readings are standardised, so that the rate of heat loss can be expressed in heat units per unit area per second, by using a "kata factor" ascertained for each instrument before it leaves the maker; this factor, which is stamped on the stem near to the top bulb, is found by determining the water equivalent of the thermometer, and actually represents the amount of heat in milli-calories per square centimetre of surface required to raise the thermometer from 95° F. to 100° F. Hence by dividing the factor by the number of seconds taken by the fluid in falling through this range of temperature, the rate of heat loss in milli-calories per square centimetre per second is obtained.

Example.—Suppose that the average of five readings of the time taken by the column to fall from 100° F. to 95° F. is 91 seconds, and that the kata factor marked on the stem of the instrument is 476. Then 476 is divided by 91, giving 5.2, which is taken to represent the cooling power of the air at that time and place.

It should be noted that when the temperature of the air exceeds 95°, the cooling power cannot be estimated, and is in fact zero or even a negative quantity. Even at somewhat lower temperatures the estimation is difficult, owing to the long time required by the column to fall. In such instances, it is generally sufficient to note that the cooling power is less than a specified value (such as 2).

For the calculation of "air velocity," the temperature as well as the cooling power of the air is required. It is, in fact, generally desirable, whenever kata readings are made, to obtain simultaneous readings of the temperature (if possible both dry and wet bulb) both inside the building in the same part where the kata is used, and outside the building in the open air.

To obtain the air velocity (in feet per minute) the cooling power of the air (determined as described above) is divided by the difference between 97.7 and the observed temperature in degrees Fahrenheit. The resulting quotient is looked for in the table given below in one of the columns headed $\frac{H}{\theta}$, and the figure opposite in the column marked V is the value required.

If the quotient is intermediate between two values of $\frac{H}{\theta}$, the value of V can be easily estimated by interpolation.

Example.—Suppose that in the example already given, the observed temperature of the air was 75.5° F. The cooling power, 5.2, is divided by 97.7–75.5, i.e., 22.2, giving 0.234. This figure is intermediate between 0.23 and 0.235 in the first column of the table, and it can be easily seen that the corresponding value for the air velocity is 60 feet per minute.

The following table shows the values of V for different values of $\frac{H}{\theta}$. Intermediate values can be quickly found by interpolation.

Air velocities for varying values of $\frac{H}{\theta}$ (British Units).

$\frac{H}{\theta}$.	V.	$\frac{H}{\theta}$.	V.	$\frac{H}{\theta}$.	V.
.155	8	.27	100	.39	280
.16	10	.275	106	.395	289
.165	12	.28	113	.40	298
.17	14	.285	120	.405	307
.175	16	.29	127	.41	316
.18	19	.295	134	.415	325
.185	22	.30	141	.42	335
.19	25	.305	148	.425	345
.195	28	.31	156	.43	355
.20	32	.315	164	.435	365
.205	35	.32	172	.44	375
		.325	181		
.21	39	.33	190	.445	386
.215	43	.335	198	.45	396
.22	47			.455	406
.225	52	.345	207	.46	417
.23	56	.35	214	.465	428
.235	61	.355	222	.47	439
.24	66	.36	230	.475	450
.245	71	.365	238	.48	461
.25	76	.37	246	.485	473
.255	82	.375	254	.49	484
.26	88	.38	262	.495	496
.265	94	.385	271	.50	508

Note.—The above table is based on the following formulae, giving the relation between dry kata cooling power, temperature and air velocity.

For air velocities greater than 8 but less than 200 ft. per minute:—

$$\frac{H}{\theta} = (0.11 + 0.016 \sqrt{V})$$

For air velocities greater than 200 ft. per minute:—

$$\frac{H}{\theta} = (0.072 + 0.019 \sqrt{V}).$$

where H = dry kata cooling power (found by dividing the "kata factor" by the time in seconds taken by the fluid in falling from 100° to 95° F.).

θ = (97.7– t) where t = air temperature in degrees Fahr.

V = air velocity in feet per minute.

Similar formulae hold in regard to wet kata cooling power and air velocity, but these lend themselves much less easily to calculation.

2

**MEDICAL RESEARCH COUNCIL
INDUSTRIAL HEALTH RESEARCH BOARD**

REPORT No. 67

**MANUAL DEXTERITY—EFFECTS
OF TRAINING**

**I. Transfer of Training in Manual
Dexterity and Visual Discrimination**

By E. M. Henshaw, P. Holman and J. N. Langdon

**II. Distribution of Practice in
Manual Dexterity**

By E. M. Henshaw and P. Holman

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PREFACE.

This Report, which is issued on the recommendation and with the approval of the Committee on Industrial Psychology of the Industrial Health Research Board, embodies the first published results of research in connection with problems which have engaged the attention for several years of some of the Board's investigators, namely—

- (1) the extent to which training in one kind of manual skill can be transferred to another and apparently similar type of dexterity and,
- (2) in the case of a simple manual operation, the effect on the rate of acquisition of such dexterity of various lengths and distributions of spells of practice.

Both these problems have a direct bearing on the technique of training, which is recognised as an important branch of industrial management. Many thousands of adolescents are constantly under instruction in factories and workshops throughout this country. It would be a definite advantage to those responsible for such training if it could be established that manual skill acquired in one form of work helped young persons to excel in similar operations.* The disadvantages of specialisation would be lessened, and the onset of monotony, resulting in boredom, could sometimes be avoided, by an exchange of "hands" between different departments in the same factory, thus reducing the turnover of labour. It has been suggested that the acquisition of one kind of dexterity may actually retard the rate of acquisition of another apparently similar type of manual skill (i.e. "negative transfer"). It is important to establish by scientific methods whether this suggestion is supported by observed facts. It may be said at once that nothing in this Report tends to confirm such a supposition.

Furthermore, whilst those responsible for the training of employees have acquired by empirical methods some information as to the optimum number and length of practice periods, it is important to supplement experience thus gained by studies derived from carefully devised tests, scientifically conducted and controlled. On this subject some light is thrown by the results of the second investigation.

Much attention has been devoted to the elucidation of these fundamental problems in the domain of scholastic education, but little regard has hitherto been paid to the cognate problems, of equal importance, relating to education in manual functions. To such studies the present Report is a serious and valuable contribution. It is based upon experiments conducted in the Psychological Laboratory of the University of Manchester, and the methods chosen were simple industrial operations.

* The production of such an effect is known, in technical language, as "positive transfer".

In all the experiments the subjects were boys, arranged by a preliminary test so as to constitute groups of approximately equal ability. They were all given an equal and adequate incentive to do their best in the tests, but were in other respects working under rigid experimental conditions.

The experiments dealt only with low-grade dexterities, and do not profess to throw any light on the question of "transfer" between highly-complicated skills or between performances which involve the formation of ideas of methods, or produce sentiments and ideals.

In the first investigation, boys trained in chain-assembling were tested in order to ascertain whether they were quicker and more accurate at certain other operations (known as "the transfer-tests") than boys not so trained. These tests were in themselves manual dexterity tests, mostly involving the component movements actually contained in the chain-assembling operation. (This is called in the Report the "successive transfer experiment".)

In the second experiment, the groups learned the chain-assembling operation together, but one had in addition extra training in cartridge-filling, an operation similar in its movements to chain-assembling, the object being to see whether any improvement in chain-assembling could be attributed to the effect of cartridge-filling. (This is called in the Report "the simultaneous transfer experiment".)

Lastly, an endeavour was made to find out whether training in visual discrimination gave any "effects of transfer", the criterion used being the estimation of the sizes of steel balls.

The second investigation studied the degree of proficiency attained as the result of different periods of practice. It also showed the relation between rate of working and length of spell.

The results of the first investigation afforded no decisive evidence of "positive transfer" of skill: it is, however, possible that in the "successive transfer experiment", conducted in the course of the second investigation, such a "transfer" might have occurred as a result of a longer period of training.

As already stated, the latter investigation afforded no evidence of "negative transfer", a result which on general grounds must be regarded as gratifying, for it has been stated, on very high authority,* that "in the rapid development of industry from hand-work to repetitive machine-work, workmen are in some danger of losing their training as craftsmen except in one particular and narrow field". The investigations seem to indicate that this tendency is not irremediable.

* Board of Education. Report of the Consultative Committee on the Education of the Adolescent, 1926, p. 233.

v

GENERAL INTRODUCTION

BY
T. H. PEAR, M.A.

The present report contains the first published results of problems on which some of the Board's investigators have been working for a period of years. A recent report* discussed the nature and extent of the relations existing between different types of human skill. It showed that the popular description of a person as "clever with his hands" is too ambiguous for scientific use, and that many difficulties connected with the grading of skills in industry, and consequently with their remuneration, are due to the lack of a satisfactory classification of skill.†

The present report considers a question which popularly is seldom raised: to what extent does training in one type of dexterity transfer to dexterities which appear to resemble it? The general question of transfer of training is fundamental in many educational problems.

In the following report, skill is taken to be an *integration of well-adjusted muscular performances*. The term "skill" is applied to the higher, more complex integrations of performance, and the term "dexterity" to the simpler patterns of specific habits.

Many popular views concerning industrial skill rest upon a belief in the possibility of extensive "positive transfer" when one type of skill is learned, to another apparently related type. Yet very little experimental work has been done upon transfer as it relates either to skill or to dexterity. During the last few years experiments upon transfer of manual dexterity have been carried on in the psychological laboratory of the University of Manchester.

Dr. C. E. Beeby‡ investigated the transfer of dexterity between performances involving one or both hands. Learners were trained, blindfold to pass a metal stylus (electrically connected to record errors) along strips of metal shaped in simple geometrical forms. An initial positive transfer of ability was found. With further practice, however, it gradually diminished, and finally it passed over into its antithesis, interference or negative transfer.

* A. E. Weiss-Long and T. H. Pear (A Classification of Vocational Tests of Dexterity, Report No. 64, 1932).

† Cf. A. Bezanson, "Skill in Industry." *Quart. J. Economics*. 1921-2, 36, pp. 6, 26, 45.

T. H. Pear, "The Nature of Skill," Presidential Address to Psychology Section, British Association Meeting, 1928.

A. Gemelli, "Ricerche sperimentale sulla natura e sulla diagnosi dell'abilità manuale", Milan, 1929, and "Sur la nature de l'habileté manuelle", *J. Psychol. norm. path.* 1930, 25.

Kellner, "Ueber das Handgeschicklichkeit." *Z. Psychol.* 1927, 2.

• M. Fairchild, "Skill and specialisation." *Personnel J.* 1930, 9, Nos. 1 and 2.

‡ C. E. Beeby, "An experimental investigation into the simultaneous constituents in an act of skill." *Brit. J. Psychol.* 1930, 20, 336-354.

The amount of transfer, both initial and final, proved to be the same, whether it occurred

- (i) from one hand's performance to that of the other,
- (ii) from a double-handed action to one of the single-handed movements constituting it,
- (iii) from a single-handed to a double-handed action.

Beeby concluded that the agency underlying the initial positive transfer was a *general mental attitude* towards the task, i.e. of "getting used to" it. He found no positive transfer of specific manipulative habits, indeed, the reverse interference. This interference explains the final negative transfer.

Translating the above result into non-technical language, it would mean that a person who learns simultaneously two types of dexterity (perhaps, too, of skill) which resemble each other may be subject to the interference of habits. Any skills which "superficially" resemble each other, e.g. tennis and badminton, ski-ing, and the two rival types of figure-skating and ice-hockey, may contain (a) similar, even identical elements which can be transferred as a unity, (b) completely antagonistic elements.*

A simple belief that "skill transfers" or that there exists an easily-tested "general muscular ability" is therefore no longer tenable. The situation is similar to that in the educational world where it is now impossible to make unchallenged the claim that a particular "subject" "trains" a certain "faculty" better than all others, since the ambiguity of all these terms as popularly used, and the lack of scientific validity of such statements are now recognised.† Educative value exists not in the subject but in the way it is taught.

Thirty years of investigation in the educational world substantiates the last sentence so far as it relates to the transfer of *knowledge*. Very little, however, is known about the transfer of skill and dexterity.

The investigation described in the present report carries our knowledge a stage further. It should be emphasised that in this investigation and that of Dr. Beeby the problem has concerned simple manual dexterity, not high-grade skill. Between these two forms of ability there is probably a hierarchy of distinguishable grades. The results of these experiments, therefore, cannot be interpreted as meaning that transfer does or does not occur between performances of a more complex kind. Such a statement would imply a generality which is unwarranted. On the other hand, their results forbid any light-hearted assumption of the "transferability of skill."

Transfer of knowledge, where such transfer can be measured experimentally is very much less than would have been naïvely supposed. Moreover, such transfer occurs in certain conditions

* On the general question of interference, cf. H. E. O. James. "The Transfer of Training." *Brit. J. Psychol.*, 1930, 20, 4, and "The Problem of Interference," *ibid.* 1931, 22, 31-42.

† Cf. Report on "Formal Training" by a committee of the Education Section of the British Association, 1930. Also *Education*, 3rd and 10th Oct., 1930.

which can be approximately specified. These conditions are, (1) when common factors of matter, of method, or of ways of approach, have been analysed out and recognised by the learner, (2) when an attitude of liking or disliking, welcoming or fearing, the one task, set up strongly in the one type of learning, has been transferred to the other, (3) when a sentiment (i.e. a relatively permanent organisation of emotional tendencies) has been formed about the first type of work, or some person connected with it, and is then transferred to the other type of learning.

If these results, obtained in the sphere of knowledge, be used as a provisional guide in investigating skill, then on the basis of mere inspection, we can never assume that because two skills superficially appear to be similar, acquisition of proficiency in one will transfer to the other. Where it does transfer, it may be as a result of common habits (though in such cases the risk of negative transfer is great), or of common "material", necessary for the exhibition of the skill. "Where positive transfer takes place it is more likely to occur through the agency of emotional attitudes, sentiments and ideals. The attitude of analysing movements, of demanding to know the reasons for them, the sentiments and ideals formed in connection with a particular teacher, or his method of regarding a certain skill, are probably the most powerful vehicles of transfer."*

The authors wish gratefully to acknowledge their debt for financial assistance in this investigation to the Lewis Scholarship in Applied Psychology in the University of Manchester, held by one of them.

* British Association Report on "Formal Training".

I.—TRANSFER OF TRAINING IN MANUAL DEXTERITY AND VISUAL DISCRIMINATION.

BY

E. M. HENSHAW, M.A., P. HOLMAN, M.A., AND J. N. LANGDON, B.Sc.

CONTENTS.

	<i>Page.</i>
A.—STATEMENT OF PROBLEM AND CUSTOMARY PROCEDURE	1
B.—EXPERIMENTAL PROCEDURE I	3
1. Adequate Motivation	3
2. Comparability of Trained and Control Groups	3
3. Constant Motivation	3
4. Equal Difficulty of Successive Transfer Tests	4
5. Working Conditions	4
6. Number of Subjects	4
7. Operation	4
8. General Results	6
C.—EXPERIMENTAL PROCEDURE II	6
1. Operations	6
2. Employment of Subjects	7
3. General Results	8
D.—EXPERIMENTAL DETAIL: TRANSFER TESTS REFERRED TO IN SECTION B., "EXPERIMENTAL PROCEDURE I"	9
E.—TREATMENT OF RESULTS	11
1. Successive Transfer	11
2. Simultaneous Transfer	16
F.—TRANSFER OF TRAINING IN VISUAL DISCRIMINATION	17
1. Description of Apparatus	17
2. Procedure and Scoring	18
3. Treatment of Results	18
G.—GENERAL CONCLUSIONS	20

A.—STATEMENT OF PROBLEM AND CUSTOMARY PROCEDURE.

The theory of transfer of training assumes that the effect of training in any specific activity may be transferred to any other activity of the same form, although dealing with different material. Education offers an illustration in the doctrine that the value of a course of study in the Latin language, quite apart from aesthetic considerations, lies in a general discipline whereby the intellect is better able to deal with whatever problems it may encounter. The application of this theory to industry seems rarely, if ever, to have been explicitly recognised. In spite of this, it is easy to see that the theory, if correct, must have important

applications. For training in one form of manual skill would then be expected to manifest itself not only in improved ability in the practised operations, but also in ability to perform other operations, which, although unpractised, might happen to be of similar form. It therefore seemed desirable to study this problem with material and conditions resembling those found in industry.

The original form of experiments on transfer of training was that used by Professor William James in 1890.* The subject was given a test in a chosen task. This was followed by training in a second task, similar to, but not identical with the first. At the end of this training he was given a further test in the first task. The difference in performance between the first and last tests was the measurement of the transfer of improvement from the intermediate training.

The essential form of this experiment, (a) test, (b) training in similar but not identical material, and (c) further test, has formed the basis of all subsequent experimental work. The results obtained, however, have led to very conflicting conclusions. Many of the experiments have not employed a sufficient number of subjects to allow of any statistical treatment, and in such cases the interpretation of results must remain largely a matter of opinion. Other sources of experimental weakness have also been disclosed. Many of the early experiments neglected the use of control subjects, whose employment is necessary in order to determine the practice effect of the tests used to detect transfer. Unless this precaution is observed, there is usually no proof that any improvement made in the end tests by the trained subjects may not be due to the practice given by the initial tests, rather than to genuine transfer from the intermediate training which they have received. Dr. W. G. Sleight† drew attention to the need for improved procedure in this respect, and also to the frequent lack of evidence that the initial and final transfer tests were of equal difficulty.

Another common criticism of experiments of this kind has been to the effect that material and conditions are often very artificial, and that subjects would not take more than a passing interest in their performance. A closely related criticism has been raised by Professor T. H. Pear‡, who emphasises the necessity for constant motivation in each of the transfer tests. He points out that there is usually no assurance, beyond the goodwill of the subject, that there is the same incentive to satisfactory performance in the first and in the final transfer tests.

Finally, in a great many experiments, the training has not been intensive, consisting merely of a brief daily practice continuing for varying lengths of time.

* *Principles of Psychology*, 1901. Vol. I., pp. 666 ff.

† Sleight, W. G. (1911). Memory and Formal Training. *Brit. J. Psychol.*, 1911, 4, 386-487.

‡ Pear, T. H. (1927). Recent Studies of Skilled Performances with Reference to Transfer of Training. *Nature*, 18th June.

B.—EXPERIMENTAL PROCEDURE I.

The experiments to be described in this and in the following report were carried out in the psychological laboratory of the University of Manchester, under the direction of Professor T. H. Pear, and with the help of Mr. H. E. O. James and Mr. S. Wyatt.

The following experimental procedure was planned to avoid, as far as possible, the defects of the usual "transfer" experiment.

1.—*Adequate motivation.*

The subjects were all boys between the ages of 15 and 18 whose services were obtained through the agency of the Manchester Juvenile Employment Bureau.* They were paid a minimum wage of 12s. per week, and in addition received a daily bonus depending entirely on the degree of improvement effected day by day. It was thus possible for a good worker to earn, on an average, two or three shillings in addition each day. By this means an adequate incentive was assured. On the days on which transfer tests were given, the subjects' bonus was made upon the basis of improvement in these. Thus there was the same incentive as in training, and the motivation was constant from test to test.

2.—*Comparability of Trained and Control Groups.*

Subjects for control and trained groups were chosen from the same age and class of boy at the Juvenile Employment Bureau. The control group was paid on the same system as the trained group. The individual amounts earned on the occasion of the first giving of the tests were based upon the performance of individual subjects, and on the two second occasions, upon improvement on the previous performance in each of the tests. Thus it seems legitimate to assume that the financial incentive was identical in both trained and control groups.

3.—*Constant Motivation.*

Attention has already been drawn to the fact that, in the usual laboratory experiment, there is no assurance that motivation is constant from test to test. Subjects are usually undergraduates who volunteer, or who are persuaded by friends to give their services to the laboratory. With subjects of this type it is probable that the attitude to the test will vary considerably on different occasions, and that what may be called the "worth-whileness" of the performance will vary with changes in the mood of the subject.

In this experiment, so far as could be ascertained, these factors were eliminated. The desire to earn as much as possible was a constant motive apparently prominent in consciousness. Information obtained by questioning the subjects confirms this statement. Since the personal influence of the experimenter in testing can seldom be

* We should like to thank Mr. Greenwell and his staff for their kind assistance.

eliminated,* each subject worked under the same experimenter for each of the three successive transfer tests.

4.—*Equal Difficulty of Successive Transfer Tests.*

The tests given on the three occasions at the beginning, in the middle, and at the end of the training, were identical. Naturally, there is a training effect due to practice in the test itself, but this can be assumed to be the same for both control and trained groups.

5.—*Working Conditions.*

The subjects were intensively trained for a fortnight with the omission of days on which "transfer tests" were given. They were all exposed for three hours, both morning and afternoon, with a fixed time for lunch, to the rigid conditions of the experiment. The discipline maintained and the supervision of the work were more rigorous than is usually the case in factory conditions. The room was entirely given up to this experiment during the whole time of the investigation. It resembled a room in the better type of factory.

The following facts are emphasized: (1) the room was in no way unusual, though forming part of a series of laboratories, (2) there is nothing inherent in the nature of a laboratory experimenter to prevent him or her from exerting disciplinary effects, (3) "Factory conditions" may vary from excellent surroundings and rigid discipline to bad surroundings, slackness and discontent. It is, therefore, logically impossible to hold as is sometimes done, that the "unnaturalness" of laboratory conditions necessarily makes them incomparable with "natural" factory conditions.

6.—*Number of Subjects.*

The trained group contained 32, and the control group 28 subjects. Statistical treatment of the results is therefore possible.

7.—*Operation.*

The operation chosen for the intensive training of the subjects is a modification of one used in the driving-chain industry.† In an investigation carried out in another connexion by Mr. S. Wyatt,‡ it was discovered that this operation gives a reliable practice curve. In the process the "subject" is seated in front of a table. This supports a circular turn-table which carries pairs of spindles on which links are placed. (See Fig. 1.) As each pair comes into position before the subject, he removes it from the turn-table, dropping the top link into a box at his right hand. At the same time he takes another link from a box at his left hand, places it on the spindle, which he re-inserts in the turn-table. He then rotates the table in order to bring the next spindle into position for this operation to be repeated.

* Cf. I. Burnett and T. H. Pear (1925), "Motives in Acquiring Skill". *Brit. J. Psychol.* 16, 77-85.

† The experimenters thank Messrs. Hans Renold, Ltd., of Manchester, who kindly supplied, on several occasions, a large quantity of links for use with the apparatus.

‡ "Machine Speeds and Output." *J. Nat. Inst. Ind. Psychol.* 1927, 3, 8. We are indebted to him for the laboratory adaptation of the apparatus.

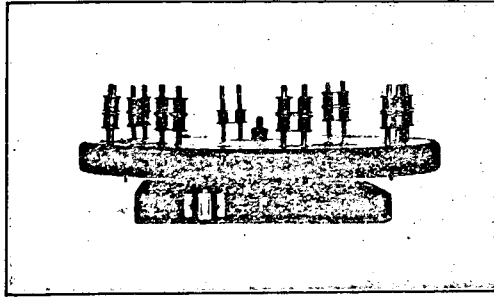


FIGURE 1.

The score, recorded automatically by a Veeder counter operated by the rotation of the turn-table, is the number of links dealt with in a period of ten minutes' work. A period of ten minutes' rest alternated with each period of ten minutes' work, and the subjects worked for eight such periods, both morning and afternoon. A typical and detailed practice curve is appended, showing for both morning and afternoon, the average number of links dealt with during each ten minutes' period. (Fig. 2.) Although it is evident from this that the full effect of practice is not yet attained, improvement in general was more than 50 per cent. of the initial score.

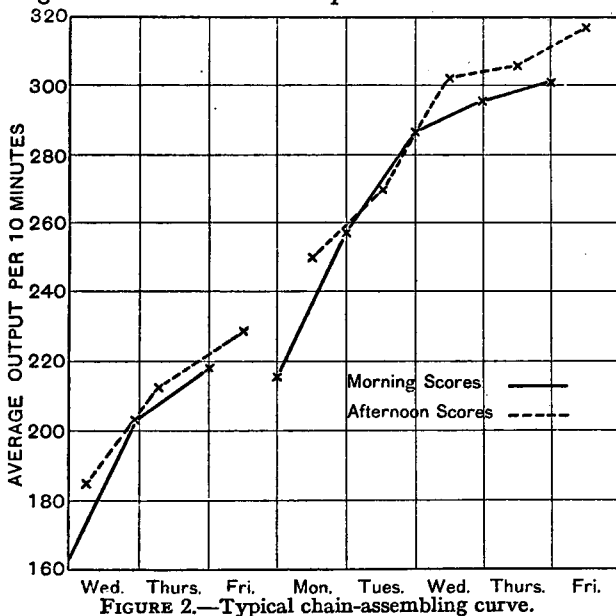


FIGURE 2.—Typical chain-assembling curve.

Altogether 32 subjects were trained in this manner, each being employed for two weeks. These constituted the trained group. A,

further 28 subjects who were approximately equal to the trained group in initial chain-assembling ability, constituted the control group. This group did not receive any training in the chain-assembling operation.

Equal-ability groups were obtained by giving a brief chain-assembling test to a group of 70 boys. These were ranked according to their performance. From this rank alternative boys were chosen for each group, thus the 1st, 3rd, 5th, 7th, 9th, etc., would be in one group, the 2nd, 4th, 6th, 8th, etc., in the other. Any boys obviously unsuitable were omitted.

Before the fortnight's training was begun, and in the middle and at the end, the performance of each subject, in both groups, was measured in the various tests designed to show the presence or absence of transfer. These transfer-tests were selected in accordance with an observational analysis of the operation with the links and spindles described above. They were mostly tests of manual dexterity, involving the simple component movements actually contained in the chain assembling operation. For example a test of "match insertion" consisted of placing matches as quickly as possible in holes pierced in a board made for the purpose. This is a simpler form of the movement necessary in placing the spindles in the turntable. Similarly, tests of threading the links on a needle, and of placing small rings on a rod, are simpler forms of the movement necessary in placing the link on the spindle.

A list of the transfer tests and the method of their presentation is given in the account of experimental detail on page 9.

8.—*General Results.*

The comparison of the two groups in the performance of the transfer tests shows no significant difference. Improvement is shown from the first to the last transfer tests, but this is approximately the same in both trained and control groups. It appears that the eight days' intensive training in the one manual operation has little or no effect on the general level of manual ability as measured by the transfer tests in other manual operations.

It was thought that this result might be partly caused by the fact that the transfer tests were not being given along with the training operation, but rather at distinct intervals, at the beginning, half-way through, and at the end of the training period. It was suggested that a further experiment be carried out in which two manual operations be learnt as far as possible together, in order if possible, to discover if any transfer occurred from the actual learning of the one to the learning of the other. With this in view the preceding experimental procedure was modified along the following lines :—

C.—EXPERIMENTAL PROCEDURE II.

1.—*Operations.*

In addition to the chain-assembling operation, a second operation was devised to be as far as possible similar to the chain-assembling

in its component movements, yet different in material. For this purpose a process involving the filling and emptying of cartridge cases* with small wooden cylinders was chosen.

A comparison, by movement-analysis, of the two operations was made along the following lines :—

Chain Assembling.

1. Picking up link with the left hand.
2. Throwing link off spindle (right hand).
3. Placing links on spindles.
4. Placing spindles in turn-table.

Cartridge Filling.

1. Picking up cartridge case with left hand.
2. Emptying wooden cylinders out of cartridge case (left hand).
3. Placing wooden cylinders in cartridge cases.
4. Placing cartridge cases in stand.

Speed in both depends on co-ordination between the two hands, and on co-ordination between hand and eye, in addition to the simple dexterity of each hand. In the cartridge-filling operation the subject has on his left-hand side a stand holding cartridge cases each containing two white wooden cylinders. He is required to take one cartridge case at a time with his left hand and to empty it into the box in front of him. With his right hand he takes two black† wooden cylinders contained in the rear section of this box, puts these in the emptied cartridge case which he then places in the stand on his right.

2.—Employment of Subjects.

As before, the subjects were paid a minimum weekly wage of 12s. and a large bonus on their improvement both in the chain-assembling and cartridge-filling operations. A strong incentive to work with maximum effort was maintained throughout.

The subjects were divided into two groups of thirty each. By preliminary tests in chain-assembling, as in the earlier experiment, it was arranged that each group began with equal initial ability in this operation. That is to say, the group averages in the initial chain-assembling were approximately equal. Both groups worked for eight ten-minute periods at chain-assembling in the morning. Group II had a further eight ten-minute periods at cartridge filling in the afternoon. Group I was not employed in the afternoon. This arrangement of work was adopted in order that the effect of the cartridge-filling operation on the improvement in the chain-assembling operation might be observed. The two groups had identical training in chain-assembling, but Group II, in addition to this, had the extra training in cartridge filling. Thus any difference

* We are indebted to Mr. S. Wyatt for suggesting this operation, and to the kindness of Messrs. Kynoch, Ltd., for the supply of cartridge cases.

† The difference in colour of the cylinders was for checking purposes only.

in the chain-assembling practice curves of the two groups could be attributed to the effect of the training in the cartridge-filling operation.

It may be noted here that throughout the experiment the effects of fatigue were eliminated by the regular insertion of rest pauses. Subjects when questioned never admitted to any fatigue or boredom. The latter was apparently eliminated by the strong financial incentive. Interest was maintained by the effect of "always working for the penny."* The subjects throughout seemed to work keenly in spite of the monotonous nature of the operation. Rest pauses were spent in eager discussion of their respective scores.

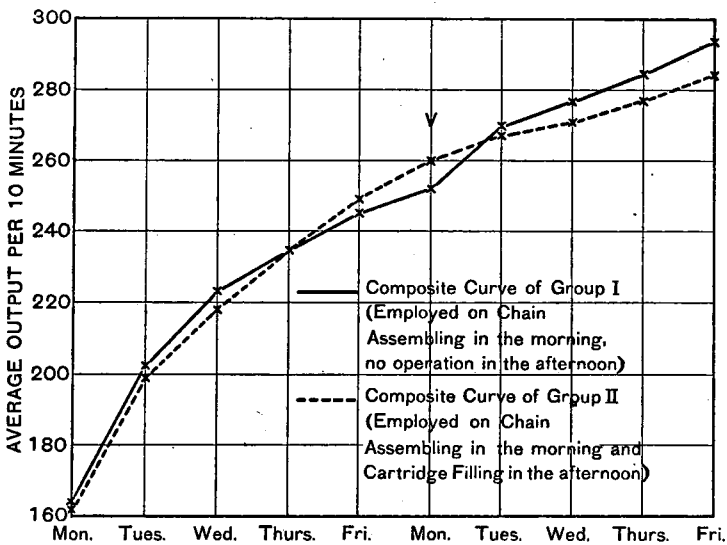


FIGURE 3.—Comparison of chain-assembling curves of Groups I and II.

3.—General Results.

Examination of the chain-assembling scores of the two groups throughout the fortnight, shows only very slight and apparently chance differences in their performances.† From Fig. 3 it can be seen that the practice curves of the two groups are almost identical. There is no indication of any transfer effect in Group II from the simultaneous training in the cartridge-filling. The extra training in cartridge-filling had no appreciable positive or negative effect on the improvement in chain-assembling.

* This is how the subjects used to refer to the bonus and the way in which it was calculated.

† Detailed treatment of these results is described on page 16.

D.—EXPERIMENTAL DETAIL—TRANSFER TESTS REFERRED TO IN SECTION "EXPERIMENTAL PROCEDURE I."

The following are the series of transfer tests given on the three occasions; before training in chain-assembling had begun, at the end of the first week, and at the end of the fortnight. In tables of results they are referred to as 1, 2, and 3 respectively.

(1) *Match insertion*.—The subject sat in front of a small board pierced with holes, in each of which a match can be inserted. He took matches one by one from a box placed in a constant position, and endeavoured in the time allowed, to insert as many matches as possible. The score is the number of matches inserted in two minutes. The test was performed with both right and left hands separately.

(2) *Placing matches in a box*.—The subject sat in front of a table on which were arranged thirty matches in a straight line. The matches were separated from each other by a distance of roughly one centimetre. In his left hand he held a match-box; with his right hand he picked the matches one by one from the table and endeavoured to fill the box as quickly as possible. The matches had to be placed neatly with the heads all one way. When this had been done, the subject fixed the cover on the box and closed it. This precaution ensured that the subject had complied with the instructions as to neatness. The experiment was then repeated with the left hand. The score is the time taken as measured by a stop watch.

(3) *Placing rings on a rod*.—The subject took curtain rings, one at a time, from a bowl placed in a constant position within easy reach of the hand he was employing. He slipped them as quickly as possible over a retort stand placed in front of him. The experiment was performed with both right and left hands separately. The score is the number of rings dealt with in two minutes, measured by the stop watch.

(4) *Threading links*.—The subject held a large needle threaded with twine. At his free hand was placed a pile of links; those used in the chain-assembling. He picked up the links one at a time and threaded them over the needle. This test was also performed with both right and left hands separately.

(5) *Arm movement*.—The apparatus consists of a cardboard semicircle of 2 feet radius. Along the circumference of this is fixed a graduated scale. At the centre is fixed a movable pointer which rotates on small wheels. At the head of the pointer is an attachment into which the subject can insert his fingers. The subject stands with his hip against the centre of the semicircle. He rests his hand on the broad head of the pointer, with his fingers in the place provided. With eyes closed, he is required to make a rotatory movement of the arm. He is then instructed to try to repeat the movement to exactly the same extent as before. He makes the movement?

in this manner altogether ten times. The score in this test is the coefficient of variation, i.e. the mean deviation from the mean expressed as a percentage of the mean.

• (6) *Moede's impulse-meter*.—The subject holds the hammer in his right hand and is instructed to strike the anvil. The force of the blow is measured on the scale. He is then told to strike the anvil again with just the same force as before. He repeats this ten times in all. Here again the score is the coefficient of variation.

(7) *Steadiness test I*.—The apparatus employed was that described in Whipple's *Manual of Mental and Physical Tests** Vol. I, p. 157. It consists of a metal plate set at an angle of 45° pierced by holes of diameter 32, 20, 16, 13, 11, 10, 9, 8, 7, sixty-fourths of an inch. This plate is in electric circuit with a buzzer and a metal stylus held by the subject. When contact between plate and stylus occurs, the buzzer is thereby sounded. The method was as follows:—The subject was instructed to hold the stylus in each of the holes in turn, from the largest to the smallest. The stylus was held in each hole for 15 seconds, with a preliminary 3 seconds before completing the electric circuit, in order to give the subject time for adaptation. At the first sound of the buzzer the subject removed the stylus from the hole he had reached, and the experiment was commenced again from the first hole. This was repeated seven times. The score in each of the seven trials is the total time elapsing before contact, that is the total of the 15 seconds in each hole dealt with successfully plus the number of seconds before the buzzer sounds in the hole where the first contact is made. The score, recorded as the subject's performance, is the middle one of these totals, that is the fourth from the lowest or highest.

(8) *Steadiness test II*.—The apparatus is described in Whipple I, p. 152. It is the usual tracing board, with a slit bounded by converging metal strips. Along one edge is mounted a millimetre scale. The subject was instructed to draw the stylus along the slit without making contact with the sides. At the first contact the subject stopped and repeated the process. This was repeated eleven times. The score in each case is the distance traversed before contact. The subject's performance is recorded as the middle one of these eleven.

(9) *Mental arithmetic*.—The material consisted of pages of sums of the following type:— $3 \times 9 = 30, 27, 12, 15$. The subject was instructed to underline the correct answer. The score is the number of answers correctly marked in four minutes.

(10) *Cancellation*.—The material is described in Whipple I. p. 126. The subject was instructed to cross out every q, r, s, and t, on the printed form. The time taken was recorded with

* Warwick & York. Baltimore. 1924.

a stop-watch. The score was calculated from a formula* based on both speed and accuracy.

The subject was informed of the method of scoring and was thus aware that both speed and accuracy were essential.

These last two tests were chosen because they have no obvious connexion with the process of chain-assembling. It was assumed that if the presence of transfer were demonstrated in all the tests, in these last to as great a degree as in the tests of manual dexterity, there would be reason to suppose that this transfer had its origin in the cultivation of a general mental attitude towards testing, in habituation to environment, or in some general factor rather than in specific practice.

The tests were always given in the same order and at the same intervals of time to all subjects.

E.—TREATMENT OF RESULTS.

The treatment of the results of the two parts of the experiment is described separately, under the headings "successive transfer" and "simultaneous transfer." The term "successive" refers to the first part of the experiment where the presence or absence of transfer was assessed by brief tests given before and after training. The term "simultaneous" refers to the second part where the detection of transfer was determined by the additional operation of cartridge-filling given daily with the training operation of chain assembling.

1.—*Successive Transfer.*

In comparing the relative ability of the two groups in the transfer tests, the method adopted is that of comparison between means. If the difference between the means of two groups of measurements is at least three times as large as the standard error of this difference, it is usually considered to be significant and not attributable to chance factors. Similarly, although the odds against its being due to chance are lower, a difference exceeding twice its own standard error is at least very suggestive.

The first step in the present treatment consisted in the calculation of the differences for each individual between the scores in transfer tests 1 and 2, and 1 and 3. This was done for both trained and control groups, and the mean of these differences was calculated in each case, together with its own standard error ($\sigma_M = \frac{\sigma_{Dis.}}{\sqrt{N}}$). These measures are shown in the first four columns of Table I. A negative sign in these four columns indicates an inferior score at the later repetition of a test. It will be seen that there is only one test, that of arm movement, in which this was the case. In every other test there was some improvement by both groups at each repetition.

* It was :—

$$E = \frac{C - W}{C + O} \times \frac{100}{T}$$

Where E = index of efficiency.

C = number of letters crossed.

W = number of letters wrongly crossed.

O = number of letters erroneously omitted.

T = time in seconds.

TABLE I.—SHOWING THE RESULTS OF TESTS OF "SUCCESSIVE" TRANSFER.

			A.— <i>Trained.</i>		B.— <i>Control.</i>		C.— <i>A.—B.</i>	
			I. 1-2	II. 1-3	III. 1-2	IV. 1-3	V. 1-2	VI. 1-3
Match Insertion	..		M = 3.03	M = 4.72	M = 2.27	M = 4.23	D = + 0.76	D = + 0.49
R. Hand	..	..	$\sigma_M = 1.27$	$\sigma_M = 0.79$	$\sigma_M = 0.79$	$\sigma_M = 0.82$	$\sigma_D = 1.49$ Not significant	$\sigma_D = 1.14$ Not significant
Match Insertion	..		M = 6.35	M = 6.81	M = 2.90	M = 4.93	D = + 3.45	D = + 1.88
L. Hand	..	..	$\sigma_M = 0.86$	$\sigma_M = 0.85$	$\sigma_M = 0.74$	$\sigma_M = 0.82$	$\sigma_D = 1.14$ Significant.	$\sigma_D = 1.18$ Not significant
Match Box	..	..	M = 5.66	M = 4.94	M = 1.90	M = 2.10	D = + 3.76	D = + 2.84
R. Hand	..	..	$\sigma_M = 1.39$	$\sigma_M = 1.43$	$\sigma_M = 1.35$	$\sigma_M = 1.84$	$\sigma_D = 1.49$ Not significant	$\sigma_D = 2.33$ Not significant.
Match Box	..	..	M = 1.72	M = 4.44	M = 2.03	M = 2.87	D = - 0.31	D = + 1.57
L. Hand	..	..	$\sigma_M = 1.22$	$\sigma_M = 1.11$	$\sigma_M = 1.61$	$\sigma_M = 1.86$	$\sigma_D = 2.02$ Not significant	$\sigma_D = 2.16$ Not significant
Rings	..	..	M = 4.34	M = 6.09	M = 3.28	M = 5.45	D = + 1.06	D = + 1.64
R. Hand	..	..	$\sigma_M = 0.96$	$\sigma_M = 1.06$	$\sigma_M = 1.03$	$\sigma_M = 1.01$	$\sigma_D = 1.41$ Not significant	$\sigma_D = 1.46$ Not significant
Rings	..	..	M = 3.66	M = 6.19	M = 4.18	M = 5.57	D = - 0.52	D = + 0.62
L. Hand	..	..	$\sigma_M = 0.69$	$\sigma_M = 1.34$	$\sigma_M = 1.16$	$\sigma_M = 1.35$	$\sigma_D = 1.35$ Not significant	$\sigma_D = 1.90$ Not significant
Threading Links	..		M = 5.00	M = 5.00	M = 1.50	M = 3.67	D = + 3.50	D = + 2.13
R. Hand	..	..	$\sigma_M = 1.68$	$\sigma_M = 1.88$	$\sigma_M = 1.52$	$\sigma_M = 1.19$	$\sigma_D = 2.27$ Not significant	$\sigma_D = 2.23$ Not significant
15 ss. only								

Threading Links ..	M = 5.07 $\sigma_M = 1.69$	M = 4.27 $\sigma_M = 1.55$	M = 1.83 $\sigma_M = 1.42$	M = 5.00 $\sigma_M = 1.55$	D = + 3.24 $\sigma_D = 2.21$ Not significant	D = - 0.73 $\sigma_D = 2.19$ Not significant
L. Hand ..						
15 ss. only						
Arm movement ..	M = - 0.93 $\sigma_M = 0.88$	M = - 0.63 $\sigma_M = 0.94$	M = - 0.38 $\sigma_M = 0.71$	M = - 0.51 $\sigma_M = 0.77$	D = - 0.55 $\sigma_D = 1.14$ Not significant	D = - 0.12 $\sigma_D = 1.21$ Not significant
Impulse Meter.. ..	M = 1.67 $\sigma_M = 1.49$	M = 1.91 $\sigma_M = 1.50$	M = 4.17 $\sigma_M = 1.78$	M = 2.88 $\sigma_M = 1.39$	D = - 2.50 $\sigma_D = 2.32$ Not significant	D = - 0.97 $\sigma_D = 2.04$ Not significant
Steadiness (Test I.) ..	M = 2.06 $\sigma_M = 1.93$	M = 3.28 $\sigma_M = 2.42$	M = 4.45 $\sigma_M = 2.59$	M = 4.52 $\sigma_M = 0.83$	D = - 2.39 $\sigma_D = 3.23$ Not significant	D = - 1.24 $\sigma_D = 2.56$ Not significant
Steadiness (Test II.) ..	M = 8.06 $\sigma_M = 7.08$	M = 11.56 $\sigma_M = 8.29$	M = 6.27 $\sigma_M = 7.14$	M = 8.23 $\sigma_M = 9.27$	D = + 1.79 $\sigma_D = 10.06$ Not significant	D = + 3.33 $\sigma_D = 12.43$ Not significant
Mental Arithmetic ..	M = 12.34 $\sigma_M = 1.75$	M = 16.93 $\sigma_M = 1.79$	M = 10.03 $\sigma_M = 1.39$	M = 14.90 $\sigma_M = 1.58$	D = + 2.31 $\sigma_D = 2.23$ Not significant	D = + 2.03 $\sigma_D = 2.39$ Not significant
Cancellation	M = 52.44 $\sigma_M = 6.87$	M = 78.45 $\sigma_M = 8.64$	M = 53.47 $\sigma_M = 5.87$	M = 91.77 $\sigma_M = 9.08$	D = - 1.03 $\sigma_D = 9.04$ Not significant	D = - 13.32 $\sigma_D = 12.53$ Not significant

Column I shows the mean difference between the 1st and 2nd applications of each test to the trained group.

Column II " " " " 1st and 3rd " " " " "

Column III " " " " 1st and 2nd " " " " control group.

Column IV " " " " 1st and 3rd " " " " "

Column V shows the difference between trained and control groups in respect of the measures shown in Columns I and III.

Column VI shows the difference between trained and control groups in respect of the measures shown in Columns II and IV.

The final problem is to determine whether the trained group improved more than the control group of subjects. Column 5 shows for the second trial of each test the difference between the improvement effected by the trained group and that made by the control group. Numerically, it is the difference between the mean improvements shown in columns 1 and 3. Similarly, column 6 gives for each test the difference between the mean improvement of the trained group shown in column 2, and the mean improvement of the control group shown in column 4. Each of the differences shown in columns 5 and 6 is shown with its own standard error, calculated in this case as the square root of the sum of the squares of the standard errors of the means concerned. A negative sign in either column 5 or 6 denotes a difference in favour of the control group.

The crucial data are given in column 6 which is based on the final stages of practice. Reference to this column shows that the majority of measures are in favour of the trained group; that is, they improved more in these tests than did the control group. It will also be seen, however, that in no case is this favourable difference equal to twice its own standard error. It therefore appears that there is no single test in which the difference between trained and untrained subjects can be said with confidence not to be due to sampling errors. At the same time, the fact that the general tendency is in favour of the trained group, particularly in those tests which can be said more properly to be of manual dexterity, is not to be disregarded.

Reliability of the transfer tests.—Reliability of a test is usually measured by the size and significance of the correlation between successive applications of the test to the same subjects. Here the following observations should be noted:

(1) If the ability tested is modified by training, then poor correlation between successive applications of the test to the same subjects, may, to some extent, reasonably be ascribed to the fact (supported by all that we know of learning in general), that some subjects learn more rapidly than others.

(2) The operation of this factor will be maximal in the initial stages of practice, because it is here that learning is most rapid.

(3) Some subjects showed appreciable improvement as the result of the small amount of practice given by the tests.

These observations may be illustrated by a table extracted from an article on "Motor Capacity," by B. Muscio.* Muscio calculated the correlation between successive applications of tests at two stages; first when practice was low, and second when practice was high. The results are given below:—

Tests.	Initial reliability Co-efficients.	Final reliability Co-efficients.
Tapping	·86	·92
Aiming	·70	·82
Match Stick Insertion .. .	·56	·88

* "Motor Capacity, with Special Reference to Vocational Guidance." *Brit. J. Psychol.* 1922. 13. pp. 157-184.

It will be noted that in each case the "initial" is smaller than the "final" co-efficient.

In the present investigation, the subjects were tested on only three occasions. Consequently, it is very unlikely that maximum practice was attained, and therefore the foregoing observations apply. That is to say, the correlations set out in the following table are probably, for the reasons given, greatly reduced below their true values. It will be seen, however, that they are sometimes high, that they are always positive and rarely non-significant.

TABLE II.—CORRELATIONS BETWEEN SUCCESSIVE APPLICATIONS OF TRANSFER TESTS.

			1-2	2-3	1-3	Mean Correlation.
Match Insertion	..		.74	.76	.75	.75
R. Hand	..	..	$\pm .06$	$\pm .06$	$\pm .06$	
Match Insertion	..		.61	.59	.55	.58
L. Hand	..	..	$\pm .08$	$\pm .08$	$\pm .09$	
Match Box	..	..	.66	.76	.47	.63
R. Hand	..	..	$\pm .07$	$\pm .06$	$\pm .10$	
Match Box	..	..	.66	.65	.53	.61
L. Hand	..	..	$\pm .07$	$\pm .07$	$\pm .09$	
Rings	..	..	.56	.66	.71	.64
R. Hand	..	..	$\pm .09$	$\pm .07$	$\pm .07$	
Rings	..	..	.44	.88	.36	.56
L. Hand	..	..	$\pm .11$	$\pm .03$	$\pm .12$	
Threading Links	..		.86	.45	.54	.63
R. Hand	..	..	$\pm .05$	$\pm .16$	$\pm .13$	
Threading Links	..		.78	.62	.72	.72
L. Hand	..	..	$\pm .08$	$\pm .05$	$\pm .08$	
Arm Movement	..		.50	.63	.17	.43
			$\pm .10$	$\pm .08$	$\pm .13$	
Impulse Meter..	..		.47	.37	.39	.41
			$\pm .10$	$\pm .11$	$\pm .11$	
Steadiness (Test I)	..		.77	.81	.59	.72
			$\pm .05$	$\pm .04$	$\pm .08$	
Steadiness (Test II)	..		.60	.42	.37	.46
			$\pm .08$	$\pm .11$	$\pm .11$	
Mental Arithmetic	..		.82	.82	.82	.82
			$\pm .04$	$\pm .04$	$\pm .04$	
Cancellation	..	..	.77	.66	.36	.56
			$\pm .06$	$\pm .09$	$\pm .12$	

Conclusions.—In no case was the difference between trained and control groups, with regard to improvement in the third over the first application of a test, of such a size as to exclude the possibility, of its being due to chance factors.

2.—*Simultaneous Transfer.*

The rate of improvement of the two groups in chain-assembling is shown in Fig. 3. Table III gives the actual numerical results from which the curves in this figure were obtained.

TABLE III.—COMPARISON OF CHAIN ASSEMBLING MEANS FOR GROUPS I AND II.* (OBTAINED IN EACH CASE FROM SCORES OF 32 SUBJECTS.)

A.M.	Group I.	Group II.	Difference between means of Groups I and II.†
Monday	164	163	+1
Tuesday	202	199	+3
Wednesday	223	218	+5
Thursday	234	234	0
Friday	245	249	-4
Monday	252	260	-8
Tuesday	269	267	+2
Wednesday	276	271	+5
Thursday	284	277	+7
Friday	293	284	+9

The method used to determine the effect of training in cartridge filling, on the performance in chain assembling of Group II, is the comparison of the daily group means in the chain assembling operation. The significance of the difference between these is shown statistically by the calculation of the standard error of the two Groups. For this difference to be significant it should be at least twice as great as the standard error of the difference. The calculation of the standard error for the days on which the difference between the two means is greatest, viz., the second Monday and the second Friday, gives a result in which the standard error is less than two-thirds of the difference. It can be assumed then that the difference between the two groups is in no instance sufficiently great for it not to be due to chance variations in the individual scores making up the group mean. However, Fig. 3 shows a tendency for the two curves to diverge consistently during the last three days. Although this is not significant even on the last day, it suggests the possibility that this divergence of the curves might have become significant had the work been continued for a longer period. This experiment was not continued sufficiently long to show whether this would occur or not.

These results show that during the first fortnight of training in chain assembly, the extra training in cartridge filling had no

* Group I employed in Chain Assembling in the morning. No operation in the afternoon.

Group II employed in Chain Assembling in the morning, and Cartridge Filling in the afternoon.

† Plus and minus signs refer to positive or negative difference of Group I over Group II.

apparent positive or negative effect on the improvement in chain assembling.

Conclusion.—Again as in the other experiments this result seems to imply that during the early stages of learning a simple manual dexterity, learning of another similar dexterity produces no transfer or interference.

F.—TRANSFER OF TRAINING IN VISUAL DISCRIMINATION.

The general experimental method in this investigation is the same as that described above. The problem in this experiment may be stated as follows :—Is the practice acquired during intensive training in estimating the size of steel balls, all lying within a given range, transferred to the estimation of size of a similar series of balls lying well outside this range ?

1.—Description of Apparatus.

The series of steel balls employed, ranged in diameter from $16/64$ to $7/64$ by differences of $1/64$ in. Ten balls of each size were used with a ball-sorting apparatus devised by Mr. S. Wyatt. This apparatus consists of a box with a sloping lid. The box is divided into a number of compartments, the number being the square of the number of different sizes of balls employed. (See Fig. 4.)

In the lid are cut ten slots with sides converging in such a manner that ball 1 drops into the first row, ball 2 into the second row, and so on to No. 10, which drops into the tenth row. If the subject is then instructed to place the balls, according to size, each in its appropriate groove, the balls correctly placed fall into the squares marked (X) in the diagram. The number and deviation from the true position of balls wrongly placed are thus obtained directly. For example, if the subject is presented with ball 4 and places it wrongly in slot 7, it will fall in the square marked E in the diagram.

S L O T S

	1	2	3	4	5	6	7	8	9	10
1	X									
2		X								
3			X							
4				X			E			
5					X					
6						X				
7							X			
8								X		
9									X	
10										X

FIGURE 4.

2.—*Procedure and Scoring.*

The experimental procedure was so arranged that the estimation of the size of ball should be limited to vision only. Thus the following precautions were adopted :—

- (a) The subject received the ball in a cup-shaped spoon and placed it by means of this in the desired slot, thus eliminating discrimination by touch.
- (b) The spoon was made of such a weight as to render imperceptible the difference between any two adjacent balls—thus eliminating discrimination by weight.
- (c) The spoon which was made of copper, was lined with felt in order to exclude any inference of size on the basis of the sound made in dropping.

The different steps in the performance were carried out to the beat of a metronome, the rate of which was decided by preliminary experiment. The balls were presented to the subject by means of a feed pipe which came through a screen hiding the experimenter's operations. They were in irregular order, but the same order was preserved in each test period. As the balls have a highly polished surface, care was taken to ensure constant conditions of illumination. After each judgment, the subject returned the spoon to the same position, so that the ball was always viewed under the same conditions. The score was taken in terms of error, measured by the total squared deviation from the true position.

