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MEDICAL RESEARCH COMMITTEE
AND
DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL
RESEARCH.

REPORTS

OF THE

INDUSTRIAL FATIGUE RESEARCH BOARD.

No. 2.—THE OUTPUT OF WOMEN
WORKERS IN RELATION TO HOURS OF
WORK IN SHELL-MAKING.

Pamphlet



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PREFATORY NOTE.

In December, 1917, the Secretary of State for Home Affairs invited the Department of Scientific and Industrial Research to appoint a Committee to investigate the subject of Industrial Fatigue on comprehensive and systematic lines, and a similar proposal was made by the Medical Research Committee.

A Research Board was accordingly appointed by the Department of Scientific and Industrial Research and the Medical Research Committee jointly, with the following membership:—

- Professor C. S. SHERRINGTON, Sc.D., F.R.S., (Professor of Physiology, University of Oxford)—*Chairman*.
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- BERTRAM WILSON, (*Assessor* representing the Ministry of Labour).
- D. R. WILSON, (H.M. Inspector of Factories)—*Secretary*.

Its terms of reference are:—"To consider and investigate the relations of the hours of labour and of other conditions of employment, including methods of work, to the production of fatigue, having regard both to industrial efficiency and to the preservation of health among the workers."

The duty of the Board is to initiate, organise, and promote by research grants or otherwise, investigations in different industries with a view to finding the most favourable hours of labour, spells of work, rest pauses, and other conditions applicable to the various processes according to the nature of the work and its demands on the worker.

Memoranda embodying the results of these investigations will be issued from time to time.

The first part of the present report is based on an investigation on the effects upon output of reducing the hours of labour of certain munition workers. The data of output were fortunately secured both before the reduction of hours had been effected, and sufficiently long after the change to avoid the disturbances associated with the transition. On account of the detailed statistics needed to effect a comparison, it was not possible to utilise more than a small number of individual records extending over a limited period. Nevertheless the total number of hourly records (which exceeded 900 in the first and 600 in the second period) was large and it is thought that the difference between the mean hourly outputs of the two periods is too great to be attributable to chance fluctuations. It is also to be remarked that owing to the large proportion of the working time absorbed by the machining operation, the speed of which is beyond the control of the operative, the apparently small increase of output per hour really signifies a considerable speeding up of the controlled part of the operation.

In the second part of the report, evidence is collected tending to show that variations of output through the shifts are consistent with the belief that, on the long shifts, considerable fatigue resulted. The causes tending to produce such fluctuations of hourly output are manifold and the individual records are not altogether consistent; these therefore do not carry entire conviction, and the data are published merely as a contribution to the body of material which will ultimately need detailed analysis.

15, Great George Street,
London, S.W.1.

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THE OUTPUT OF WOMEN WORKERS IN RELATION TO HOURS OF WORK IN SHELL-MAKING.

By ETHEL E. OSBORNE, M.Sc.,
Investigator to the Board.

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PART I.—A STUDY OF VARIATION OF OUTPUT WITH DURATION OF SHIFT.

1. INTRODUCTION.

The variation of output with the duration of hours of work is one of the fundamental problems in industrial economics from the points of view of both efficiency and fatigue of the workers. In this report, results obtained by the measurement of the output of women munition workers, during a unique opportunity of studying variation of length of shift, are set forth as a contribution to this problem.

Investigations were carried out on the "ripping" or "part off" operation in shell turning. This is the first operation to which the rough forging is subjected, and consists of cutting off the end portion of the forging to reduce it to the required length. The operation is generally considered to be the hardest in shell-making, for the shell is at its heaviest stage; and, further, the operation is a rapid one and entails constant changing of shells. In the case of the six-inch shell the operation is particularly heavy, for as will be seen from the tables a woman operator can rip up to 100 shells in a 12-hours shift (10½ working hours), and, as the forging at this stage weighs about 140 lbs., the handling by pulleys of this amount of material into and out of the lathe constitutes a strenuous day's work. Moreover, in order to save time it not infrequently happens that the women move shells without employing the pulleys, though of course against orders.

In the National Ordnance Factory, in which this investigation was carried out, women had worked on this operation for a period of about 18 months, on shifts of 12 hours duration, with night

and day work in alternate weeks, according to Scheme I. in the following table:—

TABLE I.

| Shift. | Arrangement of Hours. | | | Weekly Totals. | |
|------------------------|--------------------------|-----------------------|------------------------------|---------------------------------|-------------------------|
| | Days of week. | Period of Employment. | Meal times. | Hours of attendance in factory. | Hours of possible work. |
| SCHEME I. Day. | Mon. - Fri. | 6 a.m. - 6 p.m. | 9 - 9.30 a.m. 1 - 2 p.m. | } 67 | 59 |
| | Saturday. | 6 a.m. - 1 p.m. | 9 - 9.30 a.m. | | |
| Night. | Sun. evg. - Sat. mng. | 6 p.m. - 6 a.m. | 9 - 10 p.m. 1.30 - 2 a.m. | } 72 | 63 |
| | Total ... | — | — | | |
| SCHEME II. Morning. | Mon. - Fri. | 6 a.m. - 1 p.m. | 9 - 9.30 a.m. | } 41 | 38 |
| | Saturday. | 6 a.m. - noon. | 9 - 9.30 a.m. | | |
| Afternoon. | Mon. - Fri. | 2 p.m. - 9 p.m. | 5.45-6.15 p.m. | 35 | 32½ |
| Night. | Sunday. | 6 p.m. - 6 a.m. | 9-10 p.m. & 1.30-2 a.m. | } 52 | 48 |
| | Mon. - Fri. | 10 p.m. - 6 a.m. | 1.30 - 2 a.m. | | |
| Total ... | — | — | — | 128 | 118½ |

It then became evident that these hours were adversely affecting the women and a shortening of shift was decided upon; the plan of hours of work set out as Scheme II. was accordingly arranged.