The presentation of the 100 balls occupied ten minutes. Each period of ten minutes' work, was followed by ten minutes' rest. It will be seen that the whole procedure minimised any personal relationship between the subject and the experimenter, thus ensuring adequate constancy in this respect.

The conditions of work and of payment were the same for these subjects as in the previously described work on Manual Dexterity. The material for the transfer tests, given on three occasions as in the experiment previously described, consisted of 100 very much larger balls,* 10 of each size, ranging in diameter from 1 in. to $23/32$ by differences of $\frac{1}{16}$ in. The procedure and scoring were the same as during the training. Each transfer test was of ten minutes' duration.

The transfer test was also given under identical conditions to eighteen subjects employed as a control group. Six subjects were trained in the operation for a period of two weeks, a satisfactory degree of practice being obtained in each case.

3.—*Treatment of Results.*

Table IV shows the scores made at each test, both by trained and by control subjects. In interpreting this table, it should be remembered that improved performance is denoted by a decreased score.

* The experimenters thank the Hoffman Manufacturing Co., Ltd., who kindly supplied this series of balls.

TABLE IV.

Subjects.	Score in Test 1.	Score in Test 2.	Score in Test 3.
<i>Trained—</i>			
A	266	130	121
B	201	64	108
C	134	68	60
D	103	74	77
E	63	91	85
F	140	133	108
Total	907	560	559
Mean	151	93	93
Improvement per cent. upon Test 1.*	—	62.4	62.4
<i>Control—</i>			
a	165	157	221
b	76	67	55
c	252	69	83
d	130	69	58
e	144	117	102
f	147	71	92
g	242	92	90
h	232	128	156
j	473	290	174
k	241	89	142
l	278	149	111
m	234	227	127
n	204	100	96
o	137	70	38
p	194	109	155
q	193	100	89
r	174	125	128
s	164	102	87
Total	3,680	2,131	2,004
Mean	204	118	111
Improvement per cent. upon Test 1.*	—	72.9	83.8

It is obvious that no general validity can be attached to the mean scores of a group containing only six subjects, particularly when, as in the present case, individual differences in initial ability are very pronounced. However, the figures show, for the present subjects at least, that the intermediate practice obtained by the trained group did not result in any transfer effects whereby they would have received an advantage over the control group who received no training—a conclusion similar to that reached in the other experiments.

The same conclusion is suggested by a more detailed inspection of the table. It is possible to match each member of the trained

* As the score is expressed in terms of error, and improvement is denoted, by a lower score, the percentage improvement has been calculated from the reciprocals of the means.

group with one or more members of the control group having a comparable initial score. Thus, the following extract from the table is an illustration of such a comparison between subjects whose initial ability is about the same.

Subjects.	Score in Test 1.	Score in Test 2.	Score in Test 3.
Trained C	134	68	60
Control d	130	69	58
Control o	137	70	38

The example shows a case in which the scores made in later tests by members of the control group are equal to, or better than, those made in the same tests by a member of the trained group having a comparable initial score. Similar examples can easily be found.

It therefore appears that these results, within the limits imposed by the small number of subjects, suggest that training in this operation also is specific rather than general.

G.—GENERAL CONCLUSIONS.

The statistical treatment of the results of these experiments shows that there is no single instance where the relative superiority of trained over untrained subjects cannot be attributed to chance just as readily as to genuine transfer. On the other hand, in the experiment on "successive" transfer, although there is no single instance of statistical significance, the result is favourable to the trained group in the majority of tests, particularly in those tests which appear to have most in common with the operation in which the subjects were practised. This certainly suggests that a longer period of training might have given clearer evidence of transfer.

The negative result of the experiment on "simultaneous" transfer is in complete agreement with the conclusions of the following report on Distribution of Training in Manual Dexterity. It is shown there that practice both morning and afternoon in the operation of chain assembling, produces no better performance than that obtained by practice in the mornings only. It would not, therefore, be expected that practice in another operation, however similar, would have any greater effect. What is probably more important is that, within the limits of the practice period, the two operations did not show any significant interference with each other.

In general, while these results certainly give no indication that transfer has occurred, they also do not rule out the possibility that it might have occurred under slightly modified conditions. Thus, it has already been pointed out that the extension of the period of training might have been of interest. Connected with this is the fact, which must not be overlooked, that an integrated response is more than the mere sum of its component parts, and that transfer of a qualitative kind might occur, but be such that a measurable gain in efficiency might take some time to manifest itself.*

* James, H. E. O. (1930). "The Transfer of Training." *Brit. J. Psychol.* 4.

Finally, it is worth noting that the conditions of these experiments did not create any abstract sentiments for ideal modes of behaviour, such as neatness or accuracy of performance in general. It is just where such general sentiments have been developed that transfer is most generally held to exist.*

It may be useful to indicate the significance of these results in non-technical language. The experiment was limited to a special form of dexterity or low-grade skill. The dexterity investigated is, however, very closely related to one used in industry and is not "artificial." The external conditions of experiment—the room, supervision, etc.—resembled those of actual industry more than the usual type of laboratory experiment. Probably for the first time, and so far as the authors are aware, for the first time in recorded scientific experiments, the motive to acquire rapidly a high degree of dexterity was powerful, simple, constant and rigidly controlled. There is no possible ground for the suspicion that the learners did not "try hard."

From the conditions of the experiment there were rigidly excluded two which in ordinary learning might serve as "vehicles" of transfer.

(1) The simple nature of the work, requiring no effort of understanding and giving no opportunity to the learner for introducing methods of his own, made "transfer by learning of methods" improbable in the highest degree.

(2) There was entire absence of any encouragement to form a sentiment about the quality of the work, its interest, or the praise or blame which could be earned from the supervisors. The social relations of the latter to the workers were rigidly impersonal. No sentiment was formed about the work except as a method of earning money.

Such an experiment, therefore, shows that no significant measurable degree of transfer took place between these dexterities. On the popular assumption that there is a "general muscular ability" or a unitary "manual skill" the transfer should have been larger in extent. It does not cast light upon the question of transfer between (1) highly complicated skills, or (2) performances which involve the formation of ideas of methods or produce sentiments or ideals.

The investigation, therefore, emphasises the importance of intelligent training in muscular performance, especially when accompanied by every possible form of encouragement. It strongly suggests the sterility of mere general practice in a hope of improving manual ability.

* Sentiment is used in the psychological sense, of a system of emotional dispositions grouped about an object or an abstract ideal, e.g. the sentiment of pride in work or in the family, etc. Cf. T. H. Pear, J. N. Langdon, and Edna M. Yates, "Transfer of Training and Transference", *The New Era*, July, 1925.

Cf. also the special issue "Joy in Work" in the *Survey Graphic*, New York, 2, 5 Feb., 1923, and articles on "Making Work Worth While," by T. H. Pear, *The Listener*, 1930, 3, Nos. 61, 64 and 65.

II.—DISTRIBUTION OF PRACTICE IN MANUAL DEXTERITY.

BY

E. M. HENSHAW, M.A., AND P. HOLMAN, M.A.

CONTENTS.		PAGE
A.—INTRODUCTION		22
B.—INCENTIVE		23
C.—OPTIMAL DISTRIBUTION OF PRACTICE WITH SPECIAL REFERENCE TO THE PHENOMENON OF "OVERTRAINING"		24
1. Experimental Outline		24
2. Results		26
3. Conclusions		27
D.—THE EFFECT OF LENGTH OF PRACTICE SPELL ON QUANTITATIVE OUTPUT		27
1. Experimental Procedure		27
2. Distribution of Work		27
3. Results		29
4. Conclusions		30
E.—THE WORKER'S ATTITUDE TOWARDS DIFFERENT LENGTHS OF PRACTICE SPELLS		30
1. Results		32
2. Conclusions		32
F.—THE EFFECT OF LENGTH OF WORK SPELL ON VARIABILITY OF OUTPUT		32
Results		32
G.—THE RELATIONSHIP BETWEEN VARIABILITY AND TOTAL OUTPUT Results		34 35
H.—THE RELATIONSHIP BETWEEN FATIGUE AND VARIABILITY Conclusion		35 36
I.—SUMMARY OF CONCLUSIONS		36

A.—INTRODUCTION.

The results described in this report were obtained from investigations in which the effects of various distributions of practice in a simple manual dexterity were studied. The results fall under the following heads:—

(1) Optimal distribution of practice with special reference to the phenomenon of "overtraining."

(2) The effect of lengths of practice spell on quantitative output.

(3) The workers' attitude towards different lengths of practice spell.

(4) The effect of length of work spell on variability of output.

(5) The relationship between variability and total output.

(6) The relationship between fatigue and variability.

The experimental data were obtained from the employment of subjects in the simple chain assembling process previously used in the work on transfer of training.*

In choosing an operation for use in this type of laboratory experiment several factors have to be considered. Chain assembling was chosen because it is always found to give a reliable practice curve and because speed is the one criterion of improvement. Also the speed reached is entirely dependent on the worker and is not in any

* See p. 4.

way limited by the machine. The output can be measured exactly and with little trouble without disturbing the operative in his work. The fact that the operation is repetitive has the advantage that the same objective difficulty is presented at all stages of the day. Although the operation is a simple one it is not one in which the subjects can have had any previous practice unless they have been actually employed in the driving chain industry. This possibility was guarded against by careful questioning of all subjects before they were engaged.

B.—INCENTIVE.

One of the chief factors to be considered in any study of rate of improvement in an operation is the attitude of the subject towards that operation. It is common experience that one learns to do a new thing more quickly when there is some strong motive for learning. Yet it frequently happens in laboratory work that subjects are asked to perform a given task in order that the speed and quality of the performance may be observed with no greater incentive supplied than the wish to please the experimenter. The task itself is usually of no intrinsic interest, not even having value as a "job done," as often the actual performance has to be undone in preparation for the next subject to do it again. Such conditions are in no way constant for all subjects, or even for any one subject at all times. Some controlled incentive is required to ensure, not that all subjects are working equally hard, but that all subjects are working consistently hard round about their own particular norm. There are no criteria on which to compare amounts of human endeavour. If, for example, we compare speed or quality of work, these are affected by the ability of the subject as well as by the strength of his effort. But if some method of a systematic control of incentive be adopted which induces each subject to work consistently at his own maximum, then, other conditions being constant, we have a basis for comparison of their respective rates of improvement.

In these experiments a strong pecuniary incentive was adopted; the subjects were paid a minimum weekly sum as long as their work was satisfactory, and, in addition to this, a daily bonus when their improvement on their own previous score merited it. On the first day the subjects were urged to work their hardest by being paid in order of their success. After this they were told that they would in future be paid on their own improvement. This eliminated any danger of deliberate reduction of initial output with the idea that it would thus be easier to beat one's own score in days to come.

This method of paying subjects on their own improvement has the special advantage over any competitive payment, that all subjects are then given the same chance of earning a good bonus, and that the incentive is thus as far as possible kept constant. Competition seems to be of little value as an incentive except when subjects have approximately the same ability. This was certainly true with our subjects. Jones with 300 would compete readily with Smith whose score was 305, but would entirely ignore Johnson, who

had reached 350. And even when this competitive element was voluntarily introduced, it was always subsidiary to the pecuniary incentive. Smith was much more interested in beating his own score of 305 and thus earning a good bonus than of remaining above Jones with his 300. The money to be earned was in every case of primary interest. Only the pecuniary incentive was stressed. The subjects were told to work hard because if they did they would earn more. Their payment was always clearly understood to be in direct proportion to their effort.

The importance and success of this method of payment was apparent from the scraps of conversation heard during rest pauses. There were heated arguments on the various scores, there were loud discussions on advantages and disadvantages of details in method, there were many predictions of how much would be earned in the week. The whole atmosphere was one of keenness and interest in spite of the extreme dullness of the work being done.

It is of interest here to compare our results with those obtained by Prof. J. C. Flügel in his work on school children doing mental addition. Prof. Flügel adopted a similar method of bonus payment combined with the drawing of progress graphs. In a description of the effect of these he says:—"The combined effect of the various incentives seems to have been very successful in producing a genuine enthusiasm for the work and a continuous concentration upon the—in itself—somewhat dull and mechanical task, throughout the whole 46 days during which the experiment lasted."*

C.—OPTIMAL DISTRIBUTION OF PRACTICE WITH SPECIAL REFERENCE TO THE PHENOMENON OF "OVERTRAINING."

The question of the most profitable distribution of practice is of special importance in all fields of learning. In industry it arises when a new operation has to be learnt, or when several essential operations have to be mastered by a worker fresh to the trade. It is often asked whether it is better to master one new operation before beginning another, or whether the two can be learnt side by side. Similar questions frequently have to be faced in the planning of a school curriculum. Should two languages be learnt at once, or would it be more profitable to devote the combined time to one? The same problem arises in athletics, where the term "overtraining" is used to denote too great a concentration of practice. The economy and efficiency of training in sport is studied carefully.

1.—*Experimental Outline.*

The following results on the effect of length of practice period arose incidentally from other experimental work on the acquisition of manual dexterity. There were three groups of 30 subjects all employed on chain assembling for a training period of 80 minutes each morning. In the afternoon Group I had a further 80 minutes' chain assembling. Group II had 80 minutes' cartridge filling and Group III was not employed. The cartridge filling operation was

* "Practice, Fatigue and Oscillation." *Brit. J. Psychol. Monograph Supplements.* 13, 11.

specially designed to involve movements as like those of chain assembling as possible, though using different material.

Thus the morning occupations of the groups are identical, and the afternoon employment is the one variable.

The three groups were employed for a fortnight. The comparison between their practice curves in the morning chain assembling is shown in Fig. 1.

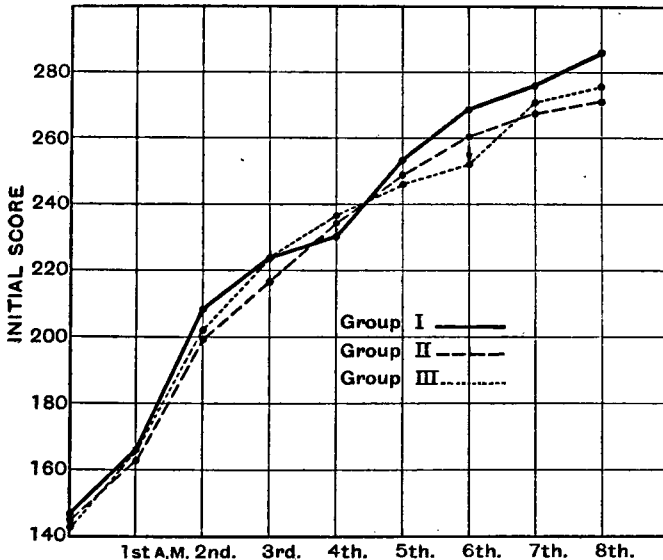


FIGURE 1.—Practice curves of chain-assembly groups.

- Group I. Chain-assembling A.M. and P.M. Sixteen 10-minute periods of chain-assembling per day.
 Group II. Chain-assembling A.M. Cartridge-filling P.M. Eight 10-minute periods of chain-assembling per day; eight 10-minute periods of cartridge-filling per day.
 Group III. Chain-assembling A.M. Rest P.M. Eight 10-minute periods of chain-assembling per day.

It will be seen that their performances were almost identical in spite of the fact that Group I, who were employed in chain assembling during both morning and afternoon, had actually twice as much training as Groups II and III, who were employed in chain assembling only in the morning.

After a period of some months, five subjects from Groups II and III were re-employed for a fortnight, in which they continued training in chain assembling for 80 minutes each morning.* After a drop due to the interruption of practice, this group continued to improve at the same rate. This shows that maximum improvement had not been reached earlier, and that the failure of the concentrated practice of Group I to effect improvement was not due to

* This interruption was due to an unavoidable necessity for the main purposes of the experiment from which the results here reported were obtained.

any flattening of the practice curves. When these five subjects had had the same total amount of training as Group I, their output was very much higher.

2.—Results.

These results show that increase of the daily training period beyond a certain length has no apparent effect. The extra 80 minutes' training in the afternoon resulted in no additional improvement whatever.

It is worth noting that each of the 80-minute training periods was divided up into eight 10-minute periods separated by 10-minute rest pauses. Moreover, the two 80-minute training periods of Group I were separated by a luncheon interval of an hour and a half. No appearance of fatigue was shown either in the mornings or the afternoons. The fact that Group I maintained as high an output in the afternoons as in the mornings, and that Group II improved steadily in cartridge filling, shows clearly that fatigue was not operative. These results further emphasise the importance of determining the optimum arrangement of training for any particular operation. It is evident that 160 minutes' training per day is well above the optimum for chain assembling, and probably also for other similar operations. In fact, the 80 minutes' morning training is probably excessive.

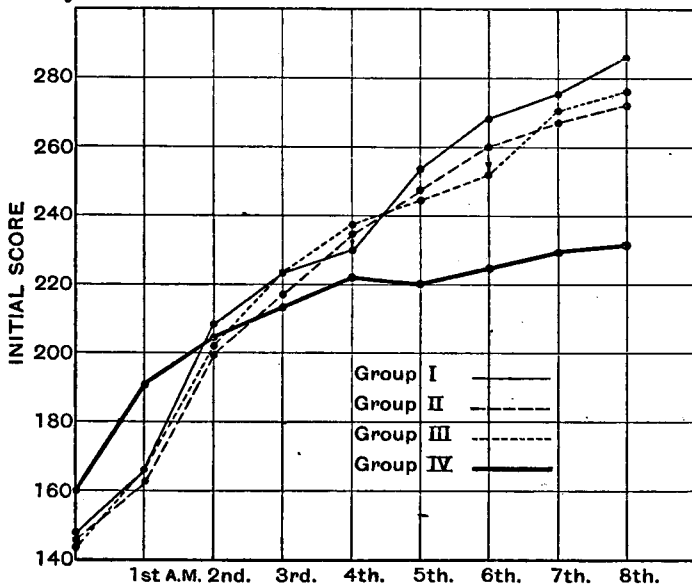


FIGURE 2.—Practice curves of chain-assembly groups.

- Group I. Chain-assembling A.M. and P.M. Sixteen 10-minute periods of chain-assembling per day.
- Group II. Chain-assembling A.M. Cartridge-filling P.M. Eight 10-minute periods of chain-assembling per day; eight 10-minute periods of cartridge-filling per day.
- Group III. Chain-assembling A.M. Rest P.M. Eight 10-minute periods of chain-assembling per day.
- Group IV. Chain-assembling. One 10-minute period in A.M.

It was found possible at a later date to employ a fourth group of subjects, under the same experimental conditions, on chain assembling for only ten minutes a day. The comparison of the practice curve of this group with Group III is shown in Fig. 2. It will be seen from this that Group IV has not reached anything like the same standard as Group III. It is evident then that ten minutes' training per day is not sufficient to give the maximum improvement. By further experiment it would be possible to discover the optimum period of training per day for this operation, which must be something between ten and eighty minutes.

3.—*Conclusions.*

These rather unexpected results seem to indicate that there is far more waste time in "overtraining" than is commonly supposed. In industry, where operatives are doing productive work as their training, this fact is not so serious, because their output is of importance, as well as their improvement. Though twice the daily training may not result in any additional improvement, it is nevertheless producing the additional output. In education and often in sport, however, the actual training time has no value except as training, and thus any time spent beyond the optimal period is completely wasted.

It is interesting in the comparison of Group II with Groups I and III to note that the simultaneous learning of the cartridge-filling operation had no detrimental effect on the improvement in chain assembling. This result seems to indicate that training time can be more profitably spent in learning several operations than in concentration upon one.

D.—THE EFFECT OF LENGTH OF PRACTICE SPELL ON QUANTITATIVE OUTPUT.

The subject of length of work spell and the introduction of rest pauses is one which has been studied in great detail in factory work. The following experiment was planned to investigate the effects of varying length of practice spell in simple manual dexterity.

1.—*Experimental Procedure.*

Five subjects who had already had a fortnight's training in chain assembly were chosen from the groups employed in the experiment on transfer. The choice had to be made from a comparatively small number who were still available. Subjects who had shown themselves to be proficient in the operation were selected. At the same time subjects were chosen whose scores in an intelligence test were as widely divergent as possible. (The intelligence test used was No. 33 of the National Institute of Industrial Psychology.)

2.—*Distribution of Work.*

Before the different spells of work were introduced, the five subjects were given an extra fortnight's chain assembling in the hope that the output might become steady and in order that they might again become absolutely at home with the operation.

After this the distribution of work in varying work spells was commenced as follows:—

On each day 4 hours' actual chain assembling was done. Five different spells of work were introduced.

The subjects worked for five weeks, each week consisting of five working days.

The work spells were as follows:—

5 days 16 $\frac{1}{4}$ -hour spells = 4 hours' actual work each day.

5 „ 8 $\frac{1}{2}$ -hour „ = 4 „ „ „ „ „

5 „ 4 1-hour „ = 4 „ „ „ „ „

5 „ 2 2-hour „ = 4 „ „ „ „ „

5 „ 1 4-hour „ = 4 „ „ „ „ „

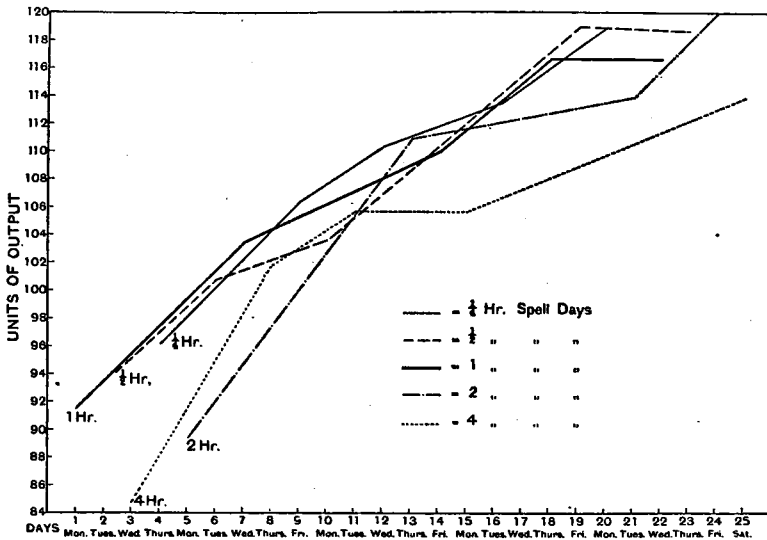


FIGURE 3.—Sample curve showing distribution of different spell days and rising output throughout the five weeks.

Note.—Each spell day occurs once on each day of the week. The spell days are distributed as far as possible equally at the different stages of the practice curve. (Owing to illness Friday of the first week had to be omitted. To compensate for this, Saturday in the last week was included.)

The days of different spells were distributed irregularly throughout the five weeks. By this means the continual increase in the subject's output was compensated and the effect of the rising practice curve was distributed over all the spells, making their various total outputs comparable. At the same time this irregular distribution was so arranged that each work spell occurred once on every day of the week. For example, the 4-hour spell might occur on Monday in the first week, Tuesday in the second, Wednesday in the third, and so on, the other work spells being arranged accordingly. In this way any peculiar "Monday effect," or other daily effect which

might exist, was distributed equally over the five different spells. This arrangement is shown in Fig. 3. Except in the 4-hour spell days the periods were divided equally between morning and afternoon. A 5-minute rest was given between each work spell and the next, except between the last in the morning and the first in the afternoon when approximately an hour was taken for lunch. The subjects were left to themselves during the rest pauses, which they spent in eager comparison of their respective scores.

On every day, 5-minute readings were taken in order that the output throughout the day could be compared and some measure of individual variability obtained.

For the purpose of comparison, the total output from the five subjects on the five days* of each work spell has been reduced to hourly output for each subject under the different work spells. This is shown in Table I. The right hand vertical column gives the average hourly output for each subject, all spells being grouped together. The bottom horizontal column shows the average hourly output for each work spell, all subjects being grouped together.

TABLE I.—COMPARISON OF AVERAGE OUTPUT UNDER DIFFERENT WORK SPELLS. (OUTPUT EXPRESSED IN LINKS PER 1 HOUR'S WORK.)

Subject.	$\frac{1}{2}$ -hour spells.	$\frac{1}{3}$ -hour spells.	1-hour spells.	2-hour spells.	4-hour spells.	Average hourly output for each subject from all spells.
A	2,798	2,628	2,643	2,716	2,513	2,660
B	2,633	2,613	2,537	2,588	2,474	2,569
C	2,104	2,141	2,147	2,127	1,928	2,089
D	2,723	2,674	2,688	2,733	2,556	2,675
E	2,294	2,347	2,371	2,349	2,262	2,325
Average hourly output from all subjects for each spell	2,510	2,481	2,477	2,507	2,345	

3.—Results.

It is evident from this table that the average hourly output is lower for all subjects when the 4 hours' work is done in one 4-hour spell than when this spell is broken up into shorter spells. The 4-hour spell seems to be too long for the subjects to be able to work at maximum efficiency throughout. But there is no such complete agreement amongst the four subjects as to the relative hourly output for the other spells. The bottom horizontal column in Table I shows

* In the case of subjects who had been absent on any day, a score depending on their previous score was interpolated. This occurred only very rarely.

a slightly higher average hourly output for the $\frac{1}{2}$ -hour spells, and the 2-hour spells,* than for the $\frac{1}{4}$ -hour and 1-hour spells. This, however, is not very marked and although shown in the composite averages for all subjects, is not consistently the case for each subject. Allowing for the rather too high value for the 2-hour spells (see footnote) it would seem that the $\frac{1}{2}$ -hour spells had a slight advantage over the others. But again this is only evident in the composite score and is not shown consistently by the individual scores. This inconsistency, combined with the fact that the difference in the composite score is only small, does not merit any conclusion being drawn. Certainly this slight extra efficiency in the shorter spell does not compensate for the extra time which is expended in the continual rest pauses involved.

4.—*Conclusions.*

These results then, suggest that in a simple repetitive operation involving no bodily fatigue, rest pauses introduced during a 2-hour spell have no apparent justification in increase of output, but that a 4-hour spell is too long in which to obtain maximum efficiency throughout.

These results support those obtained by Mr. S. Wyatt and Mr. J. A. Fraser† in their work on the introduction of rest pauses in repetitive work in Industry. They found that a rest pause in a 4-hour work spell increases output sufficiently to compensate for the loss of time entailed by the rest pause. It is suggested, amongst other causes, that the workers are stimulated to a higher efficiency by a fear that the shorter working time might result in a lower total output and thus a lower piece-rate wage. In the above experiment the total working time was kept constant and so this explanation cannot be applied. It would seem rather that a 4-hour spell without a pause is sufficiently long to cause involuntary slackening of speed of work through fatigue. In this particular experiment, no subject ever took any voluntary rests although this was not forbidden. The 4-hour spell was of completely continuous activity and in this respect is not absolutely comparable with similar work under industrial conditions.

E.—THE WORKERS' ATTITUDE TOWARDS DIFFERENT LENGTHS OF PRACTICE SPELLS.

Owing to the distribution of the different spell days in the above experiment it was difficult to obtain any true account of the subjects' views upon the distribution of work. Firstly, this difficulty arose because of the excitement of variety, the subjects not knowing what spell they were going to have until they actually began work.

* From Fig. 3 it will be noted that the 2-hour spells on the whole are introduced at a slightly later period in the practice curve. This will give a comparatively higher average output than for the other spells.

† "Studies in Repetitive Work with Special Reference to Rest Pauses."

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Secondly, any unpleasantness caused by a longer spell was counteracted by the correspondingly shorter working day. For example, where the work was done in one spell without rest pauses, the working day was shorter than usual by the total length of the rest pauses.

In order to obtain some independent measure of any difference in attitude which might exist, it was thought worth while to compare the first periods of the day for the different work spells. Difference in output in this case could be due only to a difference in attitude of the subject, not to an effect of rest pauses as would be the case in a similar comparison of some later period. This comparison is shown in Tables II, III, and IV.

TABLE II.—AVERAGE OUTPUT IN LINKS PER QUARTER-HOUR FOR THE FIRST QUARTER-HOUR OF ALL SPELLS.

		Subject A	B	C	D	E	Average for all subjects.
$\frac{1}{4}$ -hour spell	..	659	603	476	631	575	588
$\frac{1}{2}$ " "	..	635	583	497	769	577	612
1 " "	..	617	594	510	629	576	584
2 " "	..	660	606	518	670	561	600
4 " "	..	636	591	482	573	563	568

TABLE III.—AVERAGE OUTPUT IN LINKS PER HALF-HOUR FOR THE FIRST HALF HOUR OF ALL SPELLS (EXCEPT QUARTER-HOUR SPELLS).

		Subject A	B	C	D	E	Average for all subjects.
$\frac{1}{4}$ -hour spell	..	1,281	1,180	1,024	1,270	1,158	1,180
1 " "	..	1,271	1,205	1,052	1,311	1,181	1,204
2 " "	..	1,362	1,264	1,033	1,378	1,163	1,230
4 " "	..	1,302	1,217	983	1,261	1,121	1,136

TABLE IV.—AVERAGE OUTPUT IN LINKS PER HOUR FOR THE FIRST HOUR OF ALL SPELLS (EXCEPT QUARTER- AND HALF-HOUR SPELLS).

		Subject A	B	C	D	E	Average for all subjects.
1-hour spell	..	2,593	2,579	2,090	2,606	2,354	2,412
2 " "	..	2,797	2,596	2,090	2,759	2,343	2,516
4 " "	..	2,582	2,460	1,995	2,542	2,283	2,372

1.—Results.

Table II gives the average $\frac{1}{4}$ -hour's output for the first $\frac{1}{4}$ -hour of each of the different work spells. These are given for each individual subject and for the average of the four subjects. Similarly, Tables III and IV give the average of the first $\frac{1}{2}$ -hour's and 1-hour's output respectively. It will be noticed that in Table III the $\frac{1}{4}$ -hour spells are omitted, and that in Table IV the $\frac{1}{4}$ -hour and $\frac{1}{2}$ -hour spells are omitted. These were not considered to be comparable as in each case they would include one or two rest pauses. Tables II and III demonstrate that no one subject shows any consistent adjustment to the length of work spell in either the first quarter- or first half-hour of the day. But in both these tables the total average for all subjects is lowest in the 4-hour spell. This seems to indicate a general tendency for some adjustment to take place from the start. This is borne out in Table IV, where the first hour's output for all subjects is lower in the 4-hour spell than in the others.

2.—Conclusions.

From these figures it appears that a lower rate of work is adopted to compensate throughout the spell for the longer spell being worked. These particular results seem to indicate that this adaptation is not conscious. There is no evidence from these results that any such adaptation takes place in spells as short as two hours. It is evident only in the spells of 4 hours.

F.—THE EFFECT OF LENGTH OF WORK SPELL ON VARIABILITY OF OUTPUT.

In view of the emphasis which has of late been laid on the subject of variability of output and its relationship to fatigue, a detailed analysis of the figures obtained from this experiment was made, in the hope that some evidence on the subject might be available. Owing to the original nature of the experiment the measurement of variability presented some difficulties. After detailed examination of the figures, the arithmetical difference between the scores of adjacent five-minute periods was adopted as the most representative method. In order that the variation in the different spells should be directly comparable, only the differences between adjacent 5-minute scores within each $\frac{1}{4}$ -hour period were used. For example, the differences between the first and second, and second and third 5-minute scores, but not the difference between third and fourth, or between the sixth and seventh, were used, because in the $\frac{1}{4}$ -hour spell days of these latter would be separated by a rest pause and therefore would be directly comparable only with other $\frac{1}{4}$ -hour spell days.

Results.

Table V gives the total variation between adjacent scores for each subject for the five days of each spell. The average for the five

subjects is given in the bottom horizontal column. From this it seems that variation tends to increase with length of spell. The 1-hour, 2-hour and 4-hour spells have a higher variability than the $\frac{1}{2}$ -hour and $\frac{1}{4}$ -hour. This, with the exception of subject E, shows itself as a consistent tendency throughout the individual records.

Furthermore, it must be remembered that Table V gives absolute records, and when it is considered side by side with the total output (Table I) it will be realised that the 4-hour spells, though actually showing a slightly smaller average numerical variation than the 2-hour spells in Table V, have actually a larger relative variation. This is shown in Table VI, where the variation is expressed as a percentage of the total output.

TABLE V.—COMPARISON OF TOTAL VARIATION BETWEEN ADJACENT SCORES.

Subject.	$\frac{1}{4}$ -hour spell.	$\frac{1}{2}$ -hour spell.	1-hour spell.	2-hour spell.	4-hour spell.	Average variation from each subject for all spells.
A	1,294	1,216	1,616	1,708	1,573	1,481
B	1,264	1,463	1,478	1,584	1,403	1,438
C	1,227	1,148	1,171	1,341	1,332	1,244
D	1,490	1,392	1,426	1,539	1,709	1,511
E	1,335	1,293	1,567	1,279	1,270	1,349
Average variation for each spell from all subjects.	1,322	1,302	1,452	1,490	1,457	

TABLE VI.—COMPARISON OF VARIATION IN DIFFERENT SPELLS EXPRESSED AS A PERCENTAGE OF THE TOTAL OUTPUT.

Subject.	$\frac{1}{4}$ -hour spell.	$\frac{1}{2}$ -hour spell.	1-hour spell.	2-hour spell.	4-hour spell.	Average for each subject from all spells.
A	2.32	2.32	3.06	3.14	3.14	2.80
B	2.40	2.80	2.92	3.06	2.82	2.80
C	2.92	2.68	2.73	3.16	3.46	2.99
D	2.74	2.61	2.65	2.82	3.34	2.82
E	2.92	2.76	3.31	2.72	2.81	2.91
Average from each spell for all subjects	2.66	2.63	2.93	2.98	3.11	

TABLE VII.—RELATIONSHIP BETWEEN INDIVIDUAL OUTPUT AND VARIABILITY.

c		A	B	C	D	E
$\frac{1}{4}$ -hour spell..	Output ..	55,963	52,667	42,081	54,463	45,876
	Variation ..	1,294	1,264	1,227	7,490	1,335
	% Variation..	2.32	2.40	2.92	2.74	2.92
$\frac{1}{2}$ -hour spell..	Output ..	52,563	52,260	42,828	53,475	46,934
	Variation ..	1,216	1,463	1,148	1,392	1,293
	% Variation..	2.32	2.80	2.68	2.61	2.76
1-hour spell..	Output ..	52,850	50,731	42,937	53,757	47,425
	Variation ..	1,616	1,478	1,171	1,426	1,567
	% Variation..	3.06	2.92	2.73	2.65	3.31
2-hour spell..	Output ..	54,314	51,765	42,549	54,663	46,976
	Variation ..	1,708	1,584	1,341	1,539	1,279
	% Variation..	3.14	3.06	3.16	2.82	2.72
4-hour spell..	Output ..	50,261	49,488	38,567	51,125	45,235
	Variation ..	1,573	1,403	1,332	1,709	1,270
	% Variation..	3.14	2.82	3.46	3.34	2.81
Average for all spells {	Output ..	53,190	51,382	41,792	53,497	46,489
	Variation ..	1,481	1,438	1,244	1,511	1,349
	% Variation..	2.80	2.80	2.99	2.82	2.91

G.—THE RELATIONSHIP BETWEEN VARIABILITY AND TOTAL OUTPUT.

The relationship between individual output and variability can be seen from Table VII. This table gives for each subject the total output, total variation, and the variation expressed as a percentage of the total output. Owing to the method used in obtaining the measure of variability, these percentages are only valid for comparative purposes and are not of any absolute significance. The data in this table are expressed graphically in Fig. 4. The absolute and percentage variation is plotted against output for each of the five subjects. Fig. 4 groups all the different "spell-days" together.

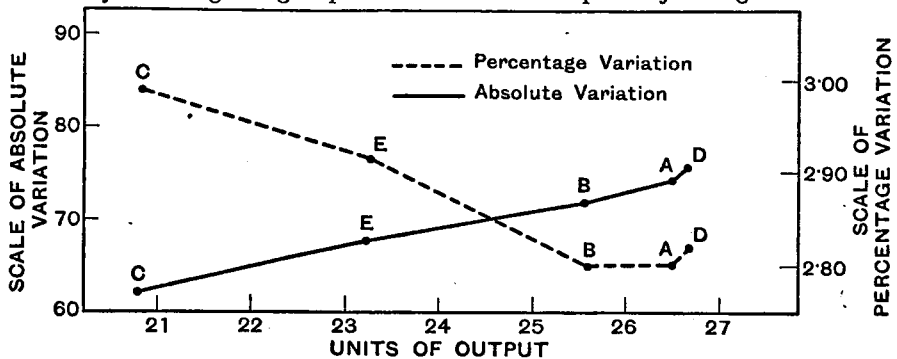


FIGURE 4.—Relationship between absolute and percentage variation and output (all spells grouped). Letters A, B, C, D and E indicate readings for five individual subjects.

Results.

It was found that the absolute variation increases with output, i.e. the higher the subject's output the greater is his absolute variation. Moreover, the comparative figures for all the "spell-days" give evidence that percentage (i.e. relative) variation *decreases* with output. A subject with a higher average output tends to maintain a more constant level of work. A subject with a lower average output tends to have a higher variation. The figures for the separate "spell-days" do not show this quite so consistently, but these being obtained from a smaller range of data are more influenced by individual irregularities.

H.—THE RELATIONSHIP BETWEEN FATIGUE AND VARIABILITY.

It has sometimes been suggested that variation is a better measure of fatigue than output. Where workers are paid on a piece-rate it seems probable that this increase in variation might occur more regularly than a corresponding decrease in output. In spite of fatigue great effort is often made to keep up the output in order to earn the minimum wage. In this case fatigue would not be indicated in any record of total output, but yet might appear in a measure of the variability of output.

Comparison of Tables VIII and IX, which give records of morning and afternoon variability and morning and afternoon output gives some support to this hypothesis. A detailed consideration of Table VIII shows that with the exception of subject A in the $\frac{1}{2}$ -hour period and Subject E in the $\frac{1}{2}$ -hour period, variation is always greater in the afternoon than in the morning. The right-hand vertical column giving the total variation for all subjects shows throughout a higher afternoon variation. The same tendency is shown in the comparison of the 1st and 2nd two hours of the 4-hour period. The second 2 hours gives a higher variation than the first 2 hours. On the other hand examination of Table IX indicates a slight tendency for output to be higher in the afternoon than in the morning, but this does not occur in the second two hours of the 4-hour period. Here output is lower than in the first two hours.

TABLE VIII.—COMPARISON OF MORNING AND AFTERNOON TOTAL VARIATION FOR EACH SUBJECT IN EACH SPELL. (THE FIRST VARIATION OF BOTH MORNING AND AFTERNOON IS OMITTED.)

Spells.	Subject.	A	B	C	D	E	Total.	
							A.M.	P.M.
$\frac{1}{2}$ -hour	A.M.	538	423	577	463	589	2,417	
	P.M.	560	535	647	575	539		2,494
$\frac{1}{2}$ -hour	A.M.	574	579	521	504	506	2,188	
	P.M.	470	701	638	521	581		2,642
1-hour	A.M.	620	581	554	463	584	2,205	
	P.M.	775	685	617	486	730		2,602
2-hour	A.M.	685	605	553	534	494	1,964	
	P.M.	689	721	700	625	515		2,207
4-hour	1st 2 hrs.	523	561	772	528	557	2,173	
	2nd "	836	651	765	662	526		2,364

TABLE IX.—COMPARISON OF MORNING AND AFTERNOON TOTAL OUTPUT FOR EACH SUBJECT IN EACH SPELL.

Spells.	Subject.	A	B	C	D	E	Total.	
							A.M.	P.M.
$\frac{1}{4}$ -hour	A.M.	27,294	27,010	20,687	27,134	23,216	125,335	125,715
	P.M.	28,669	25,657	21,394	27,329	22,666		
$\frac{1}{2}$ -hour	A.M.	26,273	25,739	21,138	26,668	23,526	123,344	124,716
	P.M.	26,290	26,521	21,690	26,807	23,408		
1-hour	A.M.	25,645	24,976	20,290	26,673	23,709	121,293	126,407
	P.M.	27,205	25,755	22,647	27,084	23,716		
2-hour	A.M.	26,868	26,829	20,956	26,994	23,717	125,364	124,903
	P.M.	27,446	24,936	21,593	27,669	23,259		
4-hour	1st 2 hrs.	25,284	24,931	20,092	25,261	22,934	118,502	116,174
	2nd "	24,977	24,557	18,475	25,864	22,301		

It seems reasonable to assume that the subjects were not as fresh and free from fatigue in the 2 hours' afternoon work as in the 2 hours' morning work. No decrease of output* indicates this. On the other hand it is suggested by an increase in variability.

In the second 2 hours of the 4-hour period, where fatigue can be assumed to be more marked, there is both an increase in variability and a decrease in output.

Conclusion.

These figures seem to indicate that fatigue is more sensitively measured by variation than by output. From observation of these particular subjects this seems to be due to the greater effect of incentive on total output than on constancy of output. The fatigue, though masked in the total output, is indicated in detailed examination of the variation of output.

I.—SUMMARY OF CONCLUSIONS.

By a system of bonus-payment, in this laboratory experiment, the subjects employed on the simple repetitive operation of chain assembling were all induced to work with maximum effort throughout each work spell. In these conditions the following results were obtained, but it should be stated that, although very consistent, they are mainly based on the records of five students learning the process, and of course do not necessarily apply indiscriminately to all operations, particularly to such as may be very dissimilar both in nature and conditions.

(1) Increase in daily training period beyond a certain length is of no value. Eighty minutes' training per day in chain assembling was found to give just as much daily improvement as double this length. It is likely that the optimal training period was even below the eighty minutes.

* The slight increase in output in the afternoon might be ascribed to the fact that the practice curve is still rising (see Fig. 1).

(2) A 4-hour spell is too long for maximum efficiency to be maintained.

(3) Output from 2 hours of work is not increased if this is sub-divided into $\frac{1}{4}$ -, $\frac{1}{2}$ -, or 1-hour spells. From consideration of output it appears that rest pauses given in a 2-hour work spell are not justified.

(4) Adjustment to the length of work spell, indicated by a slower rate of work, takes place in the 4-hour spell. This is not shown in any spell shorter than 4 hours.

(5) Although division of a 2-hour spell into shorter work periods has no effect on total output, variability of output tends to increase with the length of work spell. The 1-hour, 2-hour, and 4-hour spells have a higher variability than the $\frac{1}{4}$ -hour and $\frac{1}{2}$ -hour spells.

(6) Subjects with a higher average output show a higher absolute variability, but a lower relative variability, than those with a lower average output. The more efficient subjects on the whole produce a more constant output.

(7) Variability for the second 2 hours' work of the day is higher than for the first 2 hours. This seems to indicate that variability increases with fatigue.

(8) The fact that output does not show any decrease as the day proceeds, suggests that variability rather than output is the more sensitive measure of fatigue.

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REPORT No. 69

**INCENTIVES IN REPETITIVE
WORK**

**A PRACTICAL EXPERIMENT
IN A FACTORY**

**By S. Wyatt
Assisted by L. Frost and F. G. L. Stock**

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PREFACE

Repetitive work has for some years been the chief study of Mr. S. Wyatt and his assistant collaborators, and the Board have published the results of several investigations made by them into the psychological problems which are becoming increasingly evident in such work as the mechanization of labour progresses (Reports 26, 30, 32, 51 and 63).

In previous work, the prevalence and nature of monotonous work have been studied both in the simpler and in the more complex processes, and suggestions made for alleviating its effects. These effects, of which boredom is a principal symptom, have been shown to influence output in a characteristic way, and the variations in output produced have, in their turn, been used as a measure of the effects of boredom on the workers, both as groups and as individuals.

The present report describes an investigation which set out to study the reactions of a number of individual workers, differing in type and temperament, to varying kinds and conditions of work, in particular to the effects of the varying incentives embodied in different wage-systems.

The experiments were essentially practical, as the laboratory in which they took place was part of a real factory, in which the subjects of the experiments were employed by the manufacturers of a well-known proprietary article, and where their produce formed part of the daily factory output, the only difference being that the place of the usual factory supervisors was taken by the Board's investigators.

The operatives themselves were under close and continuous observation for over a year, and this period gave sufficient opportunities for the investigators to note important obstacles to efficiency and contentment at work, which are apt to escape notice in less intensive, or more general, investigation of groups.

Reactions to conditions of work such as are indicated by personal behaviour, and even by topics of conversation, are shown to be relevant; in fact the report may be said, so far as the Board are aware, to present the first "close-up" psychological picture of a group of operatives engaged in repetition work, which has been taken in this country.

INCENTIVES IN REPETITIVE WORK: AN EXPERIMENT IN A FACTORY

BY S. WYATT, M.Sc.,
ASSISTED BY L. FROST AND F. G. L. STOCK

CONTENTS

	<i>Page</i>
I.—INTRODUCTION	1
II.—EXPERIMENTAL CONDITIONS	2
III.—RESULTS OBTAINED	3
1. Method of payment	3
A.—Rate of improvement	3
(i) Group results	3
(ii) Individual results	9
(a) Individual differences in output	9
(b) Individual differences in improvement	12
B.—Variations within the spell of work	14
C.—Lost time	17
D.—Behaviour	19
E.—Opinions of the workers	23
2. Type of work	24
A.—Rate of improvement	24
B.—Variations within the spell of work	31
C.—Lost time	33
3. Personal factors	35
A.—Group and individual influences	36
(i) Group behaviour	36
(ii) Individual effects	38
(iii) Effect of rearranging the workers within the group	39
(iv) Effect of isolation	41
B.—Temperamental tendencies	43
C.—Intelligence	46
D.—Talking	47
IV.—DISCUSSION OF RESULTS	48
V.—SUMMARY	55

I.—INTRODUCTION

The experiment which forms the subject of this report was devised for the purpose of studying the nature and causes of the reactions of different individuals to various types and conditions of work. It represents an attempt to apply intensive methods of procedure to a small group of operatives employed under controlled conditions for a total period of 54 weeks.

There is reason to believe that the more general form of investigation based upon the collection of weekly records from a large number of workers fails to disclose some of the more elusive but important determinants of efficiency and contentment. These can be studied only by a close and continuous method of observation, and such a procedure necessarily imposes a limit to the number of individuals that can be observed. Some of the results cannot, therefore, be regarded as conclusive until larger numbers have been observed, but must await confirmation from other investigations conducted along similar lines. At the same time there is little doubt that several of the principles discussed in this report are common to many forms of industrial work, and to this extent a repetition of the procedure may be expected to yield similar results.

The greater part of the present experiment was also concerned with the behaviour of operatives during the learning period, and it might be thought that the results obtained would have little relation to the reactions of more experienced workers. In most repetitive processes, however, the attitude of the learners towards the conditions of work remains practically unchanged after the novelty of the first few weeks has disappeared. The capacity for improvement is, of course, greater in learners than in experienced operatives, and to this extent the beneficial effects of a change in the conditions of work will usually be greater in the former than in the latter. The tendency, as distinct from the amount will, however, be the same in both cases.

It may also be objected that a procedure which requires the continued presence of an observer creates an artificial situation which is different from the usual conditions in the factory. The present experiment was performed in a factory with factory material, and the attitude of the workers after the first few days was indistinguishable from that of an ordinary factory group towards the regular overlooker. In any case the presence of an observer was a constant factor in the experimental situation, and the greater part of the report deals with the effect of variables which were introduced during the course of the experiment. The remainder is concerned with the influence of factors which were largely independent of experimental conditions.

II.—EXPERIMENTAL CONDITIONS

Workers.—The workers employed in this experiment were ten girls aged between 15 and 16 years. They were selected from a number of applicants on the basis of personal characteristics as shown during an interview and in the performance of special tests. In particular an attempt was made to include different temperamental types as this factor was believed to be an important determinant of suitability for work.

Processes.—Under ordinary industrial conditions each worker is usually employed on a single operation and there are no means of ascertaining her reactions to other types of work. It is, however, important to know how the same individual responds to different industrial processes. Consequently, in the present experiment each worker learned and became thoroughly experienced in five different operations. These were :—

(1) *Unwrapping.*—In this process the operatives merely removed the paper from pieces of toffee which had been imperfectly wrapped by machines.

(2) *Wrapping.*—This process consisted of wrapping chocolates in tin-foil.

(3) *Packing.*—The material used in this process was a pile of small squares of wrapped toffee, a batch of tins, and a separate quantity of lids. Four pieces of toffee were packed in each tin, which was then closed by fixing the lid.

(4) *Weighing.*—The workers stood while performing this operation, which consisted in filling a tin with wrapped pieces of toffee, weighing the filled tin, and adjusting the contents to give the required weight. The operation was completed by adding a paper slip and fixing the lid.

(5) *Weighing and wrapping.*—This process also involved standing at a bench. The workers were supplied with large tins capable of holding 4 lbs. of toffee, a pile of wrapped toffee, decorative paper, and wrapping material. The pan of the scales, which was designed to hold the approximate weight required, was filled by plunging it into the pile of toffee on the bench and a few adjustments gave the correct weight. A decorative piece of paper was placed around the inside of the tin, which was then filled with the weighed toffee. After pressing and levelling the contents a paper slip was inserted and the lid fixed. The tin was then wrapped in brown paper, tied with string, and finally labelled.

It will be noticed that the processes, although repetitive, increased in variety and complexity in the order given. The average number of units of output completed in the same time was approximately :—

1. Unwrapping	..	..	40
2. Wrapping	..	..	20
3. Packing	..	..	12
4. Weighing	..	..	6
5. Weighing and wrapping			1

The material and methods of work employed in the experiment were similar to those used in the corresponding departments in the factory and the operatives were part of the ordinary factory staff.

Procedure.—The scheme of work adopted in this experiment was as follows :—

			A.B.	G.D.	E.F.	G.H.	I.J.
Monday	..	..	1	2	3	4	5
Tuesday	..	..	2	3	4	5	1
Wednesday	..	..	3	4	5	1	2
Thursday	..	..	4	5	1	2	3
Friday	..	..	5	1	2	3	4

The letters refer to the operatives and the numerals to the operations. Thus, on any given day, two workers were employed on each of the five processes, and in the course of a week all the operatives had worked for one day on each of the tasks. Saturday mornings were spent in the performance of a series of special tests and in writing answers to questions regarding the attitude towards the conditions of work.

The experiment was conducted in a separate room which was specially equipped for the purpose by the management. Since the arrangement of the workers and processes was found to have an important bearing on the results obtained, a diagram may be useful (Fig. 1).

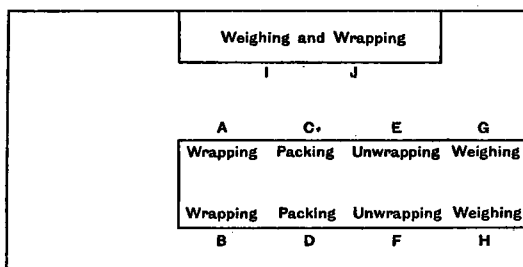


FIG. 1. Diagram of working positions.

Thus in four processes the operatives worked facing each other in pairs on the same bench, and in this respect they formed a fairly compact group. The two operatives employed on the combined weighing and packing operation stood with their backs to the others at a separate bench, and were in consequence somewhat isolated from the remainder of the group.

The hours of work were from 8 to 12 and from 1 to 5, but the first five and the last ten minutes in each spell were devoted to answering questions on feelings of fitness, boredom, fatigue, and the like. Thus the actual number of hours worked in each spell

was 3½. The behaviour of the operatives during work, their remarks and appearance, were also noted by the experimenter, and output was recorded every quarter-hour.

Although the general scheme of the experiment was planned in advance, it was naturally impossible to foresee the reactions of the operatives to the conditions of work, consequently the procedure was varied whenever a situation developed which seemed to warrant an experimental change. The nature and effects of these changes, which may be regarded as important variations within the general structure of the experiment, occupy a prominent position in the report.

III.—RESULTS OBTAINED

1. METHOD OF PAYMENT

In accordance with the usual practice in industry, the workers in this experiment were first paid a fixed weekly wage. This method of payment was continued for nine weeks and was followed by a competitive bonus system which remained in operation for fifteen weeks. During this period the operatives were ranked each week according to output, and the slowest worker was given the same wage as before. The next in order of output received an additional sixpence and so on throughout the group, so that the quickest worker earned 4s. 6d. more than the slowest. It will be seen that while the total amount paid each week in wages remained the same, though 22s. 6d. higher than during the first period, individual earnings could vary within a limited range. This system of payment was followed by a flat piece-rate which remained unchanged for another twelve weeks. Thus, for a period of 36 weeks, the different methods of payment represented the only significant external changes in the conditions of work, and their effects on output and behaviour will now be discussed.

A.—Rate of Improvement

(i) *Group results*

The results obtained have been used to show, in the first place, the average rate of improvement when the workers were considered as a group. For this purpose the results obtained from all the workers in the different processes have been combined and expressed as a percentage of the output in the first week. This method of treatment gave the curves shown in Fig. 2.

The amount of improvement during the time-rate period was relatively small (12 per cent.) and there were indications that a continuation of this method of payment would have resulted in no appreciable increase in output. It was for this reason that the bonus scheme was introduced, and the immediate effect was an increase in output of 46 per cent. The curve of output continued to rise for the greater part of this period, but towards the end it remained at a fairly uniform level, and a further change in the

method of payment seemed desirable. The flat piece-rate was accordingly introduced, and again there was a notable increase in output (30 per cent.) which, after a temporary reaction, was maintained with very little change.

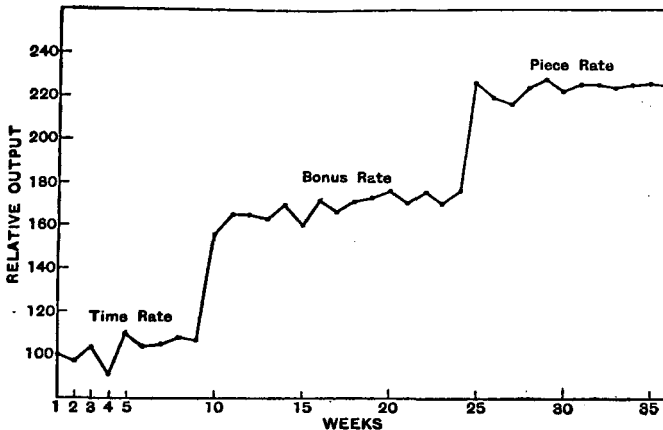


FIG. 2. Effect of different systems of payment on rate of improvement.

It is evident that, in this experiment, a time-rate proved to be a comparatively weak incentive to work. It produced very little improvement in output, and performance was undoubtedly much below capacity. During the first few weeks of the bonus scheme the workers were stimulated by its novel and attractive possibilities. Later, however, there was a reaction on the part of some of the workers and a corresponding reduction in productive effort. A rough measure of the effect of this weakening incentive is given by the increase in output recorded after the introduction of the piece-rate.

In general, therefore, the workers responded in a positive manner to each change in the method of payment, but sooner or later the rate of working became stabilised at a level which remained practically unchanged as long as the conditions of work remained the same.

In a subsequent stage of the experiment an attempt was made to determine the effect of further changes in the system of payment. In this case the three methods already used were applied simultaneously to the different processes. The piece-rate was retained in the wrapping and packing operations, but the bonus scheme was revived in the two weighing processes, while in unwrapping the original time-rate was restored. The average output obtained under these three systems of payment, which were in force for a period of six weeks, may be compared with the average output recorded during the preceding six weeks when all the processes were paid by piece. Such a comparison is shown in Table I.

TABLE I.—EFFECT OF FURTHER CHANGES IN THE METHOD OF PAYMENT ON OUTPUT

Method of payment.			Average hourly output.	Method of payment.	Average hourly output.	Per cent. difference.
Wrapping	..	Piece	442.4	Piece	450.7	+ 1.9
Packing	..	"	268.2	"	269.5	+ 0.5
Weighing	..	"	110.0	Bonus	120.6	+ 9.6
Weighing and wrapping.	..	"	21.2	"	24.3	+14.6
Unwrapping	..	"	807.6	Time	602.3	-25.4

As might be expected, there was practically no change in output in the two processes which remained on the piece-rate. The revival of the bonus scheme, however, tended to have a favourable effect, but this does not necessarily mean that the bonus rate was inherently superior to the piece-rate as an incentive to work. If the change had been from bonus to piece-rate, it is possible that the favourable effects would have equalled or exceeded those observed in the present case. The change to the bonus scheme was regarded as an interesting diversion and tended to counteract the effects of the monotonous conditions of work.

The most striking feature of the results was the significant decrease in output caused by the revival of the time-rate. The workers reverted to the indifferent attitude which was so noticeable during the original time-rate period, and the results support the view that the lower output caused by the time-rate is not confined to the early stages of the learning process, but may be equally apparent in the case of more experienced workers. Incidentally the results agree with the belief already expressed that no appreciable increase in output was to be expected from an extension of the original time-rate period.

Although a time-rate method of payment is comparatively ineffective as an incentive to work, and retards the rate of improvement in the learning of simple repetitive tasks, this system of payment is invariably applied to beginners in industry. Some form of payment by results is desirable, but a flat piece-rate is impracticable because of the increasing output which would generally involve a periodic cutting of rates. The competitive bonus scheme seems to be particularly suited to the learning period, and its value may be illustrated by some results obtained from the same group of workers who, after the 45th week of the experiment were employed in filling small cartons with tablets. This operation was very similar to the packing process included in the main experiment, and the results obtained in the two series are given in Fig. 3. The output in each week has been expressed as a percentage of that recorded during the first week.

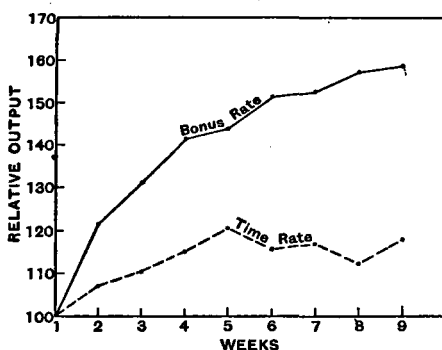


FIG. 3. Comparative effects of (a) time-rate; (b) bonus-rate in two packing processes.

It will be seen that the rate of improvement under the bonus system of payment was greater than that recorded under the time-rate and the superiority became more marked in each successive week. In the ninth week the difference was almost 35 per cent.

Lest it should be thought that the tendencies observed in the present experiment were exceptional, some additional information on the effect of methods of payment was obtained from different groups of operatives in the factory. The results in question are shown in Fig. 4, and refer to

(a) a group of 10 workers employed in feeding machines with toffee. During the first eight days a time-rate was in operation but afterwards a bonus was paid when the daily output exceeded 60,000 pieces. This rate remained unchanged until the twenty-fourth day when the daily output had to reach 68,000 pieces before the bonus could be earned.

(b) a group of 19 operatives engaged in filling small cartons with tablets. Ten of these workers were paid by time throughout the whole period but the remaining nine, after the first five days, were put on a piece-rate.

In the case of the first group of workers (lower curve) there was a sharp increase in output when the first bonus was introduced. The immediate increase was approximately 20 per cent., and the subsequent output continued to fluctuate around the level required for the bonus. When the modified bonus was introduced there was a further increase in output of approximately 18 per cent. which was more than maintained to the end of the period. Thus the introduction of the bonus scheme which was dependent on a certain level of output being reached acted as an additional incentive to activity, and in this respect the results agree with those obtained in the main experiment.

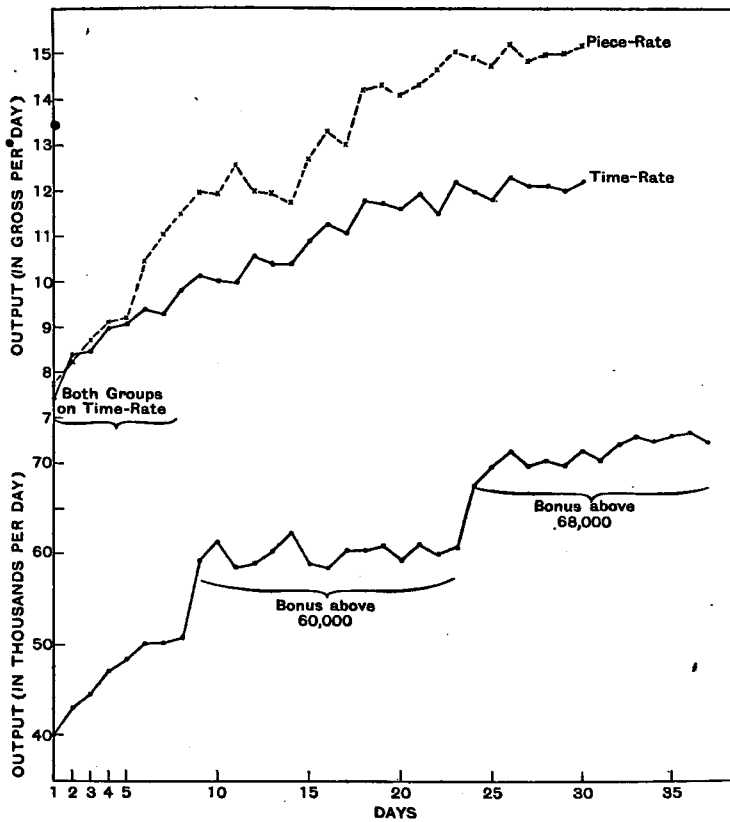


FIG. 4. Effect of different systems of payment on rate of improvement (factory groups).

In the case of the second group of workers (upper curves) the output of the two sections was practically the same during the first five days under the common time-rate, but afterwards the piece-rate members of the group began to draw away from those who remained on the time-rate, and in the final stages the difference in output was approximately 25 per cent. The results accordingly provide further evidence of the relative weakness of a time-rate as an incentive to work during the learning period.

Somewhat similar results were also obtained from a group of experienced workers in the same factory. They were employed in feeding wrapping machines with chocolate and the results show the effect of changing from a time to a piece-rate method of payment. These are given in Fig. 5 and the points on the curves represent the average weekly output (in lbs. per hour) before and after the change.

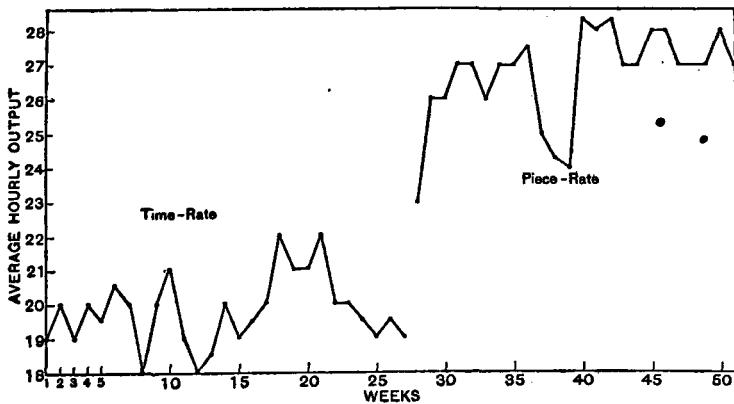


Fig. 5. Effect of changing from a time-rate to a piece-rate (machine feeding).

In this case the introduction of a piece-rate resulted in an average increase in output of 36 per cent. During the time-rate the operatives worked in a careless and indifferent manner. Minor stoppages of an avoidable nature, such as the choking of the mechanism by chocolate or paper, were numerous, and more serious breakdowns which required the help of a mechanic were unnecessarily prolonged. After the introduction of the piece-rate the operatives gave more attention to the machines with the result that stoppages were both shorter and less frequent. This had a beneficial effect not only on output but also on the life of the machines.

It is apparent, therefore, that the rate of working both during and after the learning period is largely dependent on the method of payment. Output seems to become stabilised at a level which is proportional to the strength of the monetary incentive. Under a time-rate this level was much below the limits of possible achievement and was associated with an attitude of indifference on the part of the operatives concerned. A change to a bonus or piece-rate broke down this attitude and resulted in a new level of output which was usually from 20 to 40 per cent. above that recorded under a time-rate.

(ii) *Individual results*

The preceding results refer to the workers considered as a group and consequently deal with general tendencies. One of the aims of the present experiment was, however, to determine the nature, extent, and probable causes of individual differences in behaviour under the same and varied conditions of work, consequently it is necessary to consider the results from this standpoint.

(a) *Individual differences in output.* Industrial managers and vocational psychologists are interested in the question as to whether differences in output in a group of beginners decrease, increase, or

remain the same during the learning period. This is part of the general problem as to whether the same amount of instruction, training, or experience makes people more alike or dissimilar. If practice reduces the differences in output between one worker and another to such an extent as to make them practically negligible then from this standpoint almost any person may be chosen for a specific industrial task and selection becomes unnecessary. If, on the other hand, they increase with practice, the value of some method of selection will be correspondingly increased.

Most of the published results on learning show that individual differences in performance decrease with training. These results* refer to laboratory tests of short duration repeated at regular intervals, and as a rule the subjects were induced to work as quickly as possible. The conditions were accordingly very different from those which prevail in industry and the results cannot be accepted as applicable to factory operatives.

The data obtained in the present inquiry may be used to illustrate the tendency under factory conditions. Individual differences in output have been measured by the coefficient of variation from the group average in each week and the results so obtained are given in Fig. 6.

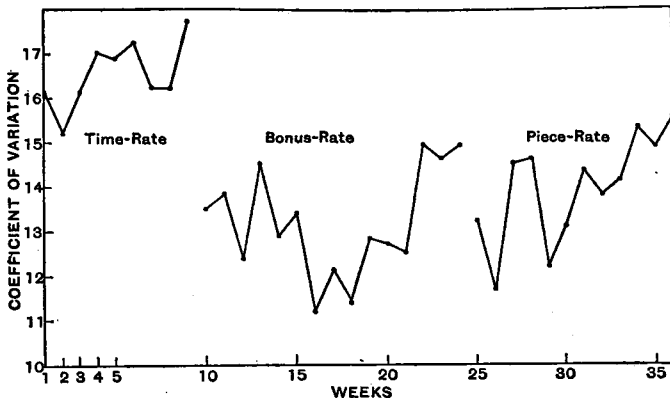


Fig. 6. Individual differences in output in successive weeks.

It will be seen that although individual differences in output decreased after each change in the method of payment, the tendency was afterwards reversed. During the time-rate the more conscientious and industrious members of the group continued to improve at a reasonable rate but the indifferent workers showed an increasing tendency to relax as the experiment proceeded. The change to the bonus method of payment caused a general

* See, for instance, the summary given by M. Kincaid in the *Psych. Rev.*, 1925, 32, 34-53.

revival of interest which persisted in some individuals more than in others. A similar state of affairs existed after the introduction of the piece-rate and the effects are reflected in the curves.

The preceding results refer to variations from the group average, but since the workers were employed in pairs within the group the relative rate of working of the two members in each pair may be considered. It will be remembered that on any given day operatives A and B, for instance, worked opposite to each other and were employed on the same process. At the same time the other operatives worked in pairs but each pair was engaged on a different type of work. Other things being equal, the differences in output between A and B should decrease with practice, but the results show that this expected tendency was reversed by each successive change in the method of payment. The results in question are given in Table II, and show the percentage difference between the output of each pair of workers under each method of payment.

TABLE II.—PERCENTAGE DIFFERENCE IN OUTPUT BETWEEN THE TWO MEMBERS OF EACH PAIR UNDER EACH SYSTEM OF PAYMENT

<i>Workers</i>	<i>Time rate</i>	<i>Bonus rate</i>	<i>Piece rate</i>
A and B ..	3.6	8.7	9.7
C and D ..	6.4	9.7	9.8
E and F ..	5.6	7.5	9.6
G and H ..	13.0	25.6	29.4
I and J ..	6.3	10.1	7.7
Average ..	7.0	12.3	13.2

The differences in output between the members of each pair were least during the time-rate period but increased under the two systems of payment by results. Thus, although the deviations in output from the group average were greater under the time-rate than under the bonus method of payment (Fig. 6), the difference in output between the members of each pair showed the opposite tendency.

During the course of this experiment the same group of workers acted as subjects in a series of special tests which were repeated every Saturday morning for a period of 37 weeks. The tests involved simple forms of manual speed and dexterity and each test lasted five minutes. The individuals were promised a substantial bonus based upon the amount of improvement in successive weeks and were constantly reminded of the importance of working as quickly as possible. There is little doubt that the results obtained in this series coincided closely with individual capacity, since they represented maximum achievement during short periods and were practically unaffected by boredom or fatigue. Differences in output between one worker and another are given in Table III. They are expressed as the coefficient of variation from the group average in (a) the first two tests and (b) the final four tests.

TABLE III.—INDIVIDUAL DIFFERENCES IN OUTPUT IN THE EARLY AND FINAL STAGES OF A SERIES OF TESTS PERFORMED AT MAXIMUM SPEED

Test		1st 2 weeks	Last 4 weeks
Threading beads ..	..	16.7	12.5
Arranging metal tubes ..	..	19.9	12.8
Knotting ..	..	23.4	13.6
Putting nuts on bolts ..	..	28.8	21.1
Peg insertion ..	..	12.0	9.9

In this series the differences in output were also greater at the beginning than at the end of the experiment and although the rate of decrease is not shown in the Table it was most marked in the early stages and progressively decreased as the experiment proceeded. The results agree with those previously mentioned and indicate that differences in capacity, as measured in short tests of maximum achievement, continue to decrease with practice.

The results in general are consistent with the view that practice will cause decreasing differences in output only when the incentives to work are strong and all the individuals respond according to their respective capacities. When the inclination to work remains relatively strong in some individuals but progressively weakens in others, differences in output may tend to increase.

(b) *Individual differences in improvement.* Although individual differences in output may decrease with practice, it is also useful to know whether the different workers responded in a similar manner to each change in the method of payment. The results bearing on this question are summarised in Table IV. They show the average percentage increase or decrease in output during each period of payment and are based upon the results obtained during the first and last three weeks in each period.

TABLE IV.—PERCENTAGE INCREASE (+) OR DECREASE (—) IN OUTPUT UNDER EACH METHOD OF PAYMENT

	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.
Time-rate ..	+ 9.8	+6.2	+ 5.5	— 0.3	+11.9	+4.2	+16.6	+7.8	+0.4	+3.1
Bonus-rate ..	+16.2	+8.9	+ 3.6	+ 2.9	+17.0	+8.1	+15.3	+2.3	+1.8	+1.9
Piece-rate ..	+ 3.6	+4.2	+15.1	+13.0	+ 4.1	—2.1	+ 5.7	—8.0	—7.5	—7.3

The results show, in the first place, that the amount of improvement during the time-rate period though small, was variable. The variations in question could, of course, be caused by individual differences in slackness during the first three weeks. This, however, is highly improbable, since all the workers seemed eager to demonstrate their powers in the early stages of the experiment when the work was novel and comparatively interesting. It is even more certain that the results had little or no relation to capacity for improvement since there was a large and immediate increase in output as soon as the bonus scheme was introduced (see Fig. 2) and those workers who had previously improved least, improved most

when the change of payment was made. (This was found to be the case but the individual results are not shown in Fig. 2.) It is fairly evident, therefore, that the variations in improvement were due largely to individual differences in the inclination to work. During this period there was no monetary inducement for one worker to do better than another, consequently the results provide a fairly unadulterated measure of the inherent appeal of the work and enable the operatives to be graded according to their response to this appeal. Only those who were anxious to work and were able to resist the infectious behaviour of the remainder showed any outstanding tendency to improve. From this standpoint it is evident that the most suitable workers were A, E and G, while at the other extreme were D, I and J. In other words, three individuals out of ten evidently possessed the personal characteristics which enabled them to tolerate or even to enjoy the work for its own sake, while the remainder apparently disliked the processes. If these tendencies are confirmed by other investigations, they suggest that a large proportion of the individuals employed on repetition work have little or no interest in the processes and that proficiency in this kind of work must, in consequence, be largely dependent on external or derived incentives.

Secondly, although the change from the time to the bonus method of payment caused a large and immediate increase in output, the subsequent rate of improvement during the bonus period was also variable and had many resemblances to that observed under the time-rate. Thus workers A, E and G continued to show the greatest improvement, while the increases in the other cases were usually small. As in the time-rate period, these individual differences were not determined by the capacity for improvement, since the subsequent introduction of the piece-rate showed that all the workers were capable of much higher performances. They were a reflection of the varying attitude of the different individuals towards the conditions of work. Thus workers C, D, H, I and J resumed their attitude of boredom and indifference after the initial novelty of the scheme had disappeared. The chance of earning an extra sixpence or shilling by competing against the others was thought to be not worth the additional effort involved, and they were content to receive the wage which was guaranteed by this method of payment even though their output was low. The results in general show the differential effects of the bonus scheme upon the individuals concerned and reveal some of its limitations. The existence of a substantial minimum wage created a feeling of security and tempted the less capable, less interested, or less ambitious workers to do as little as was compatible with decency and discipline. To these individuals the bonus scheme was no better than the time-rate, and any increase in output was due chiefly to the suggestive influence of the more industrious and interested members of the group.

Finally, the results obtained during the piece-rate period were chiefly notable for the comparatively large increases in output observed in the case of workers C and D. Prior to this period these

workers had shown very little desire to improve, but when the weekly wage depended solely on individual effort and achievement there was a remarkable change in attitude and activity. Workers I and J, on the other hand, continued to display a lack of interest and effort, and it was fairly evident that they had a strong aversion from this type of work. The comparative failure of worker H was due partly to an increasing feeling of inferiority caused by working opposite to the quickest member of the group. She became discouraged and depressed and her output suffered in consequence.

Thus the experiment revealed notable variations in the reactions of different individuals to repetition work and to the different methods of payment. The majority of the operatives disliked the work and in some cases their attitude remained unchanged even when payment was based on results. In others the disinclination to work continued until the introduction of the piece-rate, while a small minority were comparatively industrious whether paid by time or by piece.

The preceding results accordingly suggest that the relative output of different individuals may show important changes during the learning period, and that in certain cases there may be little or no relation between initial and final performance. Worker C, for instance, was 14 per cent. below the group average during the first three weeks, but was 15 per cent. above in the final stages of the experiment, while worker H began by being 9 per cent. above the average and ended 14 per cent. below. In these two cases any estimate of final efficiency which was based on output during the first three weeks would have been unreliable. Workers I and J, on the other hand, occupied the same relative position throughout the experimental period, while the remainder varied between these two extremes.

Many employers maintain that it is possible to predict the ultimate efficiency of beginners from their output during the first week. Others state that a few weeks, or even months, are necessary for this purpose. Since workers are retained or dismissed on the basis of these beliefs it is obviously important that their validity should be tested. In the present experiment it was not until the workers had been employed for approximately six months that the correlation with final efficiency exceeded $\cdot 9$, and predictions based upon performance during the first few weeks would certainly have been misleading.

In most forms of industrial work, learners are first paid by time and afterwards by results. The conditions are accordingly similar to those which prevailed in the present experiment and might be expected to yield similar results.

B.—Variations within the Spell of Work

Since the three methods of payment employed in this experiment were applied at different stages of the learning process, their influence on the shape of the daily output curves may be obscured by the

varying effects of practice, which are most marked in the early part of the learning period and progressively decrease as the individuals become more experienced. In order to consider this possibility, the results obtained under the time-rate, which included the first nine weeks of the experiment, have been divided into three equal parts. These are given in Fig. 7 and show the average variations in the rate of working throughout the day in each consecutive period of three weeks. The results refer to the wrapping process but they are similar to those observed in the other operations.

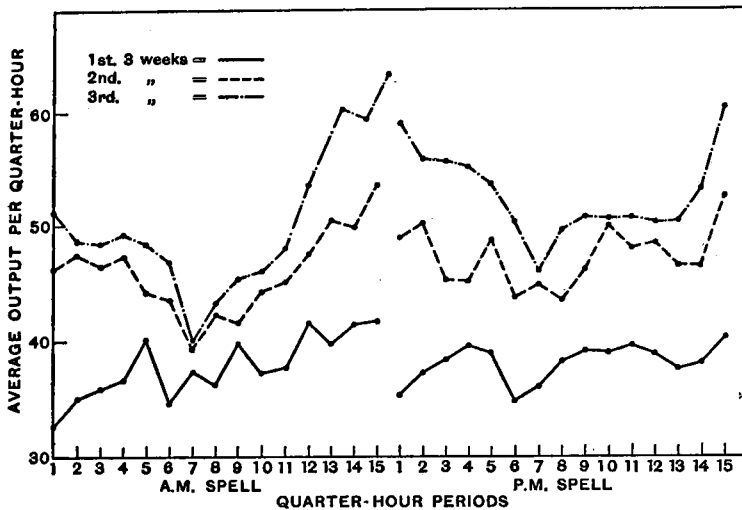


FIG. 7. Variations in output at different stages of the learning period (wrapping).

It will be seen that the curves for the first three weeks show a tendency to rise throughout the spell of work. At this stage of the experiment the effects of practice were most prominent and the novelty of the work acted as an antidote to adverse influences, consequently there was little to interfere with the natural tendency to improve. In the second three weeks the work was no longer novel and the effects of practice were gradually decreasing. At the same time the drop in output in the middle of the spell suggests a weakening of the inclination to work, due to the increasing effect of boredom and the decreasing effect of novelty. This tendency was still more marked in the last three weeks and the results in general show the progressive transition from the early stages of the learning process when positive factors were predominant to the later stages when negative elements appeared to be supreme.

Although the highest level of output had not been reached in the last three weeks of this period, it is unlikely that practice had any effect on variations *within* the spell of work. It accordingly seemed

justifiable to use these results for comparison with those obtained under the bonus and piece-rate methods of payment. The adoption of this procedure gave the curves shown in Fig. 8. They were obtained by expressing the average output recorded in each quarter-hour throughout the day as a percentage of the daily average.

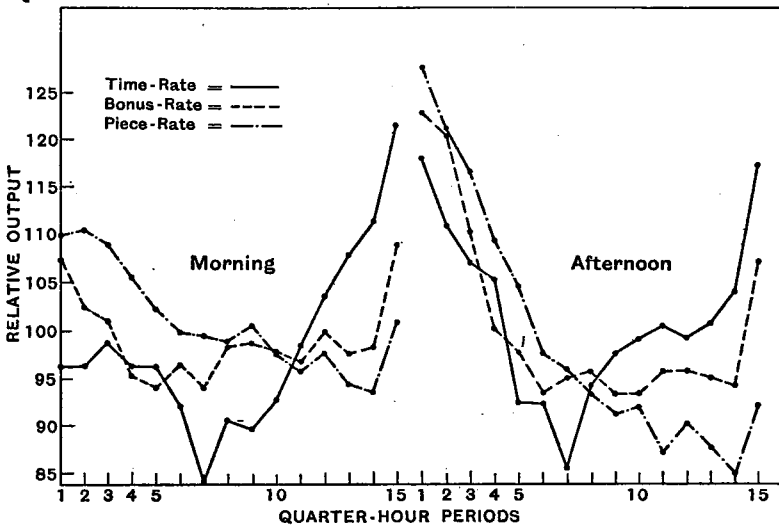


FIG. 8. Effect of different methods of payment on output.

The most noticeable features of the curves for the time-rate period are the relatively low output in the early part of the morning, the mid-spell depression and the final spurt. The first was due to the depressing outlook at the beginning of the day. Remarks such as "I nearly turned back when I remembered what was in store for me" and "I dread every morning in the week except Sunday" illustrate the attitude in question. The disinclination to work seemed to reach a maximum shortly before the middle of the spell, and at this stage the boredom experienced was probably more intense than at any other time during the day. After passing the half-way stage the workers began to be affected by the prospect of the dinner-hour break and a certain amount of interest was aroused by the approaching release from work. The rate of working towards the end of the spell was the highest recorded during the day and was 25 per cent. above that observed at the beginning. When work was resumed in the afternoon the output was relatively high, but afterwards there was a sharp fall of roughly 35 per cent. and the course observed in the morning curve was repeated in the afternoon.

The results obtained under this method of payment are consistent with the presence of boredom and there were few signs of fatigue. The inclination to work was weak but capacity remained comparatively unimpaired.

During the bonus period the relative output was initially higher than under the time-rate, and although this was followed by the usual fall it was less than that observed under the time-rate and the subsequent recovery was not so marked. These changes in the curves were still more noticeable under the piece-rate and the results obtained in this period suggest a progressive impairment of the capacity for work.

In general, therefore, it may be said that the time-rate was least effective in preventing boredom. It may be noted, however, that when a relatively high output occurred at the beginning of the spell it was followed by a correspondingly low output towards the end, and vice versa. Thus the average rate of working of the operative who is more bored than fatigued may not be very different from that of the worker who is more fatigued than bored.

The output curves obtained from the different workers in each period of payment were remarkably similar and indicated the presence of an important common factor. The similarity in question seemed to be due to social influences which will be considered in some detail later in the report.

C.—*Lost Time*

In this investigation, as in all other forms of factory work, there were occasions when the workers were idle for short periods. These stoppages, which were usually due to incidental disturbances or to a desire to rest, seldom lasted for more than a fraction of a minute and consequently were difficult to measure. The workers, however, sometimes left the room and the duration of these stoppages was accurately noted. It might be thought that stoppages of this type were necessary and would remain fairly constant in number and duration throughout the period of the experiment. The results show, however, that they form a very sensitive index of the reactions to different systems of payment. These results are given in Fig. 9 and represent the average time lost per spell in successive weeks.

It will be seen that the average amount of time lost through being absent from the room varied in successive weeks. It was reduced by each change in the method of payment but increased as the workers became adapted to the change. The rapid increase in the time-rate period reflects the waning interest in work which was accelerated by the absence of a monetary incentive. Interest was revived by the novelty and competitive possibilities of the bonus scheme, and there was a decrease in lost time which remained fairly constant until the workers began to realise the limitations of this method of payment. The drop in the curve during the last week of this period was due to the increased incentive associated with the approaching Easter holiday. When the piece-rate was introduced the amount of time lost in the first week was practically negligible, and although there was an increase in subsequent weeks it never reached the high level recorded under the other two methods of payment.

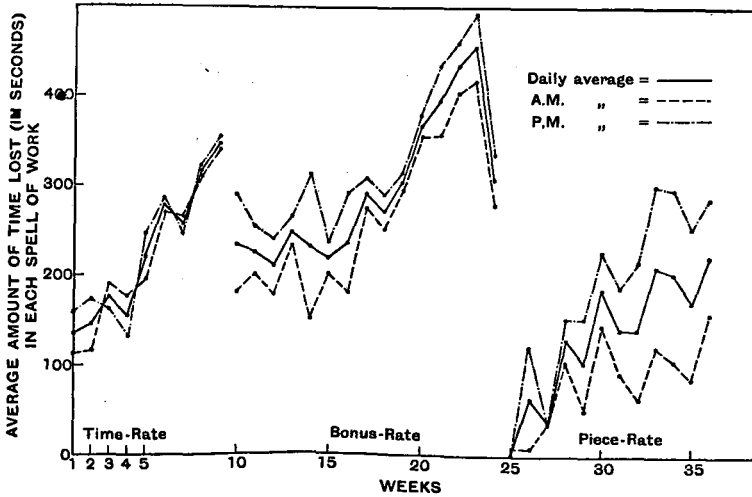


FIG. 9. Effect of different methods of payment on lost time.

In general, the amount of lost time was undoubtedly inversely related to the strength of the inclination to work and the results show that stoppages of this type are by no means necessarily constant but reflect the attitude of the operatives towards the conditions of work. They show the gradual change in outlook produced by the different methods of payment and support the views put forward in connection with the results discussed in the previous sections.

It will also be noticed that the amount of time lost was greater in the afternoon than in the morning spell of work. The difference in question was most marked under the piece-rate but fell to 23 per cent. under the bonus scheme and was only 5 per cent. during the time-rate. On the assumption that the amount of time lost was inversely related to the inclination to work it is evident that, under the time-rate, the strength of this desire was fairly similar in both the morning and afternoon spells. Under the bonus scheme it was stronger in the morning than in the afternoon and this tendency was still more pronounced under the piece-rate. The most probable cause of these differences seems to be connected with the relative amount of boredom and fatigue produced by work under the different systems of payment.

The preceding results show the general tendency of the workers considered as a group, but there were some notable individual differences. These are shown in Table V, which gives the amount of time lost by the different workers expressed as a percentage of the group average under each system of payment.

TABLE V.—INDIVIDUAL DIFFERENCES IN LOST TIME UNDER EACH METHOD OF PAYMENT

		A.	B.	C.	D.	E.	F.	G.	H.	I.	J.
Time-rate	..	50	118	113	158	24	108	40	89	168	132
Bonus-rate	..	24	94	133	151	15	132	22	110	169	150
Piece-rate	..	15	74	95	110	0	106	24	194	186	196

Thus, individual differences in the amount of time lost were least under the time-rate, increased under the bonus scheme, and were still greater under the piece-rate. (The mean variation from the average was 39·4, 49·0, and 58·4 respectively.) The differences are not statistically significant but it seems not unreasonable to infer that the desire to rest or seek a change was more uniformly distributed among the members of the group when payment was based on time worked. This interpretation agrees with the view already expressed (page 11) that a time-rate had a levelling effect upon the performance of the different workers.

It will also be seen that while some workers, such as A, B, and E showed a relative decrease in the duration of voluntary stoppages in each successive period of payment, others, such as H and J, showed the opposite tendency. In other cases (e.g. C and D) there was no improvement relative to the group until after the introduction of the piece-rate. Finally, the amount of time lost by some workers such as E and G was almost negligible, while in other cases such as I and J it tended to become excessive.

The results in general provide further evidence of the varying responses of the different individuals to the conditions of work. As a rule those workers who lost most time in any period of payment also showed a relatively small increase in output in that period* (Table IV). It seems fairly evident that both lost time and amount of improvement were objective expressions of the prevailing attitude towards the conditions of work and may be used as indications of individual suitability for work.

D.—Behaviour

In previous investigations attention has usually been directed to the quantitative aspects of behaviour as shown by output while qualitative features have been comparatively neglected. The latter are important and may be just as instructive as numerical records of the rate of working and lost time. They are, of course, much less susceptible to measurement and consequently a precise statement of their nature and effects is seldom possible. At the same time general tendencies may be observed and described and some of these are closely connected with the elusive but important question of industrial contentment and unrest.

* The rank coefficients of correlation (ρ) were ·93, ·89, and ·52 for the time-rate, bonus-rate, and piece-rate periods respectively.

Since the workers who took part in this experiment were under continuous observation it was possible to keep a fairly complete record of their behaviour under the different wage systems. A numerical classification of the more important forms of behaviour is given in Table VI. It shows the average number of times per week when (a) one worker acted in a manner which disturbed or distracted the majority of the others, (b) two or more workers became definitely annoyed and exchanged "words" and (c) complaints were made regarding the material or conditions of work.

TABLE VI.—COMPARATIVE FREQUENCY OF DISTURBANCES, QUARRELS AND COMPLAINTS UNDER EACH SYSTEM OF PAYMENT

		<i>Disturb- ances.</i>	<i>Quarrels.</i>	<i>Complaints.</i>
Time-rate ..	..	20.1	1.4	2.9
Bonus-rate ..	..	16.6	6.9	7.1
Piece-rate ..	..	11.3	4.2	10.8

It will be seen that during the time-rate period disturbing forms of behaviour were comparatively frequent while quarrels and complaints were relatively few. The workers talked freely and were inclined to be playful and frivolous, but they were generally on friendly terms and there was a notable absence of friction. Instances of envy or jealousy because one worker happened to be doing more than another were rare and whenever an argument or dispute arose it was usually about events outside the factory. There was no desire to do as much as possible, consequently minor difficulties or interruptions which interfered with progress seldom gave rise to complaints.

After the introduction of the bonus method of payment there was a change in behaviour and unpleasant incidents were fairly frequent. Some of the workers accused the others of being "mean" and "hurrying" and jealousy was shown whenever an unusually high level of output was attained. Abusive and insulting remarks were fairly common and friendships were sometimes strained or broken. Needless to say, the slower and less capable operatives were generally responsible for these incidents. On the whole, the workers were more irritable and sensitive to any factor, whether real or imagined, which was likely to impede output. During this period the toffee was repeatedly said to be too big for the tins; string seemed to develop a tendency to break, and wrapping paper was blamed because it was too thin and liable to tear. The material was exactly the same as that used during the time-rate when such complaints were seldom heard. The bonus method of payment revealed unpleasant personal tendencies which had remained dormant under the time-rate and the individuals no longer worked as a harmonious group.

During the piece-rate period most of the undesirable characteristics observed under the bonus scheme were still in evidence, but on the whole they were less numerous and intense. The workers were more inclined to find fault with the material and the conditions of work, and anything which seemed to interfere with productive activity was usually resented. Outbursts of jealousy, spite, or abuse were, however, not so conspicuous as under the bonus scheme, presumably because each worker realised that output and earnings were an individual matter and not dependent on the rate of working of the other members of the group. The slower operatives were still inclined to be unfriendly and quarrelsome, and in at least one case the system of payment by results revealed a tendency to lie and cheat when output was being recorded.

On the whole, the time-rate tended to promote friendly relations and social unity while payment by results stimulated individualistic and competitive impulses and aroused some of the more undesirable features of human nature. There is little doubt that the more objectionable forms of behaviour observed under the bonus and piece-rates were due largely to an awareness of inferiority which was accentuated whenever a naturally slow worker was placed near to one of the quicker members of the group.

The behaviour of the operatives under the different methods of payment may also be illustrated by the tendency to talk while working. In most forms of industrial work a reasonable amount of talking is permitted, and is only suppressed when it becomes excessive or unduly loud. The workers employed in this experiment were also allowed to talk within reasonable limits, and whenever a worker talked a note was made of the quarter-hour period in which this talking occurred. This is admittedly a somewhat crude measure since it makes no distinction between a worker who talks for only part of the period and one who talks during the entire quarter-hour. A more refined method of procedure was impracticable and the method adopted seemed to serve a useful purpose. Its weakness would, of course, be most apparent when comparing one worker with another, but when studying the effect of different situations upon the operatives considered as a group the defect in question tends to disappear.

The relative amount of talking under the different methods of payment was found to be—

<i>Time-rate.</i>	<i>Bonus-rate.</i>	<i>Piece-rate.</i>
1.00	0.79	0.71

Thus, talking was more frequent under the time-rate than under the methods of payment by results. Under a strong incentive to work there is usually little or no inclination to talk because attention and interest are concentrated on the process. As the incentive weakens there is a corresponding increase in the desire to talk or to respond to distractions; consequently the results provide a further illustration of the relative weakness of the time-rate as an incentive to work.

The three methods of payment were also responsible for differences in the distribution of talking throughout the day. The results are given in Fig. 10 and show the relative frequency of conversation in successive quarter-hour periods.

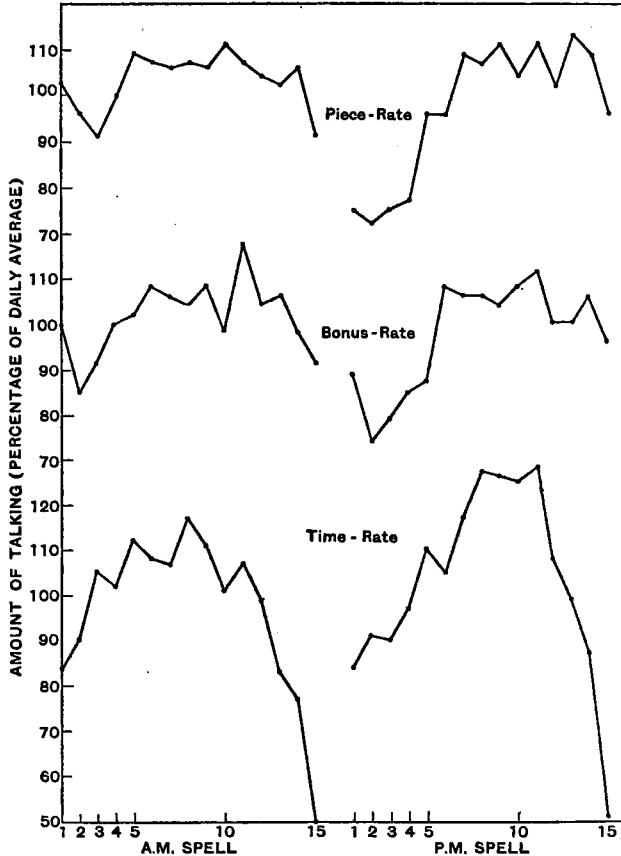


FIG. 10. Variations in the amount of talking throughout the day under different methods of payment.

Under the time-rate the amount of talking increased as work proceeded and reached a maximum around the middle of the spell, but afterwards there was a sharp decrease which became more marked as the end of the spell drew near. The results are consistent with the view that interest in work was at a minimum about half-way through the spell and was greater at the end than at the beginning. The general shape of the curves is almost the reverse of those representing the variations in the rate of working under the same method of payment (Fig. 8) and the coefficient of correlation between the

two series was —·66. Thus a low rate of working was associated with an increased amount of talking and vice versa, and there is little doubt that both the fluctuations in output and in talking were expressions of varying degrees of interest or boredom.

The variations in the amount of talking under the bonus and piece-rates were less than those observed under the time-rate and the final decrease was not so pronounced. The results support the view already expressed that payment by results creates a stronger and more sustained interest which acts as an antidote to boredom but tends to give rise to a certain amount of fatigue.

E.—Opinions of the Workers

At frequent intervals during the course of this experiment the operatives were questioned on their attitude towards the different systems of payment and at the end of each period they summarised their views on this subject.* Throughout the experiment they had been encouraged to express their opinions on various aspects of the conditions of work and there is no reason to doubt the reliability of the statements made. Introspective data of this type may be just as important as objective criteria and throw light on each other.

The remarks made by the operatives show that they were fully aware of the advantages and defects of the different wage systems. This is not surprising since the weekly wage seemed to be the chief, if not the only incentive to activity.

The time-rate was regarded as unfair because the slacker received the same wage as the industrious worker. Since there was no relation between earnings and output a high rate of working was considered to be a foolish and somewhat unnecessary procedure. Interest in work was negligible, the day seemed long, and boredom was very pronounced. Only in cases of natural incapacity or temporary indisposition was a time-rate regarded with a certain amount of favour.

The bonus scheme, although regarded as a great improvement on the time-rate, was disliked by some workers because it imposed an upper limit to earnings. Further, the wage of any single worker depended on the activities of the remainder and rewards were not always proportional to individual increases in output or effort. At the same time the competitive element was very prominent and the workers showed a keen interest in each others performance. Time was said to pass more quickly than under the time-rate and the work was less monotonous and dull.

There is little doubt, however, that the flat piece-rate made the strongest appeal to interest and activity and it was generally said to be fair because the reward was proportional to the work done. The operatives seemed to regard each unit of output in terms of its cash equivalent and thoughts were more often directed to work and its

* Relevant extracts are given in the Appendix.

possibilities. The expenditure of energy was facilitated, the mind was less absorbed with the unpleasant aspects of work, and boredom tended to be replaced by fatigue.

In the previous sections it was suggested that the quantitative differences in output and lost time, observed under the different methods of payment, were due to variations in the inclination to work rather than to differences in capacity. The opinions of the operatives support this view, and they tend to confirm the belief that efficiency in repetition work is largely a question of releasing energy by means of suitable external incentives.

2. TYPE OF WORK

A. Rate of Improvement

In the preceding chapter the rate of improvement and subsequent efficiency were seen to depend on the method of payment, but since the operatives were employed on five different processes, the results can also be used to show their reactions to different types of work.

The relative output recorded in successive weeks in each process is shown in Fig. 11. Each point on the curves represents the combined results of ten workers and is expressed as a percentage of the output in the first week.

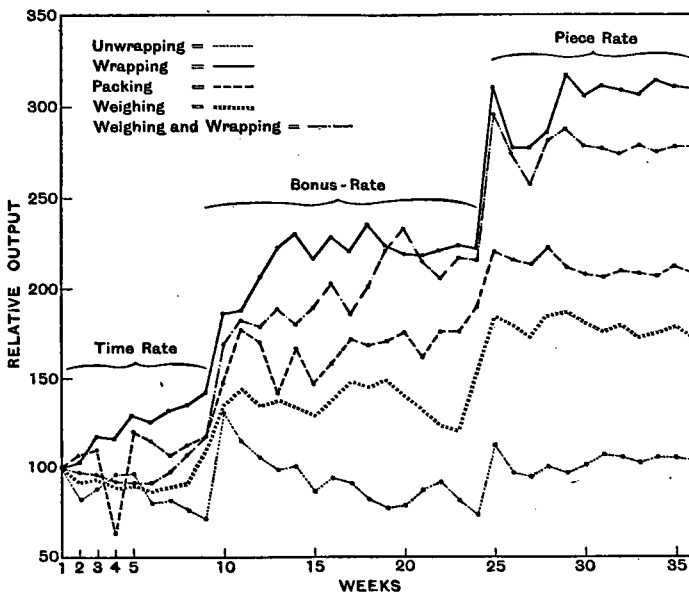


FIG. 11. Relative output in successive weeks in each process.

Although each change in the method of payment was followed by a marked increase in output in all the processes save one, the extent of the increase varied according to the type of work. In the wrapping

process there was a total increase of over 200 per cent. while in the very similar but converse operation of unwrapping there was practically no improvement and the output throughout the experimental period was usually less than that recorded during the first week. The improvement in the other operations varied between these two extremes and when it is remembered that the different processes had much in common the variations in the results are rather surprising.

There is reason to believe that the causes of these differences were closely related to personal likes and dislikes. This belief is supported by the results given in Table VII which shows (a) the average order of preference for the different processes* and (b) the relative amount of improvement expressed in a similar manner.†

TABLE VII.—RELATION BETWEEN THE ORDER OF PREFERENCE AND RELATIVE IMPROVEMENT IN THE DIFFERENT PROCESSES

	Order of Preference.			Relative improvement.		
	Time rate.	Bonus rate.	Piece rate.	Time rate.	Bonus rate.	Piece rate.
Unwrapping	5	5	5	5	5	5
Wrapping..	1	1	1	1	1	1
Packing ..	2	3	2	2	3	3
Weighing ..	4	4	4	4	4	4
Weighing and wrapping.	3	2	3	3	2	2

It will be seen that the two series of rankings were identical under the time and bonus rates and were fairly similar under the piece-rate, consequently the relative improvement in the five processes was clearly associated with the degree of preference shown by the workers for the respective tasks.

Although the demonstration of this relationship is interesting, it is also necessary to consider the reasons for the observed order of preference. These seem to be given in the answers to the weekly questions, which may be summarised as follows.

Unwrapping.—This was regarded as an aimless and destructive process since it involved undoing what had already been done. The operation was also disliked because there was a tendency for the paper to stick to the toffee. The unpleasant nature of the task, combined with its apparent aimlessness, created a feeling of aversion which weakened the inclination to work and caused the operation to be described as boring and dull.

* Based on the weekly statements obtained from the workers.

† i.e., the process showing the greatest relative improvement was ranked 1, the next 2, and so on.

Wrapping.—This was said to be a clean, neat, and attractive process which could be performed with rapidity and ease. It required a minimum of attention and was free from interruptions and variations so that the operatives were able to adopt a rhythmical method of work.

• *Packing.*—As a rule this operation was liked but a jarring note was introduced by the danger of cut fingers and the occasional difficulty caused by the handling of badly fitting lids. Some workers were easily discouraged by these minor interruptions and difficulties and the effect on output was often appreciable.

Weighing.—The majority of the operatives disliked this process, but a few described it as interesting. It required more attention and judgment than the previous operations but not enough to keep the mind fully occupied. The short but frequent interruptions caused by inserting paper slips in the tins and the packing of the tins in cartons were said to be annoying because they interfered with the main operation. The continuous standing posture also induced a certain amount of fatigue.

Weighing and Wrapping.—The varied and somewhat complex nature of this process was liked by the operatives since it acted as an antidote to boredom and made time appear to pass more quickly. The accumulating pile of large and attractive looking tins also seemed to be satisfying. At the same time the muscular effort involved in filling and lifting large tins of toffee together with the continuous standing posture was said to be tiring.

It is evident that, in the first place, the value attached to an operation may have an important effect on productive activity. Thus the material, movements, and abilities involved in wrapping and unwrapping were very similar and might have been expected to give rise to similar results. Although part of the difference in the amount of improvement was due to the difficulty of handling sticky toffee, a certain amount was attributable to the belief that unwrapping was a wasteful and comparatively useless procedure. It seemed to offer no reward for the amount of effort expended and failed to give that satisfaction which accompanies the production of attractive and saleable commodities. It may be mentioned that in the third week of the experiment, the operatives asked to be allowed to read when unwrapping. The request was granted and for two or three weeks the output showed a tendency to rise. Afterwards the amount of time devoted to reading began to decrease as the unwrappers found it difficult to ignore the conversation between the other members of the group.

A dwindling interest in work was also noticeable after the 19th week in the weighing process. From this point the finished tins, instead of being dispatched for sale, were emptied in the factory and returned to the experimental group. This procedure was continued until the end of the experiment and was necessitated by overproduction of this particular article. As soon as the workers realised that the products were not for sale, but were being returned in order

to keep them employed, they began to lose interest in the process although they continued to be paid by results. Remarks such as "This is a silly business" and "I don't see any point in filling the same tins over and over again" illustrate the prevailing attitude and indicate the weakening of the incentive to work produced by the impaired belief in the value of the operation.

It appears, therefore, that comparatively slight differences between one form of repetition work and another can produce very different attitudes in the workers which, in turn, are reflected in large differences in output. Dislike of an operation is capable of neutralising the positive effects of practice so that the final output may be no greater than that recorded at the beginning of the learning period.

Secondly, the greater variety and complexity of the mental and muscular activities involved in the combined weighing and wrapping process together with the attractive appearance of the finished tins seemed to give satisfaction. This operation occupied the mind as well as the hands and the changes in the type of work tended to promote interest and to retard the onset of boredom.

Finally, the statements of the operatives contained many references to minor features of the work which were regarded as annoying interruptions because they interfered with the continuity of the process and impeded progress. Thus the short but frequent interruptions in the weighing process were disliked while the continuity of the wrapping operation was enjoyed. In the latter process the operatives were able to develop a rhythmical method of work, but in the former the movements were discontinuous and abrupt. If the belief that rhythmical work is capable of creating a pleasant emotional accompaniment be true, one reason for the greater popularity of the wrapping process is thereby explained. Further, the wrapping operation was highly mechanised and the operatives were able to day-dream or indulge in conversation while the intermittent attention involved in the weighing process interfered with these antidotes to boredom.

The annoyance caused whenever the cycles of movement were interrupted or impaired was intensified by occasional defects in the material. Such conditions existed in the fourth week in the packing operation when a supply of slightly larger pieces of toffee made the operation more difficult. Somewhat similar conditions prevailed in the first eight weeks in the weighing process when the workers had to deal with a batch of tightly fitting lids. Observation suggests that the decreased output on the former occasion, and the decreasing output during the eight weeks of the latter, although due partly to the longer time required to complete each unit, were attributable chiefly to a weakening of the inclination to work.

A further illustration of this tendency was provided in the latter part of the experiment when the weighing and packing processes were replaced by two operations which involved the filling of small cartons with tablets. These operations were identical except as

regards the number of tablets packed in the cartons. In the one case the carton held two tablets but in the other it held five. When handling the smaller cartons the workers had some difficulty in closing the flaps, but the larger cartons were free from this trouble. The average hourly output obtained in successive weeks in the two processes is shown in Fig. 12.

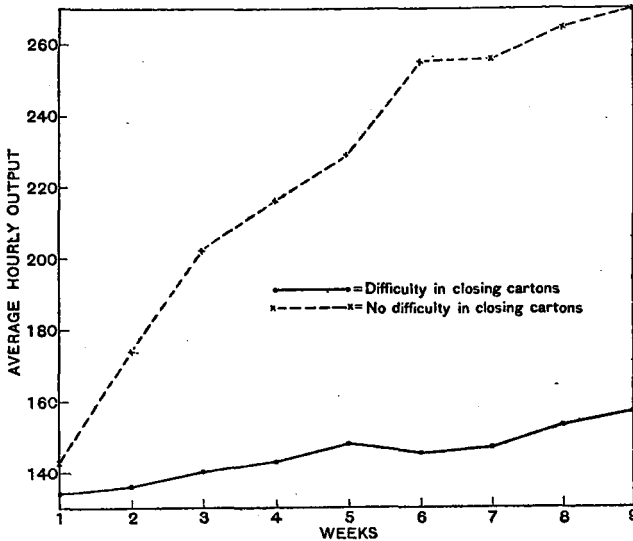


FIG. 12. Effect of difficulty of handling material on output.