The male workers remained on the 12 hours shift as outlined above, but the women workers (with the exception of charge hands, who worked the hours laid down for men), were placed on a three-shift system, the shifts being so arranged as to fit in with the two-shift system adopted for the men. Thus the hours of work were shorter than they would have been had the whole factory been transferred to a three-shift system of eight hours each. The anticipated "change over" provided an excellent opportunity for taking output data for comparison.

Some months previously data of *actual hourly output* had been obtained for all women working on this operation, and an analysis made of the returns. In the meantime the machines had been changed to a type which considerably reduced the demands made on the women for violent physical exertion. The old system of chuck and crowbar clamping was replaced by a jaw clamp, in which the shell forging was comparatively easily fixed, and the violent jerks necessary to secure the forging were no longer required. Further, the level at which the shell was fixed was lower and more convenient for the women workers. Lastly, the cutting itself was automatic, whereas formerly the tool required constant guidance by the operator. In spite of these modifications, this operation was still considered very heavy, and

afforded a fruitful field for computing the variation in output with the length of shift.

Now that the actual cutting had become automatic, the only time in which the operator could speed up or go slow was during the handling and fixing in of the shell—heavy work on which the effect of fatigue would be very marked.

Owing to these modifications in machinery a new set of output data was taken, hourly records for all operators being kept for a whole week for both night and day shift, before any disturbance in connection with the readjustment of hours had taken place. A corresponding set of data was then collected after the change over to the three-shift system had been effected, but a certain time was allowed to elapse until the workers had become tuned to the shortened hours.⁽¹⁾

Actually, five months elapsed, for at one time a different forging was being used which altogether upset the output, and at another period a strike of skilled men occurred which finally led to the entire cessation of work. No further alterations in machinery took place after the output records on the long shift were taken, and so the second series is definitely comparable with the first, the only variable factor being the alteration in the hours of work.

In order to obtain an hourly record of output and a record of the time when any breakdown in machinery or failure of power occurred, the method of booking shells had to be modified, as the plan usually employed gave only records for the shift and not for the hour. The records were obtained in two shops which are designated A. and B. throughout the tables. The returns of the different shifts are tabulated separately.

2. REFERENCE TO TABLES.

1. Tables were first prepared giving the hourly outputs of the individual women on both day and night shifts, in Shops A. and B.⁽²⁾ during the periods covered by Scheme I. and Scheme II. respectively. For each operator the actual number of shells turned out per hour for each period of the day was found and the weekly average number of shells turned out per hour calculated for the total complete periods during which she worked. In addition, the number of possible hours of work was recorded. In some cases this is higher than the number of hours actually worked, owing to such causes as breakdown in machinery.

2. The data obtained under Scheme I. are summarised in Table II. which shows opposite the check number of each operator:—

- (i.) the total hours in the factory;
- (ii.) the total possible hours of work;
- (iii.) the total hours actually worked; and
- (iv.) the total number of shells for the week;

⁽¹⁾ Vernon found that a period of four months was necessary before an equilibrium output of work for a certain length of shift was attained in making fuses. (Health of Munition Workers Committee, Memorandum 18.)

⁽²⁾ Owing to an error in booking the records of the night shift in Shop B. had to be discarded.

and further, for each shift for all operators the average hourly output of shells for:—

- (i.) the total hours in factory;⁽¹⁾
- (ii.) the total possible hours of work;⁽¹⁾
- (iii.) the total hours actually worked.

TABLE II.—*Hourly Output in Ripping Operation under Scheme I.*

| Night Shift. | | | | | Day Shift. | | | | |
|---------------------------|--------------------|------------------------|------------------------|-----------------|---------------|--------------------|------------------------|------------------------|-----------------|
| Check Number. | Hours in Factory. | Possible Hrs. of Work. | Hours actually worked. | Total Shells. | Check Number. | Hours in Factory. | Possible Hrs. of Work. | Hours actually worked. | Total Shells. |
| (1) | Hf. (2) | Hp. (3) | Hw. (4) | T. (5) | (6) | Hf. (7) | Hp. (8) | Hw. (9) | T. (10) |
| <i>Shop A.</i> | | | | | | | | | |
| 797 | 72 | 63 | 61 | 544 | 735 | 67 | 59 | 51 | 413 |
| 622 | 72 | 63 | 61 | 502 | 1,856 | 60 | 52½ | 52 | 326 |
| 740 | 72 | 63 | 61 | 543 | 70 | 64 | 56 | 54 | 398 |
| 677 | 72 | 63 | 61 | 542 | 229 | 67 | 59 | 52 | 347 |
| 691 | 48 | 42 | 38 | 349 | 244 | 67 | 59 | 58 | 500 |
| 692 | 48 | 42 | 40 | 355 | 74 | 67 | 59 | 58 | 440 |
| Total | 374 | 336 | 322 | 2835+33 2868 | — | 392 | 344½ | 325 | 2424+15 2439 |
| <i>Shop B.</i> | | | | | | | | | |
| 1,655 | 72 | 63 | 59 | 482 | 2,552 | 67 | 59 | 55½ | 488 |
| 1,596 | 72 | 63 | 59½ | 419 | 2,501 | 67 | 59 | 59 | 506 |
| 1,703 | 72 | 63 | 63 | 498 | — | 60 | 52½ | 51½ | 478 |
| 1,654 | 72 | 63 | 63 | 481 | — | — | — | — | — |
| 1,659 | 72 | 63 | 59½ | 424 | — | — | — | — | — |
| Total | 360 | 315 | 304 | 2304+12 2316 | — | 194 | 170½ | 166 | 1472+5 1477 |
| Average Shells per hour:— | | | | | | | | | |
| <i>Shop A.</i> | $\frac{T+33}{Hf.}$ | $\frac{T+33}{Hp.}$ | $\frac{T}{Hw.}$ | | | $\frac{T+15}{Hf.}$ | $\frac{T+15}{Hp.}$ | $\frac{T}{Hw.}$ | |
| | 7·66 | 8·53 | 8·80 | | | 6·22 | 7·07 | 7·45 | |
| <i>Shop B.</i> | $\frac{T+12}{Hf.}$ | $\frac{T+12}{Hp.}$ | $\frac{T}{Hw.}$ | | | $\frac{T+5}{Hf.}$ | $\frac{T+5}{Hp.}$ | $\frac{T}{Hw.}$ | |
| | 6·43 | 7·35 | 7·57 | | | 7·61 | 8·66 | 8·66 | |

The corresponding data for Scheme II. are summarised in Table III., which is compiled in exactly the same manner as Table II.