Although the method of payment was the same in both processes the rate of improvement was very different. In the case of the smaller but more difficult cartons the average output in the first week was only 5.6 per cent. below that in the other process. At this stage of the experiment the workers were interested in the change of work and the difference in output may be regarded as roughly equivalent to the difference in the time required to perform the respective operations. The closing of the cartons occupied about 10 per cent. of the total time taken to complete each unit of output in the straightforward process, and about 20 per cent. in the difficult process; thus the two processes had a large portion in common, and to this extent if improvement occurred in one process it should also occur in the other. Further, improvement due to practice might have been expected in closing the more difficult cartons. Thus it might have been anticipated that the two curves would be approximately parallel. The marked divergence can only be attributed to a progressive weakening of the inclination to work when filling the smaller cartons. The operatives became discouraged and "fed up" and lost all interest in the work. In the latter stages of the experiment the output on the more difficult material was

42 per cent. less than that recorded on the easier process and the greater part of this difference was undoubtedly due to subjective influences.

In the fourth week of the experiment when the workers employed on the packing process were supplied with a batch of slightly larger pieces of toffee and in the 43rd week when the wrappers had to deal with a harder type of chocolate, which made the tin-foil more liable to tear, the percentage decreases in output* on these occasions were

	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.
Packing ..	38.5	40.0	58.6	58.1	35.8	42.6	39.8	41.5	59.2	56.8
Wrapping ..	6.7	6.9	29.4	26.1	4.9	20.9	9.7	10.3	20.4	20.0

It will be seen that the fall in output was much greater in some cases than in others. Since there was no objective justification for these individual differences it must be inferred that the variations in question were due to personal factors. The greatest decreases were observed in the case of those individuals who, throughout the course of the experiment, showed the least inclination to work. Thus C, D, I and J were always easily distracted and unwilling to work and an additional obstacle in the form of difficult material was almost the last straw. Other individuals, such as A, B, E and G were relatively keen and industrious and were not so easily discouraged by the refractory material.

The preceding results illustrate the importance of elements in the conditions of work which are usually overlooked or regarded as insignificant. In the absence of a strong incentive or interest the workers were easily annoyed and discouraged and a minor difficulty had greatly exaggerated effects on efficiency and pleasure in work.

The observed differences in the amount of improvement in the five operations have so far been explained in terms of positive and negative incentives to activity, but the rate and amount of improvement in any process may also be a function of its complexity and of the number of times each cycle of movement is repeated in a given period. An examination of the results showed, however, that the possible effects of such factors seemed to be submerged by the influences already discussed and any other method of treating the results appeared to be futile.

Although the group as a whole preferred some processes to others and showed the most improvement in those operations which they liked best, the order of preference for the different processes was by no means the same for all the members of the group. Thus weighing was much disliked by the majority of the workers, yet in certain cases it was ranked comparatively high in the scale of preference. Most people would also agree that unwrapping was a particularly unattractive and even distasteful operation yet two of the workers preferred it to some of the other processes. Such differences in

* Based upon the output recorded in the previous week.

personal likes and dislikes are important since they mean that certain types of repetition work which are unpleasant to some individuals may be performed by others with comparative satisfaction.

Further, there were some interesting individual differences in the amount of improvement in the different types of work. It is unnecessary to give all the results bearing on this question, consequently a few examples have been chosen which serve to illustrate the more important tendencies observed. These are shown in Fig. 13 and refer to workers A and B when engaged in wrapping and packing respectively.

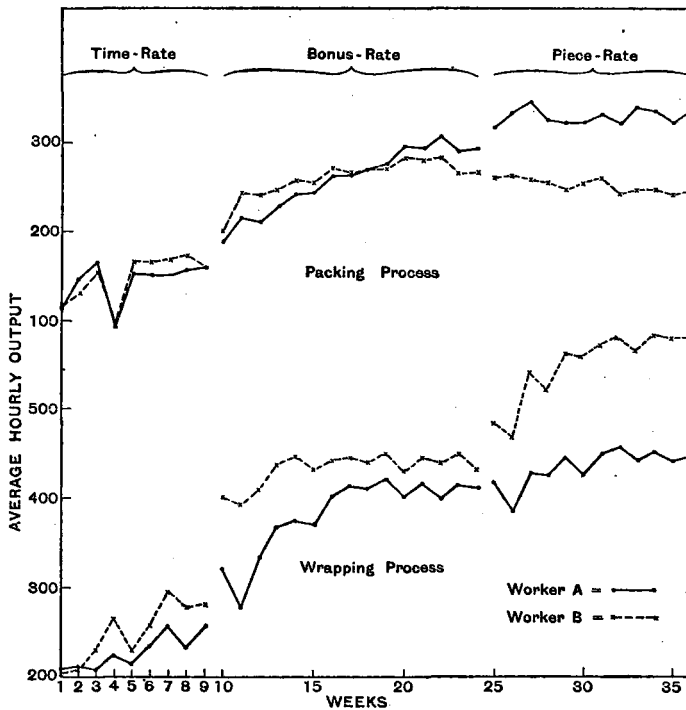


FIG. 13. Individual differences in improvement in (a) wrapping and (b) packing.

The two operatives worked opposite each other and it will be noticed that a rise or fall in the output curves of one worker was accompanied by a similar variation in the curves of the other.

The differences in the height of the curves, as distinct from their shape, varied according to the type and conditions of work. In the wrapping process the differences in output increased in each successive period of payment. Within the bonus period, however, the opposite tendency was noticeable and was due to the fact that

worker B, who was already producing more than any other member of the group, had nothing to gain financially from a further increase in output. The piece-rate imposed no such limit to earnings with the result that B no longer restricted her rate of working. The output of these two workers was approximately the same in the first week of the experiment when both were undoubtedly trying to do as much as possible and a similar attitude prevailed during the piece-rate period. Thus in this process worker B had a greater capacity for improvement than worker A and in the final stages her output exceeded that of A by roughly 30 per cent.

The results obtained in the packing process show that there was very little difference between the output of the two workers in the time-rate period, but under the bonus method of payment worker B was gradually overtaken by worker A, whose superiority was still more marked under the piece-rate. In other words the learning curves crossed each other as the experiment proceeded and the final output of worker A was approximately 32 per cent. higher than that of worker B. The latter individual was the most ambitious member of the group and did her best to excel in output. In the packing process, however, her capacity for improvement was less than that of worker A and after being overhauled by the latter she became discouraged and her output suffered in consequence.

The curves illustrate principles and tendencies which are by no means confined to these two workers. They show, for instance, that an individual who is relatively superior in one form of repetition work may be comparatively inferior in another. Although recent investigations* have provided evidence in favour of the existence of a general factor of manual dexterity, the inter-correlations between the performances in the different types of work were small and the conception of a general suitability for repetition work seems to be subject to many exceptions and limitations.

The curves in Fig. 13 also show that individuals who have apparently the same capacity for work at the beginning of the learning period may show large differences in output when they become fully experienced. Conversely, workers who differ widely in their initial performance may become more alike after a period of training. Such tendencies are responsible for the imperfect relation which is usually found to exist between initial and final performance in the learning period and they illustrate the degree of error which is liable to enter into predictions of ultimate efficiency which are based on output in the first few weeks.

B.—Variations within the Spell of Work

Previous investigations have shown that the shape of the daily work-curve is dependent on the type of work and it was thought that the varying nature and complexity of the five processes included in the present experiment might also give rise to differences in the

* cf. Report No. 66 of the I.H.R.B.

shape of the output curves. The results obtained at corresponding times on different days in each process have accordingly been combined and averaged. They are given in Fig. 14 and show the output in each quarter-hour throughout the day expressed as a percentage of the daily average.

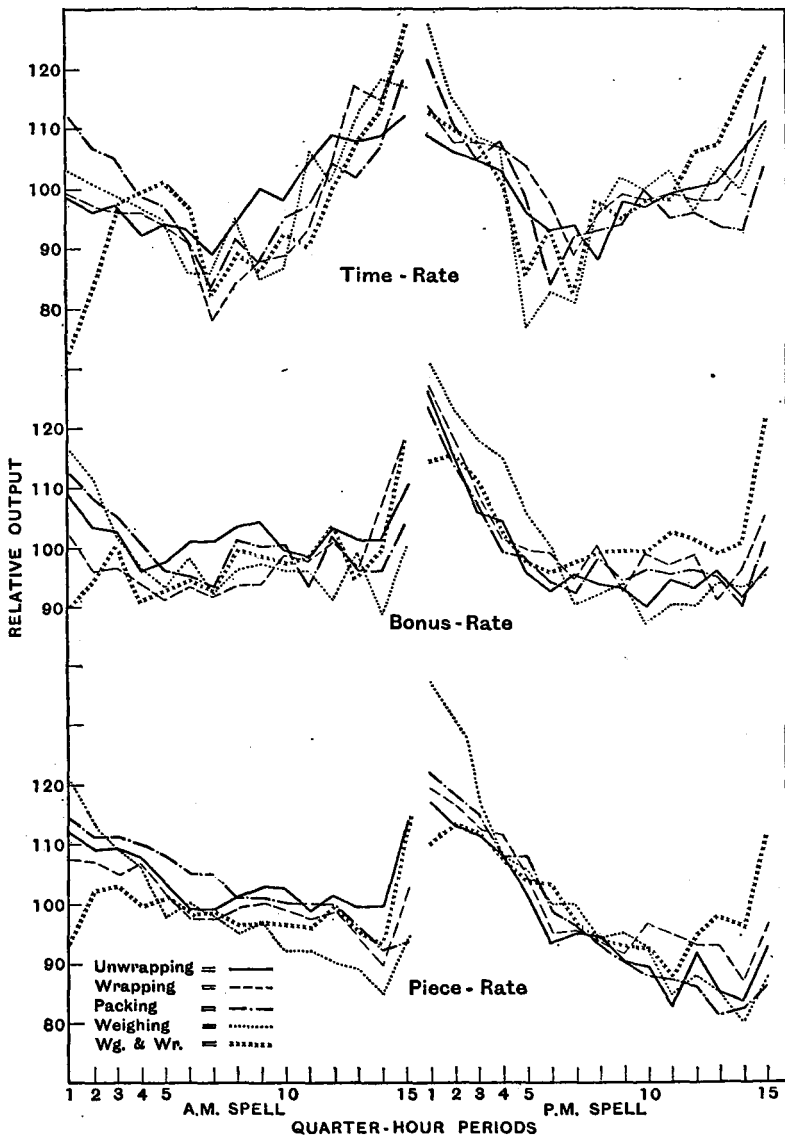


FIG. 14. Variations within the spell of work in each process.

It will be seen that the variations in the rate of working in the different processes were very similar, and appeared to be practically independent of the type of work. The only noticeable exception was in the combined weighing and wrapping process, which showed a rising output in the early part of the morning spell and a greater recovery in the latter part of the afternoon spell. It may also be noted that the initial output in weighing was usually relatively high.

The similarity is rather striking, and indicates that performance in the five operations was under the influence of one or more predominant common factors. All the processes were, of course, merely different forms of repetition work, and in this respect they had much in common. They varied, however, in nature and complexity, and were regarded with different degrees of interest, consequently it is unlikely that the similarity in the curves was due entirely to any uniformity in the type of work. It seems more probable that the resemblance in question was caused by the prevailing general attitude towards the conditions of work. This was found to be the case in a previous investigation* when it was shown that the rate of working of the different individuals in a fairly compact group tended to follow the same course. In the present experiment, although the pairs of workers were engaged on different tasks, the five operations were performed simultaneously by the group, and the individuals responded in a similar manner to the group "atmosphere." Thus on some occasions during the day an industrious attitude would prevail which resulted in a general increase in the rate of working; at other times the group as a whole would show signs of slackness or indifference, and the individuals reacted accordingly. These general tendencies completely neutralised any variations in the rate of working which might have been caused by differences in the type of work.

C.—*Lost Time*

The total duration of voluntary stoppages also seemed to be dependent on the type of work. Thus the relative amount of time lost in the different processes was :—

Wrapping	..	..	..	..	100
Packing	..	..	..	..	105
Weighing and wrapping	..	..	..	..	106
Weighing	..	..	..	..	117
Unwrapping	..	..	..	..	120

It will be seen that 20 per cent. more time was lost in unwrapping than in wrapping, and intermediate values were obtained in the other processes. The differences in question bear little or no relation to the severity or fatiguing nature of the work, but seem to be due to the same causes which were responsible for the varying amount

* Report No. 32 of the I.H.R.B., p. 27.

of improvement in the different tasks. Thus the ranking of the operations according to the amount of time lost was the same as that obtained when the five processes were arranged by the workers in order of preference. In other words, the operatives were more reluctant to stop work on those operations which they liked, and vice versa. The reasons for the varying likes and dislikes have already been given (p. 26).

Some additional evidence in this connection was provided by the number of occasions when the operatives were absent from work. The total number of spells recorded during the experiment was as follows :—

Wrapping	10
Packing	11
Weighing and wrapping	11
Weighing	16
Unwrapping	17

Since cases of genuine illness were fairly evenly distributed over the five operations, it is reasonable to believe that the increases observed in weighing and unwrapping were again due to their relative unpopularity. Absenteeism on these occasions was usually attributed to headache or getting up late, but the workers seemed to be free from these complaints when they were due for work on the other processes.

The relative amount of time lost by each worker in the different processes is also instructive. The results are given in Table VIII and are expressed as a percentage of the average in all the processes.

TABLE VIII.—RELATIVE AMOUNT OF TIME LOST BY EACH WORKER IN THE DIFFERENT OPERATIONS

	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.
Unwrapping ..	25	105	106	156	10	137	39	157	208	152
Wrapping ..	21	86	79	144	21	115	19	123	153	151
Packing ..	9	91	117	141	17	83	29	149	171	147
Weighing ..	69	115	121	147	6	121	37	119	161	171
Weighing and wrapping.	26	78	147	112	11	119	20	106	179	167

As a rule the same worker lost more time in some processes than in others, and in almost every case the least amount of time was lost in the process which was liked best, and vice versa. Thus comparatively slight differences in the type of work may induce marked variations in the tendency to relax, and the results in general illustrate the importance of a correct adjustment between the individual and her work. Merely to discover that an individual is suitable for repetition work is not enough ; it is also necessary to consider the reactions of the individual to different types of repetition work.

D.—*Behaviour*

The general behaviour of the operatives employed in this experiment was also related to the type of work. A numerical comparison of the disturbances and unfriendly incidents which arose when the operatives were employed on the different processes is given below. The figures are expressed as a percentage of the average for the five operations.

				<i>Disturbances.</i>	<i>Quarrels.</i>
Unwrapping	..	..	..	90	103
Wrapping	..	..	..	112	87
Packing	..	..	..	114	96
Weighing	..	..	..	134	147
Weighing and wrapping	..	..	..	50	67

Thus the workers were most disturbing and quarrelsome when employed on the weighing process. It will be remembered that this operation was said to be uninteresting, and was generally disliked. The workers in consequence sought other means of outlet for emotions, with the result that disturbing forms of behaviour were comparatively numerous. Since work on this process induced an irritable mood it is only natural that the disturbances often took the form of unfriendly remarks and behaviour.

It might also be expected that the unwrapping process would give rise to similar forms of behaviour as it was ranked last in order of preference. This was found to be the case, but since the workers were allowed to read when unwrapping the disturbances were not so frequent as in weighing.

It will be noted that there was a marked improvement in the behaviour of the workers when they were employed on the combined weighing and wrapping operation, presumably because they were comparatively isolated from the remainder of the group.

On the whole the behaviour of the workers reflected the degree of satisfaction or displeasure induced by the respective operations. Each process created a certain attitude or mood, and behaviour was coloured by this background of thought and feeling. The persistent nature of a mood and its tendency to express itself on all kinds of persons and things was very apparent, and there is little doubt that continued exposure to industrial conditions may have an effect on feelings and behaviour which is by no means confined to the hours of work. This feature of industrial relationships has not yet received the prominence it deserves, but it is clearly connected with personal likes and dislikes, and is closely related to problems of supervision and discipline.

3. PERSONAL FACTORS

The results obtained in this experiment have so far been considered from the standpoint of monetary incentives and the type of work, but it was also evident that the output of the workers was dependent on the collective attitude and behaviour of the group and upon certain individual characteristics.

A.—Group and Individual Influences

(i) *Group behaviour*

Whenever individuals are employed as a fairly compact group they no longer behave as independent units, but tend to respond in a similar manner to the prevailing group "atmosphere." Thus it was shown in Fig. 14 that variations in the rate of working throughout the day were practically independent of the type of work, and the similarity in question was attributed to the suggestive influence of the group upon the individuals concerned. Throughout the course of this experiment the output curves of the different workers were remarkably similar as regards shape, and were undoubtedly influenced by a common factor which could only be assigned to the existing group attitude. As a rule the workers were not aware of this collective influence, which formed an intangible background and determined the general nature of the reactions to the conditions of work. On some occasions, however, the behaviour of the group was directly affected by one of its members, especially if she happened to be assertive and domineering. This was particularly noticeable in the case of worker D who seemed to be the leader of the group. The records made at the time of the experiment contain many references to her disturbing influence, and the curves in Fig. 15 provide a suitable illustration of the effects observed.

During the first 75 minutes of this spell all the workers were quiet and industrious. Worker D then began to show signs of restlessness, and started a conversation about film heroes with her partner C. As a result there was an immediate fall in the rate of working of these two operatives. It was evident that D wanted to involve the whole group in the discussion for she began to address questions to the adjoining pair (I and J), who readily responded to her remarks. A little later the next pair (G and H) were drawn into the conversation, and the disturbance then spread to the more remote pair (A and B). The last to be affected were E and F, who were employed in weighing and wrapping at a separate bench. The disturbance was started and sustained by D, and spread gradually throughout the group. As a result the effect on output was most marked in the case of her immediate neighbours, but decreased as the position of the workers became more remote.

It was often noticed that worker D seemed to be happy and satisfied when she had succeeded in attracting the attention of the entire group, and she showed signs of annoyance when the others were slow or reluctant to respond. In this respect she had a close rival in worker I, and the competition for supremacy often led to unfriendly behaviour and abusive remarks.

Although D and I were the most disturbing members of the group and were often the cause of a general reduction in output, somewhat similar effects were sometimes attributable to workers B and F. The remainder, especially A, E, and G, seldom attempted to distract the others, and were reluctant to take an active part in discussions.

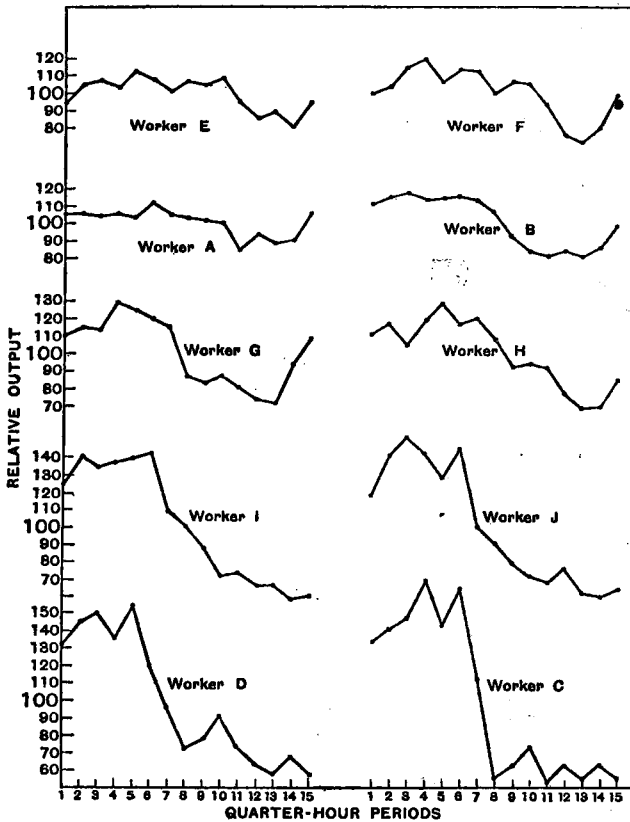


FIG. 15. Effect of a disturbing individual (D) in the remainder of the group.

In almost every spell the operatives were quiet and maintained a relatively high rate of working for about an hour. One of the workers would then begin to talk, and there was a general relaxation of attention which gradually spread throughout the group. On the few occasions when attention was continuously directed to work there was an increase in output of 20 to 30 per cent.

The effect of particular individuals upon the rate of working of the other members of the group may also be illustrated by the results obtained when a worker was absent. Thus worker D was absent on eight occasions and the output of the remainder showed an average increase of 12.5 per cent. over that of the preceding and following weeks when D was present. Similar effects were noticeable when worker I was away, and on these occasions there was an increase in

the average output of the remainder of 10·2 per cent. In the case of the other workers the corresponding effects were small and sometimes opposite in tendency.

(ii) *Individual effects*

Although group influences affect behaviour in the manner described, the closest resemblance in the rate of working was observed when the operatives were considered in pairs. On any given day the two workers who sat facing each other were employed on the same process, and the variations in their rate of working were remarkably similar. This resemblance has been expressed in the form of correlation coefficients between the average output recorded in corresponding quarter-hour periods throughout the day. The correlations in question are given in Table IX, and they have been calculated separately for each period of payment.

TABLE IX.—COEFFICIENTS OF CORRELATION (r) BETWEEN THE RATE OF WORKING IN CORRESPONDING QUARTER-HOUR PERIODS THROUGHOUT THE DAY.

		Workers.					
		A.B.	C.D.	E.F.	G.H.	I.J.	Average.
Wrapping	Time-rate ..	0·83	0·70	0·67	0·72	0·80	0·74
	Bonus-rate ..	0·69	0·85	0·40	0·88	0·85	0·73
	Piece-rate ..	0·68	0·78	0·45	0·56	0·85	0·66
Packing	Time-rate ..	0·66	0·86	0·61	0·91	0·88	0·78
	Bonus-rate ..	0·86	0·77	0·67	0·88	0·98	0·83
	Piece-rate ..	0·76	0·79	0·76	0·83	0·93	0·81
Weighing	Time-rate ..	0·92	0·84	0·90	0·91	0·97	0·91
	Bonus-rate ..	0·98	0·94	0·81	0·85	0·99	0·91
	Piece-rate ..	0·93	0·90	0·89	0·90	0·69	0·86
Unwrapping	Time-rate ..	0·50	0·74	0·75	0·59	0·66	0·65
	Bonus-rate ..	0·65	0·86	0·50	0·65	0·73	0·68
	Piece-rate ..	0·83	0·79	0·84	0·70	0·68	0·77
Weighing and wrapping.	Time-rate ..	0·97	0·96	0·71	0·88	0·81	0·87
	Bonus-rate ..	0·70	0·94	0·90	0·76	0·99	0·86
	Piece-rate ..	0·55	0·89	0·61	0·78	0·87	0·74
Average ..		0·77	0·84	0·70	0·79	0·85	0·79

Coefficients exceeding ·4 would only occur by chance once in 50 times.

The coefficients are all positive and significant and indicate the close similarity in the shape of the output curves for each pair of workers. They were highest in the weighing process (·89) but were closely followed by the combined weighing and wrapping operation (·82) and packing (·81) while wrapping and unwrapping gave average correlations of ·71 and ·70 respectively. The three former processes involved the filling of tins which, when completed, were piled on the bench. The relative number done could be seen at a glance and an increase or decrease in the rate of working of one

operative tended to produce a similar response from the other. In the case of wrapping and unwrapping the completed units were dropped into tins and the operatives were ignorant of the actual number done. This difference may account for the higher correlations obtained in the weighing and packing processes and illustrates the effect of a visible and measurable output on the rate of working.

The results also show that the correlations varied in the different pairs of workers. They were highest in the case of I and J and were lowest between E and F. As regards the former pair, worker J was very much influenced by worker I and although capable of attaining fairly high speeds she seemed afraid of doing more than worker I. In the case of workers E and F the former was the steadier of the two and took little interest in the activities of the others. She was the least affected by distractions and was the last to react to group effects. Worker F, on the other hand, was very susceptible to the behaviour of the remainder and the lower correlations recorded in connection with these two workers were largely due to the relative independence of worker E.

It is fairly evident, therefore, that the working positions of the operatives had a marked effect on the shape of the individual output curves. The variations in the rate of working of any two operatives who sat facing each other at the same bench were very similar and the degree of resemblance was partly dependent on the personal characteristics of the individuals concerned. These varied from complete dominance or submission to partial independence and there is little doubt that the arrangement of the workers within a group may have an important effect on output and pleasure in work.

(iii) *Effect of rearranging the workers within the group*

Since the variations in the rate of working of an operative were closely related to those of the opposite worker and were partly dependent on the personal characteristics of the individuals concerned it was thought that a rearrangement of the workers within the group might provide instructive results. Such a change was made in the 37th week of the experiment and the new arrangement was continued for a period of 18 weeks. The positions of the workers before and after the change were :—

<i>Before.</i>			<i>After.</i>		
A	opposite	B	A	opposite	E
C	"	D	B	"	D
E	"	F	C	"	F
G	"	H	G	"	I
I	"	J	H	"	J

The effect on average output is shown in Table X. The results refer to the wrapping process and are based on the output recorded in two periods of eight weeks immediately before and after the change.

TABLE X.—INDIVIDUAL CHANGES IN AVERAGE OUTPUT AFTER REARRANGING THE WORKERS WITHIN THE GROUP

Worker.	Before change.	After change.	Difference.	Per cent. difference.
A	423	444	+ 21	+ 5.0
B	507	668	+161	+31.8
C	576	445	-131	-22.7
D	447	493	+ 46	+10.3
E	456	465	+ 9	+ 2.0
F	493	468	- 25	- 5.1
G	582	473	-109	-18.7
H	383	425	+ 42	+11.0
I	363	317	- 46	-12.7
J	409	483	+ 74	+18.1

The differences are significant except in the case of workers A, E, and F.

It will be seen that while the average output of some workers remained practically unaffected by the change, that of the majority showed a notable increase or decrease. The more important causes of the changes in question may be summarised as follows :

(a) The output of a worker tended to increase when she was moved from the neighbourhood of a slower to that of a quicker worker. This was partly responsible for the increases observed in the case of B, D, and J. Conversely, the output of a worker tended to decrease when her new partner was slower than the one replaced. The fall in output shown by worker G was partly due to this cause.

These tendencies, however, may be modified according to the personal characteristics of the individuals concerned. If, for instance, one member of the pair was domineering and the other submissive, the individual with the stronger personality tended to set the pace. Thus worker J was dominated by worker I and the former was heard to remark " I could do many more but I have to keep waiting for this slow coach. I am fed up and it is through working next to her that my output is so low." Afterwards worker J became associated with a fairly submissive individual (H) and the resulting increase in output was due largely to her escape from the retarding influence of worker I. The dominating and disturbing effects of the latter worker were then transferred to her new neighbour G.

A further modification was noticeable when the difference in output between two workers was large and the slower worker was sensitive to this difference. Under such circumstances she tended to become discouraged and depressed. Thus the output of G was from 30 to 50 per cent. greater than that of H when they worked opposite to each other. During this period worker H was sulky, irritable, and constantly grumbling. She seemed to be thoroughly disgruntled and unhappy and accused G of being mean, unfair, and spiteful. Later G was replaced by J whose rate of working was

fairly similar to that of H. There was an immediate and marked improvement in the behaviour and attitude of the latter operative and her output increased.

(b) The output of two adjacent workers was also partly dependent on the blending or otherwise of their personal characteristics. If these were conducive to harmonious relations the individuals "pulled together" and output tended to increase. Thus the large increase in output recorded in the case of worker B was due chiefly to her removal from the vicinity of a quiet worker (A) who generally refused to take part in any conversation, to the neighbourhood of D who was similar to B in type, temperament, and tastes. Although worker B had been quite friendly towards A she was irritated by the continued silence of the latter and tended to become moody and depressed. When placed opposite to D she became bright and cheerful and worked with great speed and enthusiasm.

A somewhat opposite effect, however, was observed when worker C became associated with worker F. Both were lively, talkative, and had much in common and their juxtaposition resulted in a spate of conversation which made them happy but less productive than before.

It is evident, therefore, that output and contentment may be seriously affected by the rate of working and behaviour of a neighbouring operative. Personal characteristics and tendencies seem to be particularly important in this connection and their effects may be just as important as individual differences in ability. The question is complicated and only a few of its various aspects have been indicated but there is little doubt that contentment and efficiency would be increased if more attention were given to this aspect of industrial work.

(iv) *Effect of isolation*

The preceding results show that the output and behaviour of an individual were dependent on the proficiency and personal characteristics of the opposite worker. It was accordingly decided to see what happened when each worker in turn was separated from the remainder of the group. The wrapping process was used for this purpose and one member of the pair employed on this operation was placed at a bench in a room adjoining the one in use. She was the only worker in this room and was unable to see the other operatives. She returned to the group in alternate weeks and her position was taken by the other member of the pair. This procedure was continued for six weeks and apart from the isolated position of the individual concerned the conditions of work remained unchanged.

The results, in the first place, may be used to show the effect of isolation on output. As compared with the average output before and after the period of isolation the percentage increase was found to be as follows :

A.	B.	C.	D.	E.	F.	G.	H.	I.	J.
23.6	23.2	52.0	41.9	22.7	43.5	37.0	38.8	22.6	55.7

Thus a significant increase in output was produced merely by removing each individual in turn from the influence of the group and it is evident that the group arrangement was responsible for a rate of working which was much below the possible achievement of the individuals concerned.

At the end of each spell the operatives were questioned on their attitude during the periods of isolation. They all agreed that it was possible to work much better when alone and stated that time seemed to pass more quickly when working "hard." "When I do a lot the day seems short" and "Being alone makes you work hard because you can't talk" were fairly typical of the replies received. In order to "fill" the time the operatives often counted the number done or attempted to complete a certain number of units in a given period. Day-dreaming was also common and statements such as "I was thinking of something right grand when I found it was time to stop" and "I can think better when by myself" illustrate the tendency in question. The isolated worker, however, often complained that she felt lonely and was unable to talk. The surroundings, although fairly similar to those in the experimental room, were said to be ugly and unpleasant, while the seat, which was unchanged, was found to be hard and conducive to backache. Separation evidently made the operative more susceptible to elements in her surroundings which passed unnoticed when she was employed as a member of the group.

The results obtained in this part of the experiment may also be used to show the effect of freedom from group influences upon the shape as distinct from the average level of the work-curves. Under the usual conditions of work the individual output curves showed a close resemblance to the variations in the rate of working of the remainder of the group but when isolated the similarity tended to disappear. Thus the coefficients of correlation between the output recorded in successive quarter-hour periods throughout the day for (a) each worker and (b) the average of the remainder of the group were :

A.	B.	C.	D.	E.	F.	G.	H.	I.	J.
0.63	0.88	0.90	0.83	0.74	0.86	0.63	0.82	0.65	0.78

but when isolated the corresponding values were :

A.	B.	C.	D.	E.	F.	G.	H.	I.	J.
-0.03	0.45	0.31	0.23	0.34	0.31	-0.13	0.74	0.63	0.54

The results accordingly provide a further illustration of the influence of the group upon the individual.

It might be thought that the higher rate of working observed when each individual was isolated would be conducive to increased fatigue. A comparison of the results obtained before and after the change showed that while the curves of A, E, and H indicated a greater fall in output towards the end of the spell, those of the remainder were, if anything, more buoyant.

On the occasions when one member of the pair of wrappers was isolated the other worker remained attached to the group and there would appear to be no particular reason for any marked change in her rate of working. Yet the results obtained on these occasions showed an increase in output in every case. The percentage increases were as follows :—

A.	B.	C.	D.	E.	F.	G.	H.	I.	J.
22.1	21.4	40.3	15.8	12.4	30.8	26.7	21.4	9.5	36.9

The improvement in question might be attributed to (a) the removal of a talkative and disturbing neighbour, and (b) the stimulus created by the knowledge that the isolated member of the pair was likely to produce an unknown but relatively high level of output. If the former, a similar effect should be observed when, under the usual conditions of work, one member of the pair was absent. This occurred on 65 occasions and resulted in an average increase in the output of the worker who was present of only 5.1 per cent. It is highly probable, therefore, that the competitive element was the cause of the increase in question and was induced by the suspected higher rate of working of the isolated operative. The workers reacted in this manner in spite of the fact that the earnings of each individual were independent of the output of the remainder. The results seem to provide a particular illustration of the general principle that an individual is impelled to greater activity when he knows that others employed on the same kind of work may be "stealing a march". If he is familiar with their rate of progress he tends to adjust his own activities accordingly.

A doubt may be expressed as to whether the increases in output observed during the periods of isolation would be maintained if such conditions were continued indefinitely. While such a possibility undoubtedly exists the indications in the present experiment were slight. Thus, if the period of isolation be divided into three parts, the average decrease in output in the second two weeks was only 4.3 per cent. while the further decrease in the third two weeks was less than 2.0 per cent. However, the possibility of retaining the advantages of this procedure while minimising its defects are probably fairly obvious.

The preceding results show the interactions between one worker and another and illustrate the futility of regarding the individual as an independent unit. The same individual behaves very differently when working alone and when employed in close proximity to other operatives and the arrangement of the workers within the group may have an important effect on output and happiness. There is little doubt that the factors which were found to exist in the present experiment would be reproduced whenever workers are employed as a fairly compact group.

B.—Temperamental Tendencies

By temperament is meant that constitutional tendency to act and feel in a certain manner which characterises the behaviour of each individual. Thus a man may be constitutionally buoyant or

gloomy, impulsive or cautious, excitable or phlegmatic, and at present these and other familiar terms must suffice to describe what is meant by temperament.

It will be apparent that temperament, unlike intelligence and manual dexterity, is seldom adequately expressed in short performance tests and consequently it is not easily measured. It is revealed most clearly in the ordinary behaviour of an individual during the changing conditions of everyday life and continuous observation over long periods is likely to provide the most reliable clues. This was the procedure adopted in the present experiment and the estimates of temperamental tendencies were based on the records of three observers over a period of fifteen months.

In order to provide a numerical basis for the discussion of this subject, some assorted but relevant data are given in Table XI. In each case the results are expressed as a percentage of the group average.

TABLE XI.—SUMMARY OF CERTAIN INDIVIDUAL DIFFERENCES

	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.
Output	104	120	109	96	103	106	115	90	76	81
Capacity* ..	91	109	104	103	86	113	111	90	100	93
Lost time ..	30	95	114	140	13	115	29	131	174	159
Disturbances ..	5	104	101	263	22	90	47	38	201	129
Quarrels ..	0	53	80	120	7	40	113	200	206	181
Talking ..	60	108	123	136	52	118	85	94	124	100

* Based on records obtained in the second quarter-hour of each afternoon spell when the operatives were asked to work as quickly as possible.

From the temperamental standpoint the most suitable workers were A and E. They were quiet, unobtrusive, and seemed to be practically immune to distracting influences. Sometimes they worked for hours without speaking and yet they appeared to be reasonably happy and content. Their voluntary stoppages were negligible and they were seldom disposed to quarrel or complain. Although incapable of attaining the high speeds which could be reached by some of the other workers, their level of output was above the average for the group. They were the most consistent and conscientious workers and could be trusted to work without supervision. A suitable temperament enabled them to make the most of an inferior capacity and they seemed to derive satisfaction from the simple and uniform conditions of work.

Worker G had much in common with A and E but she was more determined, energetic, and disturbing. Although her rate of working was often high and consistent she had periods of slackness when she seemed to be disgruntled and bored. As a rule she was placid and attentive but the streak of restlessness made her a less suitable and contented worker than A or E.

Workers C and F were slim, vivacious, and quick in all their movements. They were lively, cheerful, and talkative and their chatter was animated and amusing. Their rate of working was

very variable and half-an-hour or so of intense productive activity would be followed by a period of restless behaviour in which there was little work but much talking. When unable to talk they were usually very bored. Although capable of attaining unusually high speeds they were temperamentally unstable and from this standpoint were unsuitable for simple forms of repetition work.

Workers D and I were two of the most troublesome and unproductive members of the group. Physically they were big, muscular and somewhat masculine in appearance while temperamentally they were boisterous, assertive and expressive. They were talkative and noisy and liked to distract the others. Worker D in particular was never really happy unless she had an appreciative audience. Both seemed to be incapable of attending to work for any length of time and they were obviously not interested in the processes. As a result their rate of working was erratic and much below their limits of possible achievement. After the completion of the experiment they were transferred to machine-feeding processes in another department. The noise and somewhat isolated positions of the machines made talking difficult and D left after a few months.

Worker B was similar to these two both physically and temperamentally, but a superior capacity for work combined with an intense desire to excel made her the most productive member of the group. She was very proud of her outstanding achievements, and seemed to enjoy the work because of her superiority in this respect. The desire to lead stimulated her to outbursts of great activity, and she was constantly trying to break "records." In her case interest and satisfaction seemed to be dependent on successful competition, and when moved to the machine-feeding department where she was inferior to some of the other workers she left after four months.

Worker J was an introvert who spent most of her time in day-dreaming, and often behaved childishly. She had a fertile imagination and wanted to be a novelist. From time to time she invented romantic stories in which the hero or heroine was usually simple or mad. When not day-dreaming she was intensely bored, but as a rule she found relief in a fantastic world of her own creation. She was not by nature quarrelsome but was extremely sensitive and easily disturbed or provoked by the behaviour of her neighbours.

Worker H was sullen, secretive and sometimes vengeful. She was heavy and dull, had no sense of humour, and was often teased unmercifully by the others. She often talked quite openly of her success with "boys" and the attention thus aroused seemed to provide some compensation for her inferiority in other respects. Her highest output was obtained in the combined weighing and wrapping process, and when engaged on this operation she became more confident, assertive and cheerful. Her behaviour on this and on the other operations provided a striking example of the effects of success and failure on disposition and mood. This operative was temperamentally suitable for repetition work, providing it did not involve contact and comparison with workers of superior ability.

The preceding summary of individual characteristics leaves little doubt that suitability for repetition work is closely related to temperamental tendencies. A worker may have the necessary speed and dexterity but her performance in practice may be seriously impaired because of an unsuitable temperament and may be inferior to that of a less capable worker who is better equipped temperamentally. Thus a knowledge of the mental and muscular capacities of an individual gives only an imperfect indication of suitability for repetition work, and any prediction which ignores temperamental characteristics is likely to be misleading.

From the temperamental standpoint the most suitable workers for simple repetitive processes seem to be the quiet, steady and persistent type who lack ambition and imagination, and remain placid and unperturbed in the midst of distractions. The most unsuitable type appears to be the animated, variable and volatile individual who is expressive, responsive and easily disturbed. Since temperamental tendencies are believed to persist with little variation throughout life, it was thought that school records would be a useful guide to industrial behaviour. The teachers were accordingly approached and were asked to summarise the chief temperamental characteristics of the workers as observed during their last few years at school. The summaries showed a remarkably close resemblance to the individual characteristics already described, and it was obvious that the most prominent temperamental tendencies displayed by the different workers during the experimental period could have been predicted from their school records with an unusually high degree of reliability. Thus traits such as steadiness, persistence and stability of attention were said to be the outstanding characteristics of those individuals who afterwards proved to be the most suitable workers, while restlessness, variability and fluctuating attention were mentioned as being characteristic of those who proved to be the most troublesome and unsatisfactory members of the group. Apparently the individual who is unable to give the necessary attention to comparatively interesting and frequently varied school-subjects will not be able to endure the longer periods of unvaried work in industry. As regards temperament, therefore, it seems probable that school records compiled by observant teachers are likely to provide the most reliable evidence of general suitability for repetition work in industry.

C.—*Intelligence*

It is, of course, common knowledge that different types of work require different degrees of intelligence for their successful performance. It is also widely recognised that an individual who, for instance, possesses just enough intelligence to make him a competent clerk could never hope to become a successful lawyer, but it is not so widely known that the individual with the intelligence of a lawyer would tend to be unsatisfactory as a clerk. The masses of repetition workers in industry include many individuals who are endowed with

far more intelligence than is required for such types of work. They tend to become dissatisfied and bored so that output often bears little relation to capacity for work. This was found to be the case in a previous investigation,* and similar tendencies were noticeable in the present experiment. The number of marks obtained by each worker in a test of intelligence† was—

A.	B.	C.	D.	E.	F.	G.	H.	I.	J.
106½	66½	80½	59	49½	95½	79	57	112	111

A comparison of these results with the output figures given in Table XI shows that the two most intelligent workers (I and J) were the least productive members of the group, while the best worker (B) was relatively inferior in intelligence. The coefficient of correlation (ρ) between the two series is $-.13$, hence in this group of workers a high output was not associated with a high degree of intelligence. There was, however, a small but positive correlation ($.24$) between intelligence and capacity for work. Thus, although the more intelligent individuals also tended to possess a superior capacity for work their performance in practice was no better, and was sometimes inferior to that of the less intelligent members of the group. In other words, they appeared to be more susceptible to adverse elements associated with the conditions of work.

The simple and uniform processes included in this experiment required little or no intelligence for their successful performance, and there was ample evidence that the minds of the more intelligent operatives were insufficiently occupied by the conditions of work. Either they were bored or they adopted compensatory forms of activity in order to divert attention from the monotony of the processes. Often they varied the methods of work or arranged the material in the form of pleasing designs, and it was noticeable that most of the diversions in the form of verbal games, guessing competitions, and the like were started and sustained by the more intelligent members of the group. The less intelligent workers, on the other hand, seemed to be more satisfied with the conditions of work. They were not so restless and troublesome, and showed a greater stability and uniformity in their rate of working. More attention was given to work and they were less inclined to take part in competitions and games.

The results accordingly support the view already expressed that too much intelligence may be detrimental to success and personal satisfaction in simple forms of repetition work.

D.—Talking

The preceding sections contain several incidental references to talking and its relation to the conditions of work. The tendency to talk and the nature of the subjects discussed are, however, symptomatic of personal desires and characteristics, and it may be useful to consider the question from this standpoint.

* Report No. 56 of the I.H.R.B., p. 29.

† Measured by Series 33 of the National Institute of Industrial Psychology.

The workers employed in this experiment talked freely and a fairly complete record was made of the topics discussed. A representative sample taken from the first twelve weeks of the piece-rate period is given below :—

<i>Subject.</i>						<i>Frequency.</i>
1.	The opposite sex	..	..	..	..	42
2.	Films and film stars	..	..	..	..	27
3.	Local gossip and scandal	..	..	..	..	14
4.	Suicides, murders, and accidents	..	..	..	..	10
5.	Local events	..	..	..	..	11
6.	Conditions of work (features disliked)	..	..	..	..	32
	(features liked)	..	..	..	..	5
7.	Outside activities—					
	Rambles	..	..	..	..	8
	Dirt-track racing	..	..	..	..	12
	Rugby football	..	..	..	..	2
	Girl guides	..	..	..	..	16
	Swimming	..	..	..	..	5
	Dancing	..	..	..	..	8
	Gardening	..	..	..	..	6
	Holidays	..	..	..	..	8
	Home Life	..	..	..	..	7
8.	Personal—					
	Photographs	..	..	..	..	7
	Clothes	..	..	..	..	12
	Food	..	..	..	..	5
	Money	..	..	..	..	9

72

33

The results speak for themselves but attention may be directed to the frequent references to features of the work which were disliked. Repetitive workers have plenty of time for thought, and it is not surprising that difficulties and annoyances should occupy a prominent place in their minds. The individual is constantly reminded of the unpleasant features of work, and the mind tends to dwell on these aspects of the industrial situation. As a result they become greatly exaggerated and form a subtle but developing background of discontent which reduces pleasure and interest in work.

It will also be noticed that the most popular subject of conversation connected with outside activities was the girl guide movement, presumably because several of the workers were members of a troop organised by the firm. The interest in this movement evidently provided food for thought during work, and the results illustrate an important effect of social activities associated with factory life.

IV.—DISCUSSION OF RESULTS

The results obtained in this experiment illustrate the nature and effects of various factors which are conducive to the contentment and efficiency of operatives employed on simple forms of repetition work. They show, in the first place, that repetition work in itself is generally incapable of promoting that degree of interest and activity which is necessary for the attainment of a reasonable level of output. Few, if any people would be willing to devote the greater

part of their daily life to the performance of repetition work for its own sake, consequently it is only performed because it provides a means to a number of ends. In other words, the inducement to work is dependent on external or derived incentives and of these the most important is undoubtedly the weekly wage. This is intimately connected with the struggle for existence and overshadows all other incentives to work. It is not surprising, therefore, that apparently slight changes in the form or rate of payment should produce important effects.

A method of payment by results is undoubtedly superior to a time-rate as an incentive to work. It appeals to the desire for personal gain and provides an additional interest which makes work more satisfying and less boring. At the same time it is often responsible for undesirable forms of behaviour and may be the cause of much unhappiness. It stimulates the selfish and assertive tendencies in human nature and while the more capable workers find this pleasant and satisfying, those who are less well endowed may become discouraged and depressed. It is not easy for a slow worker to remain unmoved by the knowledge that her neighbour is in the habit of receiving a substantially higher wage. Such conditions are conducive to envy and jealousy and may lead to strained if not to hostile relations. Operatives employed on repetition work seldom indulge in that form of philosophic reflection which enables an individual to become resigned to inferiority and to find happiness in limited achievement. Contact with other individuals of superior ability throws their limitations into greater relief and the effect is often disturbing. Further, a worker of inferior capacity feels less secure and lives nearer to the brink of unemployment than her more fortunate neighbour. This may have an important effect on disposition and mood and it would be interesting to know the relative incidence of nervous disorders in workers of superior and inferior abilities. Under existing industrial conditions the individual who is inadequately endowed by nature for the performance of work is exposed to stresses and strains which may have far-reaching effects on health and happiness. The remedy seems to lie in the selection of workers so that each group consists of individuals who are approximately equal in capacity, or, alternatively, the different workers employed on the same process should be arranged so that differences in capacity between adjacent workers are as small as possible.

The results obtained in this investigation also show that comparatively slight differences in the type of work may give rise to notable differences in proficiency, behaviour, and pleasure in work. In particular, the importance attached to an operation seemed to be especially significant and the situation has much in common with the material and methods used in certain forms of test procedure. Thus ability in manual dexterity is often measured by performance in such operations as threading beads, inserting matches in the holes in a board, and the like. To many adults these

performances seem to be childish and futile and are not regarded seriously. As a result performance is not always proportional to capacity and there is little doubt that the lack of agreement in the results obtained in this type of psychological experiment is due largely to the nature of the test material and its varying effects upon the attitude of the individuals concerned. The results might be more reliable and consistent if the test material were disguised as elaborate and imposing pieces of scientific apparatus.

In this experiment the rate of improvement and subsequent efficiency were closely related to personal likes and dislikes. It is often difficult so say whether an operative likes her work because she does it well or does it well because she likes it. There is little doubt that success creates pleasure, and to this extent a scientific process of selection would tend to ensure a higher level of output and happiness. At the same time it is by no means uncommon to find that productive capacity is impaired by distasteful elements in the conditions of work. An operative may have the necessary ability, but performance is inhibited because the work is disliked. Thus anything which obstructs or interrupts the fulfilment of a desire will be regarded with displeasure, and if these annoying features are repeated the activity itself will tend to be disliked. This was found to be the case in the present experiment, and was responsible for a marked deterioration in output and interest.

Although there is some evidence that different types of repetition work have something in common and to this extent an individual who does well in one process is likely to do well in others, the deviations from this general tendency are important and deserve consideration. It should be possible by means of suitable tests to discover those individuals who possess a general qualification for repetition work. This is one of the functions of vocational guidance and should ensure a certain amount of harmony between the operative and her work. There is also reason to believe that certain forms of manual dexterity contain a common or group factor and it is possible that further group factors will be found to exist in the wide and varied field of repetition work. The discovery of such factors will refine still further the methods of vocational guidance and will reduce, but not eliminate the possibilities of error in the adjustment between the individual and her work. The final stage in this selective process seems to lie inside the factory. Thus an individual who has been found to possess the necessary qualifications for repetition work in general and at the same time has been shown to have the degree of manual dexterity required for the performance of a certain group of processes should be given a trial in each of these tasks. Even though the operations are very similar she will probably be more proficient on one than on another and the trial procedure may make all the difference between success and failure. Each factory usually contains many types of repetition work and a reshuffling or redistribution of the operatives so that each is finally employed on the process which makes the

strongest appeal is capable of increasing efficiency and pleasure in work. Usually an individual is placed on an operation without considering whether she is likely to enjoy the work. If she fails or becomes discontented she may be dismissed or may try to find work elsewhere. Industry contains thousands of workers who are chosen and employed in this way. They are left to make the best of a doubtful situation while there would be little to lose and much to gain by giving them a short trial on different types of work.

Although the type of work is an important factor in promoting efficiency and contentment, the effects may be augmented or reduced by influences associated with the conditions of work. One of the outstanding features of the results obtained in this experiment was the marked effect of one individual on another. The extent of this influence, of course, will be dependent on the distance between the individuals concerned but in most factories space is an important consideration. In the present inquiry the arrangement of the workers was similar to the usual factory procedure and it was obvious that the rate of working of each individual was closely dependent on that of her neighbour and upon the behaviour of the group as a whole.

When workers are employed as a fairly compact group they no longer behave as individual units but respond as a collective whole to the prevailing group "atmosphere." This may be conditioned by a variety of factors such as the method of payment, the type of work, the attitude of the foreman, and a prevailing grievance. In some cases the effect is favourable but in others it is reflected in discontent and decreased efficiency. The creation of a suitable attitude or "atmosphere" is accordingly a matter of some importance and as a rule there is scope for improvement in this direction. It is by no means uncommon to find differences in efficiency between groups of workers of 5 to 20 per cent. which are attributable entirely to variations in attitude towards the conditions of work.

In the case of comparatively small groups the prevailing habits of work are sometimes determined by its most assertive and domineering member. If she happens to be capable and industrious the effect will be favourable, but if she is talkative, disturbing, and slack, the group will tend to be infected accordingly. In any single group there are usually some individuals who are dominant and others who are submissive. The former, because of that undefined something which makes them imposing and authoritative are able to influence the more submissive and suggestible individuals and in this way they tend to regulate the conduct of the group.

In addition to the important but somewhat intangible effects of the group "atmosphere" the rate of working of an individual was also found to be closely related to that of her neighbour. In some cases the similarity was remarkable and seemed to be due to a mixture of conscious and unconscious influences. From time to time a worker made a deliberate effort to keep pace with her neighbour, but more often the resemblance in question seemed to be due to the subtle effect of suggestion. Whatever the cause there was no doubt about

the effect on output and whenever a more capable worker was placed next to one of inferior capacity the former tended to lose more in output than the latter gained. This, of course, is only to be expected since it is easier for a quicker worker to lose headway than it is for a slower operative to pick up speed.

The arrangement of the workers within the group was also responsible for certain forms of behaviour, which varied according to the characteristics of the individuals concerned. Thus an intelligent operative was bored and irritated by a comparatively dull and stupid neighbour, while a lively, talkative, and sociable worker became annoyed and sometimes angry and abusive because of the continued silence and indifference of her companion. People with incompatible temperaments and tastes may tolerate each other for short periods, but when they are thrown together for the greater part of their daily life the situation tends to cause friction. It is rather surprising that this feature of industrial relationships is so neglected in practice, since the rearrangement of the operatives within the group is one of the simplest forms of reorganisation. The advantages of scientific methods of selection and guidance may be reduced or even nullified by this factor and the duties of labour managers or advisers should be extended so as to include this aspect of industrial work.

Another notable feature of the results obtained in the present experiment was the marked response of the operatives to slight changes in the conditions of work. In some cases the changes acted as positive incentives to activity while in others they had the opposite effect. An example of the latter type was provided by the occasional difficulties experienced in the handling of the material. On these occasions the increased time taken to complete a unit of output was much longer than the conditions warranted. The operatives became discouraged and there was a notable weakening in the inclination to work. Similar difficulties encountered in the course of an interesting occupation would have been comparatively ignored or would have acted as a stimulus to increased effort. The behaviour of the operatives in the present experiment seemed to be due to the monotonous conditions of work so that a slight variation, whether positive or negative, produced important effects. The situation may be compared with certain familiar experiences in everyday life. Thus the gift of a book or a shilling to a man who has few books or is unemployed will be an important event and the pleasure derived will be much greater than that produced by a similar gift to a man who has a well-stocked library or is earning a substantial wage. The effect of the increment, as in ordinary sensory experiences, is related to the existing conditions, and a change which has a marked effect on one level of life may be scarcely perceptible on another. Unconsidered trifles are to be found in most forms of repetition work and they provide a fruitful source of pleasure or discontent. Their importance is seldom realised by the industrial supervisor or manager because they are regarded as inevitable and insignificant items in the daily routine.

The output obtained in this experiment, as in all forms of industrial work, was the resultant of positive and negative incentives to activity. Obviously output will be increased whenever the former are strengthened or the latter reduced in intensity. It is advisable, however, to direct attention in the first place to the possible existence of negative factors which are impeding production. Their detection and removal will have the same effect as the introduction of a stronger positive incentive such as an increased rate of payment. It is clearly uneconomical to increase wages in order to obtain a higher output while the effects are being neutralised by disregarded obstacles to production. Only a thoughtless driver would waste fuel in attempting to drive a car without first taking off the brakes. The results obtained in this experiment provided several examples of the discouraging effects of factors associated with the conditions of work and the notable improvement in behaviour and output which followed their removal.

Finally, the uniformity and simplicity of the processes included in this experiment provided ample evidence of the existence and effects of boredom. The operations occupied the hands but not the mind, and the operatives adopted many devices in order to divert attention from the monotonous conditions of work. They varied the method of procedure and indulged in talking, competitive games, day-dreaming and the like. Talking, of course, is one of the most familiar antidotes to boredom, but its relation to output is rather complex. If a worker is bored and does not talk her output falls. If she talks she is less bored but output falls because talking impairs the rate of working. Thus, in both cases boredom reduces output either directly by inhibiting productive activity or indirectly by increasing the desire to talk. Only when work is entirely automatic, as in walking, does talking have no effect on output.

It will probably be remembered that the workers employed in this experiment asked to be allowed to read when unwrapping and this form of distraction was found to be satisfying and conducive to increased output. It is not suggested that reading is the most suitable and practical antidote to boredom for obviously its use in industry is limited and the procedure would seldom meet with the approval of the management. The principle involved, however, is important, and throws light on the nature of boredom. It seems to be due to an awareness of the monotonous conditions of work and is consequently mental in origin. Mental states, of course, have their accompanying feelings and boredom is no exception to this rule. The beginnings, however, are in the mind and the remedies must also be mental. The problem is how to divert thought from the monotonous conditions of work and the devices adopted by the operatives illustrate the need and importance of this procedure. The difficulty seems to lie in devising a situation which appeals to the mind without impairing the movements of the hands. A visual form of distraction, such as reading, is clearly not the most suitable for this purpose, but there seem to be possibilities in auditory stimuli.

The gramophone or the wireless set immediately suggest themselves in this connection, and there is little doubt that the broadcasting of suitable music or talks for about an hour around the middle of the work-spell would be appreciated by the workers and have a favourable effect on output. In order to reduce the cost of maintaining a varied programme a form of library exchange system might be arranged. Some employers still cling to the idea that output is merely a function of the scheduled hours of work, but it is becoming increasingly evident that attention must be directed to the mental effects of continued exposure to monotonous conditions of work.

One of the most frequent devices adopted by the operatives for the purpose of relieving boredom was the creation of definite aims. From time to time they attempted to complete a certain number of units in a given period; arranged the material in the form of pleasing designs; or competed against each other during short outbursts of great activity. The weekly wage, even when based on output, was too remote to act as a complete antidote to the monotonous conditions of work and failed to satisfy immediate aims and desires. The operatives accordingly created additional standards of performance which appealed to their constructive and competitive tendencies. This spontaneous behaviour on the part of the workers is suggestive and indicates an important personal need, which could be satisfied to a certain extent by the provision of an output recording device. Such a device would induce the operative to compete against herself and would provide a visible record of her rate of progress. A still stronger stimulus and interest would be created if the indicator registered the accumulating output in terms of *£ s. d.* In many factories a bonus is paid whenever the weekly output of the worker exceeds a certain level. Such a scheme has a limited effect on the rate of working because the incentive is too diffused and dilute when spread over a number of days. For the same reason the incentive created by profit-sharing schemes seems to be limited to the periods immediately preceding and following the time of distribution. Operatives employed on repetition work prefer to have a series of more immediate aims and this desire might be satisfied by the payment of a bonus whenever a certain standard of output was reached in each hour, spell or day. There is some reason to believe that hourly intervals would be the most effective for this purpose but the most suitable unit of time could be determined by experiment. The problem is closely related to the question of the optimum amount of material supplied to the workers and the capacity of receptacles for receiving the finished products.

It will be apparent from the preceding discussion that repetition work gives rise to many important and interesting problems and although in several cases the present experiment has merely demonstrated their existence it is hoped that the results will act as a stimulus to thought and action.

V.—SUMMARY

The results obtained may be summarised as follows:—

1. The type of repetition work included in this experiment contained little that was inherently interesting and only three workers out of ten showed any tendency to be satisfied by the work for its own sake. Proficiency in this kind of work was accordingly dependent on external or derived incentives and of these the most important was the weekly wage.

2. A time-rate was found to be comparatively weak as an incentive to work, and output under this method of payment seemed to be largely dependent on constant supervision and the fear of dismissal.

The differences between one worker and another were less under the time-rate than under the other methods of payment and the slower workers tended to set the pace. The time-rate was found to be conducive to boredom and was responsible for an increase in the number and duration of voluntary stoppages. At the same time it tended to promote friendly relations, and instances of envy and jealousy because one worker did more than another were comparatively rare.

3. A change from a time-rate to a competitive bonus scheme caused a substantial increase in output and the latter method of payment was found to be particularly suited to the learning period when an ordinary piece-rate is usually impracticable. As compared with a time-rate it was found to accelerate the rate of improvement so that after a period of nine weeks the output under the bonus scheme had increased by 35 per cent. more than under the time-rate.

Although the competitive bonus scheme was preferred to the time-rate and made the conditions of work more interesting, it had certain limitations and was responsible for undesirable forms of behaviour.

4. The subsequent introduction of a flat piece-rate produced a further notable increase in output. It was regarded as the fairest of the three methods because rewards were dependent on achievement. Under the piece-rate there was a reduction in the amount of lost time and the workers were less talkative and troublesome than under the time and bonus methods of payment. The undesirable forms of behaviour observed under the bonus-scheme were, however, still in evidence, but on the whole they were less numerous and intense.

5. In general the rate of working, both during and after the learning period, became stabilised on a level which increased with the strength of the monetary incentive. Under the time-rate this level was much below the limits of possible achievement and was associated with an attitude of indifference on the part of the workers concerned. A change to a bonus or piece-rate broke down this attitude and resulted in a new and higher level of output which was usually from 20 to 40 per cent. above that recorded under a time-rate.

6. The rate of improvement and subsequent efficiency, the amount of lost time, and the general behaviour of the operatives were also dependent on the type of work. In one process there was a total increase of over 200 per cent. during the learning period, while in another but fairly similar operation there was very little improvement. The increases in the other processes varied between these two extremes.

The causes of these differences were closely related to personal likes and dislikes induced by:—

(a) the value attached to an operation. Thus a process which involved the unwrapping of finished but defective products was regarded as a wasteful and comparatively useless procedure, while the completion of attractive and saleable articles was satisfying and stimulating.

(b) the continuity of the process. Short but frequent interruptions to the usual cycle of movements were disliked because they interfered with the continuity of the process, impeded progress, prevented a rhythmical method of work, and made mind-wandering difficult. Conversely a highly mechanised and rhythmical operation tended to give satisfaction.

(c) the complexity and variety of the work. A somewhat complex operation which involved changes in the form of work was liked because it tended to occupy the mind as well as the hands and time in consequence appeared to pass more quickly.

As a rule the operatives were most troublesome and wasted most time on those processes which they disliked, and *vice versa*.

Although the group as a whole preferred some processes to others and showed the most improvement on those operations which they liked best, it was also apparent that certain types of repetition work which are unpleasant to some individuals may be performed with comparative satisfaction by others.

7. The relative rate of working of different individuals exposed to the same conditions of work may show important changes during the learning period so that final output may bear little or no relation to initial performance. There is some evidence that final capacity may be predicted with a fair degree of certainty, but in practice the value of this prediction may be nullified by the variable behaviour of the different individuals in response to the conditions of work. For this reason beginners in industry should be allowed to continue at work for a few weeks or even months before the question of their suitability is considered.

8. The variations in the rate of working of the different individuals tended to follow a similar course which was dependent on the prevailing group attitude or "atmosphere." Certain individuals had an important influence on the behaviour and productive activity of the remainder and the effects were most noticeable when the individual was of the domineering and disturbing type. The absence of such a worker caused an increase in the output of the remainder of $12\frac{1}{2}$ per cent.

In particular, the rate of working of an operative was closely related to that of her immediate neighbour and this relationship was perhaps more marked when the completed units of output enabled the rate of progress to be ascertained at a glance.

9. The rearrangement of the working positions of the operatives within the group caused some notable changes in the output and behaviour of the individuals concerned. In several cases the changes in output varied from 15 to 20 per cent., while the effect on disposition, mood, and pleasure in work was often striking. The more important tendencies observed were as follows:—

(a) The output of a worker tended to increase when she was moved from the neighbourhood of a slower to that of a quicker worker, and *vice versa*.

(b) The extent of the increase in output and the amount of pleasure derived from work were dependent on personal characteristics, such as—

- i. dominating or submissive tendencies,
- ii. an awareness of inferiority or superiority,
- iii. compatibility of temperaments.

10. When each individual in turn was isolated from the remainder of the group the average output of the isolated workers increased from 20 to 50 per cent.

11. Suitability for repetition work is partially dependent on temperamental characteristics. A worker may have the necessary speed and dexterity, but her performance in practice may be seriously impaired because of an unsuitable temperament and be inferior to that of a less capable worker who is better equipped temperamentally.

Steadiness, persistence, imperturbability, and placidity seem to be the most desirable temperamental qualities while the animated and variable individual who is expressive and easily distracted is probably the least suitable for this type of work.

There is some evidence that school records provide a good indication of temperamental suitability for repetition work.

12. Too high a degree of intelligence may be detrimental to success and personal satisfaction in simple forms of repetition work while a lower degree of intelligence seems to be associated with a greater ability to endure the monotonous conditions of work.

13. A feature of the results obtained in this experiment was the marked response of the operatives to slight changes in the conditions of work. In particular they became unduly discouraged by minor difficulties. This seemed to be due to the monotony of the conditions so that comparatively slight variations produced important effects.

APPENDIX

*Opinions of Workers on Methods of Payment**Time-rate*

Worker A.—A time-rate is unfair because a slacker can earn the same amount as a hard worker. There was not so much work done because we did not try to beat each other and could not earn more money. That made you want to talk and led to less work. Whether time passes quickly or slowly depends on how much you do.

Worker B.—Some girls were doing more work than others and just getting the same wage. I thought that time-work was very slow but you could always find time to talk. Time very rarely goes quickly unless you are working fast. It also seems to go quicker when you talk. A time-rate is all right if you are not bothered about your wage.

Worker C.—This method of payment wasn't half as interesting as the others. We could slack or work hard and still get the same wage, and there was no chance to earn more than the fixed amount. It was boring and time seemed to drag.

Worker D.—I don't care for a time-rate because there is no chance to earn more. If I work harder than another girl I only get the same amount.

Worker E.—A time-rate is not as good as the others because you don't get a chance to earn more. It makes the day seem very long.

Worker F.—A time-rate is good when a girl cannot work as well as the others. Still I do not like this method of payment as it is not fair. Some girls work hard but others slack yet they still get the same wage. A time-rate is uninteresting and boring.

Worker G.—The time-rate was all right because we could do as little work as possible and still get the same wage. We could talk and slack and it didn't affect our wage. When you feel a bit off colour you can take your time.

Worker H.—I did not care for the time-rate because it was uninteresting. If I did a lot of work I didn't get more money. Time seemed to go slowly.

Worker I.—A time-rate does not encourage us to work hard. Seeing that we were paid according to the hours we were here made us inclined to slack. We all found the time went slowly and were bored.

Worker J.—I did not like the time-wage because it had no interest. However hard a girl worked she only earned the same as the others. There was no encouragement to work and the only time I liked this method of payment was when I was not in form.

Bonus-rate

Worker A.—This was fairer than the time-rate and made us work harder to get to the top. Still if we slacked we could not get less than the time-rate. A girl might do a lot more than another and only get 6d. more. It makes you keener to do more work and the more work you do the quicker the time goes. Before the work seemed to be more boring and time went slowly.

Worker B.—When you are on bonus you work harder in order to earn more money. It is more interesting than the time-rate.

Worker C.—This method of payment is not quite so good as the piece-rate. For instance, if I work quite hard but someone works still harder I shouldn't have such a good chance as on piece-rate. It not only depends on yourself how much you earn but on the others. However hard you work you know that you cannot earn more than a certain amount. The bonus system is more interesting than the time-rate because I know that if I work hard I shall have something to gain at the end of the week.

Worker D.—I like bonus because I know that I shall not get less than a certain amount, if I think to myself that I want to take a bit more money home I can hurry. When you are on bonus you do more and the work is not so dull.

Worker E.—Bonus is better than time because you can earn more and the work is not so dull.

Worker F.—The bonus-rate is not bad because you can never get less than a certain amount. You do not hurry as much as on piece-rate because you can't get more than the highest rate. Time goes more quickly on bonus than on time.

Worker G.—The bonus was better than the time-wage because everybody gained by it. It was nice to have the honour of being top as well as getting the higher wage. You have to do your best otherwise the other girls will beat you.

Worker H.—I like the bonus better than the time-rate because you can earn more, and it is better than the piece-rate because you don't have to work so hard. Still, if you go all out you can't earn more than the highest rate.

Worker I.—The bonus-rate gives you encouragement and you aim to be at the head of the list each week. The days don't seem so long because we have something to think about and we work harder. Also there is some excitement in looking forward to Saturday when we are informed who has earned the highest sum.

Worker J.—I think the bonus system was good because it was interesting to see if we could get higher every week. However, one disadvantage for a good worker was that if she happened to work very hard she couldn't earn more than the highest wage, but if she didn't work very hard she couldn't go below the lowest rate.

Piece-rate

Worker A.—This is the fairest method of payment. If a girl slacks she gets a low wage, but if she works hard she gets a high wage. What we earn depends on what we do.

Worker B.—I like a piece-rate because if you work hard you get a good wage. The day seems shorter when you are working hard.

Worker C.—A piece-rate gives all an equal chance and your wages do not depend on what others do. It is interesting because you feel that you are earning something all the time you work.

Worker D.—A piece-rate is all right for those who can work well, but if you are not able to work fast you sometimes get a low wage.

Worker E.—On a piece-rate you get what you deserve. It makes you work harder and is more pleasant.

Worker F.—It is not good for the slow workers but it makes you try to earn a good wage. It is annoying when you can't get on with your work.

Worker G.—The piece-rate is best because it depends on yourself. It is more tiring than the others but not so dull.

Worker H.—A piece-rate is all right but you have to work hard to earn a lot. When I am able to work well I like a piece-rate, but sometimes I would rather be paid by time.

Worker I.—This is the best method of payment. You enjoy the work when working hard as the day does not seem so long. The piece-rate was not so monotonous as the others.

Worker J.—It is interesting because we have an idea how much we are earning as we go along. It is also interesting to compare your earnings with the other girls.

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References, hours of work and rest pauses also occur in Report No. 56.

* For overseas agencies see p. 67.

(ii). Dexterity.

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REPORT No. 77

**FATIGUE AND BOREDOM IN
REPETITIVE WORK**

**By S. Wyatt and J. N. Langdon
(Assisted by F. G. L. Stock)**

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PREFACE

Continued study of repetition work in industry is justified by the increasing number and variety of repetitive processes, and by the importance of the human problems associated with this type of work. The repeated performance of simple and uniform movements provides small opportunity for the exercise of thought and skill, and imposes restrictions on personal abilities and desires which favour the onset of boredom; it may have effects which extend even beyond the period of work.

The results of several previous studies of repetitive work by Mr. S. Wyatt and his collaborators have been published in the Board's series of reports (Reports Nos. 26, 30, 32, 52, 63, and 69). These investigations have been concerned chiefly with the detailed study of boredom and its effects in small groups of workers. The information thus obtained formed the starting point of the inquiry described in the present report, which deals with larger numbers and extends the methods previously used.

The first part of the present report deals with the incidence of boredom symptoms in 355 experienced girls employed on various forms of light repetition work. Boredom assessments, based on the replies to a number of carefully prepared questions, were obtained for each worker, and the results may be regarded as fairly representative of the distribution of boredom in workers employed on repetition work generally. This procedure represents a departure from the more objective methods of measurement used in former investigations on this subject.

Much is now known regarding the nature of boredom and its relation to personal characteristics and to conditions of work; and this knowledge is available as an aid in selecting individuals who are most suitably qualified for repetition work, and in the arrangement of working conditions so that boredom is less likely to arise. The possibilities of applying knowledge in this direction are discussed in the report.

The provision of gramophone music as an antidote to boredom, which was made the subject of a special experiment, is also discussed; there is reason to believe that this is an effective and practical measure which is likely to find adherents in the future.

In order to ascertain the attitude of operatives towards particular features associated with the conditions of work, a modification of the questionnaire procedure was adopted. The results obtained throw light on the more important sources of satisfaction and discontent. Some of these, such as security of employment and opportunity for promotion, are limited by practical considerations; others, such as the grouping of the workers and the material conditions of the work, are under managerial control.

The kind of information given in this report, besides being useful to managements, tends to remove sources of misunderstanding between them and their employees.

FATIGUE AND BOREDOM IN REPETITIVE WORK

By S. WYATT and J. N. LANGDON (Assisted by F. G. L. STOCK)

CONTENTS

	PAGE
I. INTRODUCTION	2
II. RESULTS OBTAINED	4
1. Boredom	4
A. Boredom Symptoms in Different Factory Groups	4
(a) <i>Incidence of Boredom Symptoms</i>	5
(b) <i>Particular Features</i>	6
(i) <i>Time estimations</i>	6
(ii) <i>Day-dreaming</i>	9
B. Boredom and the Type of Work	11
C. Personal Characteristics and Boredom	16
(a) <i>Intelligence</i>	19
(b) <i>Divided Attention</i>	20
(c) <i>Perseveration</i>	20
(d) <i>Introversion-Extroversion</i>	21
(e) <i>Creative Ability</i>	22
(f) <i>Personal Preferences</i>	25
D. Boredom and Output	26
(a) <i>Maximum and Average Rate of Working</i>	26
(b) <i>Output Curves</i>	29
E. Boredom and Gramophone Music	30
(a) <i>Different Distributions of Music</i>	32
(i) <i>Effect on Average Output</i>	33
(ii) <i>Variations in Output within the Spell of Work</i>	34
(iii) <i>Individual Differences in Output</i>	36
(iv) <i>Personal Opinions</i>	39
(b) <i>Different Types of Music</i>	40
2. Attitudes towards Work	43
A. Relative Importance of Factors connected with Work	43
(a) <i>Opportunity for Promotion</i>	45
(b) <i>Security of Employment</i>	48
(c) <i>Supervision</i>	49
(d) <i>Working Companions</i>	50
(e) <i>Wages</i>	51
(f) <i>Hours of Work</i>	53
(g) <i>Comfortable Working Conditions</i>	54
(h) <i>Work and Thought</i>	54
B. Causes of Dissatisfaction	56
C. Occupational Preferences	61
3. Boredom and Attitudes towards Work	61
A. Boredom and Individual Preferences	62
B. Boredom and Dissatisfaction	62
C. Boredom and Occupational Preferences	64
III. DISCUSSION OF RESULTS	65
IV. SUMMARY	72
Appendix	74

I.—INTRODUCTION

The general aim of this inquiry was to collect information on the nature, causes and prevalence of boredom and discontent among operatives employed on simple types of repetition work.

Since boredom and discontent are personal experiences which cannot be directly observed or measured, evidence of their existence must depend primarily on introspective data. To obtain such data it is necessary to induce individuals to describe their thoughts and feelings, either in the form of a free expression of opinion or in response to questions. In this inquiry both methods were used, and the one served to check or amplify the other.

The questions were based upon the various symptoms of boredom and discontent observed in previous investigations.¹ Thus, in the case of operatives employed on repetition work, boredom had been found to be most intense around the middle of the work-spell and was associated with restless behaviour, a lower and more variable rate of working, and an apparent increase in the length of time devoted to work. It tended to decrease and to disappear as the end of work drew near, so that the rate of working increased and time seemed to pass more quickly. Further, the operatives attempted to counteract the effects of boredom by talking, singing, or varying the form of activity, while in extreme cases they expressed a desire for a change of occupation.

The questions relating to boredom symptoms, together with others which contained direct references to its existence, were given to different groups of workers and the replies enabled each operative to be assessed for boredom and for general satisfaction with work.

The procedure admittedly has certain limitations since the assessments depend on the reliability of the views expressed by the workers and on the judgment of the investigator. To minimise these weaknesses the same question was often repeated in a different form and the assessment was based on the independent opinion of two investigators. A certain amount of objective corroboration was also obtained from detailed records of the rate of working throughout the day.

Since susceptibility to boredom is partly dependent on personal characteristics and tendencies, the study of individual differences and their relation to the amount of boredom experienced becomes a matter of practical importance. The possibilities in this direction have been explored by a number of tests, which were expected to reveal differences in intelligence, temperament, perseveration,² distribution of attention, and creative ability. It was hoped that this procedure would provide information on the nature of those

¹ Reports of the Industrial Health Research Board, Nos. 69, 56, 52.

² i.e. when a recent activity reasserts itself without any apparent cue or stimulus to arouse it (cf. p. 17).

obscure but important personal factors which determine the attitude towards monotonous conditions of work.

In industry one wants to know whether proneness to boredom is specific or general. It may happen that some individuals are bored by one type of repetition work but not by another. On the other hand, boredom may be experienced whatever the type of work. Several of the operatives included in the present inquiry had been employed on different processes in the same factory, and their views provided a certain amount of information on the general or specific nature of boredom. The question was also studied experimentally in a small group of workers who were employed for monthly periods on five different types of repetition work.

The possibility of providing suitable antidotes to boredom was also considered. Previous investigations¹ on this aspect of monotonous work have shown the value of rest-pauses, changes in the form of work, and the regulation and distribution of supplies. In the present inquiry attention was directed to the effects of gramophone music, and the question was made the subject of a special experiment.

Finally, the workers were questioned on their attitude towards particular features associated with the conditions of work and an attempt was made to ascertain their likes and dislikes. Afterwards comparisons were made between the results obtained from the most and least bored members in each group.

The workers included in this inquiry were employed in four factories situated in widely different parts of the country. They were engaged in fairly simple forms of repetition work, but the type and conditions varied in different groups. Results were obtained from 355 workers, and each worker was interviewed and tested separately in a room set apart for this purpose. The interview and tests lasted from one to two hours, and in several cases supplementary questions and tests were given at a later date. All the subjects were experienced female workers, and co-operation in the experiment was voluntary. The number of operatives who were reluctant to take part in the inquiry was almost negligible, while the majority regarded the procedure as an interesting break in the daily routine.

The general nature and purpose of the inquiry was explained to each worker, and emphasis was placed upon the confidential nature of any opinions expressed during the interview. Almost all the operatives showed a keen interest in the procedure and spoke without restraint or reserve. It should be mentioned that all of these operatives were unmarried. Moreover, they started the day fresh, i.e. without having any housework to do at home before starting for the factory.

It should also be mentioned that wastage, i.e. for sickness or loss of employment, did not occur in any of the groups which were under continuous observation.

¹ cf. Reports Nos. 25, 26, 30, 32, and 52 of the I.H.R.B.

II.—RESULTS OBTAINED

1. THE INCIDENCE AND EFFECTS OF BOREDOM

A. BOREDOM SYMPTOMS IN DIFFERENT FACTORY GROUPS

The evidence considered in this part of the inquiry was obtained in the form of replies to a number of questions which were given to each worker during the interview. The questions were:—

1. (a) Do you think you work better in the morning or the afternoon ?
Why ?
(b) When do you think you work best in the morning ? Why ?
(c) When do you think you work best in the afternoon ? Why ?
(d) When do you think you work worst in the morning ? Why ?
(e) When do you think you work worst in the afternoon ? Why ?
2. Is there anything about the work which you don't like ? Why ?
3. (a) Do you find your work interesting or would you prefer something else ?
(b) If so, what would you like to do ? Why ?
4. (a) In what part of the morning does time seem to pass most quickly ?
Why ?
(b) In what part of the afternoon does time seem to pass most quickly ?
Why ?
(c) In what part of the morning does time seem to pass most slowly ?
Why ?
(d) In what part of the afternoon does time seem to pass most slowly ?
Why ?
5. (a) Do you feel bored at any time during the morning ? When ?
(b) Do you feel bored at any time during the afternoon ? When ?
(c) Which is the more boring, the morning or the afternoon ? Why ?
6. (a) Do you feel like stopping work and doing something else ?
(b) If so, what would you like to do ?
7. Do you like the sort of job which once you have learned it you needn't bother about any more, or the job where you have to be thinking and planning out new things ?
8. Is there any other job in the factory which you would like ? Why ?
9. Do you prefer work which you can do without thinking, or work which makes you think all the time ?
10. When you find you are bored and time seems to drag, what do you do ?
11. Do you prefer easy uniform work or more difficult and varied work ?
12. Would you like to change from time to time from one job to another ?
Why ? How often would you like to change ?
13. Is there anything about your work which you particularly like ?

The reply to each question was given the value 0, 1, 2, 3, 4, or 5,¹ according to the absence or severity of boredom symptoms, and the final assessment was the average of the marks awarded to all the questions in the list. The questions merely served to direct the course of the interview and were often varied and supplemented to meet individual peculiarities.

¹ The scale used was 0 — 1 = practically free from boredom.
1 — 2 = slightly affected by boredom.
2 — 3 = moderate degree of boredom.
3 — 4 = suffered severely from boredom.
4 — 5 = never free from boredom.

The replies to questions such as Nos. 7, 9 and 11, which implied simple alternatives, were assessed as 1 and 4 respectively, unless the answer was further qualified by the worker.

Although this procedure gave only a general indication of the amount of boredom experienced by different individuals, it undoubtedly separated those who were definitely bored from those who were interested in work. As an example of these differences the replies obtained from two chocolate packers are given in the Appendix (A).

(a) *Incidence of Boredom Symptoms*

The distribution of boredom symptoms among the workers in each of the four factories is shown in Table I. The results are expressed as a percentage of the total number of workers in each group.

TABLE I.—*Showing the Incidence of Boredom Symptoms in different Factory Groups expressed as a percentage of the total in each group*

Factory.	No. in group.	Severity of symptoms.				
		0-1	1-2	2-3	3-4	4-5
A ..	142	1	26	43	28	2
B ..	102	3	42	37	16	2
C ..	81	5	39	33	19	4
D ..	30	3	13	37	30	17
Average ..	—	3	33	38	23	3

The boredom assessments probably underestimate the amount of boredom actually experienced by the workers. In the first place, the investigators adopted a conservative attitude when assessing the results, as this was thought to be the safer policy. Secondly, there is a general tendency for workers to accept conditions which have become habitual and to mention only those factors which are unduly persistent or prominent. Finally, it must be remembered that the workers in each factory represent a highly selected group since the majority of those individuals who were unable to endure the conditions of work had already left. These reasons probably account for the comparative absence of individuals in the category denoting extreme boredom.

Translating the results of Table I into more general terms, it may be said that, on the average, 3 per cent. of the workers were practically free from boredom, 33 per cent. were slightly affected, 38 per cent. experienced a moderate degree of boredom, 23 per cent. suffered severely, and 3 per cent. were never free from boredom. This distribution probably gives a fairly accurate picture of the relative amount of boredom experienced by female operatives employed on repetition work in industry, and although extreme cases were rare, the prevalence of the symptoms justifies the importance of boredom as a subject for experimental research.

The results also show that the distribution of symptoms was very similar in Factories B and C, but in Factories A and D it was weighted in the direction of increased boredom. In the two former factories the operatives worked independently at the bench or machine while the work was comparatively varied and under the control of the

operatives. In Factory A the workers were employed on conveyors and the operations were simple, uniform, and largely controlled by the speed of the belt, while in Factory D they were engaged in tying small blocks in pieces of calico and the process was accordingly very monotonous. These differences in working conditions are sufficient to explain the varying degrees of boredom experienced by the groups in question.

(b) *Particular Features*

The questions (page 4), which formed the basis of the boredom assessments were framed to reveal various symptoms and effects of boredom and the replies to some of these questions have been subjected to a more detailed method of treatment.

(i) *Time estimations.*

Most people will agree that time seems to pass quickly when work is interesting, but slowly when the worker is bored. Thus, the apparent flight of time provides an indirect indication of the amount of boredom experienced. The workers were accordingly asked to state (Q. 4) in which part of the morning and afternoon time seemed to pass most quickly and most slowly, and the results obtained are represented graphically in Fig. 1.¹

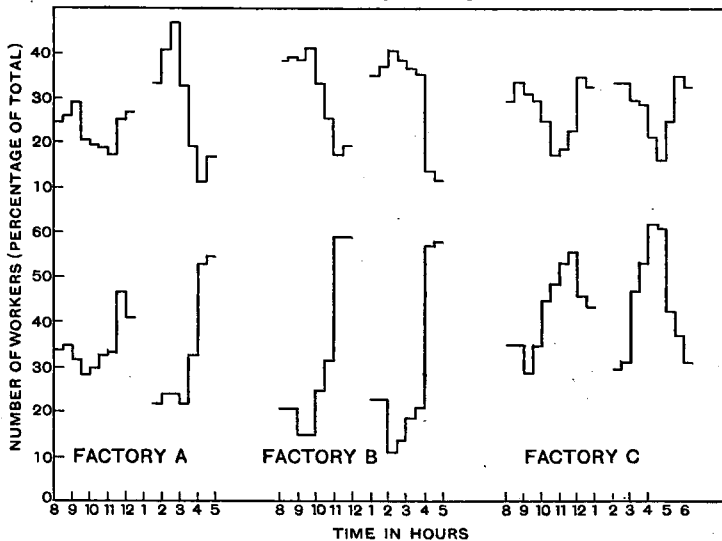


FIG. 1—Percentage of workers who found time to pass most quickly (lower curves) and most slowly (upper curves) at the times shown.

¹ The figures corresponding to these curves are given in the Appendix (B). Results from Factory D have been omitted because of the small number in the group. Although the replies to Q.4. have been tabulated in half-hourly periods, the actual time given by a worker was usually longer than half-an-hour (cf. Appendix A). Thus if the time was said to pass most quickly from 8 to 9.30, this was included in the periods 8-8.30, 8.30-9.0, and 9.0-9.30. For this reason the totals in the Table (Appendix B) exceed 100.

The general trend of the results (lower curves) shows that the proportion of workers who found time to pass most quickly during the first hour of work was comparatively small. The number tended to decrease during the second hour, but afterwards there was a sharp rise which, with the exception of Factory C, reached a maximum in the last hour of the spell. As might be expected, the results based upon the periods when time seemed to pass most slowly show the opposite tendency (upper curves). On the assumption that the apparent flight of time is inversely related to the amount of boredom experienced, it would appear that boredom was a fairly common experience during the first hour of the spell, was still more frequent during the second hour, but decreased considerably as the end of the spell drew near (apart from the tendency already noted in the results of Factory C). This interpretation agrees with the results obtained in a previous investigation¹ in which other criteria were used as indicators of boredom.

The exception noted in the results from Factory C may be due to the fact that the hours of work were from 8 to 12.45 and from 2 to 6.15, while in Factories A and B the length of the working day was 8 hours. As will be shown later, the proportion of workers who complained of fatigue was greatest in Factory C, and since fatigue tends to accumulate as work proceeds, the effect on time estimations would be most noticeable in the last hour of work.

The general trend of the preceding results shows that interest and incentives vary considerably at different times during the day. In the majority of cases interest was stronger in the latter part of the work-spell and during this period the provision of additional incentives seems to be unnecessary. It was in the remaining part of the spell that interest was weak, so that attention should be directed to the question of alleviating boredom during the first two or three hours of work.

It will probably be agreed that a normal, healthy and completely rested individual should be most vigorous and eager for work at the beginning of the day.² Only 22 per cent. of the workers stated that they felt fresher and more energetic during the first one to two hours of work, while about 35 per cent. said that they felt sleepy, unsettled, and not in the mood for work. A few workers (4 per cent.) preferred this part of the day because they had "more to talk about," but double this number stated that "coming back to the same old thing" and "having the whole day in front of them" made the prospects tedious and dull. About 29 per cent. of the workers found that time passed most quickly around the middle of the morning spell because they had "settled down and were working better," but approximately an equal number were bored and "fed-up" during this period. About 9 per cent. complained of hunger and were "longing for dinner-time," while 7 per cent. stated that this part of the morning was particularly uninteresting because conversation had become exhausted.

¹ Report No. 56 of the I.H.R.B. ² Apart from the initial "warming-up" period.

The largest proportion of these workers (45 per cent.) found that time seemed to pass most quickly during the last hour of work. About two-thirds of these said it was due to the knowledge of the approaching end of work, while the remainder gave as a reason the fact that they were trying to make up for lost time. Those who found that the last hour passed slowly complained of fatigue and hunger, which made them "unable to keep their eyes off the clock".

The type and distribution of opinions expressed in connection with the afternoon spell of work were practically the same as those recorded in the morning spell. The only differences were a reduction in the number who complained of hunger and a slight increase in the frequency of references to fatigue and to the desire to complete a certain quantity of output in the latter part of the day.

The results in general provide a fairly reliable indication of the feelings and desires of the workers at different periods of the day. In many cases they deviate from popular expectations and beliefs and necessitate a partial readjustment of existing opinions regarding attitudes towards work. They illustrate the predominant incentives, both positive and negative, which influence working activity and show the rise or fall in interest as work proceeds throughout the day. A feature of the results was the varying response of different individuals towards the same objective conditions. At one period of the day some were interested and active while others were bored and disinclined to work, but at another period the position would be reversed. Such variations obviously increase the difficulty of discovering a remedy which is likely to satisfy individual needs.

As a supplementary question the operatives in Factory B were asked which part of the working-day they liked (*a*) best and (*b*) least, and to give reasons for their replies. The results obtained, expressed as a percentage of the total number in the group (102), were :—

<i>Liked best.</i>			<i>Reasons.</i>
Beginning of morning	..	20	Fresh. More energy. Work interesting.
Middle of morning	..	3	Settled down to work.
End of morning	..	14	Looking forward to break.
Beginning of afternoon	..	3	Refreshed after dinner.
Middle of afternoon	..	2	Waking-up.
End of afternoon	..	45	Everyone cheerful. Looking forward to going home.
No difference	..	13	
<i>Liked least.</i>			<i>Reasons.</i>
Beginning of morning	..	25	Not in mood for work. Whole day ahead.
Middle of morning	..	17	Bored and fed-up.
End of morning	..	5	Tired and hungry.
Beginning of afternoon	..	12	Don't feel like coming back.
Middle of afternoon	..	27	Looking for the end. Bored.
End of afternoon	..	1	Tired.
No difference	..	13	

The results support the views already expressed, and it is evident that the workers as a whole were more interested in the prospects of leaving work than in its actual performance.

As a matter of curiosity most of the operatives in Factories B and C were asked which of the seven days of the week they liked, (a) best and (b) least. The replies, expressed as a percentage of the total number questioned (150) were :—

			<i>Liked best.</i>	<i>Liked least.</i>
Monday	..	..	0	74
Tuesday	..	..	0	3
Wednesday	..	..	0	7
Thursday	..	..	0	10
Friday	..	..	5	0
Saturday	..	..	78	0
Sunday	..	..	17	6

The results probably agree with expectations since Saturday was by far the most popular day, while Monday was almost equally unpopular. The preference for Saturday was attributed to the fact that work was finished for the week and the operatives were able to satisfy their desire for pleasure and amusement. Those who preferred Sunday stated that they appreciated the opportunity for complete rest and freedom. Monday was disliked because the day seemed long and work "dragged" after the week-end. A large number "hated the idea of coming back to the same old thing," while others complained that the next week-end "seemed so far away". A few individuals "felt miserable" on Tuesdays and Wednesdays because they "hadn't reached the middle of the week" and "there was nothing special to look forward to," while others disliked Thursday because the shops were closed and "the end of the week was too slow in coming".

The results provide interesting comments on the attitude towards work and play, and some of the enthusiasm for the latter might be transferred with advantage to the former.

(ii) *Day-dreaming*

In previous investigations it was suggested that the amount of boredom experienced by operatives employed on repetition work was partly dependent on the ability to think of other things while working. This frequently takes the form of day-dreaming or reverie and is one of the most effective antidotes to boredom. The study of this aspect of repetition work is important, consequently the workers included in this inquiry were questioned on the nature of their thought processes.

The first question in this series was "Can you think of other things while working?" The replies, expressed as a percentage of the number in each group, were as follows :—

			<i>Yes.</i>	<i>No.</i>	<i>Not often.</i>
Factory A	..	..	91	3	6
Factory B	..	..	77	15	8
Factory C	..	..	89	5	6
Factory D	..	..	97	0	3

Thus a large proportion of the operatives were able to detach their thoughts from work, the smaller number in Factory B being due to a group of 28 workers who were employed in feeding fast wrapping machines which required attention and thought.

Since most of the operatives were able to think of other things while working, it would be interesting to know something about the nature of their thoughts. In an American inquiry¹ it was found that a group of spinners in a textile factory indulged in reveries which were "apparently monotonously and uniformly pessimistic". This is rather surprising as it is generally believed that day-dreaming is a compensating activity which enables the individual to fulfil (in imagination) the desires which are suppressed in everyday life. In the present inquiry the workers were asked :—

"When you think of other things during work, are your thoughts often about—

(a) pleasant, cheerful things, or troubles and worries ?

(b) imaginary things that are not likely to happen or real things that have happened ?"

These questions were given to the workers in Factories B, C and D, and their replies, expressed as a percentage of the number in each factory, were :—

	<i>Pleasant.</i>	<i>Troubles.</i>	<i>Both.</i>	<i>Real.</i>	<i>Imaginary.</i>	<i>Both.</i>
Factory B ..	84	5	11	59	16	25
Factory C ..	79	12	9	52	28	20
Factory D ..	90	3	7	40	37	23

Thus a majority of the workers indulged in reveries which were pleasant and connected with real events while very few seemed to brood over their troubles. The results in general suggest that few, if any, of the individuals suffered from morbid anxieties or obsessions.

Many of the workers volunteered information on the subject of their reveries and the remainder were invited to describe the usual nature of their thoughts. A large majority mentioned evening pursuits, while a smaller number seemed to reflect on home affairs and everyday events. The remainder were concerned with such matters as clothes, marriage, school-days, books, and church duties. A few speculated on what they would do if they had plenty of money, or allowed their thoughts to dwell on the lives of the "idle rich". Most of those whose reveries were of a troubled nature were disturbed by thoughts regarding fitness for work and the possibilities of being able to "earn their money". Others wondered how they could "get out of this hole", while a particularly pessimistic individual dwelt repeatedly on the question as to "why we are in this world at all, since we just work and go home to sleep".

It is generally recognised that mind-wandering or controlled thought seems to make time pass more quickly. Additional information on this point was provided by the replies to the question

¹ Elton Mayo : (1925) "Day-dreaming and output in a spinning mill." *J. Nat. Inst. Industr. Psychol.*, 2, 203.

"Does time seem to pass more or less quickly when you think of other things?" The percentage of positive, negative, or neutral replies was:—

		<i>More quickly.</i>	<i>Less quickly.</i>	<i>No difference.</i>
Factory A	..	88	5	7
Factory B	..	83	7	10
Factory C	..	89	5	6
Factory D	..	97	0	3

The results agree with expectations and illustrate the importance of controlled or imaginative thought-processes as antidotes to boredom.

B. BOREDOM AND THE TYPE OF WORK

The preceding results show that an individual may be bored by the particular type of repetition work on which she happens to be employed. The question arises as to whether this individual would be equally bored by other types of repetition work, i.e., whether boredom is specific or general.

The theoretical and practical aspects of this question are important and are closely connected with the principles and practice of vocational guidance. If, for instance, the experience of boredom is general so that an individual is likely to be bored by all kinds of repetition work, then the process of guidance becomes correspondingly simplified. If, on the other hand, a worker is bored by one type of repetition work but not by another, it is important to determine the particular kind of work which is likely to provide the greatest degree of interest and satisfaction.

A thorough investigation of the specific or general aspects of boredom would require the employment of a large group of individuals on many types of repetition work. The facilities for such an inquiry are not likely to be found in industry, and a complete answer to the question may be difficult to obtain. It sometimes happens, however, that the same workers are changed from one process to another, or are trained in two or more kinds of work, and within these limits a certain amount of information may be obtained.

In the present inquiry a group of 19 workers was employed in filling boxes with chocolates according to a specified design. The boxes were of three sizes, which held 14 lb., 4 lb. and 1 lb. respectively, and the workers changed from one size to another according to factory needs. These conditions provided an opportunity for ascertaining the attitude of the workers towards the different kinds of work, since each operative was fully experienced in the packing of the different boxes. They were asked to rank the three operations in order of preference, assuming the same fixed wage in each kind of work. The results obtained are given in Table II.

Although a majority of the workers gave their first preference to the large boxes, there remained some notable individual differences which became still further accentuated when the operatives were asked to give reasons for their choice.

TABLE II.—*Number of workers who gave first, second or third place to the large, medium, and small boxes respectively.*

		1st.	2nd.	3rd.
Large boxes ..	..	10	1	8
Medium boxes ..	..	3	14	2
Small boxes ..	..	6	4	9

Some workers preferred the large boxes because the pattern was simple and the work straightforward and comparatively free from change. They disliked the small boxes because they were troublesome, "fussy", and required too much thought. Others stated that the large boxes were too easy and monotonous and they "never seemed to come to the end of a box", while the filling of small boxes was interesting because the work was varied and they "could do a lot in a short time".

The average output of those workers who preferred the large boxes but disliked the small size was 5.0 per cent. above the group average when employed on the large boxes, but was 6.5 per cent. below when filling the small size. Similarly, the workers who liked the small boxes but disliked the large size produced 7.3 per cent. more than the group average when employed on the small boxes but 5.1 per cent. less when filling the large size. These differences are instructive because the movements involved in filling the different boxes were almost identical, so that, from the standpoint of capacity, those who were superior or inferior in one process would be expected to remain equally superior or inferior in the other. It seems reasonable to infer, therefore, that relative output in the slightly different types of work was determined by personal likes and dislikes. If such differences in attitude and output are produced by slight variations in the type of work, there is little doubt that much greater differences would be found in the more varied types of repetition work.

In the course of the present inquiry it was possible to arrange for a group of ten workers to be employed for monthly periods on five different processes. The processes were:—

- (1) Making paper crackers. (Single type.)
- (2) Packing boxes (14 lb.) with chocolates.
- (3) Packing boxes (4 lb.) with chocolates.
- (4) Tying small rectangular pieces of wrapped chocolate into bundles.
- (5) Cornering cardboard boxes. (Known as "Staying".)

At the end of each month the workers moved from one department to another according to a prearranged scheme and throughout the experiment they received their usual weekly wage.

From time to time they were questioned on their attitude towards the type and conditions of work, and at the close of the experiment they were asked to compare the processes from the standpoint of interest and general satisfaction with work.

The final order of preference of each worker is given in Table III.

TABLE III.—Processes arranged in order of preference.

Worker.	Order of preference.				
	1.	2.	3.	4.	5.
A ..	Staying.	Packing 14 lb.	Packing 4 lb.	Crackers.	Bundling.
B ..	Packing 14 lb.	Packing 4 lb.	Staying.	Crackers.	Bundling.
C ..	Staying.	Crackers.	Packing 14 lb.	Packing 4 lb.	Bundling.
D ..	Packing 14 lb.	Staying.	Packing 4 lb.	Crackers.	Bundling.
E ..	Packing 4 lb.	Packing 14 lb.	Staying.	Bundling.	Crackers.
F ..	Packing 14 lb.	Packing 4 lb.	Crackers.	Bundling.	Staying.
G ..	Crackers.	Packing 4 lb.	Packing 14 lb.	Staying.	Bundling.
H ..	Crackers.	Packing 4 lb.	Packing 14 lb.	Staying.	Bundling.
I ..	Packing 14 lb.	Packing 4 lb.	Staying.	Crackers.	Bundling.
J ..	Packing 4 lb.	Staying.	Packing 14 lb.	Crackers.	Bundling.

A numerical ranking of the processes may be obtained by assigning 5, 4, 3, 2 and 1 marks to the 1st, 2nd, 3rd, 4th and 5th preferences respectively. This gives the following results :—

Packing chocolates (14 lb. boxes) ..	40 marks.
Packing chocolates (4 lb. boxes) ..	38 "
" Staying " cardboard boxes ..	32 "
Making crackers	28 "
Bundling chocolates	12 "

Thus the most popular process was packing chocolates in boxes, while the operation of bundling and tying chocolates was relatively disliked. The more important likes and dislikes expressed by the workers in connection with each process may be summarised as follows :—

Packing chocolates (14 lb. boxes).—This process was said to be interesting because the chocolates had to be arranged in the form of a design. Yet two workers disliked the operation because they were compelled to follow a specified pattern and would prefer work where they were free to make their own design. A further source of satisfaction was the attractive appearance of the filled box and the knowledge that it would be shown to the public. The final weighing of the boxes with the accompanying adjustment and rearrangement of chocolates was generally disliked because it interfered with progress and disturbed the appearance. Yet one worker (G) liked " watching the scales go down and taking out chocolates to adjust the weight ", and another (I) was " very fond of weighing and used to weigh things in the shop of a friend ". In some cases the process was disliked because the boxes were too big and " it took too long to finish a box ". Finally, while one worker (C) " hated the job because you have to keep your mind on it ", others enjoyed it because " there was always plenty to do and to think about ".

Packing chocolates (4 lb. boxes).—With the exception of the size of the box, this process was similar to the previous and was generally said to have the same interesting features. Those workers who ranked it first in order of preference mentioned in particular the satisfaction derived from the filling of smaller boxes. " You seem

to be on top of the work " and " You are able to finish a box before you get fed-up " were typical of the remarks made by these workers. The smaller boxes provided a series of frequent aims or goals which acted as recurring incentives to activity and helped to sustain interest in work.¹

Cornering cardboard boxes.—In this process the wire which held together the edges of a cardboard box was inserted by a machine, but the movements and rate of working were under the control of the operator. This work also gave rise to notable differences of opinion, which illustrate still further the importance of studying individual responses to the same conditions of work. Thus worker C found the work very interesting and liked everything connected with it. She said, " It is fascinating watching the machine doing its work and it is very pleasant to feel that I can make the machine do what I like. I was very happy on this job and time passed ever so quickly." Worker F, on the other hand, " Hated the job, as it was the same thing all the time. The work was terribly monotonous and the day seemed awfully long. The colour of the cardboard and the everlasting sameness was enough to make me go daft."

The results in general showed that four members of the group enjoyed this process because of the feeling of power over the machine, the rhythmical possibilities of the work, and the interest in the movements of the machine. The remainder disliked the operation because of the mechanical uniformity, the drabness of the material, or fear of the machine.

Cracker-making.—The interest in this process was chiefly attributable to the brightly coloured material, the cheerful surroundings, and the attractive appearance of the finished article. " The work is interesting and makes you think of pleasant things " and " I enjoy working with bright colours and pretty material " were some of the remarks received. Most people would probably regard cracker-making as one of the most interesting types of repetition work, yet several members of the group disliked the process. They complained of the monotony arising from the repeated production of the same kind of cracker, and were often irritated by the " fiddling " nature of the work. Some objected to the process because the paper was easily torn or creased and they were either unable or unwilling to devote the necessary care to the handling of the material. Thus cracker-making provided another example of a process which gave complete satisfaction to some workers but was disliked by others.

Bundling chocolates.—Almost all the workers disliked this process because " it was just picking up a few wrapped chocolates, tying them in a bundle, putting on a seal, and dropping them into a box ". It was said to be " childish ", " too easy and monotonous ", and " just a job you had to put up with ", while the workers " often hurried and tried to race the clock to make it more interesting ". The

¹cf. Reports of the I.H.R.B. No. 52, p. 26; No. 56, p. 35 and *Journal of the National Institute of Industrial Psychology*, Vol. IV, No. 8, p. 431; Vol. V, No. 5, p. 261.

dislike was intensified by the hot and noisy surroundings as the operatives occupied part of a heated room containing a number of unusually noisy machines. It is highly probable that the heat and noise were largely responsible for the intense dissatisfaction expressed by the workers when employed on this process.

The preceding remarks reveal various features connected with different processes which make work interesting or unsatisfying. In particular, they show wide differences of opinion in the case of operatives employed under the same conditions of work, and illustrate the importance of assigning a worker to a process which appeals to her interests and desires.

With regard to the question as to whether boredom is specific or general, some information was obtained from the replies to the series of questions listed on page 4. These were given after the completion of each of the monthly periods of work, and the replies were assessed for boredom in the manner previously described (page 4). It will be remembered that the assessments ranged from 0, which means "complete absence of boredom", to 5, which denotes "seldom free from boredom". The results obtained are given in Table IV.

TABLE IV.—*Showing the incidence of boredom symptoms in the case of the same group of workers employed for monthly periods in different processes.*

Worker.	Packing (14 lb.).	Packing (4 lb.).	Staying boxes.	Making crackers.	Bundling chocolates.
A ..	0.4	1.5	1.9	4.0	4.2
B ..	0.7	1.1	2.0	4.8	4.6
C ..	3.5	4.0	1.1	1.8	4.3
D ..	1.4	2.5	1.8	3.7	4.8
E ..	1.0	0.3	2.1	3.4	3.2
F ..	1.1	1.9	4.7	1.0	4.4
G ..	0.9	0.5	3.2	0.3	4.1
H ..	3.2	2.6	3.0	1.2	4.5
I ..	0.8	1.5	1.6	2.0	3.8
J ..	3.6	1.0	1.5	1.9	4.0
Averages ..	1.7	1.7	2.3	2.4	4.2

It will be noticed that each worker was bored by some processes but was comparatively free from boredom when employed on other types of work. This, of course, does not preclude the possibility that some individuals would be bored by all kinds of repetition work. Neither does it prove that boredom in repetition work is specific rather than general. It may happen, for instance, that a worker is comparatively interested in one process but severely bored by another because the one possesses features which appeal to the majority of workers. It is necessary to know, therefore, if the individual who experiences pronounced boredom in one operation will also experience pronounced boredom in another operation when both operations produce the same degree of boredom in a number of people. The limited results in Table IV provide some evidence that boredom may be specific, but a much more comprehensive investigation is necessary

before a definite answer can be obtained. It is, however, important to remember that a distinct change in attitude was often produced by slight differences in the type of work. All the processes had much in common and some, such as packing larger and smaller boxes, were almost identical. Yet some workers were bored and dissatisfied by one process, but found interest and satisfaction in others.

The results also show that the amount of boredom experienced by the workers as a whole when employed on the different processes was inversely related to their preference for the different types of work (Table III).

A further interesting feature of the results was the difference in the increase in output in successive weeks between the most and least bored members of the group. These results are given in Table V.

TABLE V.—*Relative output in successive weeks in each process.*

			<i>Weeks.</i>			
			1.	2.	3.	4.
Making crackers	.. { Most bored	..	100	135	143	151
	.. { Least bored	..	100	142	161	180
Packing (14 lb.)..	.. { Most bored	..	100	113	119	123
	.. { Least bored	..	100	133	147	151
Packing (4 lb.) ..	.. { Most bored	..	100	125	146	150
	.. { Least bored	..	100	137	155	167
Bundling chocolates	.. { Most bored	..	100	118	126	129
	.. { Least bored	..	100	124	133	140
" Staying " boxes	.. { Most bored	..	100	121	132	136
	.. { Least bored	..	100	128	140	148
Average	.. { Most bored	..	100	122	133	138
	.. { Least bored	..	100	133	147	157

In each process the improvement was greatest in the case of those individuals who suffered least from boredom, and the difference between the two groups increased in successive weeks. The actual output during the first week was practically the same for both groups, consequently it is unlikely that the difference in improvement was due to initial differences in capacity. There can be little doubt that it was caused by the inhibiting effects of boredom which progressively increased as work proceeded. Thus the rate of working when learning an industrial process is reduced when the worker is bored.

C. PERSONAL CHARACTERISTICS AND BOREDOM

Any large and unselected group of workers employed on the same type of repetition work will contain some individuals who are bored by the process and others who find the work comparatively interesting. Thus the amount of boredom experienced is also dependent on personal factors, and the discovery of these is clearly a matter of some importance.

The problem may be approached by considering some of the clues which have emerged during this and previous investigations on the same subject.¹

In the first place there is much evidence in favour of the view that susceptibility to boredom is related to intelligence.