(¹) In calculating these figures, in some cases extra shells, cut during periods when the machines had broken down and excluded in estimating the speed of work, were added.

TABLE III.—Hourly Output in Ripping Operation under Scheme II.

| Morning Shift. | | | | | Afternoon Shift. | | | | | Night Shift. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---------------------------------|---------------------------------------|--------------------------------------|----------------------------|----------------------|---------------------------------|---------------------------------------|--------------------------------------|-----------------------------|-----------------------|----------------------------------|--|---------------------------------------|-----------------------------|--|------------------|------------------|------------------|---|---|------------------|------------------|------------------|---|---|------------------|------------------|------------------|---|----------------|------|------|------|---|---|------|------|------|---|---|------|------|------|---|----------------|------|------|------|---|---|------|------|------|---|---|---|---|---|---|
| Check Number. (1) | Hours in Factory. HF. (2) | Possible Hours of Work. HP. (3) | Hours actually worked. HW. (4) | Total Shells. T. (5) | Check Number. (6) | Hours in Factory. HF. (7) | Possible Hours of Work. HP. (8) | Hours actually worked. HW. (9) | Total Shells. T. (10) | Check Number. (11) | Hours in Factory. HF. (12) | Possible Hours of Work. HP. (13) | Hours actually worked. HW. (14) | Total Shells. T. (15) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Shop A.</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1,873 | 41 | 38 | 38 | 328 | 677 | 35 | 32½ | 32½ | 304 | 71 | 40 | 37½ | 37½ | 355 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1,851 | 41 | 38 | 38 | 346 | 740 | 35 | 32½ | 32½ | 322 | 74 | 40 | 37½ | 37½ | 313 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1,857 | 41 | 38 | 38 | 357 | 615 | 28 | 26 | 25 | 193 | 1 | 48 | 45 | 45 | 431 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1,829 | 41 | 38 | 38 | 366 | 673 | 35 | 32½ | 32½ | 266 | 244 | 48 | 45 | 45 | 420 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| — | — | — | — | — | 622 | 35 | 32½ | 32½ | 254 | 100 | 40 | 37½ | 37½ | 298 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| — | — | — | — | — | 797 | 35 | 32½ | 32½ | 295 | — | — | — | — | — | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Total | 164 | 152 | 152 | 1,397 | — | 203 | 188½ | 187½ | 1,634 | — | 216 | 202½ | 202½ | 1,897 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Shop B.</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2,052 | 41 | 38 | 38 | 316 | 1,519 | 35 | 32½ | 32½ | 298 | — | — | — | — | — | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2,112 | 41 | 38 | 38 | 308 | 1,655 | 35 | 32½ | 29½ | 230 | — | — | — | — | — | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2,074 | 38 | 35 | 35 | 287 | 1,659 | 35 | 32½ | 32½ | 279 | — | — | — | — | — | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| — | — | — | — | — | 1,596 | 35 | 32½ | 31½ | 244 | — | — | — | — | — | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| — | — | — | — | — | 1,654 | 35 | 32½ | 32½ | 285 | — | — | — | — | — | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Total | 120 | 111 | 111 | 911 | — | 175 | 162½ | 158½ | 1,366 | — | — | — | — | — | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Average Shells per Hour:— | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table style="width:100%; border:none;"> <tr> <td></td> <td>$\frac{T.}{HF.}$</td> <td>$\frac{T.}{HP.}$</td> <td>$\frac{T.}{HW.}$</td> <td>—</td> <td>—</td> <td>$\frac{T.}{HF.}$</td> <td>$\frac{T.}{HP.}$</td> <td>$\frac{T.}{HW.}$</td> <td>—</td> <td>—</td> <td>$\frac{T.}{HF.}$</td> <td>$\frac{T.}{HP.}$</td> <td>$\frac{T.}{HW.}$</td> <td>—</td> </tr> <tr> <td><i>Shop A.</i></td> <td>8'51</td> <td>9'19</td> <td>6'19</td> <td>—</td> <td>—</td> <td>8'04</td> <td>8'66</td> <td>8'71</td> <td>—</td> <td>—</td> <td>8'41</td> <td>8'97</td> <td>8'97</td> <td>—</td> </tr> <tr> <td><i>Shop B.</i></td> <td>7'59</td> <td>8'20</td> <td>8'20</td> <td>—</td> <td>—</td> <td>7'63</td> <td>8'22</td> <td>8'41</td> <td>—</td> <td>—</td> <td>—</td> <td>—</td> <td>—</td> <td>—</td> </tr> </table> | | | | | | | | | | | | | | | | $\frac{T.}{HF.}$ | $\frac{T.}{HP.}$ | $\frac{T.}{HW.}$ | — | — | $\frac{T.}{HF.}$ | $\frac{T.}{HP.}$ | $\frac{T.}{HW.}$ | — | — | $\frac{T.}{HF.}$ | $\frac{T.}{HP.}$ | $\frac{T.}{HW.}$ | — | <i>Shop A.</i> | 8'51 | 9'19 | 6'19 | — | — | 8'04 | 8'66 | 8'71 | — | — | 8'41 | 8'97 | 8'97 | — | <i>Shop B.</i> | 7'59 | 8'20 | 8'20 | — | — | 7'63 | 8'22 | 8'41 | — | — | — | — | — | — |
| | $\frac{T.}{HF.}$ | $\frac{T.}{HP.}$ | $\frac{T.}{HW.}$ | — | — | $\frac{T.}{HF.}$ | $\frac{T.}{HP.}$ | $\frac{T.}{HW.}$ | — | — | $\frac{T.}{HF.}$ | $\frac{T.}{HP.}$ | $\frac{T.}{HW.}$ | — | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Shop A.</i> | 8'51 | 9'19 | 6'19 | — | — | 8'04 | 8'66 | 8'71 | — | — | 8'41 | 8'97 | 8'97 | — | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Shop B.</i> | 7'59 | 8'20 | 8'20 | — | — | 7'63 | 8'22 | 8'41 | — | — | — | — | — | — | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