Secondly, individuals differ in their ability to mechanise work, and there is reason to believe that boredom may be most pronounced in those persons who are unable to detach their thoughts from uninteresting work.

Thirdly, some people find it difficult to switch from one type of activity to another. The ideas and movements set in motion by the repeated performance of the first process tend to persist and to interfere with the activities of the second process. Others seem to be practically free from this kind of interference, and it is possible that proneness to boredom may be related to the one or the other of these tendencies. The spontaneous recurrence of past experiences is usually known as *perseveration*.

Fourthly, it is highly probable that temperamental characteristics play an important part in determining suitability for repetition work.

These clues have been used as the basis of an attempt to discover the personal characteristics which determine susceptibility to boredom. The method adopted was to select in each factory group those individuals who experienced least boredom and to compare their mean performance in each of the functions studied with that of an equal number who experienced most boredom. The tests used in this procedure were as follows.

Intelligence.—This was measured by Test IV in the series (33) published by the National Institute of Industrial Psychology. The time allowed was five minutes.

Ability to think of other things while working.—The tests used for this purpose were (i) Knotting, and (ii) Peg insertion.

(i) *Knotting.*—The worker was provided with short pieces of string of equal length and was required to tie a simple knot on each piece as quickly as possible. The time allowed was ten minutes, but during the last five minutes the worker was asked a number of simple questions¹ and was required to reply while continuing to work as quickly as possible. The ability in question was measured by the percentage decrease in output during the second five minutes of the test.

(ii) *Insertion.*—In this test the worker was provided with a supply of metal tubes closed at one end, a quantity of steel balls which fitted the tubes, and a board containing holes into which the tubes could be inserted. A single ball was picked up with the left hand, a metal tube with the right, the ball was dropped into the tube and the latter into a hole in the board. This process was repeated as quickly as possible for ten minutes, but during the second five minutes the worker was again required to carry out a series of simple mental tasks.² The results were scored as before.

¹ Reports Nos. 56 and 69 of the I.H.R.B.

² The list of questions is given in the Appendix (C).

The insertion test was given to the workers in Factories B and C, but the knotting test was confined to the workers in Factory C.

Perseveration.—The tests used were (i) the inverted S test,¹ (ii) the triangle test,¹ and (iii) the cancellation test.

(i) *Inverted S test.*—The subjects were required to write :—

- | | | | | | |
|-----|--------|----|----|----|-----------------|
| (a) | SSSSSS | .. | .. | .. | for 30 seconds. |
| (b) | zzzzzz | .. | .. | .. | for 30 seconds. |
| (c) | SSSSSS | .. | .. | .. | for 30 seconds. |
| (d) | zzzzzz | .. | .. | .. | for 30 seconds. |
| (e) | SzSzsS | .. | .. | .. | for 2 minutes. |

The score was obtained by expressing the total number of letters written (errors included) in the first two minutes of the test as a percentage of the total number of letters written correctly in the last two minutes.

(ii) *Triangle test.*—The subjects were instructed to draw a series of triangles according to the following plan :—

- | | | | | | |
|-----|------|----|----|----|-----------------|
| (a) | △△△△ | .. | .. | .. | for 30 seconds. |
| (b) | ▽▽▽▽ | .. | .. | .. | for 30 seconds. |
| (c) | △△△△ | .. | .. | .. | for 30 seconds. |
| (d) | ▽▽▽▽ | .. | .. | .. | for 30 seconds. |
| (e) | △▽△▽ | .. | .. | .. | for 2 minutes. |

The method of scoring was the same as in the previous test.

(iii) *Cancellation.*—The subject was provided with a number of printed sheets containing the letters of the alphabet arranged in a definite but irregular order and was required to put a mark through each "E" and a ring round each "R". After working as quickly as possible for ten minutes the marking instructions were reversed and the test was continued for another five minutes. Perseveration was measured by expressing the efficiency in the first ten minutes of the test as a percentage of the efficiency in the last five minutes.²

The inverted "S" and triangle tests were given to the workers in Factories A and C and the cancellation test to those in Factories B and C.

¹ The inverted "S" and triangle tests were selected from a series used by Bernstein (1924). "Quickness and intelligence." *Brit. J. Psychol. Monog. Suppl.*, III, No. 7.

² Efficiency was calculated from the formula suggested by Whipple: "*Manual of mental and physical tests*" (Simpler processes), p. 313, viz. :—

$$E = e \left(\frac{c - w}{c + o} \right)$$

where E = efficiency.

e = total number of letters examined.

c = number of letters marked.

w = number of letters wrongly marked.

o = number of letters omitted.

Temperament.—The procedure in this case was limited to a questionnaire on introversion-extroversion¹ of the type²:—

Which do you prefer—

- (a) to be by yourself a great deal ?
- (b) to be with others about half the time ?
- (c) to be seldom alone ?

The first part (a) is supposed to indicate introversion and was given a value of -1 ; the second part (b) represents no marked tendency either way and was given the value 0, while the third part (c) is believed to indicate extroversion and was given the value $+1$. The individual was required to underline one of the three parts in each question and the final score was the algebraic sum of the marks awarded.

It was thought that a questionnaire of this type might reveal individual differences which would show some connection with susceptibility to boredom.

The test was given to the workers in Factories B and C.

(a) Boredom and Intelligence

The average scores in the test of intelligence obtained by those individuals who received the highest and lowest assessments for boredom are given in Table VI.

TABLE VI.—Average scores in a test of intelligence obtained by those individuals who received the highest and lowest assessments for boredom.

Factory.	Group.	Most bored.		Least bored.		Difference between groups.
		No. in Intelligence group.	scores.	No. in Intelligence group.	scores.	
A	A.1	10	20.0	10	15.5	Significant.
	A.2	7	20.4	7	17.9	Not significant.
	A.3	7	20.3	7	15.7	Not significant.
B	B.1	5	19.6	5	12.2	Significant.
	B.2	4	26.0	4	19.7	Not significant.
	B.3	5	28.0	5	21.0	Significant.
C	B.4	4	24.6	4	15.8	Significant.
	C.1	6	15.7	6	14.5	Not significant.
	C.2	6	15.8	6	15.5	Not significant.
	C.3	4	20.0	4	14.7	Not significant.

Although the groups were small and the differences seldom statistically significant,³ yet in each of the ten groups the average

¹ Introvert and extrovert, according to Jung, are two opposed types of temperament. Individuals of the former type tend to find satisfaction primarily within their own mental processes, while extroverts find their chief satisfaction in contact with external reality. The distinction corresponds to some extent with the popular comparison between the man of thought and the man of action.

² Given by A. B. Root (1931): "A short test of introversion-extroversion." *Personnel J.*, 10, 250. The questions used are given in Appendix II.

³ In this and in other similar tables in this section the significance of the difference between the means has been tested by Fisher's method. "Statistical methods for research workers," p. 110 (1925).

score in intelligence of those who were most bored by the industrial process was higher than the corresponding score obtained by the least bored members of the group. For this reason it is permissible to conclude that the amount of boredom experienced by operatives employed on repetition work increases with their degree of intelligence. Conversely, the individuals who are likely to find most satisfaction in simple forms of repetition work are those of a relatively low order of intelligence.

(b) *Boredom and Divided Attention*

The percentage decrease in output in the Insertion and Knotting tests caused by answering questions during the performance of these tests is given in Table VII. As before, the results refer to the most and least bored members in each of the factory groups.

TABLE VII.—Percentage decrease in output in two simple manual processes caused by answering questions during their performance.

Test.	Group.	Most bored.		Least bored.		Difference between groups.
		No. in group.	Per cent. decrease in output.	No. in group.	Per cent. decrease in output.	
Insertion	B.1	5	12.7	5	14.3	Not significant.
	B.2	4	10.5	4	12.5	Not significant.
	B.3	5	11.4	5	9.8	Not significant.
	B.4	4	13.6	4	8.0	Not significant.
	C.1	6	15.7	6	11.9	Significant.
	C.2	6	25.0	6	13.1	Significant.
	C.3	4	11.4	4	7.6	Not significant.
Knotting	C.1	6	7.1	6	4.6	Not significant.
	C.2	6	7.5	6	7.4	Not significant.
	C.3	4	7.5	4	6.4	Not significant.

The results are somewhat inconsistent and the differences are significant in only two cases out of ten, yet within these limits there seems to be some tendency for boredom in factory repetition work to be associated with inability to think and work at the same time. In other words, the individual who is least able to mechanise simple processes and is consequently least able to indulge in talking or day-dreaming is most likely to be bored by factory repetition work. This tentative conclusion agrees with the views expressed on page 17, where it was stated that boredom tends to arise when the operative has difficulty in detaching thought from work.

Although the preceding results are inconclusive, the type of test seems to have promising possibilities and should be included in future research along these lines.

(c) *Boredom and Perseveration*

The results obtained in the three tests of perseveration are given in Table VIII. In each test a high score indicates greater perseveration than a low score.

TABLE VIII.—Scores obtained in tests of perseveration by the most and least bored members in different factory groups.

Test.	Group.	Most bored.		Least bored.	
		No. in group.	Perseveration score.	No. in group.	Perseveration score.
Inverted "S"	A.1 ..	10	115.5	10	132.8
	A.2 ..	7	117.7	7	132.0
	A.3 ..	7	133.2	7	119.1
	C.1 ..	6	103.7	6	104.0
	C.2 ..	6	121.7	6	106.3
	C.3 ..	4	108.6	4	118.5
Triangle ..	A.1 ..	10	119.6	10	109.2
	A.2 ..	7	119.7	7	119.3
	A.3 ..	7	127.9	7	134.1
	C.1 ..	6	124.3	6	149.0
	C.2 ..	6	116.7	6	117.8
	C.3 ..	4	110.2	4	121.4
Cancellation ..	B.1 ..	5	95.1	5	104.9
	B.2 ..	4	104.4	4	100.0
	B.3 ..	5	102.8	5	95.1
	B.4 ..	4	110.9	4	98.6
	C.1 ..	6	100.0	6	103.4
	C.2 ..	6	96.5	6	108.4
	C.3 ..	4	96.4	4	103.6

The results are very irregular and there is little indication of any relation between the amount of boredom experienced in factory repetition work and performance in tests of perseveration. These results, combined with the uncertainty regarding the exact nature of perseveration, make the tests valueless for the present purpose.

(d) *Boredom and Introversion-Extroversion*

The average scores obtained in the questionnaire on introversion-extroversion by those individuals who were respectively most and least bored by factory repetition work are given in Table IX. A plus (+) sign indicates extroversion and a minus (−) sign introversion.

TABLE IX.—Average scores obtained in a questionnaire on introversion-extroversion by the most and least bored members in different factory groups.

Group.	Most bored.		Least bored.		Difference between groups.
	No. in group.	Average score.	No. in group.	Average score.	
B.1 ..	5	+3.00	5	−2.33	Significant.
B.2 ..	4	+2.50	4	−1.00	Significant.
B.3 ..	5	+0.50	5	+0.50	Not significant.
B.4 ..	4	+0.25	4	−0.20	Not significant.
C.1 ..	6	+4.73	6	−0.50	Significant.
C.2 ..	6	+2.25	6	−1.25	Not significant.
C.3 ..	4	+0.77	4	+0.35	Not significant.

The general tendency of the results obtained from the different factory groups is fairly consistent and to this extent it would appear that those individuals who are most bored by factory repetition work tend to be extroverts rather than introverts. This view agrees with the tendencies observed in a previous investigation and may be connected with the greater day-dreaming propensities of the introverted type of individual. A more extensive study of this question is necessary before the observed indications can be accepted as conclusive.

(e) *Boredom and Creative Ability*

When questioning the workers it became increasingly apparent that some individuals preferred simple forms of repetition work involving a minimum of attention and thought while others expressed a desire for processes which required initiative and creative ability. It accordingly seemed highly probable that some form of test which was capable of reflecting these differences would be a useful addition to the series already described. After several preliminary trials a test was chosen which seemed to measure (a) a simple form of speed and accuracy of movement similar to many types of repetition work in industry ; (b) the repeated copying of a given pattern ; and (c) the ability to create original designs.

The test material consisted of a quantity of blue, green, red, yellow, and grey balls and a rectangular piece of thick cardboard containing holes in which the balls had to be placed. The holes were arranged in the form of a number of hexagons, thus—

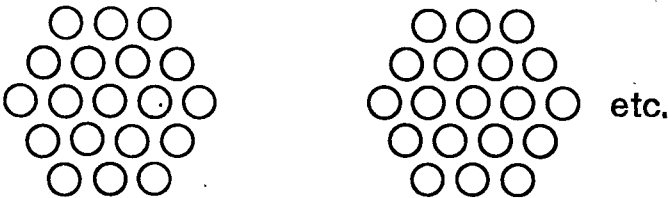


FIG. A.

In the first part of the test (a) the subject used only the box of grey balls and was instructed to pick them up one at a time and place them in the holes. The score was the number of balls inserted in five minutes.

In the second part of the test (b) the subject was required to copy the following pattern.



FIG. B.

In this case also the score was the number of balls inserted in five minutes.

In the third part of the test (c) the subject was asked to make a different design in each of the hexagonal arrangements of holes. The time allowed was five minutes and two measures of performance were used, viz. :—

- (i) Quantity—the number of balls inserted in five minutes.
- (ii) Quantity and quality—4, 3, 2, 1, or 0 marks were awarded according to the degree of originality shown in each successive design.

The tests were given to 26 workers in Factory C, and the average score in each test, together with the coefficient of variation from the average, are given in Table X.

TABLE X.—Average score and coefficient of variation from the average in each test.

			Test (c).			
			Test (a).	Test (b).	Quantity.	Efficiency.
Average	..	..	222.8	186.3	150.8	26.2
C. of V.	..	..	9.1	11.1	17.2	21.9

As might be expected, the rate of working in the simple test of speed and accuracy of movement (Test (a)) was retarded when the individuals had to copy a given design (Test (b)) and was still further restricted in the test of creative imagination (Test (c)). A more interesting feature of the results, however, was the increase in the coefficient of variation in successive tests. In other words, individual differences in performance increased as the operation became more complex. The practical significance of this tendency will be obvious to vocational advisers.

In order to find whether the relative performance of the different individuals remained unchanged in the three tests, the individual scores in Test (a) were correlated with those in Tests (b) and (c) respectively. The rank coefficient of correlation between the results of Tests (a) and (b) was +0.56, consequently those individuals who were superior in a simple form of repetition work were not necessarily equally superior in a process which involved the same movements but a certain amount of discrimination.

The rank coefficient of correlation between the number done in Tests (a) and (c) was +0.04, while between Test (a) and efficiency in Test (c) it was +0.02. Thus there was no relation between the ability to perform a simple movement and the same movement when used as a medium for creative imagination. It would accordingly appear that a test of this type is able to differentiate between those individuals who excel in a simple form of repetition work and those who are superior in a test of creative ability.

It is reasonable to suppose that the latter would be found among those operatives who are most bored by repetition work, and this possibility has been tested by comparing the boredom assessments of those who were most and least successful in the test of creative imagination. This gave the results shown in Table XI.

TABLE XI.—*Boredom assessments of those who did best and those who did worst in a test of creative imagination. (Five workers in each group.)*

<i>Best 5 in test.</i>			<i>Worst 5 in test.</i>		
<i>Worker.</i>		<i>Assessment.</i>	<i>Worker.</i>		<i>Assessment.</i>
1	..	3·5	22	..	1·9
2	..	2·7	23	..	1·6
3	..	2·9	24	..	1·8
4	..	3·8	25	..	0·9
5	..	2·6	26	..	1·7
Average ..		3·1	Average ..		1·6

The difference between the two groups is statistically significant ; consequently in the case of this limited number of workers the individuals who excelled in a test of creative imagination suffered more from boredom when performing factory repetition work.

After completing the three tests the workers were invited to give their views on each type of work and to rank the tests in order of preference. The resulting preferences were as follows :—

	<i>Test (a).</i>	<i>Test (b).</i>	<i>Test (c).</i>
1st preference	.. 0	8	18
2nd preference	.. 6	14	6
3rd preference	.. 20	4	2

Thus a majority of the workers preferred to make original designs (Test (c)), while the performance of simple repetitive movements (Test (a)) was correspondingly unpopular. Almost all the workers stated that the latter test was monotonous and had " nothing in it " and the process was generally disliked. Yet this type of work is very common in industry, consequently it may be inferred that any satisfaction which arises from doing this work is due to external or derived interests.

It will be noticed that approximately one-third of the workers preferred to copy a given design rather than create original patterns. These individuals disliked work which made them think and preferred to have something " which you can get on with " and " where you know exactly what you have to do ". This attitude would seem to indicate suitability for repetitive rather than creative work.

Those who preferred to make original designs found satisfaction in the expression of their creative tendencies and in the contemplation of the attractive results. " When making your own pattern you have more to think about and you could never get bored. It is nice to think that you made the designs yourself." This was typical of the remarks made by these workers.

It has already been suggested in this and in previous reports that boredom is likely to be most intense when work is uninteresting but requires a certain amount of attention and thought. A perfect illustration of this view was provided by the statements made by one of the operatives, viz. :—

Test (a).—" This very soon gets monotonous, but you are able to get over it by not thinking about the job."

Test (b).—"It gets monotonous because it is the same thing over and over again and it keeps monotonous because you can't think of anything else."

Test (c).—"This is very interesting because you have to think all the time about the work and it is nice to see the different patterns grow while you work."

The preceding results, although obtained from a small group of workers, are instructive and suggestive. They indicate diagnostic possibilities which may be particularly useful in vocational guidance and selection.

(f) *Boredom and Preferences for Different Types of Work*

After completing the tests described on pages 17 and 18, the workers were asked to arrange three of the tests—Intelligence, Cancellation, and Insertion—in order of preference and to give reasons for their choice. These tests were chosen because they represented different types and levels of activity. The first involved the use of the higher mental processes; the second required speed and accuracy of visual discrimination but little intelligence, while the third depended on speed and accuracy of movement and represented a simple type of manual repetition work.

The results obtained from the 20 workers who were most bored by the factory processes have been compared with those obtained from the 20 workers who were least bored. These are given in Table XII, and show the number of workers in each group who gave first, second and third choice to each of the three tests.

TABLE XII.—*Ranking of tests according to order of preference by (a) the most bored and (b) the least bored members of two factory groups.*

		Factory A.			Factory B.		
		1st.	2nd.	3rd.	1st.	2nd.	3rd.
Most bored	Intelligence ..	14	4	2	12	6	2
	Cancellation ..	2	6	12	6	4	10
	Insertion ..	4	10	6	2	10	8
Least bored	Intelligence ..	2	2	16	0	8	12
	Cancellation ..	2	14	4	2	10	8
	Insertion ..	16	4	0	18	2	0

The general trend of the results obtained from the workers in the two factories is consistent and shows that the presence or absence of boredom in factory repetition work was associated with distinct differences in the order of preference for certain tests. The least bored workers showed a decided preference for the test of insertion (manual repetition work) but disliked the test of intelligence, while the most bored workers preferred the test of intelligence. Thus performance tests of short duration are capable of revealing individual differences in likes and dislikes which provide useful indications of suitability for repetition work.

When it is remembered that there was no significant difference between the performance of the two groups (i.e., the most and least bored) in the test of insertion, the difference in attitude towards this test becomes even more striking. It means that personal likes and dislikes may be more sensitive than measures of performance in tests which are used for indicating susceptibility to boredom. In any case the results suggest a promising line of research which may have an influence on vocational guidance procedure.

D. BOREDOM AND OUTPUT

The effect of boredom on output has been considered from the standpoint of (a) the relation between maximum and average rate of working, and (b) the variations in the rate of working throughout the day.

(a) *Maximum and Average Rate of Working*

In almost all forms of repetitive handwork, output is usually expressed in terms of the average rate of working throughout the day or week. This measure may give little or no indication of the potentialities of the worker, and fails to show the extent to which activity is depressed by unfavourable elements associated with the conditions of work. In a previous publication¹ it was shown that the maximum rate of working attained under the most favourable conditions could be used for this purpose. This approximates to the physiological limit which is set by nature to every kind of activity. Thus a man may run 100 yards in 9.6 seconds or type 200 words in one minute and as long as the conditions remain the same further improvement is practically impossible. It is, of course, quite obvious that the rate of working which can be achieved with effort by any worker for a short period under optimal conditions will be greater than the rate which can be maintained with reasonable comfort over a longer period. Evidence has been collected, however, which shows that the difference between maximum and average rate of working is often very much greater than can be explained by this consideration alone, and the difference in many cases has been found to originate in the psychological reaction of the worker to the conditions of work. There is accordingly some reason to suppose that those workers who experience most boredom would tend to work at a rate which bears a lower ratio to potential achievement than is the case with workers not affected in this way. In this part of the inquiry, therefore, an attempt was made to determine the difference between maximum and average rates of working and to consider the possible relationship between these differences and the amount of boredom experienced.

Results were obtained from four different groups of workers containing 60, 32, 63, and 30 individuals respectively. During the period covered by the results the workers in each group were employed on the same process and the general conditions of work remained unchanged.

¹ Wyatt, S. (1930). "Maximum Capacity and Average Achievement." *Brit. J. Psychol.*, 20, 251.

In order to obtain a measure of the maximum rate of working, each operative was asked to work as quickly as possible for five minutes. This procedure was repeated after an interval of several days and in two groups the observations were continued for several weeks. The average of the results obtained from each worker was used as the measure of her maximum rate of working or potential capacity.

The average rate of working of each operative was obtained from weekly records of output over a period of three to six months. In a period of this length it is usually found that variable or incidental disturbances, such as enforced stoppages, shortage of material, atmospheric conditions and the like, tend to average out or to impinge more or less equally on all the members in a group. In any case a scrutiny of the records showed that the week to week variations in output of any single worker were comparatively small.

A third series of measures can be derived by calculating the ratio of the average to maximum rate of working. This may be termed the *efficiency ratio* and is probably the most useful measure for the present purpose, since a low ratio denotes susceptibility to adverse influences while a high ratio indicates relative freedom from their effects. Thus one worker may maintain an average rate of working which is only 40 per cent. of her maximum rate while another may reach a level of 80 per cent., and it is important to seek the reasons for such differences.

The maximum and average rates of working, together with the efficiency ratios calculated from these measures, are given in Table XIII. The maximum rate of working of the individuals in each group was first expressed as a percentage of the group average, and the results in the table are based upon this common standard.

TABLE XIII.—*Relation between maximum and average rates of working.*

Group.	Number in sub-group.	Maximum		Average		Efficiency ratio
		Range.	Mean.	Range.	Mean.	(Percentage of means).
I ..	12	110-120	111.7	62-83	69.4	62.1
	18	100-109	103.8	60-81	70.6	68.0
	20	90-99	96.6	49-73	64.2	66.5
	10	80-89	86.1	58-70	62.6	72.7
II ..	6	110-120	112.3	51-84	70.9	63.1
	12	100-109	104.3	56-82	70.2	67.3
	11	90-99	94.0	45-75	61.6	65.5
	3	80-89	80.7	52-57	54.7	67.8
III ..	5	120-130	122.8	63-86	71.8	58.5
	9	110-119	114.1	61-82	69.9	61.3
	22	100-109	106.0	53-79	68.0	64.1
	14	90-99	95.7	47-71	58.4	61.0
	9	80-89	85.0	49-64	55.1	64.8
	4	70-79	74.5	46-56	51.6	69.3
IV ..	6	110-120	116.1	63-76	68.1	58.7
	10	100-109	104.2	58-79	67.1	64.4
	8	90-99	94.1	47-60	54.0	57.4
	6	80-89	84.7	43-67	56.6	66.8

The relation between the maximum and average rate of working is shown in greater detail in Fig. 2. The curves are based on the data obtained from the 60 workers in Group I, and they represent (a) the maximum rate of working of each operative arranged in descending order of magnitude (continuous line) and (b) the corresponding average rate (broken line).

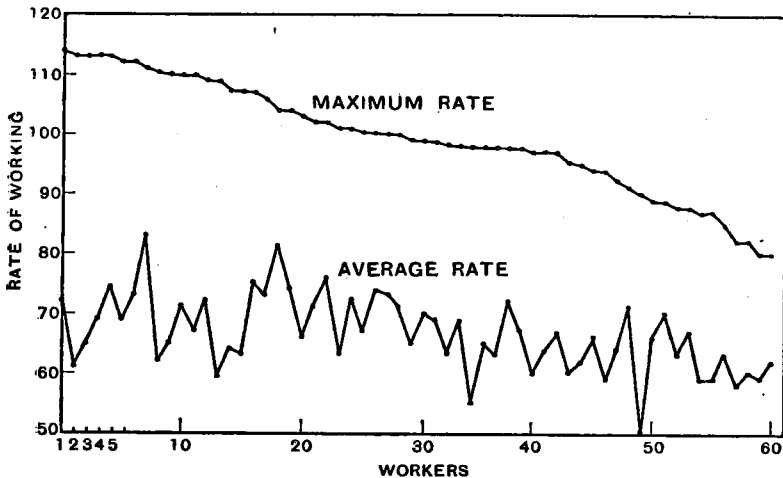


FIG. 2—Relation between average and maximum rate of working in a group of 60 chocolate coverers.

The results show, in the first place, that the average rate of working decreased as the maximum rate decreased.

Secondly, although the relation between the maximum rate of working and the efficiency ratios was irregular, the individuals with the highest maximum rates had lower efficiency ratios than those with the lowest maximum rates. In other words, the workers of inferior capacity tend to work more closely to their maximum than do the workers of superior capacity. This is a matter of some importance since it seems to imply that the less capable workers are relatively more industrious and presumably expend more effort than those who are better equipped for the task. They are naturally spurred more strongly by the fear of dismissal and are consequently less inclined to relax or talk. As a result they probably experience a greater degree of strain.

The individuals of superior capacity, on the other hand, have a greater margin of economic security and are able to indulge more freely in conversation while maintaining a rate of working which is above the average. They work more in accordance with their inclinations and are consequently less likely to suffer from boredom and strain.

The results in general show that the highest average rate of working tends to be maintained by those who have the greatest

capacity, but that the latter do not necessarily put it to the most effective use in daily practice. Thus high potential capacity is not the only criterion which should be used in selecting operatives for this kind of work; an equally important factor is relative immunity to influences which prevent the workers from making full use of their potentialities.

(b) *Output Curves*

Since the ratio between the average and maximum rate of working may be due to many factors, the preceding method of treatment cannot be expected to yield definite and consistent results in every case. Thus two individuals may have the same ratio, but in one case the chief inhibiting factor may be fatigue and in the other boredom. For this reason several workers were subjected to continuous observation throughout the spell of work and output was recorded at quarter-hour intervals. The number of workers studied in this manner was 68, and in some cases detailed records of output were obtained over a period of two or three months.

A general inspection of the results showed that although there was no regularly recurring feature which was common to all the curves, there were certain well-defined characteristics in the curves of individual workers. Almost perfect examples of each of the following types were found.

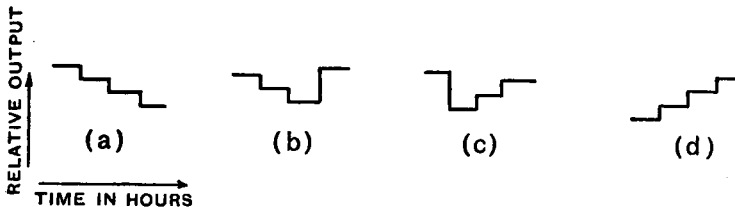


FIG. C.

Theoretical considerations, which have often been confirmed in practice, suggest that a curve of type (a) is produced when the worker is interested but suffers from progressive fatigue, while type (d) occurs when the work is distasteful and the operative is severely bored. In the latter case rate of working is low to start with, but gradually improves as work proceeds, partly owing to the pleasurable anticipation induced by the approaching end of work, and partly because it is necessary for the worker to produce a minimum output in each spell.

It seems probable, therefore, that when the factors which are unfavourable to efficiency are largely of neuro-muscular origin they produce a curve of type (a). When their nature is chiefly psychological they yield a curve of type (d). Most curves are of mixed origin and approximate to the type shown in (b) or (c). Thus the shape of the output curve may be used as a fairly reliable indication

of the amount of boredom experienced by the worker, and the four stages represented by the curves (a), (b), (c), and (d) provide a useful basis for classification purposes. The output curves obtained from the 68 workers, when classified in this manner, gave the following results :—

No boredom (Type (a))	..	..	6 workers.
Slight boredom (Type (b))	..	..	20 „
Moderate boredom (Type (c))	..	..	26 „
Severe boredom (Type (d))	..	..	16 „

These results agree fairly closely with the average of the boredom assessments for the same groups of workers, viz. :—

Type of curve.	Boredom. ¹
a	0·9
b	1·7
c	2·8
d	3·6

Thus both output curves and assessments based upon the results of a questionnaire provide a practical means of estimating susceptibility to boredom either in the case of workers employed on the same process or in different groups of workers.

E. BOREDOM AND GRAMOPHONE MUSIC

Although individuals employed on repetition work indulge in day-dreaming, talking, singing, and the like, their efficacy as antidotes to boredom is often limited.

Day-dreaming, for instance, is possible only when the work is simple, uniform, and free from interruptions. Although many industrial processes are of this type, others make varied and intermittent demands upon attention and judgment, and to this extent they interfere with mind-wandering. Even when uninterrupted day-dreaming is possible, there is a growing belief that prolonged indulgence in flights of fancy may be undesirable or even harmful.

As regards talking, the possibilities in this direction are obviously dependent on the proximity of other workers, but in most factories two or more workers are usually within talking distance of each other. At the same time there is little doubt that talking, although an effective antidote to boredom, is by no means the ideal remedy. As a rule a certain amount of visual attention is required for the successful performance of the industrial task and anything which causes the operative to look in other directions will have an adverse effect on the speed and accuracy of production. Most workers when talking are affected in this way and output suffers accordingly. This does not mean that talking should be forbidden, as such a procedure would be conducive to boredom and the resulting output

¹ Calling no boredom 0-1, slight boredom 1-2, moderate boredom 2-3·5, and severe boredom 3·5-5·0, the curve assessments agree with the boredom assessments in 4 cases out of 6, 15 out of 20, 22 out of 26, and 10 out of 16 respectively.

would probably be lower than before. It merely indicates that, from the standpoint of production, talking has certain disadvantages.

The objections to talking do not apply to singing. Unfortunately the majority of employers regard singing as a form of frivolity which would desecrate the atmosphere of serious work. They overlook the fact that singing is not only a wholesome means of escape from boredom, but is also a stimulant to cheerful feelings and increased activity.

Since boredom is due to an awareness of the monotonous conditions of work, its alleviation will depend upon the extent to which the mind can be distracted from these conditions. Clearly the form of distraction must appeal to the ear rather than to the eye, and music in some form or other seems to be the most suitable medium for this purpose.

The experiment described in the following pages was accordingly devised in order to determine the effects of music on operatives employed on a fairly simple form of repetition work. For this purpose a factory department was equipped with a gramophone, amplifier, and loud speakers, and the music was provided by records obtained from a local lending library. The total duration of the experiment was 24 weeks, but during this period there were several variations in procedure.

The conditions which existed during the course of this experiment were as follows.

Type of work.—The workers were employed in making paper crackers. In this process the crepe paper, which forms the outer part of the cracker, is placed flat on the bench and on the top of this is laid a piece of white paper, a "bomb," a conundrum, and a piece of sulphite paper. These are then rolled round a hollow metal tube and the process is completed by inserting a "filling" and tying the cracker in two places.

The time taken to complete one cracker was about half a minute, so that the process, while highly repetitive, yet involved a certain amount of variety in each cycle of movements. A further degree of variety was provided by the papers of many colours which were used in the making of different batches of crackers, and the department as a whole presented an unusually bright and cheerful appearance. Further, the making of crackers and the attractive appearance of the finished article undoubtedly appeal to the creative tendencies in human nature and in this respect the work may be regarded as fairly interesting and satisfying; although in the case of the small group of workers referred to in Table III, cracker-making was not the most popular choice.

Thus the type and conditions of work provided more variety, colour, and creative enjoyment than is the case in many forms of repetition work, and in so far as boredom is a function of these factors, the process of cracker-making has certain advantages. If, therefore, music is found to be an effective antidote to boredom, it is reasonable to infer that the effects will be still more marked in the less attractive types of repetition work.

Workers.—The number of workers included in this experiment was 68 and their ages ranged from 14 to 35. The older and more experienced operatives were engaged in making elaborate table decorations, and this work was both highly skilled and varied. The changing conditions of work made comparative measurements of output impossible and the information obtained from these workers was limited to personal opinions on the effects of music.

The crackers made by the younger workers were more simple and uniform in type and the work was essentially repetitive. The output of 12 of these workers was automatically recorded¹ at quarter-hour intervals during the morning spell of work and these records form the main basis of the results which follow.

Variations in procedure.—During the course of this experiment the following variations in procedure were introduced :—

Period I (6 weeks)—Usual conditions of work (i.e. no music).

Period II (3 weeks)—Miscellaneous dance music from 10–11.15 and from 4–5.

Period III (3 weeks)—Miscellaneous dance music in the morning from 9.30–10 and from 11–11.45. In the afternoon from 4–5.

Period IV (2 weeks)—Miscellaneous dance music in the morning from 8.45–9.15, 9.45–10.15, 10.45–11.15, and 11.45–12.15. In the afternoon from 4–5.

Periods II and III were given in order to compare the effects of music when played for (a) one period of 75 minutes around the middle of the morning spell, and (b) two shorter periods at approximately equal intervals within the spell. In both cases the total duration of music was the same. Afterwards it was decided to try the effect of music during alternate half-hours in the morning spell of work, and period IV was introduced for this purpose.

Period V (5 weeks)—Usual conditions of work (i.e. no music).

Period VI (5 weeks)—Music played from 10–11.15 and from 4–5.

In the last period the aim was to determine the effects of different types of music and the procedure adopted is described later in the report.

Straight piece-rates were in operation throughout this department, and the hours of work were from 8 to 12.45 and from 2 to 6.15. There was no work on Saturday mornings.

(a) *Different Distributions of Music*

The results obtained when music was played at different times within the spell of work (Periods II, III, and IV) have been compared

¹The apparatus used for this purpose was capable of recording the continuous output of 12 individuals on a moving paper band. It was devised and constructed by Dr. E. Schuster to whom the writers express their indebtedness and thanks.

with those recorded before the music was introduced (Period I). These results refer to the long morning spell when detailed records of output were obtained.

(i) *Effect on average hourly output*

The combined results obtained from the twelve workers who composed the experimental group are given in Fig. 3. They

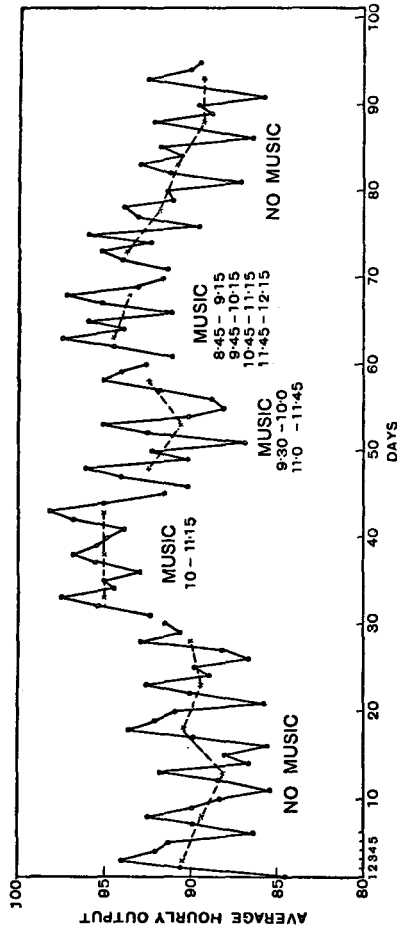


FIG. 3.—Average hourly output on successive days under different conditions of work.

represent the average hourly output on successive days (continuous line) under the different conditions of work. The weekly averages (broken line) have also been included in the graph.

The curves show that a new and higher level of output was reached when music was introduced from 10 to 11.15. The average increase over the preceding period without music was 6.0 per cent.

In the next period, when music was played twice within the spell of work, the output fell to a lower level, but was still 2.6 per cent. higher than that of the first six weeks. Finally, the introduction of music during alternate half-hours resulted in an increase in output of 4.4 per cent. over that of the initial period without music.

Thus, music had a small but favourable effect on average output¹ and the best results from this standpoint were obtained when music was played during a single period of 75 minutes about the middle of the work spell.²

This part of the experiment was concluded by a period of five weeks during which the operatives reverted to the usual conditions of work (i.e. no music) and it will be seen that output fell to its original level. The decrease was gradual and suggested a progressive change in attitude towards the changed conditions of work. In this respect the results differed from those recorded after the first introduction of music when there was an immediate effect on output.

Incidentally it will be noticed that the output curves form a series of waves which are repeated at weekly intervals. In each week the output was lowest on Monday and rose to a maximum on Wednesday, and the average hourly output on corresponding days in the different weeks was :—

Monday	..	..	..	..	..	88.5
Tuesday	..	..	..	..	..	92.1
Wednesday	..	..	..	..	..	94.7
Thursday	..	..	..	..	..	91.6
Friday	..	..	..	..	..	91.6

The relatively low output on Monday is an example of the familiar "Monday morning effect," while the high output on Wednesday was due to "booking up" which took place at the end of this day. The results in general show a fairly regular rhythm which reflects the varying strength of the ability or inclination to work as the week proceeds.

(ii) *Variations in output within the spell of work*

Since output was recorded at quarter-hour intervals, it was possible to determine the variations in the rate of working within the spell of work. For this purpose the results obtained at corresponding times on different days have been combined and averaged for each experimental period, and the resulting curves are given in Fig. 4.

Considering first the results obtained when music was introduced from 10 to 11.15 (upper curves), it will be seen that the effect on output, although most marked during the music period, was not

¹ The results are statistically significant.

² The results, of course, do not show the permanent effects of music on output but 18 months after the completion of this experiment music was still being played for an hour in the middle of each work-spell and the management continue to be satisfied with the results.

entirely confined to the time when music was played. The average increase in output before and after the playing of music was 4·3 per cent., while during the 75 minutes of music it was 11·3 per cent.

In the next experimental period (middle curves) the increase in output during the first 30 minutes of music was 9·7 per cent., while during the subsequent 45 minutes when music was played it was

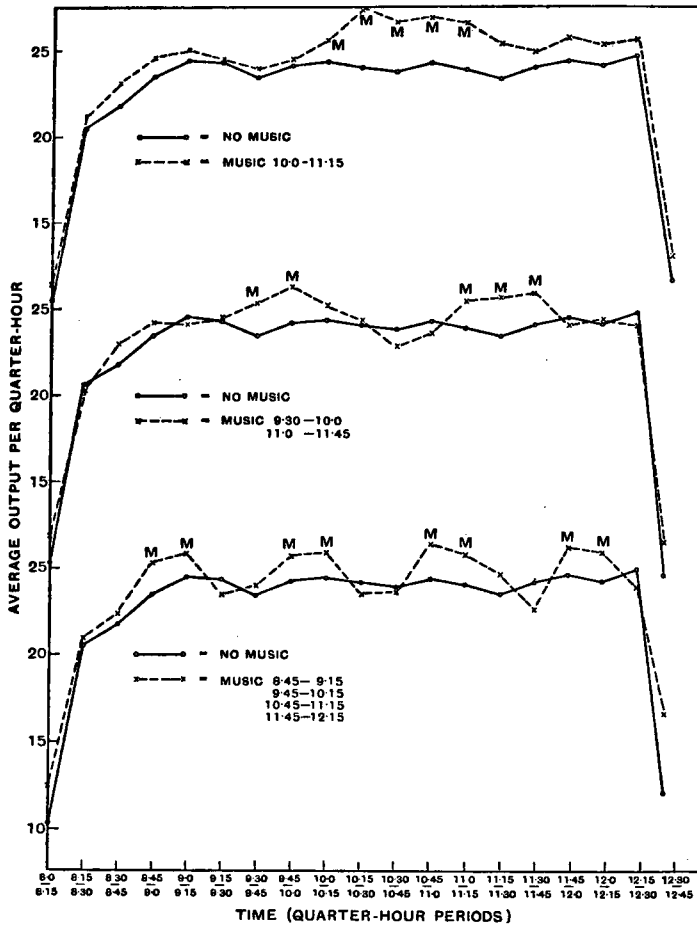


FIG. 4.—Variations in the rate of working throughout the spell of work.

8·1 per cent. As in the previous case, there was also a slight increase (2·2 per cent.) in the earlier part of the spell, but between 10 and 11, when no music was played, a slight relapse in the rate of working was noticeable.

The next change in the distribution of music (lower curves) also caused an increase in the rate of working during the half-hour periods

when music was played. This increase varied from 6.2 to 8.3 per cent., but during the intervening half-hours the output was sometimes a little lower than that observed at corresponding times under the usual conditions of work.

In general, therefore, it may be said that the type of music played under the varying conditions of this experiment produced an increase in output during the playing period ranging from 6.2 to 11.3 per cent.¹ There was also a tendency for the output to be higher near the beginning and the end of the spell of work.

(iii) *Individual differences in output*

The preceding results refer to the workers considered as a group, but there were also some notable individual differences in response to the introduction of music. These are shown in Table XVI, which gives the percentage increase or decrease in output² during those parts of the spell of work when (a) music was played and (b) there was no music.

TABLE XIV.—Percentage increase (+) or decrease (—) in output during those parts of the spell when (a) music was introduced and (b) there was no music.

Worker.	Period II.			Period III.			Period IV.		
	Music.	No music.	Spell ave.	Music.	No music.	Spell ave.	Music.	No music.	Spell ave.
A ..	+ 7.8	— 2.4	+ 0.3	+ 5.8	+ 0.2	+ 1.7	+ 9.5	— 1.1	+ 3.4
B ..	+ 9.4	+ 7.3	+ 7.9	+ 0.3	+ 0.6	+ 0.5	+ 7.8	+ 4.3	+ 5.8
C ..	+ 5.8	— 1.9	+ 0.2	+ 3.0	— 0.5	+ 0.5	+ 5.2	— 0.6	+ 1.9
D ..	+ 12.9	— 0.1	+ 3.3	+ 4.6	— 2.9	— 0.9	+ 3.4	+ 2.0	+ 2.6
E ..	+ 12.3	+ 1.9	+ 4.6	+ 9.4	— 1.7	+ 1.2	+ 6.5	+ 2.3	+ 4.1
F ..	+ 11.9	+ 3.6	+ 5.8	+ 10.9	— 1.0	+ 2.1	+ 6.8	+ 3.6	+ 5.0
G ..	+ 1.1	+ 4.9	+ 3.9	+ 10.0	+ 2.8	+ 4.7	+ 5.7	+ 3.2	+ 4.3
H ..	+ 21.7	+ 3.1	+ 8.0	+ 17.9	+ 3.7	+ 7.4	+ 10.6	+ 4.1	+ 6.9
I ..	+ 12.4	+ 3.5	+ 4.1	+ 11.8	— 1.1	+ 2.3	+ 7.7	+ 3.3	+ 5.2
J ..	0.0	— 1.2	— 0.9	+ 0.8	+ 0.4	+ 0.2	— 1.6	+ 1.5	+ 0.2
K ..	+ 23.1	+ 19.7	+ 20.6	+ 17.9	+ 3.2	+ 7.1	+ 12.3	+ 4.0	+ 7.5
L ..	+ 17.3	+ 12.7	+ 13.9	+ 13.0	+ 1.1	+ 4.2	+ 9.9	+ 2.8	+ 5.8
Avg.	+ 11.3	+ 4.3	+ 6.0	+ 8.8	+ 0.4	+ 2.6	+ 7.0	+ 2.4	+ 4.4

It is apparent from the results given in Table XIV that while the majority of the workers responded to the music by an increased output, which in some cases was very marked, there were isolated cases in which the music seemed to have little or no effect.

In order to examine the possible causes of these differences, an attempt was made to measure the general susceptibility of each operative to the usual conditions of work. For this purpose the average output under ordinary conditions (i.e. without music) was compared with the maximum rate of working attained during quarter-hour periods when the operatives were asked to work as quickly as possible. These short period measurements were made

¹ The results are statistically significant.

² i.e. compared with the corresponding times when no music was played during the spell of work.

at hourly intervals, and the results so obtained indicate maximum capacity as distinct from ordinary achievement. The difference between maximum capacity and average achievement gives the total effect of all the factors which are detrimental to working activity. These differences, expressed as a percentage of the maximum, were found to be—

A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.	L.
36.6	43.0	31.3	39.9	40.4	33.9	40.8	49.0	42.7	25.1	57.1	52.0

In this group of workers the differences between the average and maximum rates of working were unusually large, and the results suggest the presence of important factors which impaired performance under the usual conditions of work.

A comparison of the above results with those giving the average response to music (last column in each of the three music periods in Table XIV) shows a direct relation between (a) difference between maximum and average rate of working on the one hand, and (b) average increase in output due to music on the other. The corresponding coefficients of correlation (rank) are +.87, +.68, and +.91 respectively. Thus those individuals who worked most slowly¹ under the usual conditions of work showed the greatest increase in output when music was introduced, and vice versa. The former, of course, had more scope for improvement than the latter, but this does not explain their greater response to music. The statements made by the operatives, their replies to weekly questions, and observations of their behaviour while at work showed unmistakably that some individuals suffered more than others from boredom, and that relative slowness in the rate of working was clearly associated with the amount of boredom experienced. Since music acted chiefly as an antidote to boredom, it was accordingly most effective in those cases where boredom was most intense.

Corroborative evidence was provided by the curves showing the variations in the rate of working throughout the spell of work, and the point in question may be illustrated by the results obtained from workers J and K, who seemed to be respectively the least and the most bored members of the group. These results are given in Fig. 5, which shows the variations in the rate of working (a) under the usual conditions of work (continuous line) and (b) when music was introduced from 10 to 11.15 (broken line). They have been expressed as a percentage of the maximum rate of working observed during quarter-hour periods at hourly intervals throughout the spell of work (dotted line).

The most noticeable features of the results obtained from worker K under the usual conditions of work are a very slow start, a relatively low and decreasing output in the middle part of the spell, and a pronounced final spurt. Performance was always well below capacity, which remained unimpaired throughout the work-spell. This operative seemed most reluctant to begin work, and the disinclination continued until the end of work was near. In other words

¹ i.e. relative to their respective capacities.

she was intensely bored by the usual conditions of work, and the introduction of music provided a welcome and effective means of escape which was reflected in a more buoyant and cheerful attitude and a greatly increased rate of working. The music gave her "something to look forward to" and she was "not always thinking about what she had to do".

The corresponding results for worker J, on the other hand, are characterised by a good start followed by a fairly steady but slightly

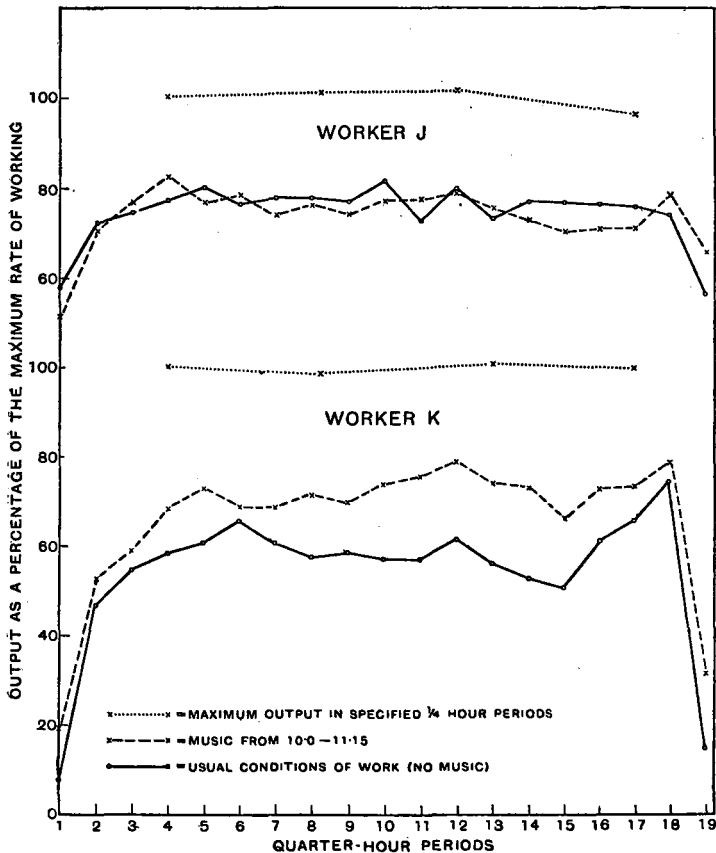


FIG. 5.—Curves illustrating individual difference in response to music.

decreasing rate of working to the end of the spell. The difference between maximum capacity and actual performance was also relatively small. Such results suggest a fairly interested operative who was eager for work and was able to maintain a high and consistent rate of working over a long period. This operative was seldom bored, but began to feel a little fatigued towards the end of the spell.

In her case the introduction of music, although regarded as pleasant, had little or no effect on output.

The results obtained from the other members of the group varied between these two extremes, but on the whole the general tendencies showed a closer resemblance to those of worker K.

(iv) *Personal opinions*

At intervals during the course of this experiment the workers were questioned on their feelings and attitude towards the music and at the end of the series their views on the different distributions of music were obtained. These questions were given to all the workers in the department, and they provide an interesting and illuminating supplement to the records already discussed.

In the first place there was a decided preference for the introduction of music during alternate half-hours throughout the spell of work. There were only seven dissentients out of a total of 68, and the objections raised by the small minority seemed to be due to an increased awareness of the passage of time. Thus one worker remarked that she didn't like this arrangement because "It tells you the time and I don't want to be reminded of the amount of time still to be worked". There was also a feeling that each half-hour of music was too short as "We were just getting nicely warmed up when the music stopped." The majority, however, preferred the alternate half-hours of music because the day seemed much shorter. Remarks such as "You look forward to the next half-hour of music as soon as the previous one is finished" and "You seem to be having music all the time and you don't miss the half-hours when no music is played" illustrate the attitude in question.

Secondly, almost all the workers agreed that music did not interfere with work, and a large majority stated that it was a distinct help. In some cases the rhythm was mentioned as an aid to production as "You try to work to the music especially when the time is quick" and "A rather quick time makes you work quickly". In others the music was said to "Make you work better because you talked less". In particular almost all the workers expressed the opinion that music was most helpful when the work was difficult or troublesome. "When on a bad job I thought more about the music than about the job", "The music helped you to take your mind off your troubles" and "If on a bad job the music most certainly helps you to forget it and stops you from grumbling" were typical of the numerous remarks regarding this aspect of the work.

Finally, there were frequent references to the cheering and diverting effects of music. It was said, for instance, that music "Brightens things up", "Makes you more cheerful and lively", "Takes you out of yourself", and "Gives you something to occupy your mind". The anticipatory effects of music were also revealed in remarks such as "We look forward to the music from the time we start work" and "Music makes you look forward to coming to work", while a particularly appreciative operative "Felt that she was not

coming to work, but just to enjoy the music". It was also said that music was exceptionally welcome on Wednesday, which was the day for "booking up" and "We wanted to work well".

The opinions regarding the value of music seemed to bear some relation to the different types of work performed by the operatives. Thus some individuals were engaged in making elaborate table decorations or novelties, and in this work the music was said to be less helpful than when making crackers. Typical remarks were "You pay less attention to music when making novelties than when making crackers" and "When on novelties you get so interested in the job that you don't pay much attention to music". These opinions merely illustrate the general principle that the greater the degree of interest aroused by the industrial process the less will be the attention devoted to music. In other words the beneficial effects of music are likely to bear a direct relation to the degree of monotony associated with the daily work.

There is not the least doubt that the workers in this department appreciated the introduction of music. It diverted the mind from the monotonous conditions of work, provided an attractive aim, made time seem to pass more quickly, and created a more cheerful attitude towards work.

(b) *Different Types of Music*

This variation in experimental procedure was introduced in order to find whether different kinds of music produced any noticeable differences in output and in attitude towards the conditions of work. For this purpose five types of music were used, viz. marches, waltzes, one-steps, fox-trots and "light" music. A preponderance of dance music was included in the programme because of its undoubted appeal to the modern female worker. The "light" music, which included such compositions as the Indian Love Lyrics, Schubert's Serenade, Dances from Nell Gwynne, and selections from the Mikado, was introduced merely as a speculative variation. In the event of the latter proving to be an unexpected success, provision was made for the inclusion of classical music, but an extension of the programme in this direction seemed to be unwarranted by the results obtained.