The results in Tables II. and III. are further summarised in Table IV. which gives for all the shifts on Scheme I. and for all the shifts on Scheme II. the average number of shells for:—

- (i.) the total hours in factory;
- (ii.) the total possible hours of work; and
- (iii.) the total hours actually worked.

TABLE IV.—*Summary of Output.*

| Shop and Shift. | Hourly output of shells. | | | Total Shells. |
|---|--------------------------|-----------------------------|---------------------------|---------------|
| | Per hours in Factory. | Per possible hours of work. | Per actual hours of work. | |
| SCHEME I. | | | | |
| A—Night | 7.66 | 8.53 | 8.80 | 2,868 |
| B—Night | 6.43 | 7.35 | 7.57 | 2,316 |
| A—Day | 6.22 | 7.07 | 7.45 | 2,439 |
| B—Day | 7.61 | 8.66 | 8.86 | 1,477 |
| Totals... .. | 27.92 | 31.61 | 32.68 | 9,100 |
| Average hourly output of shells per shift | 6.98 | 7.90 | 8.17 | |
| Percentage Average | 85.43 | 96.57 | 100 | |
| SCHEME II. | | | | |
| A—Night | 8.41 | 8.97 | 8.97 | 1,397 |
| B—Morning... .. | 7.59 | 8.20 | 8.20 | 911 |
| A—Morning... .. | 8.51 | 9.19 | 9.19 | 1,817 |
| A—Afternoon | 8.04 | 8.66 | 8.71 | 1,634 |
| B—Afternoon | 7.63 | 8.22 | 8.41 | 1,336 |
| Totals | 40.18 | 43.24 | 43.48 | 7,095 |
| Average hourly output of shells per shift | 8.04 | 8.65 | 8.70 | |
| Percentage Average | 92.41 | 99.42 | 100 | |

3. RESULTS.

I. The average number of shells per operator per actual hour worked is 8.17 on the long hours, Scheme I., (an average of 55.85 hours per week) and 8.70 on the short hours, Scheme II., (an average of 35.65 hours per week), corresponding to an increase in output of 6.5 per cent. (for an average reduction of 20.20 hours per week).

As has already been pointed out the actual cutting is automatic and this increase in output must, therefore, be due entirely to speeding up during the strenuous work of fixing and removing the shells. I have accordingly estimated that fraction of the total working time occupied in the automatic cutting of the shells, and so obtained the time during which the operators were handling the shells, that is, the period in which speeding-up was possible.

As a result of certain observations carried out on this operation, the average time of automatic cutting was found to be five minutes two seconds per shell. Taking the average number of shells per operator per actual hour worked as 8.17 on Scheme I., and 8.70 on Scheme II., the actual duration of cutting per hour was:—

for Scheme I., $5\frac{1}{30} \times 8.17 = 41.12$ minutes, and
for Scheme II., $5\frac{1}{30} \times 8.70 = 43.79$ minutes.

Thus in each hour, only 18.88 minutes under Scheme I. and 16.21 minutes under Scheme II. were occupied in work on which the operator could vary her speed. In the first case in 18.88 minutes, 8.17 shells were handled, *i.e.*, for each shell an average period of 2.31 minutes was required; in the second case in 16.21 minutes 8.70 shells were handled, *i.e.*, for each shell an average period of 1.86 minutes was required.

Hence the work (under the control of the women as far as speed was concerned) accomplished in 100 minutes of the long hour system was carried out in 80.5 minutes of the short hour system—a decrease of 19.5 per cent. in time.

2. Comparison of the average shells per operator per possible hour of work with the average shells per operator per hour actually worked gave a striking result. Thus, if the output per actual hour of work is in each case taken as 100 then under Scheme I. the output per possible hours of work is represented by 96.57 and under Scheme II. by 99.42. On the long hours, therefore, there was a drop in possible output of 3.43 per cent., whilst on the short hours there was a drop of only 0.58 per cent.

This difference must be regarded as in some degree a measure of the actual efficiency of the running of the machinery, and it may indicate that when short hours are being worked, those in charge have to keep the running plant in a higher state of efficiency than when running on longer hours, in order that the operators working on piece rates may be more satisfied with their output and hence with their wages.¹

3. Again taking the average hourly output of shells "per hour of actual work" as 100, then the average hourly output of shells "per hour in the factory" under Scheme I. is represented by 85.43, and under Scheme II. by 92.41. The drop in possible output when calculated on this basis was, therefore, 14.67 per cent. under Scheme I., and under Scheme II. 7.59 per cent.

These figures illustrate the advantage of short hours as compared with long hours in the case of women on a heavy shell operation, and, especially, of a shift of only sufficient duration to require a single meal break.

(1) This point was brought out in the Final Report of the American Industrial Commission (1912) and is specially stressed by Josephine Goldmark. ("Fatigue and Efficiency," page 172.)

PART II.—A STUDY OF DAILY FATIGUE BASED ON ACTUAL HOURLY OUTPUT.