It has already been pointed out that the rate of working of the operatives varied according to the day of the week quite apart from any other changes in the experimental conditions. In order to study the influence of different kinds of music it was necessary to counteract the effect of these variations, and the following scheme was adopted:—

	<i>Monday.</i>	<i>Tuesday.</i>	<i>Wednesday.</i>	<i>Thursday.</i>	<i>Friday.</i>
1st week	.. One-steps.	Fox-trots.	Light music.	Marches.	Waltzes.
2nd week	.. Fox-trots.	Light music.	Marches.	Waltzes.	One-steps.
3rd week	.. Light music.	Marches.	Waltzes.	One-steps.	Fox-trots.
4th week	.. Marches.	Waltzes.	One-steps.	Fox-trots.	Light music
5th week	.. Waltzes.	One-steps.	Fox-trots.	Light music.	Marches.

Thus in the course of five weeks each kind of music was played on the different days of the week and the resulting averages will be unaffected by the existing daily variations in output. These averages are given in Table XV, which shows the relative output obtained by each worker under the different types of music.

TABLE XV.—*Relative output under each type of music (expressed as a percentage of the average for each worker during all the music spells).*

Worker.	Marches.	Waltzes.	One-steps.	Fox-trots.	Light music.
A ..	97.2	103.7	103.6	99.5	96.0
B ..	99.9	101.4	102.0	99.6	97.1
C ..	100.1	96.9	104.0	104.4	94.6
D ..	104.6	99.4	98.3	102.3	95.3
E ..	98.5	98.4	101.6	104.0	97.5
F ..	95.8	101.8	105.4	101.1	95.9
G ..	97.8	100.3	99.6	102.8	99.5
H ..	97.0	95.8	107.2	102.7	97.3
I ..	98.1	96.5	102.4	103.1	99.9
J ..	98.9	99.8	102.9	98.9	99.5
K ..	102.0	98.4	103.7	96.0	99.9
L ..	100.3	99.9	104.5	100.3	95.0
Average	99.2	99.4	102.9	101.2	97.3

Differences between averages exceed four times the probable error of their differences in the case of (a) Marches and One-steps, (b) Waltzes and One-steps, (c) Light music and One-steps, and (d) Light music and Fox-trots.

The general effects of the five kinds of music are shown by the averages at the foot of each column, and it will be seen that the differences are fairly small. The greatest difference was only 5.6 per cent., although in the case of certain individuals it amounted to approximately 10 per cent.

The highest output was obtained with one-steps and the lowest with light music. In only four cases, however, were the differences between the group averages statistically significant.

There are indications that the observed differences in output were connected with the different rhythms which characterised the five types of music. Thus in the case of the dance tunes the rhythms (arranged in descending order of speed) are one-steps, fox-trots, and waltzes, and the corresponding outputs show a similar decreasing tendency. In the case of the light music the rhythm was usually slower, less marked, and more variable than in the dance tunes, and this may be one of the reasons for the lower output observed when light music was played. The quick and lively march tunes, on the other hand, gave rise to a relatively low output, and other reasons must be sought for the lack of agreement in this case.

At the end of each week the workers were asked which type of music they preferred, and the results obtained are given in Table XVI.

TABLE XVI.—*Type of music preferred by the different workers.*

<i>Worker.</i>	<i>1st week.</i>	<i>2nd week.</i>	<i>3rd week.</i>	<i>4th week.</i>	<i>5th week.</i>
A ..	Waltz.	Waltz.	Waltz.	Waltz.	Waltz.
B ..	Waltz.	Waltz.	Waltz.	Waltz.	Waltz.
C ..	Fox-trot.	Fox-trot.	Waltz.	Waltz.	Waltz.
D ..	Fox-trot.	Fox-trot.	Fox-trot.	Fox-trot.	Fox-trot.
E ..	Fox-trot.	Fox-trot.	Fox-trot.	Fox-trot.	Fox-trot.
F ..	Waltz.	Fox-trot.	Fox-trot.	Fox-trot.	Fox-trot.
G ..	Light music.	Waltz.	Waltz.	Fox-trot.	Waltz.
H ..	Waltz.	Waltz.	Waltz.	Waltz.	Waltz.
I ..	Waltz.	Waltz.	Waltz.	Waltz.	Waltz.
J ..	Fox-trot.	Fox-trot.	Fox-trot.	Waltz.	Fox-trot.
K ..	Light music.	Fox-trot.	Fox-trot.	Fox-trot.	Fox-trot.
L ..	Fox-trot.	Fox-trot.	Fox-trot.	Fox-trot.	Fox-trot.

Thus the most popular types of music were fox-trots (30 votes) and waltzes (28 votes), while one-steps and marches were not mentioned. There was accordingly little or no relation between personal preferences and relative output (Table XV), and in only two cases out of twelve did the highest output coincide with the type of music preferred.

A possible reason for this disparity was suggested by one of the workers, who said " I like waltzes ever so much, but they make me feel sleepy and languid, and I can't get on ". This view was endorsed by several other members of the group, and probably most people will agree that waltzes are more restful and less stimulating than one-steps and marches.

The relative unpopularity of one-steps and marches may be due to their comparatively quick rhythm, which was said to make the workers feel " lively and restless ". Yet these two types of music had different effects on output. The rhythm is, of course, different in the two cases, and the tunes played as one-steps were usually more familiar and presumably had happier associations than the marches. Many of the younger workers stated that marches " got on their nerves " and made them feel " jumpy ", and there is reason to believe that the strongly accented march rhythm clashed with some of the movements involved in tying crackers. In this case there would be a conflict of forces which might easily create a dislike for the imposed rhythm. In this connection it may be mentioned that a small majority of the older workers in this department were in favour of march tunes. These workers, it will be remembered, were employed in making elaborate table decorations, and there was a complete absence of rhythm in their movements. Thus there would be no rhythmic interference between march music and productive activity.

As regards the light music, this seemed to give a mild degree of pleasure in certain cases, but, unlike the waltzes and fox-trots, it was never demanded " by request ".

On the whole the workers expressed a preference for a varied programme of dance music, and it is highly probable that a similar taste exists in most industrial workers.

2. ATTITUDE TOWARDS WORK

Some information on the attitude of operatives towards the type and conditions of work has already been given in the previous section, but the evidence in question was incidental to the particular aims of that part of the inquiry. A wider and more systematic survey of attitudes seemed desirable, and the procedure used in this part of the investigation was designed to fulfil this purpose.

It is, for instance, useful to know the relative importance assigned by workers to such questions as opportunity for promotion, security of employment, high wages, and the like. Knowledge of the workers' opinions on these matters and the extent to which their desires are likely to be satisfied by existing conditions of work will show the more important sources of dissatisfaction and should direct attention to the possibilities of their removal.

In addition to the attitude towards the more remote and sometimes intangible factors which form the background to industrial activity, it is also important to know the view of the operatives on those features of their working environment which impinge more directly on thought and work. These include physical factors such as noise and temperature; material conditions such as waiting for work and trouble with the machine; and personal relationships such as working companions and the type of supervisor. Likes and dislikes induced by the more concrete and immediate elements in the working environment are sometimes very intense, yet their existence and importance are often overlooked or ignored.

Information on these aspects of industrial work was obtained during the interview with the workers, who were asked to give their views on the more important causes of satisfaction and discontent and to rank in order of importance a number of items in a prepared list. The latter were based upon the experience gained in previous investigations and included a fairly wide range of factors which were likely to give rise to positive or negative attitudes towards work. This method of procedure facilitates numerical comparison between individuals or groups. It was applied to the 325 workers in Factories A, B, and C, and the results obtained are given and discussed in the pages which follow.

A. RELATIVE IMPORTANCE OF FACTORS CONNECTED WITH WORK

The procedure adopted in this part of the inquiry was used for the purpose of ascertaining the views of the workers on the relative importance of certain factors associated with the conditions of employment. The factors chosen for this purpose were¹ :—

1. Opportunity for promotion.
2. Security of employment.
3. Good supervisor.
4. Pleasant working companions.
5. High wages.

¹ Adapted from Chant, S. N. F. (1933) : " Measuring the factors that make a job interesting." *Personnel J.*, 11, 1.

6. Short hours.
7. Opportunity to use your own ideas.
8. Comfortable working conditions.
9. Work which makes you think.
10. Work which needs no thought.

The intention was to have these factors ranked according to importance, but a direct comparison of ten items is rather difficult and confusing. To avoid this difficulty the longer but more reliable method of "paired comparisons" was used. In this procedure the items are arranged in pairs and each item is compared with every other item in the list. This gives an arrangement such as:—

- | | |
|-------------------------------|------------------------------|
| 1. Opportunity for promotion. | Security of employment. |
| 2. Good supervisor. | Pleasant working companions. |
| 3. High wages. | Short hours. |
| Etc. | |

The complete list ¹ contained 45 pairs and was composed of the permutations of the 10 factors, two at a time. The worker was asked to underline what she considered to be the more important member in each pair, consequently each factor could have been selected nine times. The order of preference was obtained from the number of times each factor was underlined and the results are given in Table XVII.

TABLE XVII.—*Relative importance of factors associated with the conditions of work. (Average of the number of times each factor was chosen by a worker in three factories—the maximum in each case being 9.)*

					Factory.		
					A.	B.	C.
1.	Opportunity for promotion	..	..	..	4.30	4.12	4.00
2.	Security of employment	..	..	..	7.70	7.46	7.63
3.	Good supervisor	..	..	..	4.65	5.92	5.58
4.	Pleasant working companions	..	..	..	5.35	5.86	5.54
5.	High wages	..	..	..	4.41	4.07	3.94
6.	Short hours	..	..	..	3.50	2.95	2.95
7.	Opportunity to use your own ideas	..	..	..	4.18	3.60	3.27
8.	Comfortable working conditions	..	..	..	5.89	5.57	6.45
9.	Work which makes you think	..	..	..	3.77	3.65	2.78
10.	Work which needs no thought	..	..	..	1.00	1.80	2.83

There is a fairly close resemblance between the results obtained from the three factories. Since the latter were situated in widely different parts of the country the views expressed by the operatives may be regarded as fairly representative of female repetition workers in general.

Most importance was attached to security of employment, which received between 80 and 90 per cent. of the possible number of votes. As this factor is closely connected with fundamental desires, its dominant position in the list is not surprising. The

¹ The complete list is given in the Appendix (E).

next in order of preference were comfortable working conditions, pleasant working companions, and a good supervisor. These three factors received roughly the same number of votes and they are obviously closely related to the comfort and contentment of the operatives while at work. They represent the personal and material factors in the immediate environment of the operative, and anyone familiar with working conditions will appreciate their value as determinants of pleasure in work. The desire for promotion occupied an intermediate position in the list, and this was closely followed by the interest in high wages. The relatively low position of the latter factor was somewhat unexpected as wages are usually believed to occupy a focal position in the thoughts of the workers. Finally, the operatives were not unduly perturbed about the amount of thought required by work or opportunities to use their own ideas. Whether work required much or little thought seemed to be relatively unimportant compared with the other items in the list.

The preceding remarks refer to the tendencies shown by the results as a whole, but a more detailed treatment of the data revealed additional features of importance.

(a) *Opportunity for Promotion*

It will probably be agreed that the desire for promotion is closely related to self-assertion and ambition, and is a trait in human nature which is by no means unimportant in industry. The "paired comparison" test serves the useful purpose of discovering those individuals who are strongly endowed with this characteristic. Clearly, it would be irrational to promote a worker who regarded such a form of self-advancement as less important than most of the other factors given in the list, while an individual who showed a strong desire for promotion obviously possesses an important qualification in this respect.

The number of preferences given to "Opportunities for promotion" by the 325 individuals included in this inquiry was:—

Preferences ..	9	8	7	6	5	4	3	2	1	0
No. of workers	7	18	37	42	40	45	53	31	28	22
Percentage of total ..	2.2	5.6	11.5	13.0	12.4	13.9	16.4	9.6	8.7	6.8

Thus only 7 workers, or 2.2 per cent. of the total, regarded promotion as the most important factor in the list, while 18 workers, or 5.6 per cent. of the total, selected it on eight occasions out of a possible nine. If, therefore, it were necessary to promote some of these workers, attention should be directed in the first place to the seven individuals who placed it first on the list.

It is evident that the desire for promotion is dependent on personal characteristics since some individuals were keenly interested in the question while others showed no inclination in this direction. One of these personal factors seems to be the amount of intelligence possessed by the worker. Thus a comparison of the number of

votes given to "Opportunities for promotion" and the scores obtained in a test of intelligence gave the following results:—

<i>Votes given to "Opportunities for promotion."</i>			<i>Number in * group.</i>	<i>Relative in- telligence.</i>
7-9	..	..	62	108.7
4-6	..	..	127	99.5
0-3	..	..	136	91.9

In this case there was a direct relation between the amount of importance attached to promotion and the level of intelligence.

Additional evidence was provided by the results obtained from the 60 chocolate coverers and 82 chocolate packers who composed the group of workers included in Factory A. The educational attainment of these two groups, as shown by the percentage in each of the three upper standards on leaving school, was as follows:—

			<i>Standard.</i>	
			7—	7+
Coverers ..	..	22	48	30
Packers ..	..	7	53	40

The packers attached more importance than the coverers to opportunities for promotion, and it seems reasonable to associate this difference with the capacity to excel in school subjects which, in turn, is probably dependent on intelligence.

It also seemed probable that the desire for promotion might bear some relation to age, and the results have been considered from this standpoint. There was a fairly wide range in the age of the workers included in Factories B and C, but not in Factory A, consequently the latter group has been omitted from this treatment. The combined results obtained from the workers in the other two factories are given below.

<i>Age.</i>				<i>Number in group.</i>	<i>Average number of votes given to promotion.</i>
15-19	..	..	..	57	4.34
20-24	..	..	..	65	4.22
25-29	..	..	..	39	4.13
30+	..	..	..	22	2.74

In this case there was very little change in the amount of importance attached to promotion up to the age of 29 or thereabouts, but after this age the decrease was more pronounced. It is generally acknowledged that opposition to changes in the conditions of work increases with age, and the above results probably provide a particular example of this tendency.

At the same time it is possible that the highest age-group may contain proportionately fewer individuals who are anxious for promotion because of the number who have already been promoted. A retrospective survey showed, however, that only one worker had been promoted from this group.

The results thus far discussed are relative to the other factors included in the list of "paired comparisons" and fail to show the actual number of workers who would like to be promoted or who have no desire to change their present conditions of work. Some information on this point was obtained from replies to the question "Which would you prefer, (a) to have a job where you are likely to be promoted to more important work, or (b) to have a job where you know exactly what you have to do and can work without change year after year?" This question was included in a list given to the workers in Factories B and C and the percentage of replies in favour of (a) and (b) was as follows:—

<i>Factory B.</i>		<i>Factory C.</i>	
(a)	(b)	(a)	(b)
63	37	59	41

Thus a majority of the workers expressed a preference for the type of work which was likely to lead to promotion. At the same time it may cause a little surprise to find that 39 per cent. seem to have no desire for promotion, but are apparently content to remain employed on simple forms of repetition work.

In reply to the further question "Which would you prefer, (a) to arrange and plan the work for others and tell them what to do, or (b) to have everything arranged for you so that you know exactly what to do?" the following results were obtained:—

<i>Factory B.</i>		<i>Factory C.</i>	
(a)	(b)	(a)	(b)
35	65	24	76

This question specified the type of work which is usually associated with the duties of a supervisor, and it will be seen that only a small minority desired this particular form of promotion.

The chief objections to supervisory work were the dislike of responsibility and the fear of failure. This attitude is illustrated in the following remarks which are fairly typical of the replies received:

"The responsibility of being a forewoman would be too worrying. I'm no disciplinarian and should not be able to control the girls."

"I shouldn't like to be in charge of anyone; there would be too much worry. I prefer to remain at the bench with the other girls and not to boss them. You change when you become a forewoman and are not so popular."

"The work of a forewoman does not appeal to me. I should be too much of a big bully and should shout at the girls if they did their work wrong."

Those workers who were anxious to be promoted to forewomen were, on the other hand, of the confident, assertive, and ambitious type. A fairly typical statement made by one of the workers was: "I should like to be in charge of girls and to enforce discipline. I love bossing people about. At school I often acted as prefect and was very successful. It would be awful if I thought that I had to stay at the bench all my life."

Thus, although 60 per cent. of the workers were favourably disposed to the question of promotion, only half of these were willing to undertake the duties of a supervisor.

(b) *Security of Employment*

The most striking features of the attitude towards security of employment were the high and consistent nature of the results obtained from all the factory groups. Whatever the occupations of the workers, and they included such operations as chocolate covering and packing, weighing, machine-feeding, box-making, cracker-making, and display work for window decoration, the factor of security was uniformly and outstandingly important.

A more detailed analysis of the results, however, gave some indication of a relationship between fear of unemployment and individual efficiency. Owing to variations in the type or conditions of work the results of only three groups of workers, containing respectively 29, 19, and 24 individuals, could be used to demonstrate this tendency. The workers in each group were divided into two classes on the basis of output, and the amount of importance attached by each class to security of employment was then evaluated. The results so obtained were as follows :—

<i>Output.</i>	<i>Average number of votes given to security of employment.</i>		
	<i>Group 1.</i>	<i>Group 2.</i>	<i>Group 3.</i>
Above average ..	6.93	6.30	6.75
Below average ..	8.14	7.89	7.83

The numbers in the different groups were small and the differences between the means barely significant, but some weight may be given to the consistent nature of the results. To this extent it is permissible to conclude that the less efficient workers attached more importance than the more efficient operatives to security of employment. This is probably not surprising since the less capable workers are always in greater danger of dismissal and consequently feel less secure than those who are capable of attaining a relatively high output. It is merely one example of the numerous handicaps which disturb the mind of the less efficient worker.

It was also thought that the attitude towards security of employment might vary with age, and the results obtained from Factories B and C have been examined from this standpoint. These are given in Table XVIII and show (a) a classification of the workers into three groups according to age, and (b) the average number of votes given by each of these age-groups to security of employment.

TABLE XVIII.—*Relation between age and attitude towards security of employment.*

<i>Age groups.</i>	<i>Factory B.</i>		<i>Factory C.</i>	
	<i>No. in group.</i>	<i>Security of employment.</i>	<i>No. in group.</i>	<i>Security of employment.</i>
14-19	26	7.07	31	7.42
20-25	46	7.40	27	7.70
Over 25	28	8.04	25	7.77

Although the results from the two factories are consistent, the differences between the age-groups are statistically insignificant. The consistent tendency, however, is probably not wholly due to chance, and to this extent it may be inferred that increasing age is associated with a greater regard for security of employment.

During the course of this inquiry the workers were given a list containing a number of factors which might be expected to cause annoyance or dissatisfaction in the performance of their daily work. They were required to underline those items in the list which they disliked or found to be disturbing, and included on the list was "Fear of unemployment". The percentage number of workers in each of the three factories who marked this factor was :—

A.	B.	C.
37	30	54

Thus, although the workers as a whole regarded security of employment as the most important factor in the industrial situation, the number who were actually disturbed by the fear of unemployment varied from one-third in Factories A and B to one-half in Factory C.

The excess in the latter group was undoubtedly due to a period of unemployment caused by the closing of the factory for reorganisation under a new management. The memory of this experience, together with the uncertainty which necessarily accompanies a new venture, was still a disturbing factor in the minds of these workers, although at the time of this inquiry they had been in continued employment for a period of two years.

These results will probably help to draw attention to the fear of unemployment which exists in the minds of many workers, and to the importance of providing as much security as is reasonably practicable. The diminution or removal of this fear would create a background of increased contentment and would help to eliminate a form of mental disturbance and distraction which frequently interferes with productive activity.

(c) *Supervision*

The results of this inquiry show that the workers regard supervision as one of the most important factors in the working environment. In Factory B the item "Good supervisor" was ranked next in importance to security of employment, while in Factories C and A it occupied the third and fourth positions in the list.

The supervision in most of the departments in Factory B was unusually good and was characterised in particular by a friendly and human atmosphere. The supervisors on the whole were sympathetic but firm, and there was a notable absence of harsh or bullying treatment. The workers never hesitated to ask for advice and their difficulties were handled with tact and understanding. Most of the supervisors seemed to have a sound knowledge of the personal characteristics and peculiarities of each worker, so that different methods of treatment were applied in different cases. With

one or two exceptions each group gave the impression of a large and happy family.

During this inquiry there were many opportunities of studying the methods employed by the different supervisors and several voluntary statements on this subject were made by the workers. The most unpopular supervisors seemed to be those who—

- (a) displayed many of the characteristics which are usually associated with the regimental sergeant-major ;
- (b) tended to be spiteful and unjust in their treatment of the workers ;
- (c) never praised but always blamed ;
- (d) remained aloof and ignored complaints from the workers.

A comparison of the output produced in one department with that obtained under similar conditions in an adjoining room showed a balance in favour of the latter of 17·8 per cent. The only noticeable difference between the two departments was the type of supervision employed by the two forewomen, and the observed difference in output was due to the repressive and unsympathetic methods adopted by the forewoman in the less productive department.

It must not be assumed that unpopular supervisors are very common in industry. In this inquiry they represented a minority and most of the forewomen were undoubtedly admirably qualified for their work. In Factory A, for instance, the forewomen seemed to take a genuine interest in the girls themselves as well as in their output, and the rank of forewoman was much higher than is usually the case. Most of the women occupying this position were well educated, and in at least one case the forewoman was a university graduate.

(d) *Working Companions*

The results in Table XVII show that a great deal of importance was attached to working companions. The operatives were more concerned about this feature than about such questions as the hours of work, wages, and the chances of promotion. Further, the results obtained from all the different groups were very consistent and seemed to be independent of the type of work.

The percentage of workers in each factory who stated that they were dissatisfied with their neighbours was¹

<i>Factory A.</i>	<i>Factory B.</i>	<i>Factory C.</i>
25	28	46

In other words, 93 individuals out of a total of 325 complained of this aspect of the conditions of work.

As might be expected, the irritating cause in many of these cases was incompatibility of temperament. Thus a bright and cheerful worker stated that she hated being next to X because "She's so miserable and grumpy and makes me feel depressed", while

¹ The results are extracted from Table XXI.

another said that she was often annoyed and unable to get on with her work because "Miss K is so talkative and restless and gets on my nerves". Similar statements could be multiplied almost indefinitely, and they are symptomatic of a familiar but neglected source of dissatisfaction and unrest.

Another frequent cause of friction between adjoining workers could be attributed to differences in working capacity. It was by no means uncommon to find one worker producing from 20 to 50 per cent. more than her neighbour, and such situations often give rise to expressions of jealousy and spite. In many cases the workers were unfriendly or quarrelsome and the quicker worker was blamed or abused because of her superior capacity. She was condemned for "rushing" and for "playing-up to the supervisor"; for being "stuck up" and "pretending to be more than she really was". Sometimes the inferior worker accused the forewoman of "always giving me the difficult jobs" or "putting me on the worst machine in the room", although there was no justification for these charges.

The general effect of inferior capacity when thrown into relief by proximity to greatly superior ability was the creation of a disgruntled, irritable and sometimes vindictive individual, who tended to blame others for her deficiencies. Less frequently the situation created a growing mood of depression, lack of confidence, and uneasiness which reduced output and pleasure in work and made the individual an uncongenial member of the group.

(e) *Wages*

It is often believed that industrial workers attach more importance to wages than to any other factor associated with the conditions of work. The results of this limited inquiry fail to support this belief and show that, within the range of items included in the list, wages were ranked sixth in order of importance and were regarded as less important than pleasant working companions and comfortable conditions of work.

The workers in general seemed to accept the prevailing wage level as satisfactory and regarded the weekly earnings as the automatic sequel to the habitual factory work. If, however, the wages of any group were lower than those of other groups employed on fairly similar types of work, the individuals so affected were inclined to complain about the rate of payment. The wages question then began to occupy a more prominent position in their thoughts and tended to create a background of discontent. In Factory A, for instance, there were two groups of workers (coverers and packers) employed in the same department and the average hourly earnings of these two groups were :—

			<i>Dept. A.</i>	<i>Dept. B.</i>	<i>Dept. C.</i>	<i>Dept. D.</i>
Coverers	..	..	12·28 <i>d.</i>	11·86 <i>d.</i>	12·38 <i>d.</i>	—
Packers	..	..	12·42 <i>d.</i>	13·25 <i>d.</i>	13·05 <i>d.</i>	11·28 <i>d.</i>

The percentage of workers in each group who complained about the rate of payment was :—

			Dept. A.	Dept. B.	Dept. C.	Dept. D.
Coverers	..	..	18	22	20	—
Packers	..	..	17	8	6	43

In each of the first three departments the coverers earned less than the packers and the differences were closely reflected in the frequency of complaints. The packers in Department D earned less than any of the other groups, and their complaints were correspondingly numerous.

The workers were aware of the variations in wages in the different groups and this knowledge was the cause of the different degrees of discontent. The dissatisfied workers believed they were underpaid and an adjustment in the rates of payment was all that was necessary to remove this grievance.

Inequalities in the rates of payment were particularly noticeable in Factory C, and were prominent in some departments in Factory A, while in Factory B they appeared to be non-existent. It will be seen later (Table XXI) that the percentage of workers who expressed dissatisfaction with the existing rates was 54, 23 and 6 in Factories C, A, and B respectively.

In addition to the annoyance caused by group differences in the rates of payment, a very common source of discontent was the effect of variations in the nature of the material on earnings. Thus in one of the departments in Factory C the operatives were supplied with different kinds of material approximately every two days. Some batches of material were more troublesome to handle than others, but the cycle of movements was practically the same in all cases. The rates of payment were supposed to be adjusted to the time taken to handle the different material so that in theory the weekly earnings of the operative remained unaffected by the variations in the conditions of work. In practice, however, there were many glaring discrepancies which were the cause of numerous complaints. A representative sample is given in Table XIX.

TABLE XIX.—*Relative output and wages obtained on different types of work.*

Type of work.	Rate per gross.	Relative output.	Relative earnings.	Workers' comments.
T.1	.. 12/9	100	100	Horrible. Everything wrong. Take so long to do.
T.2	.. 11/6	124	112	Rather like them.
T.3	.. 11/-	138	119	Very nice. Pleasant work.
T.4	.. 11/6	114	103	Not too bad, but money not good enough.
T.5	.. 12/9	104	104	Nice to look at, but that's about all.

Thus differences in earnings amounting to 19 per cent. were recorded in the case of the same worker when employed on slightly different types of work and the resulting comments are equally illuminating.

As one worker remarked, "If you are 6d. or 1s. down one day, you come to work the next morning bad tempered and fed up because you have to try to make it up."

On the whole the workers included in this inquiry seemed to be much more sensitive to inequalities in the rates of payment than to the general wage level, and the primary cause of complaints¹ was defective time-study when fixing the rates.

(f) *Hours of Work*

The results given in Table XVII show that the workers attached comparatively little importance to the question of hours of work. This factor was ranked next to the last and there were no significant differences between the results obtained from the three factories. It accordingly appears that the operatives were generally satisfied with the existing hours of work and had no particular desire to see them changed. This apparent complacency may be due to the acceptance of a regularised feature of the industrial environment, but it may also be prompted by the fear that a reduction in the hours of work would result in lower wages. The comparative indifference may therefore be misleading, and the results must be accepted with reserve.

There were, however, indications that the attitude towards hours of work was dependent on the intensity or severity of the industrial process. Thus in Factory B the relative importance attached to hours of work by different groups was—

B.1	..	..	..	3.21
B.2	..	..	..	2.55
B.3	..	..	..	4.11
B.4	..	..	..	2.58
B.5	..	..	..	2.10

The workers in B.3 were engaged in feeding machines at the rate of 240 units per minute. They had difficulty in keeping the machines supplied with material and complained of strain and fatigue. Further, the supervision in this department was relatively strict. The B.1 group was also employed on machines used in the manufacture of tin boxes, and although the work was exacting, the rate of production was under the control of the operative. The remaining groups were employed on simple forms of repetitive handwork and were able to indulge in talking and the like. The varying intensity of the activities in these groups seems to explain their different attitudes towards the duration of work and the results in question provide an indirect measure of satisfaction with existing conditions.

Although the workers as a whole were not unduly concerned about the hours of work, they made many spontaneous references to the value of rest-pauses within the spell of work. These were particularly numerous in Factory C, where rest-pauses had been discontinued by the new management and the change was resented by the workers. Typical statements were "It used to help a lot when you knew you were having a break—you put on a spurt before

the break and afterwards you worked well to the end." "We used to look forward to the rest and afterwards time seemed to fly." Such remarks are instructive and express a desire which might easily be satisfied by the introduction of suitable periods for rest.

(g) *Comfortable Working Conditions*

The importance assigned by the workers to comfortable working conditions was shown by the fact that they were ranked next to security of employment and received about two-thirds of the possible number of votes.

The operatives in Factory C were more concerned about working conditions than were those in Factory B. In the former factory the general conditions of work, such as supervision, service, hours of work, intensity of work, and security of employment were inferior to those in the latter, and the results reflect the reactions of the operatives to these differences.

Some further differences were also observed in the results obtained from the five groups of workers in Factory B. The average number of votes given to "Comfortable working conditions" by each of these groups was—

B.1	..	..	..	5.12
B.2	..	..	..	5.07
B.3	..	..	..	6.94
B.4	..	..	..	5.68
B.5	..	..	..	5.40

In this case also the fast machine-feeders (B.3) attached more importance than the other groups to working conditions, and this again can be attributed to the strain and discomfort caused by keeping pace with high-speed machines.

(h) *Work and Thought*

In this inquiry an attempt was made to collect information on the attitude of the workers towards the amount of thought required by work. The three items in the list which have a direct bearing on this question are—

Opportunity to use your own ideas,

Work which makes you think,

Work which needs no thought,

and it will be convenient to consider these together.

Although these three factors were ranked low in order of importance (Table XVII) and consequently indicated a comparative indifference towards the amount of thought required by work, a further analysis of the results disclosed some interesting features.

In the first place, although the amount of thought required by work was fairly similar in the three factories, there was a significant difference between the results obtained in Factories A and C. Thus the operatives in Factory A attached relatively more importance to "Opportunities to use your own ideas" and to "Work which makes you think" than did the workers in Factory C. Conversely,

they attached relatively less importance to "Work which needs no thought". The operatives in Factory B occupied an intermediate position in their attitude towards these three items.

The reason for these differences is probably connected with the level of intelligence and degree of educational attainment of the workers composing the three factory groups. Thus the average score of the workers in Factory A in a test of intelligence was about 12 per cent. higher than the corresponding results obtained from the workers in Factory C. Further, in Factory A, attendance at a Day Continuation School for one day per week was compulsory up to the age of 18. This school aimed at a general cultural development and the operatives who attended were enabled to continue their education to a much later age than is usual with manual workers. It might be expected, therefore, that the operatives in Factory A would show a greater preference for work which required some thought.

The workers in Factory B, although more intelligent than those in Factory C, yet lacked the continued educational facilities enjoyed by the workers in Factory A, and this may account for their intermediate attitude towards the amount of thought required by the work.

The relation between intelligence and the attitude towards the amount of thought required by work was also indicated by a direct comparison of (a) the degree of importance attached by different individuals to work requiring thought, and (b) their level of intelligence. For this comparison the workers were divided into three groups according to their attitude towards—

- (a) Opportunities to use your own ideas.
- (b) Work which makes you think.
- (c) Work which needs no thought.

The measure of this attitude was the number of times each of the above items was chosen in the list of "paired comparisons". Scores of 6-9, 3-5 and 0-2 were regarded as indicating much, moderate, and little importance respectively. The results so obtained are given in Table XX.

TABLE XX.—*Relation between intelligence and amount of importance attached to work requiring thought. (Combined results of all workers.)*

	<i>Times chosen.</i>	<i>No. in group.</i>	<i>Relative intelligence.</i>
Opportunity to use your own ideas ..	6-9 3-5 0-2	74 152 99	115.5 98.3 91.2
Work which makes you think ..	6-9 3-5 0-2	84 107 134	108.9 103.9 91.7
Work which needs no thought ..	6-9 3-5 0-2	28 68 229	70.2 82.9 108.0

The results are clear and consistent and as a corollary it would appear that satisfaction with simple forms of repetition work is inversely related to intelligence.

In this inquiry about two-thirds of the operatives preferred to have work requiring thought rather than work which needed no thought, consequently only one worker in three would tend to find satisfaction in simple repetitive operations.

B. CAUSES OF DISSATISFACTION

During the course of several industrial investigations it has become increasingly apparent that operatives employed on repetitive processes are frequently dissatisfied with features associated with the conditions of work. In order to obtain a numerical estimate of the different sources of dissatisfaction and of the extent to which they exist in different departments and factories, a list of items was given to each worker and she was asked to mark any item in the list which she particularly disliked. The percentage number of workers who recorded objections to the different items in the list is given in Table XXI.

TABLE XXI.—*Percentage of workers who were dissatisfied with particular factors connected with the conditions of work.*

	Factory			All workers.
	A.	B.	C.	
1. Noise	56	26	42	43
2. Room too hot or too cold	52	69	38	54
3. Waiting for work	73	82	88	79
4. Present hours of work	6	2	57	18
5. Little chance of promotion	35	22	35	31
6. Unsuitable working companions	25	28	46	31
7. Monotony of work	58	25	32	41
8. Present rate of payment	23	6	54	26
9. Trouble with material	42	53	77	54
10. Restrictions on talking	24	16	35	24
11. Work not interesting	35	19	24	27
12. Fatigue caused by work	47	42	58	48
13. Fear of unemployment	37	30	54	39
14. Forced to work too hard	26	14	50	28
15. Work too dull—not enough thought	39	17	22	28
Average	38	30	47	38
Number of workers	142	100	83	325

The results in general reflect the prevailing attitude towards the conditions of work in the three factories and give a fairly reliable indication of the causes of discontent. They show that, on the average, the greatest number of complaints was made by the workers in Factory C, while the most satisfied workers were those in Factory B. The differences between these two groups is statistically significant and the results confirm the general impression formed during a long and close acquaintance with these two firms.

The most frequent cause of dissatisfaction was waiting for work, and complaints about this form of enforced inactivity were received from 79 per cent. of the workers. Almost all the operatives were paid by results, and it is probably not surprising that stoppages

caused by lack of material should be one of the most potent causes of irritation and discontent. In some departments the time lost through waiting for work amounted to 10 or 12 per cent. of the scheduled hours of work.

A fairly similar and frequent cause of discontent was the trouble experienced with the material or the machine. This gave rise to complaints from 54 per cent. of the workers and was disliked because it interfered with productive activity and was responsible for reduced earnings. Examples of the nature and effects of troublesome material have already been given (page 52), while records of stoppages due to mechanical difficulties showed a loss in working time which varied from 2 to 10 per cent. in different processes.

The percentage of workers who complained of bodily fatigue was also fairly high, but this does not mean that fatigue was excessive or actually due to working activity. In reply to a further question, it was revealed that 27 per cent. of those who complained of fatigue "felt tired all over". Six of these workers stated that the fatigue persisted during the evening so that they were "too tired to dance". References to general fatigue were most frequent among the workers in Factory B and were particularly noticeable in the remarks of the operators of fast machines, who felt that "work needed more energy than we've got".

A further 38 per cent. said that they felt tired in the back, neck, and shoulders. The majority of these were employed on conveyors in Factory A, and the fatigue seemed to be due to the continued sitting posture. In Factories B and C most of the operatives stood while working and complaints of fatigue in the legs and feet were very numerous. "It's not the work itself but having to stand all day that is so tiring" was a fairly typical remark.

It is significant that only 3 per cent. of the workers included in this inquiry complained of fatigue in the hands and arms, which were the parts of the body actually used in the performance of work. Thus the fatigue experienced was chiefly static or concerned with the maintenance of posture, rather than dynamic or due to bodily movement. It is not easy to measure the actual effects of postural discomfort, but there can be little doubt that it impairs the attitude towards work and results in decreased production. Yet these effects could be reduced if not entirely removed by suitable changes in the form of work.

Some additional information on the subject of posture was obtained from the replies to the question "Which do you prefer (a) to stand while working, (b) to sit while working, or (c) to stand and sit alternately?" This question was given to the workers in Factories B and C and the preferences, expressed as a percentage of the number of individuals in each group, were as follows:—

	<i>Factory B.</i>	<i>Factory C.</i>
Stand all day.. .. .	18	11
Sit all day	0	0
Stand and sit alternately ..	82	89

Thus a large majority preferred to stand and sit alternately and the remainder preferred to stand. It should be mentioned that most of these operatives had to stand while working, and it is probable that a different distribution of replies would have been obtained from workers who had to sit all day. The results nevertheless express a felt need, and although it is often impracticable to arrange for operatives to stand and sit alternately, there is scope for improvement in this direction.

The attitude of the workers towards certain aspects of their physical environment is shown by the figures relating to noise and temperature. Approximately one-half of the workers complained about these features of their surroundings, though, as might be expected, the frequency varied according to the conditions of work.

As regards noise, the complaints were most numerous in Factory A and were less than half as frequent in Factory B, yet the noise in the latter factory was undoubtedly much greater than in the former. The reasons for this apparent contradiction are probably connected with the nature of the noise in the two factories and with personal susceptibility to noise.

In Factory A all the workers were employed on conveyors which were practically silent. The chief noise was made by the movement of trolleys and was consequently irregular both as regards time and loudness. In Factory B the noise was caused by machines used for wrapping and for making tin boxes and was both loud and continuous. In addition there was the noise made by the metal-wheeled trolleys passing over an uneven stone floor. It seems probable, therefore, that an intermittent and variable noise which is heard against a background of comparative silence is more noticeable and disturbing than a louder but more continuous noise. Apparently the workers tend to become adapted to a noise which is loud and continuous, but continue to be disturbed by a weaker and irregular noise.

This view is supported by the results obtained from the different departments in Factory B. The percentage of workers in each department who complained of noise was :—

B.1	..	..	..	12
B.2	..	..	..	34
B.3	..	..	..	36
B.4	..	..	..	32

The workers in B.1 were operating machines used in the manufacture of tin boxes, and the noise was continuous and deafening. In the other three departments the noise was much less intense and was a mixture of the continuous sound of wrapping machines and the irregular noise of trolleying. Yet in B.1 only 12 per cent. of the workers complained of noise while in the other departments the complaints were three times as numerous. It is a notable fact that in this inquiry, which included 15 groups of workers employed on varied types of work, the fewest complaints about noise were received from workers employed in an unusually noisy environment.

At the same time there is some evidence that when the noise is caused by trolleying, the disturbing effects bear a close relation to the amount of noise experienced. Thus the majority of the workers in Factory A were housed on three floors in the same building and the percentage of workers on each floor who complained of noise was—

A.1 (top floor)	..	..	..	..	32
A.2 (middle floor)	..	..	..	..	49
A.3 (ground floor)	..	..	..	..	59

In each case the workers were engaged in covering and packing chocolates from conveyors, but the amount of trolleying increased from the top floor downwards, and the same tendency was noticeable in the frequency of complaints.

The difference in sensitivity to noise shown by the workers in Factories A and B may also be connected with the fact that noises made by other people, especially when unexpected, are more disturbing than the anticipated noises caused by our own activity. The clatter made by the unexpected dropping of tins by another worker is much more shattering than the same noise made by oneself. Thus the complaints received from Factory A came from workers who were not responsible for the disturbing sounds, while each of the tin box workers in Factory B operated a machine which contributed a familiar quota to the total volume of noise.

As regards the question of personal susceptibility to noise, there is some reason to believe that the workers in Factory A were more sensitive than those in Factory B. This difference in sensitivity was probably conditioned by the type of work in the two factories. The conveyor work in Factory A was certainly more monotonous and less absorbing than the individual operations performed by the workers in Factory B. More than half the workers in the former factory complained of monotony while in the latter the number was reduced to one-quarter. There is little doubt that boredom increases sensitivity to distracting stimuli, so that workers who are bored are more likely to be aware of and irritated by extraneous noises than those who are interested in their work.

The preceding remarks refer to workers who definitely complained about noise, but it is important to remember that 59 per cent. of the operatives made no complaints and presumably they were not disturbed by the noisy environment. Clearly, therefore, the same noise may be disturbing to some individuals and not to others. There is some evidence¹ that personal susceptibility to noise is associated with the presence of nervous symptoms, and this may account for some of the differences observed in the present investigation. The reaction to noise, however, is obviously the resultant of many different factors, and their complete analysis still awaits investigation.

¹ Report No. 61 of the I.H.R.B., p. 28 *et seq.*

The results in Table XXI also show that the workers were fairly sensitive to the temperature of their surroundings. More than half the number stated that the rooms were either too hot or too cold, and in Factory B the frequency of complaints amounted to 69 per cent. The main room in this factory was a converted weaving shed with stone floor and roof lights. It was difficult to heat in winter and to cool in summer. Factory C, on the other hand, was a suitably heated and ventilated modern building, and here the percentage of complaints was only 38. The heating arrangements in Factory A were also fairly satisfactory and the higher number of complaints (52 per cent.) was due largely to some temperature experiments which were being made in one of the departments where the frequency rose to 71 per cent.

Much has already been written about the effects of temperature on the rate of working of operatives, but some results obtained in an extension of the present investigation were more detailed than usual and may serve to supplement existing knowledge on this subject.

The results refer to a machine-feeding process, and records of temperature and output were kept at hourly intervals throughout the day. The average output on six consecutive days when the mean temperature was 80.2° F. has been compared with that obtained when the mean temperature was 68.0° F. and the percentage decrease on the days of high temperature was—

<i>Worker.</i>										
<i>A.</i>	<i>B.</i>	<i>C.</i>	<i>D.</i>	<i>E.</i>	<i>F.</i>	<i>G.</i>	<i>H.</i>	<i>I.</i>	<i>J.</i>	<i>Average.</i>
14.8	18.7	7.1	13.7	9.8	12.6	6.3	15.2	10.9	8.4	11.7

Thus an average increase in temperature from 68.0° F. to 80.2° F. caused a corresponding decrease in output of 11.7 per cent. As might be expected, the difference in output on the days of high and moderate temperature became more marked as work proceeded throughout the day. Thus the percentage decrease in successive hours was—

8-9	9-10.	10-11.	11-12.	1-2.	2-3.	3-4.	4-5.
5.7	7.3	9.7	12.8	10.5	12.2	15.6	19.8

Considerable reductions in output were also recorded in one of the operations in Factory B when the temperature was unusually low. During a period of three weeks, when the average temperature was 52.3° F., the output was 21.4 per cent. lower than that recorded during the preceding and following period when the average temperature was 59.1° F.

Thus both high and low temperatures are unfavourable to output in simple forms of repetition work, and it is not surprising that numerous complaints were received from the workers exposed to such conditions.

Most of the remaining items in the list (Table XXI) are repetitions of the factors included in Table XVII and have already been considered.

C. OCCUPATIONAL PREFERENCES

In order to obtain an indication of the attitude of female operatives towards different types of work, each of the individuals included in the present inquiry was given a list of common occupations and was asked to rank them in order of preference. The results obtained are given in Table XXII.

TABLE XXII.—*Ranking of occupations according to order of preference.*

			Factory A.	Factory B.	Factory C.
Office work	..	..	3	4	3
Dressmaking	..	..	4	3	4
Waitress	..	..	6	5	6
Nurse	..	..	5	6	5
Domestic servant	..	..	7	8	8
Shop assistant	..	..	2	2	2
Laundry work	..	..	8	7	7
Present work	..	..	1	1	1

The results obtained from the three factories were in close agreement, and it is interesting to note that the first position was assigned to present work. Maybe the workers would "rather bear the ills they have than fly to others that they know not of," but the preference for present work may also be due in part to the conservative tendency which seems to be an important ingredient of human nature. Workers accustomed to a familiar routine often resent even minor changes in the conditions of work, and the prospect of a complete upheaval would be most disturbing.

Almost all the workers, however, had no experience of the other occupations given in the list, and their preferences give a fairly reliable indication of the general attitude towards these different types of work. The least attractive occupation was domestic service, while laundry work was a close competitor. The most popular type of work was that of a shop assistant, and this was followed by office work and dressmaking. The occupations of nurse and waitress occupied an intermediate position in the list.

3. BOREDOM AND ATTITUDES TOWARDS WORK

In order to ascertain the relation between boredom and attitudes towards work, the results obtained in the previous section have been compared with the boredom assessments described on page 4. The method adopted was to select from each factory group those individuals who experienced most boredom and to compare their opinions as expressed in (a) the "paired comparisons" test (page 44), (b) the frequency of complaints (page 56), and (c) occupational preferences (page 61), with the corresponding results obtained from an equal number of individuals at the other end of the boredom scale. A normal distribution divided into three class intervals would give 23, 16 and 13 individuals in each of the extreme categories for Factories A, B, and C respectively, and these numbers (except

when equal scores would have necessitated an arbitrary selection) have been used in the treatment which follows.¹

A. BOREDOM AND INDIVIDUAL PREFERENCES

The average number of times each item in the test of "paired comparisons" was chosen by the most and least bored workers in each of the factory groups is given in Table XXIII.

TABLE XXIII.—*Relative importance of factors associated with the conditions of work. (Comparison of results obtained from the most and least bored workers.)*

	Factory A.			Factory B.			Factory C.		
	Most bored.	Least bored.	Diff.	Most bored.	Least bored.	Diff.	Most bored.	Least bored.	Diff.
Opportunity for promotion	5.3	3.4	1.9	6.1	2.5	3.6	4.9	3.3	1.6
Security of employment	7.2	8.1	0.9	7.3	8.1	0.8	7.5	8.3	0.8
Good supervisor	4.5	5.7	1.2	5.9	6.3	0.4	6.2	6.4	0.2
Pleasant working companions	4.1	5.7	1.6	5.0	5.7	0.7	5.4	6.1	0.7
High wages	4.4	4.7	0.3	4.8	4.8	0.0	3.1	4.2	1.1
Short hours	3.3	3.4	0.1	2.3	3.0	0.7	2.0	2.2	0.2
Opportunity to use own ideas	5.3	3.4	1.9	4.8	2.5	2.3	4.7	3.0	1.7
Comfortable working conditions	5.4	6.0	0.6	4.8	6.6	1.8	6.2	6.4	0.2
Work which makes you think	5.0	2.5	2.5	4.3	2.1	2.2	5.1	1.2	3.9
Work which needs no thought	0.2	1.8	1.6	0.2	3.4	3.2	0.6	3.7	3.1

(Differences between means which exceed three times their probable error are printed in heavy type.)

The results show that the bored workers attached relatively more importance to opportunities for promotion, to opportunities to use their own ideas, and to work which makes them think, but less importance to work which needs no thought. In other words, they felt more strongly the urge to forge ahead and the need of food for thought. Conversely, the individuals who were most satisfied with simple forms of repetition work were those who lacked ambition and were mentally lazy or dull.

The results support the view already expressed regarding the relation between intelligence, the desire for promotion, and predisposition to boredom (pages 19 and 46), and the procedure may serve as a useful supplement to the methods employed in vocational selection and guidance.

B. BOREDOM AND DISSATISFACTION

A similar method of treatment was applied to the objections recorded to particular factors associated with the conditions of work (Table XXI). The results so obtained are given in Table XXIV.

¹ The actual numbers included in each group were—

Factory A: Most bored = 27; least bored = 27.

" B: " " = 17 " " = 17.

" C: " " = 13 " " = 13.

TABLE XXIV.—Percentage of individuals in the groups of (a) most bored, (b) least bored workers who were dissatisfied with particular factors associated with the conditions of work.

	Factory A.			Factory B.			Factory C.		
	Most bored.	Least bored.	Diff.	Most bored.	Least bored.	Diff.	Most bored.	Least ^a bored.	Diff.
Noise	70.4	51.8	18.6	55.0	15.0	20.0	53.3	33.3	20.0
Temperature ..	37.0	51.8	14.8	75.0	70.0	5.0	40.0	33.3	6.7
Waiting for work ..	55.6	74.1	18.5	85.0	80.0	5.0	86.6	80.0	6.6
Present hours of work	11.1	0.0	11.1	5.0	0.0	5.0	13.3	7.3	6.0
Little chance of promotion ..	55.6	18.5	37.1	50.0	5.0	45.0	53.3	20.0	33.3
Unsuitable working companions ..	33.3	33.3	0.0	20.0	25.0	5.0	46.6	40.0	6.6
Monotony of work ..	96.3	14.8	81.5	60.0	10.0	50.0	73.3	20.0	53.3
Present rate of payment ..	29.6	18.5	11.1	5.0	5.0	0.0	33.3	26.7	6.6
Trouble with material	40.7	59.3	18.6	55.0	15.0	40.0	80.0	73.3	6.7
Restrictions on talking	22.2	25.9	3.7	15.0	10.0	5.0	46.6	26.7	19.9
Work not interesting ..	55.6	18.5	37.1	50.0	10.0	40.0	53.3	13.3	40.0
Fatigue caused by work ..	77.8	22.2	55.6	35.0	10.0	25.0	60.0	26.7	33.3
Fear of unemployment	18.5	25.9	7.4	25.0	10.0	15.0	60.0	46.6	13.4
Forced to work too hard ..	37.0	7.4	29.6	35.0	5.0	30.0	66.6	33.3	33.3
Work too dull—not enough thought ..	81.4	14.8	66.6	25.0	0.0	25.0	55.1	33.8	21.3
Average ..	48.1	29.1	19.0	38.3	14.6	23.7	55.1	33.8	21.3

(Differences between means which exceed three times their probable error are printed in heavy type.)

The results show that the frequency of complaints received from the bored workers was greater than the number made by the least bored members in each group. In particular, the bored workers complained more frequently about the lack of opportunities for promotion, monotony of work, fatigue, severity of work, and the small amount of thought required by work. A higher proportion of the bored group also tended to find fault with noise and with the material used in the industrial process. Thus boredom increases sensitivity to certain features associated with the type and conditions of work and consequently is an important factor in the promotion of dissatisfaction and unrest.

A further analysis of the results obtained from two groups of workers in Factory A who were employed on the same kind of work revealed some interesting differences. One of these groups (40 workers) experienced more boredom and were more dissatisfied than the other (60 workers), yet there seemed to be no objective reason for these differences. During the interview with these workers it became apparent that environmental conditions were the chief cause of the difference in question, and the following selection from records of spontaneous comments indicate the nature and source of discontent in the dissatisfied group.

A.I. Dislikes the room. Says "It gets on top of you. I feel as if I should like to fling everything away from me. I feel altogether different in the other rooms."

- A.2. "I like the work very much but it's the room I don't like. The low ceiling makes the room stuffy and makes one feel that one can't breathe. It's just the room that gets on your nerves."
- A.3. Likes the work but says "The room is very depressing. It seems on top of you and you feel stifled." When questioned, she said that the word "stifled" was not merely descriptive; she really thinks the atmosphere is bad.

These remarks, which are only a small sample of an almost unanimous expression of the same attitude, show quite clearly that the chief cause of dissatisfaction in this department could be ascribed to environmental conditions. The ceiling was rather low, and although the lighting was adequate for the performance of work, the room had a dull appearance. While these conditions were certainly no worse than those in many other factories, they were inferior to the other departments in Factory A, and the occasional transfer of operatives from one department to another served to intensify the relative merits and defects of the different surroundings.

The complaints about the stuffy atmosphere, which the workers ascribed to the low ceiling, are interesting. This complaint was made spontaneously by 53 per cent. of the workers, and a still larger proportion would doubtless have given similar replies if they had been directly examined on this point. In the opinion of the investigator the atmosphere was fresher than in the other departments, and it seems probable that the complaint about stuffiness was of the nature of a psychological illusion. It is well known, for instance, that the hand feels warmth when placed on a resistance coil carrying an electric current in series with a lamp, and illusory warmth is experienced when the experiment is repeated so that, unknown to the subject, the coil is cut out of the circuit but the lamp is illuminated as before. Thus it seems probable that an illusory feeling of stuffiness and physical oppression was produced by the unpleasant awareness of the low ceiling, but the effects on the workers were nevertheless very real.

C. BOREDOM AND OCCUPATIONAL PREFERENCES

The application of the same method of treatment to the occupational preferences (page 61) of the most and least bored workers in each factory group yielded the results given in Table XXV.

TABLE XXV.—Mean rank assigned to each occupation by the most and least bored members in the factory groups. (1=first choice.)

	Factory A.			Factory B.			Factory C.		
	Most bored.	Least bored.	Diff.	Most bored.	Least bored.	Diff.	Most bored.	Least bored.	Diff.
Office work ..	2.6	4.4	1.8	3.1	4.7	1.6	2.5	4.2	1.7
Dressmaking ..	4.0	3.7	0.3	3.5	3.2	0.3	3.8	4.3	0.5
Waitress ..	6.2	6.0	0.2	5.0	6.3	1.3	5.7	6.8	1.1
Nurse ..	3.5	5.0	1.5*	4.6	6.2	1.6	3.9	5.4	1.5*
Domestic servant ..	7.3	7.2	0.1	6.9	7.4	0.5	7.1	7.7	0.5
Shop assistant ..	3.1	2.9	0.2	2.6	3.4	0.8	2.1	2.7	0.6
Laundry work ..	7.6	7.7	0.1	6.5	5.6	0.9	7.2	6.4	0.8
Present work ..	3.7	1.8	1.9	3.5	1.7	1.8	3.9	1.9	2.0

(Differences which exceed three times their probable error are given in heavy type.)

* Barely significant.

Thus the individuals who were most bored by factory repetition work expressed a stronger preference for office work and nursing, but were relatively less satisfied with their present work than the least bored members of the groups.

III. DISCUSSION OF RESULTS

The general impression formed as the result of this inquiry is that repetition work contains little that is inherently interesting or satisfying. Boredom and dissatisfaction were fairly common and there was often an appreciable gap between personal desires and their satisfaction in work. This is probably not surprising since interest in work depends fundamentally upon its ability to satisfy instinctive tendencies or some acquired disposition based upon these tendencies, and repetition work is a somewhat barren field for this purpose. It is only a means to a number of ends, and, unlike the activities of the skilled craftsman or scientist, is seldom an end in itself.

Activities which are intrinsically distasteful may, of course, become comparatively pleasant when linked with a personal need. All industrial work possesses this feature since it provides the money for the necessities and some of the luxuries of life. The fact remains, however, that repetition work as a whole fails to arouse interest and hold attention, so that thoughts are often directed to the distasteful aspects of work.

This connection between thought and work provides a clue to the nature and causes of boredom. Thus boredom arises when the mental processes involved in work fail to occupy and to hold the focus of attention. If the mind is unable to find an effective substitute it tends to be directed to the unsatisfying features of work and the individual becomes bored. This experience, which is mental in origin, naturally induces an unpleasant emotional state or mood, and results in a heightened sensitivity to unfavourable elements associated with the conditions of work. Minor disturbances and distractions which would pass unnoticed by the interested worker become exaggerated and intensify still further the emotional background of discontent. One of the most important of the human problems in industry is the possibility of diverting attention from the monotony of work, and although the operatives adopt many devices for this purpose, they receive little assistance from those who are responsible for working conditions.

The experience of boredom is dependent on many factors, which may be either subjective or objective. It is, in the first place, closely related to personal characteristics and tendencies, since some individuals may be bored by a process which is interesting to others. The discovery of the particular characteristics which make the individual susceptible to boredom is accordingly a matter of some importance and is a necessary prelude to vocational guidance.

The results of this and of previous investigations show that some individuals prefer work which needs no thought or responsibility, and that these individuals are usually below the average in intelligence. Conversely, severe boredom is usually found associated with more than average intelligence. At the same time there is reason to believe that the relation between boredom and intelligence may be due partly to the fact that the more intelligent tend to have an educational and social history which leads them to consider themselves "too good for the job". There are also indications that a similar attitude may be produced by continued education, especially when combined with superior social status, in the absence of any marked degree of intelligence. It seems highly probable, therefore, that boredom is most likely to arise when superior intelligence is associated with a superior attitude towards the type and conditions of work. There is not the least doubt that large numbers of industrial operatives possess more intelligence than is necessary for the work. The numbers required for low-grade repetition work will also probably continue to increase and the demand for suitable operatives will still further outstrip the supply. This makes it all the more necessary to consider the possibilities of neutralising boredom by the creation of additional interests during work and the development of compensating activities outside work.

Closely connected with the question of intelligence is the amount of thought required by work and the ability to indulge in other forms of mental activity. Some individuals are able to work almost as automatically as they walk. Others find that work demands a considerable amount of attention and they are less able to separate thought from work. The amount of boredom experienced by both types depends upon the nature of the thought processes. Thus the automatic worker is not bored when her mind is full of the dance which she enjoyed or hopes to enjoy, i.e. when a powerful group of interests or instincts is receiving satisfaction if only in retrospect or in phantasy. She is bored when there is nothing to distract attention from the monotonous conditions of work. Outside interests, whether promoted by the firm or induced by personal desires, are the most satisfying features in the lives of these workers and form the chief food for thought during work.

The boredom experienced by the individual who is unable to detach the mind from work will depend upon the completeness of this process. If her capacity for mental detachment is slight so that work occupies the focus of attention, then boredom is not likely to arise. If, however, the work makes only partial or intermittent demands on attention so that it interferes with continuous thought, the experience of boredom may be severe. Thus individual differences in the ability to mechanise work help to account for the varying degrees of boredom experienced by workers on the same process.

The indulgence in free or directed thinking which seems to be usual in most individuals employed on repetition work will be

satisfying or otherwise according to the nature of the thought processes. A large majority of the workers included in this inquiry stated that their thoughts were pleasant, and instances of morbid obsessions or anxieties were somewhat rare. It is, however, highly probable that the more intelligent workers, who were found to be dissatisfied with their work and lack of prospects, would tend to have their thoughts coloured by these features, and the resulting state would be closely akin to boredom if not identical with it. Thus the relation between intelligence and boredom is by no means simple, yet for practical purposes it is useful to know that the most bored members of a group are regularly assessed more highly for intelligence than those who are least bored.

There is also little doubt that temperamental tendencies are important determinants of suitability for repetition work, but, like intelligence, the relationship is complex. The evidence so far collected tends to show that the extroverted type of individual is likely to experience more boredom than the introverted type, but this again may be disturbed by particular features associated with the conditions of work. Thus the introvert, providing the conditions are favourable to a separation of thought from work, is able to find relief in reverie or direct thinking, while the extrovert, who is more concerned with external reality, uses talking as an effective antidote to boredom. If work interferes with thought and at the same time is insufficient to occupy the mind, or if talking is discouraged by the management, then both the introvert and the extrovert are likely to suffer from boredom.

Finally, some individuals seem to have strong constructive tendencies while others are content to repeat the same simple cycle of movements. The majority, however, fall within the former category and drift into repetition work because no other type is available. If they were free to choose there is not the least doubt that repetition work would have few adherents; consequently it is most important that it should be made as attractive as possible.

The experience of boredom is also a function of the type of work, since the same individual may be bored by one process but not by another. In this investigation it was found that the most satisfying processes were those which involved the use of creative or constructive ability such as the production of samples for display purposes. This type of work appeals to deep-seated tendencies in human nature and results in an attractive product which can be contemplated with pleasure and pride. Yet creative work when it becomes repetitive is apt to be tedious. Thus most people would be inclined to say that the work of the potter is interesting, but if he repeatedly makes the same kind of vase the process may become monotonous and dull. The simple and more uniform activities of the bricklayer, on the other hand, may continue to give satisfaction because of the growing and visible results of his constructive efforts. In industry, however, there is little scope for the enjoyment which accompanies creative work, and the tendency is towards a further simplification of processes. From the

standpoint of monotony this tendency may not be altogether undesirable, since a reduction in the amount of attention and thought required by work automatically increases the possibilities of indulging in reveries, talking, and other similar antidotes to boredom.

Although many types of repetition work require a minimum of thought, others, such as fast machine-feeding, demand constant attention on the part of the operator. It is by no means uncommon to find an individual sliding articles on to a fast-moving belt and at the same time keeping a watchful eye on the intricate mechanism. Under such conditions the operator has little time for any kind of mental activity which is not directly connected with the functioning of the machine. Time appears to pass quickly and boredom is seldom severe or sustained. The work is fatiguing rather than boring and gives rise to different problems. At the other extreme is the worker employed in the leisurely process of placing an article at regular intervals on a moving belt. It is the type of work which induces reverie or sleep, and if this is impossible the monotonous nature of the process is likely to occupy a focal position in the mind.

A significant feature of the results obtained in this inquiry was the notable change in attitude produced in the same operator by slight differences in the type of work. Even the packing of articles in boxes of different size gave rise to marked differences in satisfaction and pleasure in work. The common practice in industry is to assign a worker to any repetitive process where a vacancy exists and the individual is expected to take it or leave it. This hit or miss method has little to commend it, yet in the present state of our knowledge it cannot be wholly condemned. The detrimental effects could, however, be greatly reduced by ascertaining the desires and preferences of an individual and giving her a trial on different types of work. This procedure would necessarily involve a slight initial loss in output, but the final result would be an efficient and contented worker.

Boredom is also related to the conditions of work, and these, unlike the type of work, are usually more easily modified and controlled. It is, in the first place, a function of the duration of activity, and any decrease in the daily or weekly hours of work will automatically reduce the amount of boredom experienced by the workers. Changes in this direction, however, are likely to be slow, and it is more profitable to consider the distribution of the hours of work throughout the day and week.

In one of the factories included in this investigation (Factory C) the hours of work were from 8 to 12.45 and from 2 to 6.15, but no work was done on Saturday morning. In the others the operatives worked from 8 to 12 (including Saturday) and from 1 to 5. Although the processes in Factory C were more interesting and attractive than those in the other factories, the workers complained more frequently about the conditions and, in particular, there was a significant increase in the number who were dissatisfied with the

hours of work. Very few individuals are able to maintain interest and activity over an unbroken period of $4\frac{1}{2}$ hours, and from the standpoint of efficiency and contentment there is much to be said, in favour of the shorter spell of work. A spell of $4\frac{1}{2}$ or 5 hours, or even one of four hours' duration, should, whenever practicable, be broken up into two or more parts by means of rest-pauses. There is plenty of evidence to support this procedure, yet many employers are reluctant to give it a trial. It changes the outlook of the workers by providing one or more intermediate aims and consequently shortens the apparent duration of work.

Although an authorised rest has certain psychological advantages, its value is increased when it is also used as an interval for refreshments. Many of the operatives stated that they had little or no breakfast before coming to work and consequently had to wait five or six hours for the first substantial meal of the day.* It is not surprising that a proportion of the workers were distracted by hunger and "longed for dinner time". For this reason a break of ten minutes for rest and refreshment after work has been in progress for $1\frac{1}{2}$ to 2 hours is desirable. A few firms have adopted this procedure with satisfactory results, and the scheme is worthy of a wider application. In such cases the introduction of a second rest (without refreshment) after a further period of $1\frac{1}{2}$ to $1\frac{1}{2}$ hours would often stimulate activity and increase pleasure in work.

The introduction of suitable rests and the provision of refreshments are frequently regarded as attempts to pamper the workers. On the contrary they cater for definite psychological and physiological needs and provide an economic method of combating the effects of exposure to long periods of uninteresting work. It is useless to argue that the workers themselves should obtain enough rest and food before coming to the factory. The fact remains that many of them are inadequately prepared in this respect and a wise employer will attempt to mitigate the effects.

The relation between boredom and the conditions of work was also shown by the results obtained from two groups of workers in Factory A who were employed on the same process in different departments. One of these groups was more bored than the other and there was unmistakable evidence that the difference was due to environmental conditions. In the one case the room was dull and complaints were numerous, while in the other it was bright and

* Haggard and Greenberg† claim that the frequency of meals—the daily food remaining the same in quantity and quality—is an important controlling factor in determining the rise and fall both of muscular efficiency and industrial output. According to them, muscular efficiency is lowest before breakfast, a time when everyone is most rested and fatigue in the ordinary sense should be absent. Muscular efficiency remains at this level if no breakfast is taken; it rises after a meal, but falls to the pre-breakfast level within a period of $2\frac{1}{2}$ –4 hours. The authors accordingly recommend that the same amount of food should be taken at more frequent intervals.

† "Diet and Physical Efficiency," by H. W. Haggard and L. A. Greenberg. Humphrey Milford, Oxford University Press, 1935.

spacious and complaints were relatively few. Although it is improbable that the inferior surroundings were the primary cause of boredom and discontent, they undoubtedly intensified existing tendencies. Conversely, it can be stated with assurance that bright and attractive surroundings help to check the onset of boredom and to reduce its effects. They do so by providing a useful form of distraction for roving thoughts and by inducing a cheerful mood which makes it more difficult for boredom to find a place. There can be little doubt that the modern factory, with windows instead of walls, a spacious interior, and pleasant colour schemes, has psychological effects which are by no means negligible. The subtle but important influence of light and colour upon disposition and mood have long been recognised, but the measurement of their effects still awaits investigation.

Finally, the possibility of reducing boredom by means of gramophone music deserves serious consideration. In this inquiry it was found that familiar types of dance music, with their well-marked rhythms and distinctive melodies, were the most popular and effective stimulants to production and pleasure in work. No attempt was made to study the isolated effects of rhythm and melody, but it is probable that both contributed to the results obtained.

It is generally agreed that rhythm induces a pleasant emotional effect which acts as a more favourable background to production. It also tends to dictate the rate of working, especially when the operation is habitually performed in a rhythmical manner. Just as a military band on the march tends to impose the same rate of walking on all within range of the music, so a pronounced rhythm in industry, whether produced by a gramophone or machinery noises, may be equally tyrannical in its effect. The influence of such a rhythm may be good or bad according to its relation to the capacities of the individuals concerned. If greatly in excess of the natural rate of working of the operative, it will produce discomfort, fatigue, or excessive strain. If much below this rate it may act as an unwelcome brake and increase the monotony of work. Clearly, the most suitable rhythm will conform fairly closely to the habitual speed employed by the operative in the performance of work. Thus a rhythm which is pleasant and stimulating to one worker may be uncomfortable and disturbing to another, and the different responses to the effects of music observed in this experiment may be due partly to this cause. It will be remembered, however, that the process was somewhat varied and irregular and provided little opportunity for sustained rhythmic movement. Thus it is highly probable that the observed increase in output and greater pleasure in work were due chiefly to the distracting effects of music and to the pleasant emotional experiences which it aroused. The knowledge that music would be played at specified times within the spell of work created a more favourable outlook so that the operatives as a whole began the day in a more buoyant and enthusiastic frame of mind. Their thoughts, instead of being directed to the prospect of a long period

of somewhat monotonous activity, were diverted by the anticipation of music. The mind became more or less detached from work, and this detachment was practically complete during the actual music period. Work at this stage was almost automatic and was usually free from the inhibiting effects of boredom. Time seemed to pass quickly and pleasantly and the workers were often agreeably surprised that so much had been done in apparently so short a time. The music provided the necessary mental distraction while productive activity was facilitated or at least remained unimpaired.

It will be obvious, of course, that the effects of music on output and feelings will vary according to the nature of the industrial process. In all forms of simple repetition work there can be little doubt that the effects will be beneficial, and since this type of work is very common in industry, there is clearly plenty of scope for its use. Several industrial processes, however, require concentrated thought for their successful performance, and in such cases the playing of music would be disturbing. These unsuitable conditions are probably less numerous than is usually believed, and it is probable that music would be objectionable only in those occupations which require intense concentration and creative thought.

There seems to be little doubt that music will be increasingly used as a means of making work more attractive and enjoyable. In most cases it will also result in increased output, but even if production should remain unaffected, the benefits derived by the operatives would still justify its adoption as an accompaniment to work.

Those employers who are inclined to introduce music into their factories should begin with a varied programme of popular dance tunes. In order to avoid staleness these should be changed at weekly intervals, and in most cases a lending library is the most suitable and economical for this purpose.

The most effective duration and distribution of the playing periods for each factory will probably have to be determined by experiment because of the existing variations in the type and conditions of work. This, however, is a simple matter, but it may be said with confidence that the total duration should be not less than one hour or more than two hours in each spell of work. If the shorter time is adopted, it should be introduced as a single period about the middle of the work-spell; otherwise the playing of music during alternate half-hours would probably be the best arrangement.

Whatever methods may be adopted for the purpose of alleviating boredom, it must be recognised that, for many individuals, a certain amount of boredom is an inescapable condition of modern factory life. Probably the most hopeful outlook lies in the direction of an improved social system which would compensate for its endurance by shorter working hours combined with greater opportunities for self-expression in the form of cultural and recreational pursuits. At the same time it must be remembered that many individuals tend to become adapted to monotonous conditions of work. Thus several of the workers, when questioned on their feelings and

attitudes, stated that they had ceased to think about such matters and accepted them as a customary feature of their daily life. A common type of remark was :—

“I have done this all my life and I shouldn't like to do anything else now. I used to feel that I should like another job, but this one seems to have got me and I am quite content.”

This philosophical resignation to prevailing conditions which seems to be a characteristic of advancing age is probably accelerated by the dulling effects of monotonous work. It is a form of adaptation which prevents conflict and promotes a peaceful frame of mind. How far it is desirable is, of course, another question.

The procedure adopted in this inquiry serves many useful purposes and could be applied with advantage to all industrial workers. It is capable of revealing the causes of dissatisfaction and makes the operatives feel that they are not merely units in the industrial machine, but living personalities whose interests and desires are worthy of consideration by the management. The duties of the employment manager (or preferably someone not in a managerial position), could easily be extended to include a periodic interview with the workers in the factory. He would act as a receptacle for suggestions and complaints and serve as a channel of communication between the operative and the employer. Above all, he would help to restore the “human touch” which is in danger of becoming extinct in large industrial concerns.

IV. SUMMARY

The more important results obtained in this investigation may be summarised as follows.

1. Boredom was a fairly common experience among the operatives included in this inquiry, but individual differences in susceptibility to boredom were very marked. While some workers were seldom free from boredom, others were rarely troubled and showed a definite preference for monotonous repetition work.

Of the 355 workers who were assessed for boredom, 3 per cent. showed practically no symptoms, 33 per cent. were slightly affected, 38 per cent. experienced a moderate degree, 23 per cent. suffered severely, and 3 per cent. were seldom free from boredom.

2. Boredom was fairly frequent during the first hour of the spell of work, was still more common during the second hour, but decreased considerably as the end of the spell drew near. This implies that additional incentives are most necessary during the early and middle parts of the work-spell.

3. In order to counteract the onset of boredom the operatives adopted several devices which served the purpose of detaching thought from the monotonous aspects of work. The most usual expedient was to talk or sing, but several individuals sought relief by working more quickly or by thinking of other things. The

majority of those who indulged in reveries stated that they were pleasant and satisfying rather than pessimistic and disturbing.

4. A high potential capacity is not the only criterion which should be used in selecting operatives for repetition work ; an equally important factor is relative immunity from influences which prevent the worker from making full use of her potentialities. The extent of these influences may be shown by the difference between the maximum and average rate of working, while their nature may be deduced from the shape of the output curves.

The application of these criteria to the results obtained showed that (a) boredom depresses the rate of working, (b) workers of inferior capacity tend to work more closely to their maximum than do workers of superior capacity, and (c) the rate of working when learning an industrial process is reduced when the worker is bored.

5. The amount of boredom experienced is dependent on personal characteristics and seems to be associated with (a) intelligence, (b) inability to mechanise simple manual processes, (c) temperamental tendencies which find satisfaction in active contact with the external world (extrovert) rather than in phantasy (introvert), and (d) a desire for creative as distinct from repetitive work. These characteristics may be detected by means of suitable tests.

Performance-tests of short duration are also capable of revealing individual differences in likes and dislikes which were found to be important factors in determining efficiency and pleasure in work.

6. Boredom and discontent are also closely connected with the type of work, and even slight differences between one process and another may have widely different effects on the operative.¹ Efficiency and contentment may be increased by giving the beginner a short trial on different types of work and assigning her to the process which she likes best.

7. Gramophone music is an effective antidote to boredom. During the time when music was played the increase in output varied from 6·2 to 11·3 per cent., while the total daily output showed an increase of 2·6 to 6·0 per cent.

The greatest increase in output was obtained when music was played for a period of 75 minutes about the middle of the work-spell, but the most popular arrangement was provided by the introduction of music during alternate half-hours throughout the work-spell.

Different types of music were found to have slightly different effects on output. The average difference was 5·6 per cent., but in individual cases it approximated to 10 per cent.

Although most of the workers responded to the music by an increased output, which in some cases was very marked, there were isolated instances in which the music seemed to have little or no effect on production. The effect in general seemed to be directly related to the amount of boredom experienced by the different individuals.

¹ cf. Report No. 45 of the I.H.R.B. (p. 40) for interesting confirmatory results.

8. A ranking according to importance of a selected number of factors associated with the conditions of work gave the following results :—

1. Security of employment.
2. Comfortable working conditions.
3. Pleasant working companions.
4. Good supervisor.
5. Opportunities for promotion.
6. High wages.
7. Opportunities to use own ideas.
8. Work which needs thought.
9. Short hours.
10. Work which needs no thought.

The bored workers attached relatively more importance to opportunities for promotion, to opportunities to use their own ideas, and to work which makes them think, but less importance to work which needs no thought. An increasing preference for work requiring thought was also associated with an increasing level of intelligence.

9. The most frequent causes of discontent (as revealed by the number of objections recorded to particular items in a given list) were waiting for work, troublesome material, atmospheric conditions, fatigue, monotony, and noise. The greatest number of complaints was made by those individuals who were assessed most highly for boredom, consequently it seems probable that boredom increases sensitivity to objectionable features associated with the conditions of work. In particular, boredom and discontent were intensified by inferior environmental conditions.

10. The proportion of workers who complained of fatigue was fairly high (49 per cent.), but it is significant that only 3 per cent. referred the fatigue to the parts of the body actually used in the performance of work. The fatigue experienced was mainly static, or concerned with the maintenance of posture, rather than dynamic, or due to bodily movement.

APPENDIX

A.—*Replies to questions (page 4) obtained from two chocolate packers*

- | <i>Worker C.8</i> | <i>Worker C.15</i> |
|---|---|
| 1. (a) Fed up when I come in the morning. | (a) No difference—loves the work. |
| (b) After 11 because it's near the end. | (b) Once I start I can't stop. |
| (c) 4.30–6.15. Only 1½ hours to go. | (c) Always the same. |
| (d) 8–11. Fed up. | (d) No difference. |
| (e) 2–4. Don't want to go back to work. | (e) 2–2.30. Haven't got over dinner. |
| 2. Don't like anything about it. | 2. Very interesting work. |
| 3. The work is awful. Would like to be in Despatch Dept. More varied and meet different people. | 3. Work very interesting and wouldn't like to do anything else. |
| 4. (a) 11.30–12.45. Nearly time to go home. | (a) 8–11.30. Most interested. |
| (b) 4.30–6.15. Soon be free. | (b) 2.30–5.30 Don't notice time. |

A.—Replies to questions (page 4) obtained from two chocolate packers—contd.

- | <i>Worker C.8</i> | <i>Worker C.15</i> |
|---|--|
| (c) 8–11. Come back to same old thing. | (c) 12–12.45. Little tired. |
| (d) 2–4.30. Bored and fed up. | (d) Never think of time. |
| 5. (a) Bored nearly all the morning. | (a) Never bored. |
| (b) Bored nearly all the afternoon. | (b) Bored a little from 2–2.30. |
| (c) Morning most boring because you have all the day in front of you. | (c) Both the same. If you are happy and interested you don't feel bored. |
| 6. Often feel like stopping work and would like to clear out. | 6. Never feel I want to stop. |
| 7. Prefer a job where you have to think and plan. More to do. | 7. Like a job which I know. |
| 8. Would like to be in Despatch Dept. | 8. Very satisfied with present job. |
| 9. Prefer work which needs thought. | 9. Likes a free and easy job. |
| 10. When bored I sing and talk. | 10. Never bored and time doesn't drag. |
| 11. Prefer more varied and difficult work. | 11. Prefer straightforward work. |
| 12. Would like to change—not so monotonous. | 12. Don't want to change as I like my work. |
| 13. Like nothing about my work. | 13. Like everything about my work. |

There can be little doubt that worker C.8 was extremely bored by the conditions of work, while worker C.15, who was employed on the same process, found the work interesting and satisfying.

Although these are extreme examples of the presence and absence of boredom and provide results which are easily assessed, the treatment of the data obtained from other workers presented little difficulty since the classification adopted was on a wide and generous scale.

B.—Percentage of workers in each of the three Factories A, B, and C who found time to pass (a) most quickly and (b) most slowly during each half-hour of the day. (Curves given in Fig. 1)

Time.	(a) Most quickly.			(b) Most slowly.		
	A.	B.	C.	A.	B.	C.
8.0 – 8.30	33.8	20.6	34.6	24.6	38.2	29.6
8.30– 9.0	34.5	20.6	34.6	26.0	39.2	33.3
9.0 – 9.30	31.7	14.7	28.4	28.9	38.2	30.9
9.30–10.0	28.0	14.7	34.6	20.4	41.1	29.6
10.0 –10.30	29.5	24.5	44.5	19.7	33.3	24.7
10.30–11.0	32.4	31.4	48.1	19.0	25.5	17.3
11.0 –11.30	33.1	58.8	53.1	17.6	17.6	18.5
11.30–12.0	46.5	58.8	55.6	25.4	19.6	22.2
12.0 –12.30	40.8	—	45.7	26.8	—	34.6
12.30–12.45	—	—	43.2	—	—	32.1
1.0 – 1.30	—	22.5	—	—	35.3	—
1.30– 2.0	21.8	22.5	—	33.8	37.2	—
2.0 – 2.30	23.9	10.8	29.6	40.8	40.2	33.3
2.30– 3.0	23.9	13.7	30.9	47.1	38.2	33.3
3.0 – 3.30	21.8	18.6	46.9	32.4	36.3	29.6
3.30– 4.0	32.4	20.6	53.1	19.0	35.3	28.4
4.0 – 4.30	52.8	56.9	61.7	11.3	13.7	21.0
4.30– 5.0	54.2	57.8	60.5	16.9	11.8	16.0
5.0 – 5.30	—	—	42.0	—	—	24.7
5.30– 6.0	—	—	37.0	—	—	34.6
6.0 – 6.15	—	—	30.9	—	—	32.1

C.—The questions given to the workers during the Knotting and Insertion Tests were of the following type

1. Repeat the numbers from 0 to 10 backwards.
2. Which letter of the alphabet comes before R, L, etc. ?
3. Add together 27 and 35 and take the result from 89.
4. If Brown runs faster than Jones and Jones runs faster than Smith, who runs the fastest ?

D.—Test of Introversion—Extroversion

1. Which do you prefer—
 - (a) to be by yourself a great deal ?
 - (b) to be with others about half the time ?
 - (c) to be seldom alone ?
2. When people are watching while you work—
 - (a) does it make you very nervous ?
 - (b) does it have no effect ?
 - (c) do you work much better ?
3. What kind of amusements do you like—
 - (a) exciting amusements ?
 - (b) quiet amusements ?
 - (c) or do you enjoy exciting and quiet amusements equally well ?
4. Which do you like best—
 - (a) to be in a crowd whenever you can ?
 - (b) to keep away from crowds whenever possible ?
 - (c) or does it make little difference whether you are in or away from a crowd ?
5. When you are with a number of people (e.g. party, games, etc.)—
 - (a) would you enjoy being the leader ?
 - (b) would you try to avoid being the leader ?
 - (c) or have you no particular desire either way ?
6. Do you prefer to express yourself in—
 - (a) writing ?
 - (b) speaking ?
 - (c) or have you no preference ?
7. If you were on a holiday where would you enjoy yourself most—
 - (a) in a quiet secluded place ?
 - (b) at a lively seaside place ?
 - (c) or don't you mind whether the place is quiet or lively ?
8. When you have to do something—
 - (a) do you generally act quickly on the spur of the moment ?
 - (b) do you like to think a long time before acting ?
 - (c) do you sometimes act quickly and sometimes after much thought ?
9. How do you prefer to spend your odd moments—
 - (a) in reading and planning ?
 - (b) in games and sports and active amusements ?
 - (c) both kinds equally well ?

E.—Paired-comparison test

- | | |
|---------------------------------------|------------------------------------|
| 1. Opportunity for promotion. | Security of employment. |
| 2. Good supervisor. | Pleasant working companions. |
| 3. High wages. | Short hours. |
| 4. Opportunity to use your own ideas. | Comfortable working conditions. |
| 5. Work which makes you think. | Work which needs no thought. |
| 6. Security of employment. | Good supervisor. |
| 7. Pleasant working companions. | Opportunity for promotion. |
| 8. Comfortable working conditions. | High wages. |
| 9. Short hours. | Opportunity to use your own ideas. |
| 10. Work which needs no thought. | Opportunity for promotion. |
| 11. Security of employment. | Work which makes you think. |

E.—Paired-comparisons test—contd.

- | | |
|--|------------------------------------|
| 12. Good supervisor. | Short hours. |
| 13. Pleasant working companions. | High wages. |
| 14. Comfortable working conditions. | Work which makes you think. |
| 15. Opportunity to use your own ideas. | Work which needs no thought. |
| 16. Opportunity for promotion. | Good supervisor. |
| 17. Security of employment. | Pleasant working companions. |
| 18. High wages. | Opportunity to use your own ideas. |
| 19. Short hours. | Comfortable working conditions. |
| 20. Work which makes you think. | Good supervisor. |
| 21. Opportunity for promotion. | Comfortable working conditions. |
| 22. Opportunity to use your own ideas. | Security of employment. |
| 23. Comfortable working conditions. | Work which needs no thought. |
| 24. Pleasant working companions. | Short hours. |
| 25. High wages. | Work which makes you think. |
| 26. Pleasant working companions. | Work which needs no thought. |
| 27. Opportunity to use your own ideas. | Opportunity for promotion. |
| 28. Short hours. | Security of employment. |
| 29. Work which makes you think. | Pleasant working companions. |
| 30. Opportunity for promotion. | High wages. |
| 31. Work which makes you think. | Opportunity to use your own ideas. |
| 32. Good supervisor. | Comfortable working conditions. |
| 33. Work which needs no thought. | Short hours. |
| 34. High wages. | Good supervisor. |
| 35. Work which needs no thought. | Security of employment. |
| 36. Short hours. | Work which makes you think. |
| 37. Good supervisor. | Work which needs no thought. |
| 38. Comfortable working conditions. | Pleasant working companions. |
| 39. Work which makes you think. | Opportunity for promotion. |
| 40. High wages. | Security of employment. |
| 41. Opportunity to use your own ideas. | Good supervisor. |
| 42. Security of employment. | Comfortable working conditions. |
| 43. Work which needs no thought. | High wages. |
| 44. Opportunity for promotion. | Short hours. |
| 45. Pleasant working companions. | Opportunity to use your own ideas. |

LIST OF PUBLICATIONS

(The prices given are net: those in brackets include postage.)

March 1938

The following publications relating to the work of the Industrial Health Research Board can be purchased directly from H.M. Stationery Office, at the following addresses: Adastral House, Kingsway, London, W.C.2; 120 George Street, Edinburgh 2; 26 York Street, Manchester 1; 1 St. Andrew's Crescent, Cardiff; 80 Chichester Street, Belfast; or through any bookseller.*

ANNUAL REPORTS

First to March 31st, 1920. 6d. (7d.); Second to September 30th, 1921 (with Analysis of Published Work). 1s. 6d. (1s. 8d.); Third to September 30th, 1922. 2s. (2s. 1½d.); Fourth to December 31st, 1923. 1s. 3d. (1s. 4d.); Seventh to December 31st, 1926. 9d. (10d.); Eighth to December 31st, 1927. 9d. (10d.); Ninth to December 31st, 1928. 9d. (10d.); Tenth to December 31st, 1929. 6d. (7d.); Eleventh to June 30th, 1931. 1s. 6d. (1s. 7½d.); Twelfth to June 30th, 1932. 1s. 0d. (1s. 1d.); Thirteenth to June 30th, 1933. 9d. (10d.); Fourteenth to June 30th, 1934. 9d. (10d.); Fifteenth to June 30th, 1935. 9d. (10d.); Sixteenth to June 30th, 1936. 9d. (10d.); Seventeenth to June 30th, 1937. 9d. (10d.)

The following reports are out of print and not included in the list, Nos. 25, 26, 28, 32, 34, 35, 36, 38, 42 and Annual Reports, Nos. 5 and 6.

REPORTS CLASSIFIED ACCORDING TO SUBJECT MATTER

(i). Hours of Work, Rest Pauses, etc.

- No. 1.—The Influence of Hours of Work and of Ventilation on Output in Tinsplate Manufacture, by H. M. Vernon. (1919.) 6d. (7d.)
- No. 2.—The Output of Women Workers in relation to Hours of Work in Shell-making, by Ethel E. Osborne. (1919.) 6d. (7d.)
- No. 5.—Fatigue and Efficiency in the Iron and Steel Industry, by H. M. Vernon. (1920.) 3s. (3s. 2d.)
- No. 6.—The Speed of Adaptation of Output to altered Hours of Work, by H. M. Vernon. (1920.) 1s. (1s. 1d.)
- No. 24.—A Comparison of different Shift Systems in the Glass Trade, by E. Farmer, R. C. Brooks and E. G. Chambers. (1923.) 1s. 6d. (1s. 7d.)
- No. 41.—Rest Pauses in Heavy and Moderately Heavy Industrial Work, by H. M. Vernon and T. Bedford, assisted by C. G. Warner. (1927.) 9d. (10d.)
- No. 47.—Two Studies on Hours of Work. I.—Five-Hour Spells for Women with reference to Rest Pauses, by H. M. Vernon and M. D. Vernon, assisted by I. Lorrain-Smith. II.—The Two-Shift System in certain Factories, by May Smith and M. D. Vernon. (1928.) 1s. 3d. (1s. 4d.)

References, hours of work and rest pauses also occur in Report No. 56.

(ii). Dexterity

- No. 63.—Inspection Processes in Industry, by S. Wyatt and J. N. Langdon. (1932.) 1s. (1s. 2d.)
- No. 64.—A Classification of Vocational Tests of Dexterity, by A. E. Weiss Long and T. H. Pear. (1932.) 1s. 3d. (1s. 5d.)
- No. 66.—An Experimental Study of Certain Forms of Manual Dexterity, by J. N. Langdon. (1932.) 1s. (1s. 2d.)

* For overseas agencies see last page.

No. 67.—Manual Dexterity: Effects of Training, by E. M. Henshaw, J. N. Langdon and P. Holman. (1933.) 1s. (1s. 2d.)

No. 73.—The Acquisition of Skill: Analysis of Learning Curves, by J. M. Blackburn. (1936.) 1s. 6d. (1s. 8d.)

(iii). Industrial Accidents

No. 4.—The Incidence of Industrial Accidents, with special reference to Multiple Accidents, by Major M. Greenwood and Hilda M. Woods. (1919.) 6d. (7d.)

No. 19.—Two Contributions to the Study of Accident Causation, by Ethel E. Osborne, H. M. Vernon and B. Muscio. (1922.) 1s. 6d. (1s. 7d.)

No. 55.—A Study of the Personal Qualities in Accident Proneness and Proficiency, by E. Farmer and E. G. Chambers. (1929.) 3s. (3s. 2d.)

No. 68.—Tests for Accident Proneness, by E. Farmer, E. G. Chambers and F. J. Kirk. (1933.) 9d. (10d.)

References to industrial accidents also occur in Reports Nos. 39 and 62.

(iv). Atmospheric Conditions

No. 11.—Preliminary Notes on Atmospheric Conditions in Boot and Shoe Factories, by W. D. Hambly and T. Bedford. (1921.) 3s. (3s. 2d.)

No. 18.—Two Investigations in Potters' Shops, by H. M. Vernon and T. Bedford. (1922.) 2s. 6d. (2s. 8d.)

No. 20.—A Study of Efficiency in Fine Linen Weaving, by H. C. Weston. (1922.) 1s. 6d. (1s. 7d.)

No. 21.—Atmospheric Conditions in Cotton Weaving, by S. Wyatt. (1923.) 2s. (2s. 1d.)

No. 37.—Fan Ventilation in a Humid Weaving Shed. An Experiment carried out for the Departmental Committee on Humidity in Cotton Weaving, by S. Wyatt, assisted by J. A. Fraser and F. G. L. Stock. (1926.) 1s. 9d. (1s. 10d.)

No. 39.—The Relation of Atmospheric Conditions to the Working Capacity and the Accident Rate of Miners, by H. M. Vernon and T. Bedford, assisted by C. G. Warner. (1927.) 1s. 3d. (1s. 4d.)

No. 46.—A Physiological Investigation of the Radiant Heating in Various Buildings, by H. M. Vernon and M. D. Vernon, assisted by I. Lorrain-Smith. (1928.) 2s. (2s. 2d.)

No. 48.—Artificial Humidification in the Cotton Weaving Industry. Its Effect upon the Sickness Rates of Weaving Operatives, by A. Bradford Hill. (1927.) 2s. 6d. (2s. 8d.)

No. 58.—A Study of Heating and Ventilation in Schools, by H. M. Vernon and T. Bedford, assisted by C. G. Warner. (1930.) 2s. 6d. (2s. 8d.)

No. 59.—Sickness amongst Operatives in Lancashire Cotton Spinning Mills, by A. Bradford Hill. (1930.) 1s. 6d. (1s. 8d.)

No. 60.—The Atmospheric Conditions in Pithead Baths, by H. M. Vernon and T. Bedford (assisted by C. G. Warner). (1930.) 9d. (10d.)

No. 76.—The Warmth Factor in Comfort at Work, by T. Bedford. (1936.) 2s. (2s. 2d.)

References to atmospheric conditions also occur in Reports Nos. 1, 5, 22, 24, 51.

(v). Vision and Lighting

- The Relation between Illumination and Efficiency in Fine Work (Typesetting by Hand), by H. C. Weston and A. K. Taylor. Joint Report of the Industrial Fatigue Research Board and the Illumination Research Committee. (1926.) 6d. (7d.)
- The Effect of Different Systems of Lighting on Output and Accuracy in Fine Work (Typesetting by Hand), by H. C. Weston and A. K. Taylor. Joint Report of the Industrial Fatigue Research Board and the Illumination Research Committee. (1928.) 4d. (5d.)
- The Relation between Illumination and Industrial Efficiency—The Effect of Size of Work. Joint Report of the Industrial Health Research Board and the Illumination Research Committee. (1935.) 4d. (5d.)
- The Effect of Lighting on Efficiency in Rough Work, by S. Adams. Joint Report of the Industrial Health Research Board and the Illumination Research Committee. (1935.) 4d. (5d.)
- No. 40.—The Effect of Eyestrain on the Output of Linkers in the Hosiery Industry, by H. C. Weston and S. Adams. (1927.) 1s. (1s. 1d.)
- No. 49.—On the Relief of Eyestrain amongst Persons performing very fine Work, by H. C. Weston and S. Adams. (1928.) 1s. 3d. (1s. 4d.)
- No. 57.—Further Experiments on the Use of Special Spectacles in very fine Processes, by H. C. Weston and S. Adams. (1929.) 1s. 3d. (1s. 4d.)
- No. 81.—The Effects of Conditions of Artificial Lighting on the Performance of Worsted Weavers, by H. C. Weston. (1937.) 9d. (10d.)
- References to vision or lighting also occur in Reports Nos. 9, 20, 23.*

(vi). Vocational Guidance and Selection

- No. 12.—Vocational Guidance (a Review of the Literature), by B. Muscio (1921.) 1s. (1s. 1d.)
- No. 16.—Three Studies in Vocational Selection, by B. Muscio and E. Farmer. (1922.) 1s. 6d. (1s. 8d.)
- No. 31.—Performance Tests of Intelligence, by F. Gaw. (1925.) 2s. 6d. (2s. 8d.)
- No. 33.—A Study in Vocational Guidance, by F. Gaw, L. Ramsey, M. Smith and W. Spielman, under the general direction of Cyril Burt. (1926.) 4s. (4s. 2d.)
- No. 43.—A Study of Telegraphists' Cramp, by M. Smith, M. Culpin and E. Farmer. (1927.) 1s. 6d. (1s. 7d.)
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- No. 78.—A Borstal Experiment in Vocational Guidance, by Alec Rodger. (1937.) 9d. (11d.)
- References to vocational selection also occur in Report No. 64.*

(vii). Time and Movement Study, Methods of Work

- No. 3.—A Study of Improved Methods in an Iron Foundry, by C. S. Myers. (1919.) 2d. (3d.)

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- No. 8.—Some Observations on Bobbin Winding, by S. Wyatt and H. C. Weston. (1920.) 1s. 6d. (1s. 7d.)
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- No. 30.—An Experimental Investigation into Repetitive Work, by I. Burnett. (1925.) 2s. 6d. (2s. 7d.)
- No. 52.—The Comparative Effects of Variety and Uniformity in Work, by S. Wyatt and J. A. Fraser (assisted by F. G. L. Stock). (1929.) 1s. 3d. (1s. 4d.)
- No. 56.—The Effects of Monotony in Work, by S. Wyatt and J. A. Fraser (assisted by F. G. L. Stock). (1929.) 2s. (2s. 1d.)
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- No. 82.—The Machine and the Worker: a Study of Machine-Feeding Processes, by S. Wyatt and J. N. Langdon. (1938.)

(viii). Posture and Physique

- No. 29.—The Effects of Posture and Rest in Muscular Work, by E. M. Bedale and H. M. Vernon. (1924.) 2s. 6d. (2s. 8d.)
- No. 36.—On the Design of Machinery in relation to the Operator, by L. A. Legros and H. C. Weston. (1926.) 2s. 6d. (2s. 7d.)
- No. 44.—The Physique of Women in Industry (A Contribution towards the Determination of the Optimum Load), by E. P. Cathcart, E. M. Bedale, C. Blair, K. Macleod and E. Weatherhead, with a special section by S. G. Overton. (1927.) 5s. (5s. 2d.)
- No. 50.—The Physiological Cost of the Muscular Movements involved in Barrow Work, by G. P. Crowden. (1928.) 1s. (1s. 1d.)
- No. 71.—The Physique of Man in Industry, by E. P. Cathcart, D. E. R. Hughes, and J. G. Chalmers. (1935.) 1s. 3d. (1s. 5d.)
- References to posture, etc., occur also in Reports Nos. 15 and 16.*

(ix). Sickness and Absenteeism

- No. 51.—A Study of Absenteeism in a Group of Ten Collieries, by H. M. Vernon and T. Bedford (assisted by C. G. Warner). (1928.) 2s. 6d. (2s. 8d.)
- No. 54.—An Investigation into the Sickness Experience of Printers (with special reference to the Incidence of Tuberculosis), by A. Bradford Hill. (1929.) 4s. 6d. (4s. 8d.)
- No. 62.—Two Studies of Absenteeism in Coal Mines, by H. M. Vernon and T. Bedford. 1s. (1s. 1d.)
- No. 75.—Sickness Absence and Labour Wastage. Part I, by May Smith and M. A. Leiper. Part II, by Major Greenwood and May Smith. 1s. 3d. (1s. 5d.)
- No. 79.—An Investigation into the Sickness Experience of London Transport Workers, with special reference to Digestive Disturbances, by A. Bradford Hill. (1937.) 6d. (7d.)

(x). **Miscellaneous**

- No. 10.—Preliminary Notes on the Boot and Shoe Industry, by J. Loveday and S. H. Munro. (1920.) 1s. 6d. (1s. 7d.)
- No. 13.—A Statistical Study of Labour Turnover in Munition and other Factories, by G. M. Broughton, E. H. Newbold, and E. C. Allen. (1921.) 3s. (3s. 2d.)
- No. 27.—Results of Investigation in certain Industries. (1924.) 6d. (7d.)
- No. 45.—Two Contributions to the Experimental Study of the Menstrual Cycle. I.—Its Influence on Mental and Muscular Efficiency, by S. C. M. Sowton and C. S. Myers. II.—Its Relation to General Functional Activity, by E. M. Bedale. (1928.) 2s. 6d. (2s. 8d.)
- No. 65.—Two Studies in the Psychological Effects of Noise. I.—Psychological Experiments on the Effects of Noise, by K. G. Pollock and F. C. Bartlett. II.—The Effect of Noise on the Performance of Weavers, by H. C. Weston and S. Adams. (1932.) 1s. 3d. (1s. 5d.)
- No. 70.—The Performance of Weavers under Varying Conditions of Noise, by H. C. Weston and S. Adams. (1935.) 6d. (7d.)
- No. 80.—Toxicity of Industrial Organic Solvents. Summaries of Published Work. Compiled by Ethel Browning under the direction of the Committee on The Toxicity of Industrial Solvents. 7s. 6d. (8s.)

REPORTS CLASSIFIED ACCORDING TO INDUSTRY

NOTE.—Most of the reports in the following list deal exclusively with the industries under which they are placed. In certain instances, however, reports have been prepared on some general subject, but yet make sufficient reference to a particular industry to justify inclusion under the appropriate heading. These reports are distinguished by an *. Reports which have no application to particular industries are not included in this section.

A.—MINING INDUSTRY

- No. 39.—The Relation of Atmospheric Conditions to the Working Capacity and Accident Rates of Miners. 1s. 3d. (1s. 4d.)
- No. 51.—A Study of Absenteeism in a Group of Ten Collieries. 2s. 6d. (2s. 8d.)
- No. 60.—The Atmospheric Conditions in Pithead Baths. 9d. (10d.)
- No. 62.—Two Studies of Absenteeism in Coal Mines. 1s. (1s. 1d.)

B.—METAL AND ENGINEERING INDUSTRIES

- No. 1.—The Influence of Hours of Work and of Ventilation on Output in Tinplate Manufacture. 6d. (7d.)
- No. 2.—The Output of Women Workers in Relation to Hours of Work in Shell-making. 6d. (7d.)
- No. 3.—A Study of Improved Methods in an Iron Foundry. 2d. (3d.)
- No. 5.—Fatigue and Efficiency in the Iron and Steel Industry. 3s. (3s. 2d.)
- *No. 6.—The Speed of Adaptation to Altered Hours of Work. 1s. (1s. 1d.)
- No. 15.—Motion Study in Metal Polishing. 2s. (2s. 1d.)

C.—TEXTILE INDUSTRIES

- No. 7.—Individual Differences in Output in the Cotton Industry. 6d. (7d.)
- No. 8.—Some Observations on Bobbin Winding. 1s. 6d. (1s. 7d.)
- No. 9.—A Study of Output in Silk Weaving during the Winter Months. 2s. 6d. (2s. 8d.)
- No. 17.—An Analysis of the Individual Differences in the Output of Silk-Weavers. 1s. 6d. (1s. 7d.)
- No. 20.—A Study of Efficiency in Fine Linen Weaving. 1s. 6d. (1s. 7d.)
- No. 21.—Atmospheric Conditions in Cotton Weaving. 2s. (2s. 1d.)

- No. 23.—Variations in Efficiency in Cotton Weaving. 3s. (3s. 2d.)
 No. 37.—Fan Ventilation in a Weaving Shed. 1s. 9d. (1s. 10d.)
 No. 40.—The Effect of Eyestrain on the Output of Linkers in the Hosiery Industry. 1s. (1s. 1d.)
 No. 48.—Artificial Humidification in the Cotton Weaving Industry. Its Effect upon the Sickness Rates of Weaving Operatives. 2s. 6d. (2s. 8d.)
 *No. 49.—On the Relief of Eyestrain amongst Persons Performing very Fine Work. 1s. 3d. (1s. 4d.)
 No. 59.—Sickness amongst Operatives in Lancashire Cotton Spinning Mills. 1s. 6d. (1s. 8d.)
 No. 70.—The Performance of Weavers under Varying Conditions of Noise. 6d. (7d.)
 No. 81.—The Effects of Conditions of Artificial Lighting on the Performance of Worsted Weavers. 9d. (10d.)

D.—BOOT AND SHOE INDUSTRY

- No. 10.—Preliminary Notes on the Boot and Shoe Industry. 1s. 6d. (1s. 7d.)
 No. 11.—Preliminary Notes on Atmospheric Conditions in Boot and Shoe Factories. 3s. (3s. 8d.)

E.—POTTERY INDUSTRY

- No. 18.—Two Investigations in Potters' Shops. 2s. 6d. (2s. 8d.)

F.—LAUNDRY INDUSTRY

- No. 22.—Some Studies in the Laundry Trade. 2s. 6d. (2s. 8d.)

G.—GLASS INDUSTRY

- No. 24.—A Comparison of Different Shift Systems in the Glass Trade. 1s. 6d. (1s. 7d.)

H.—LETTERPRESS PRINTING INDUSTRY

- *No. 16.—Three Studies in Vocational Selection. 1s. 6d. (1s. 7d.)
 *No. 26.—On the Extent and Effects of Variety in Repetitive Work.
 The Relation between Illumination and Efficiency in Fine Work (Typesetting by Hand).
 The Effects of Different Systems of Lighting on Output and Accuracy in Fine Work (Typesetting by Hand). 1s. 6d. (1s. 7d.)
 No. 54.—An Investigation into the Sickness Experience of Printers (with special reference to the Incidence of Tuberculosis). 4s. 6d. (4s. 8d.)

I.—TRANSPORT WORKERS

- No. 79.—An investigation into the Sickness Experience of London Transport Workers, with special reference to Digestive Disturbances. 6d. (7d.)

J.—LIGHT REPETITION WORK

- No. 14.—Time and Motion Study. 2s. (2s. 2d.)
 No. 25.—Two Contributions to the Study of Rest Pauses in Industry. 1s. 6d. (1s. 7d.)
 No. 26.—On the Extent and Effects of Variety in Repetitive Work. 1s. 6d. (1s. 7d.)
 No. 30.—An Experimental Investigation into Repetitive Work. 2s. 6d. (2s. 7d.)
 No. 32.—Studies in Repetitive Work with special reference to Rest Pauses. 2s. 6d. (2s. 7d.)
 No. 52.—The Comparative Effects of Variety and Uniformity in Work. 1s. 3d. (1s. 4d.)

K.—MUSCULAR WORK

- No. 29.—The Effects of Posture and Rest in Muscular Work. 2s. 6d. (2s. 7d.)
- No. 41.—Rest Pauses in Heavy and Moderately Heavy Industrial Work. 9d. (10d.)
- No. 44.—The Physique of Women in Industry. (A Contribution towards the Determination of the Optimum Load.) 5s. (5s. 2d.)
- No. 50.—The Physiological Cost of the Muscular Movements involved in Barrow Work. 1s. (1s. 1d.)
- No. 71.—The Physique of Man in Industry. 1s. 3d. (1s. 5d.)

SPECIAL REPORTS OF THE MEDICAL RESEARCH COUNCIL ON
SUBJECTS RELATED TO THE BOARD'S WORK*Alcohol*

- No. 56.—The Effects of Alcohol and some other Drugs during Normal and Fatigued Conditions. *By W. McDougall and May Smith. (1920.) 1s. (1s. 1d.)

Miners' Diseases, etc.

- No. 89.—Report on Miners' "Beat Knee," "Beat Hand," and "Beat Elbow." By E. L. Collis and T. L. Llewellyn. (1924.) 1s. 6d. (1s. 7d.)
- No. 80.—Second Report of the Miners' Nystagmus Committee. (1923.) 9d. (10d.)
- No. 176.—Third Report of the Miners' Nystagmus Committee. (1932.) 9d. (10d.)

Nutrition

- No. 87.—Report on the Nutrition of Miners and their Families. By the Committee upon Quantitative Problems in Human Nutrition. (1924.) 1s. 3d. (1s. 4d.)
- No. 151.—A Study in Nutrition. An Inquiry into the Diet of 154 Families of St. Andrews. By E. P. Cathcart and A. M. T. Murray, assisted by M. Shanks. (1931.) 1s. (1s. 2d.)
- No. 165.—Studies in Nutrition. An Inquiry into the Diet of Families in Cardiff and Reading. By E. P. Cathcart and A. M. T. Murray, assisted by M. Shanks. (1932.) 6d. (7d.)

Dust

- No. 199.—Physical Methods for the Estimation of the Dust Hazards in Industry. By H. L. Green and H. H. Watson. (1935.) 1s. (1s. 2d.)

OTHER PUBLICATIONS IN 1936-37

- BEDFORD, T.: "Requirements for satisfactory Ventilation and Heating". *Hum. Factor, Lond.*, 1936, 10, 245.
- "Warmth and Comfort." *J. Instn. Heat. and Vent. Engrs.*, 1936, 4, 383.
- "Ventilation and heating in Relation to Comfort." *Industr. Welf.*, 1937, 19, 218, 13.
- "Modern Principles of Ventilation and Heating." *H. K. Lewis & Co., Ltd., London*, 1937.
- CULPIN, MILLAIS: "Psychological Disorders in Industry." *Practitioner* 1936, 137, 324.
- "The Application of Medical Psychology in Industry." *Med. Off.*, March, 1937.

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