1. INTRODUCTION.

Hourly bookings of output such as those obtained for this enquiry are of special interest in tracing the effect of meal breaks and of fatigue; and a comparable series of such bookings on long and short hours is available.

The data obtained have been dealt with on the following lines:—

Every period during which a breakdown of machinery or stoppage of power took place was noted on the record sheets of the individual workers and has been excluded from the totals. The total number of shells has been obtained for each hourly period for the whole week, or where absences occurred, for the hours of those days when the worker was present. In certain cases allowance had to be made for meal intervals. From these period-totals and the week-totals of shells, excluding broken periods, the percentage of output for each hour of shift for the week was obtained for each worker.

2. REFERENCE TO TABLES AND DIAGRAMS.

In Tables VI.A and VI.B these percentages of the individuals are tabulated and totalled, and the average per operator calculated from the records under Scheme I. Tables VII.A, VII.B and VII.C are similarly compiled from the records under Scheme II.

TABLE VI.A.—Individual Percentage-output per hour. Scheme I.—Night Shift.

| Check No. | HOURS. | | | | | | | | | | | | | | Totals. | |
|---------------------------------|--------|------|------|----|------|------|------|------|----------------|------|------|------|------|--|---------|-------|
| | P.M. | | | | | | | A.M. | | | | | | | | |
| | 6— | 7— | 8— | 9— | 10— | 11— | 12— | 1— | 1½— | 2— | 3— | 4— | 5-6 | | | |
| Shop A. | | | | | | | | | | | | | | | | |
| 797 | 9.6 | 9.0 | 7.7 | | 9.5 | 10.7 | 11.0 | | 5.5 | 10.8 | 10.3 | 10.5 | 5.3 | | | 99.9 |
| 822 | 9.0 | 7.6 | 9.0 | | 9.6 | 10.4 | 10.5 | | 5.6 | 10.4 | 11.3 | 10.1 | 6.5 | | | 100.0 |
| 740 | 10.1 | 8.5 | 9.0 | | 9.8 | 9.8 | 10.5 | | 5.5 | 9.9 | 10.1 | 10.3 | 6.4 | | | 99.9 |
| 677 | 9.8 | 8.3 | 8.5 | | 10.1 | 10.3 | 10.1 | | 5.5 | 10.3 | 10.3 | 10.7 | 5.9 | | | 99.9 |
| 691 | 7.7 | 8.6 | 5.7 | | 10.0 | 11.5 | 11.5 | | 5.7 | 10.6 | 10.9 | 11.2 | 6.6 | | | 100.0 |
| 692 | 8.7 | 7.6 | 7.9 | | 10.1 | 10.7 | 10.1 | | 5.6 | 10.7 | 11.3 | 11.0 | 6.2 | | | 99.9 |
| Total | 54.9 | 49.6 | 47.8 | | 59.1 | 63.4 | 63.7 | | (66.8) 33.4 | 62.7 | 64.2 | 63.8 | 36.9 | | | 599.6 |
| Average percentage per operator | 9.2 | 8.2 | 8.0 | | 9.9 | 10.6 | 10.6 | | 11.1 | 10.4 | 10.7 | 10.6 | 6.1 | | | — |
| Shop B. | | | | | | | | | | | | | | | | |
| 1655 | 9.7 | 9.3 | 10.4 | | 10.6 | 10.8 | 8.9 | | 4.3 | 11.4 | 8.3 | 9.1 | 7.0 | | | 99.8 |
| 1596 | 10.0 | 10.5 | 10.3 | | 10.3 | 11.2 | 10.3 | | 3.6 | 8.8 | 8.1 | 8.6 | 8.3 | | | 100.0 |
| 1703 | 9.6 | 9.2 | 10.7 | | 9.6 | 10.1 | 9.4 | | 3.8 | 10.7 | 9.0 | 10.0 | 7.8 | | | 99.9 |
| 1654 | 10.6 | 10.2 | 9.1 | | 9.6 | 10.4 | 10.2 | | 3.5 | 9.8 | 8.5 | 9.8 | 8.3 | | | 100.0 |
| 1659 | 8.7 | 12.0 | 9.7 | | 9.7 | 9.7 | 9.0 | | 3.8 | 9.2 | 9.2 | 10.6 | 8.5 | | | 100.1 |
| Total | 48.6 | 41.2 | 50.2 | | 49.8 | 32.2 | 47.8 | | (38.0) 19.0 | 49.9 | 43.1 | 48.1 | 40.0 | | | 499.8 |
| Average percentage per operator | 9.7 | 10.2 | 10.0 | | 9.9 | 10.4 | 9.5 | | 7.6 | 10.0 | 8.6 | 9.6 | 8.0 | | | — |

TABLE VI.B.—Individual Percentage-output per hour. Scheme I.—Day Shift.

| Check No. | HOURS. | | | | | | | | | | | | | | Totals. | |
|---------------------------------|--------|------|------|----|------|------|------|------|----------------|----|----|----|-----|--|---------|-------|
| | A.M. | | | | | | | P.M. | | | | | | | | |
| | 6— | 7— | 8— | 9— | 9½— | 10½— | 11½— | 12½— | 1— | 2— | 3— | 4— | 5-6 | | | |
| Shop A. | | | | | | | | | | | | | | | | |
| 735 | 12.1 | 13.1 | 12.3 | | 11.1 | 10.4 | 10.9 | | 4.6 | | | | | | | 99.9 |
| 1856 | 9.8 | 10.7 | 8.9 | | 11.6 | 9.8 | 10.4 | | 4.3 | | | | | | | 99.9 |
| 70 | 9.7 | 10.3 | 9.5 | | 11.5 | 12.1 | 11.8 | | 3.3 | | | | | | | 99.9 |
| 229 | 10.7 | 10.4 | 12.1 | | 10.7 | 10.4 | 10.7 | | 4.0 | | | | | | | 100.0 |
| 244 | 10.6 | 11.4 | 10.6 | | 10.6 | 10.8 | 10.8 | | 3.6 | | | | | | | 100.0 |
| 74 | 9.1 | 12.5 | 11.8 | | 11.4 | 11.8 | 10.9 | | 3.6 | | | | | | | 99.9 |
| Total. | 62.0 | 68.4 | 65.5 | | 66.9 | 65.3 | 65.5 | | (46.8) 23.4 | | | | | | | 599.6 |
| Average percentage per operator | 10.3 | 11.4 | 10.9 | | 11.2 | 10.9 | 10.9 | | 7.8 | | | | | | | — |
| Shop B. | | | | | | | | | | | | | | | | |
| 2552 | 11.1 | 10.9 | 10.9 | | 9.4 | 9.2 | 10.9 | | 4.7 | | | | | | | 100.1 |
| 2501 | 8.9 | 9.5 | 10.7 | | 10.9 | 11.1 | 9.9 | | 4.9 | | | | | | | 100.1 |
| — | 9.4 | 9.6 | 8.6 | | 9.4 | 9.0 | 8.1 | | 5.2 | | | | | | | 100.0 |
| Total. | 29.4 | 30.0 | 30.2 | | 29.7 | 29.3 | 28.9 | | (29.3) 14.8 | | | | | | | 300.2 |
| Average percentage per operator | 9.8 | 10.0 | 10.0 | | 9.9 | 9.8 | 9.6 | | 9.9 | | | | | | | — |

TABLE VII.A.—Individual Percentage-output per hour. Scheme II.—Morning Shift.

| Check No. | HOURS. | | | | | | | | Totals. |
|----------------------------------|--------|------|------|----|----------------|------|------|------|---------|
| | A.M. | | | | | | | P.M. | |
| | 6— | 7— | 8— | 9— | 9½— | 10— | 11— | 12—1 | |
| Shop A. | | | | | | | | | |
| 1873 | 16.8 | 17.4 | 16.5 | | 8.2 | 15.2 | 14.9 | 11.0 | 100.0 |
| 1851 | 16.8 | 16.2 | 15.3 | | 8.7 | 15.9 | 15.6 | 11.6 | 100.1 |
| 1856 | 15.7 | 15.1 | 14.8 | | 8.4 | 15.7 | 16.2 | 14.0 | 99.9 |
| 1829 | 15.8 | 15.6 | 15.0 | | 9.3 | 15.8 | 16.1 | 12.3 | 99.9 |
| Total | 65.1 | 64.3 | 61.6 | | (69.2) 34.6 | 62.8 | 62.8 | 48.9 | 399.9 |
| Average percentage per Operator. | 16.3 | 16.1 | 15.4 | | 17.2 | 15.6 | 15.7 | 12.2 | — |
| Shop B. | | | | | | | | | |
| 2052 | 16.1 | 14.9 | 16.8 | | 7.6 | 15.8 | 16.1 | 12.6 | 99.9 |
| 2112 | 16.5 | 16.9 | 17.2 | | 7.5 | 15.2 | 16.5 | 10.1 | 99.9 |
| 2074 | 15.7 | 13.9 | 16.0 | | 8.0 | 18.1 | 17.1 | 11.1 | 99.9 |
| Total | 48.3 | 45.7 | 50.0 | | (46.1) 23.1 | 49.1 | 49.7 | 33.8 | 299.7 |
| Average percentage per Operator. | 16.1 | 15.2 | 16.6 | | 15.4 | 16.4 | 16.8 | 11.3 | — |

TABLE VII B.—Individual Percentage-output per hour.
Scheme II.—Afternoon Shift.

| Check No. | HOURS (P.M.) | | | | | | | | Totals. |
|----------------------------------|--------------|------|------|------|-------------|------|------|-------|---------|
| | 2— | 3— | 4— | 5— | 5½— | 6¼— | 7— | 8-9 | |
| Shop A. | | | | | | | | | |
| 677 | 16.1 | 15.8 | 15.8 | 11.5 | | 12.5 | 14.8 | 13.5 | 100.0 |
| 740 | 14.6 | 15.2 | 15.5 | 11.8 | | 12.4 | 14.9 | 15.5 | 99.9 |
| 615 | 17.1 | 15.5 | 15.0 | 10.9 | | 12.4 | 11.9 | 17.1 | 99.9 |
| 673 | 16.2 | 15.0 | 15.4 | 10.5 | | 12.0 | 15.8 | 15.0 | 99.9 |
| 622 | 18.1 | 17.3 | 12.6 | 9.1 | | 13.4 | 15.7 | 13.8 | 100.0 |
| 797 | 15.2 | 16.3 | 15.6 | 9.2 | | 13.2 | 15.6 | 14.9 | 100.0 |
| Total | 97.3 | 95.1 | 89.9 | 63.0 | | 75.9 | 88.7 | 89.8 | 599.7 |
| Average percentage per Operator. | 16.2 | 15.9 | 15.0 | 13.9 | | 16.8 | 14.8 | 15.0 | — |
| | | | | | Meal Break. | | | | |
| Shop B. | | | | | | | | | |
| 1519 | 15.5 | 16.1 | 14.4 | 11.7 | | 12.1 | 15.8 | 14.4 | 100.0 |
| 1655 | 17.8 | 15.2 | 17.4 | 12.2 | | 9.1 | 13.9 | 14.3 | 99.9 |
| 1659 | 14.3 | 15.4 | 14.7 | 12.2 | | 11.5 | 16.1 | 15.8 | 100.0 |
| 1596 | 11.9 | 13.1 | 13.9 | 11.1 | | 13.9 | 18.0 | 18.0 | 99.9 |
| 1654 | 15.4 | 14.7 | 13.7 | 11.6 | | 12.6 | 15.8 | 16.2 | 100.0 |
| Total | 74.9 | 74.5 | 74.1 | 58.8 | | 59.2 | 79.6 | 78.7 | 499.8 |
| Average percentage per Operator. | 15.0 | 14.9 | 14.4 | 15.6 | | 15.8 | 15.9 | 15.76 | — |

TABLE VII C.—Individual Percentage-output per hour.
Scheme II.—Night Shift.

| Check No. | HOURS. | | | | | | | | | Totals. |
|---------------------------------|--------|------|------|------|-----|------|------|------|------|---------|
| | P.M. | | | A.M. | | | | | | |
| | 10— | 11— | 12— | 1— | 1½— | 2— | 3— | 4— | 5-6 | |
| Shop A. | | | | | | | | | | |
| 71 | 13.8 | 13.5 | 13.8 | 6.8 | | 12.1 | 13.5 | 13.8 | 12.7 | 100.0 |
| 74 | 14.4 | 13.7 | 13.7 | 5.8 | | 13.1 | 13.4 | 13.7 | 12.1 | 99.9 |
| 1 | 13.7 | 13.7 | 13.9 | 6.5 | | 13.0 | 13.7 | 13.9 | 11.6 | 100.0 |
| 244 | 13.8 | 13.6 | 13.6 | 6.7 | | 12.9 | 13.6 | 13.6 | 12.4 | 100.1 |
| 100 | 12.7 | 13.7 | 13.4 | 7.4 | | 12.1 | 13.4 | 12.7 | 14.4 | 100.0 |
| Total | 68.4 | 68.2 | 68.4 | 33.2 | | 63.2 | 67.6 | 67.7 | 63.2 | 500.0 |
| Average percentage per Operator | 13.7 | 13.6 | 13.7 | 13.3 | | 12.6 | 13.5 | 13.5 | 12.6 | |

These average percentages are plotted out on Fig. 1 for Scheme I., and on Fig. 2 for Scheme II.

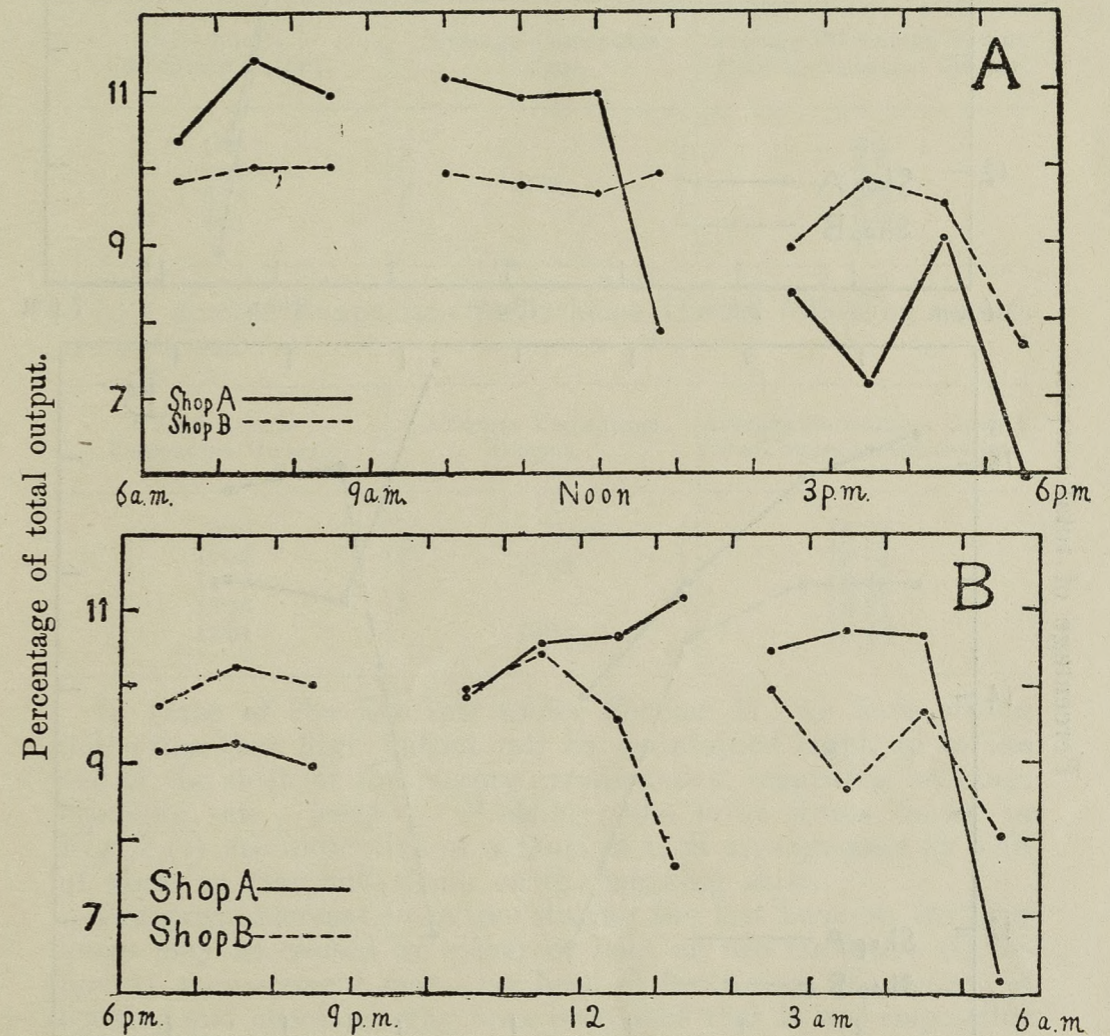


Fig. 1.—Actual hourly output expressed as percentage of total output. (Scheme I.)

A = Day Shift ; B = Night Shift.

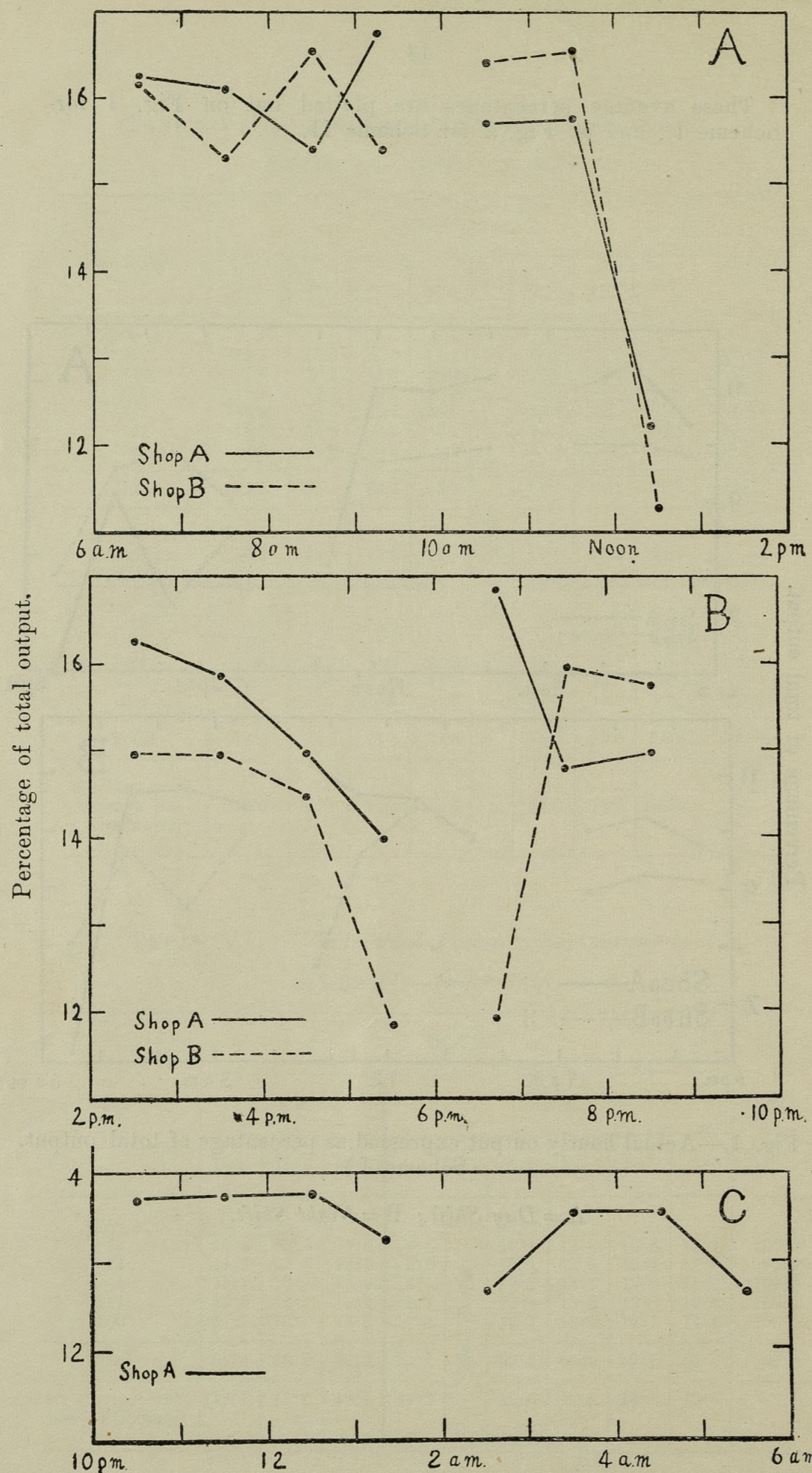


Fig. 2.—Actual hourly output expressed as percentage of total output. (Scheme II.)
A = Morning Shift ; B = Afternoon Shift ; C = Night Shift.

3. RESULTS.

I. Each of the four graphs in Fig. 1 referring to Scheme I. indicates a marked drop in output during the last hour of the shift, which is clearly shown when we compare for each shift the percentage output for the last hour with the average percentage output for all hours except the last:—

| Last hour's Percentage Output. | Average Percentage Output. | Average Percentage Output for all hours except the last. |
|--------------------------------|----------------------------|--|
| 5.93 | } 9.52 | } 9.9 |
| 7.61 | | |
| 6.16 | | |
| 8.01 | | |

In a similar comparison for Scheme II. the following results are obtained:—

| Last hour's Percentage Output. | Average Percentage Output. | Average Percentage Output for all hours except the last. |
|--------------------------------|----------------------------|--|
| 12.20 | } 15.39 | } 15.96 |
| 11.28 | | |
| 14.96 | | |
| 15.76 | | |
| 12.64 | | |
| | 13.33 | 16.13 |
| | | 15.46 |
| | | 15.31 |
| | | 13.44 |

In three of the five sets under Scheme II. we have strong indication that high output can be maintained right up to the end of the shift (if the factory arrangements regarding booking, checking, etc., permit). Probably, the large drops shown in Fig. 2 (A) are indicative of a fault in such arrangement or plan of work, as they both occur on the morning shift.

The great decrease in output during the last hour on the long hours may be caused by either or both of two factors:—(i) the factory management may have been at fault, *i.e.*, the system of booking and checking may have been such that it was impossible for the women to do more than a half hour's work in a full hour; or (ii) the decrease may have been due to fatigue of the workers.

II. The general trend of Fig. 2 indicates no tendency to fall during the second half of the shift, whereas in Fig. 1 in three out of the four graphs there is a marked falling off during the last four hours of the shift, which must without doubt be taken as a general indication of fatigue. So marked is this falling off in the case of Fig. 1 that I have been led to plot the hourly percentage outputs for the individuals on this shift in Fig. 3, which shows a distinct reduction in output over the afternoon hours, though at four o'clock a spurt is shown due to the stimulus of a cup of tea taken at the machines.

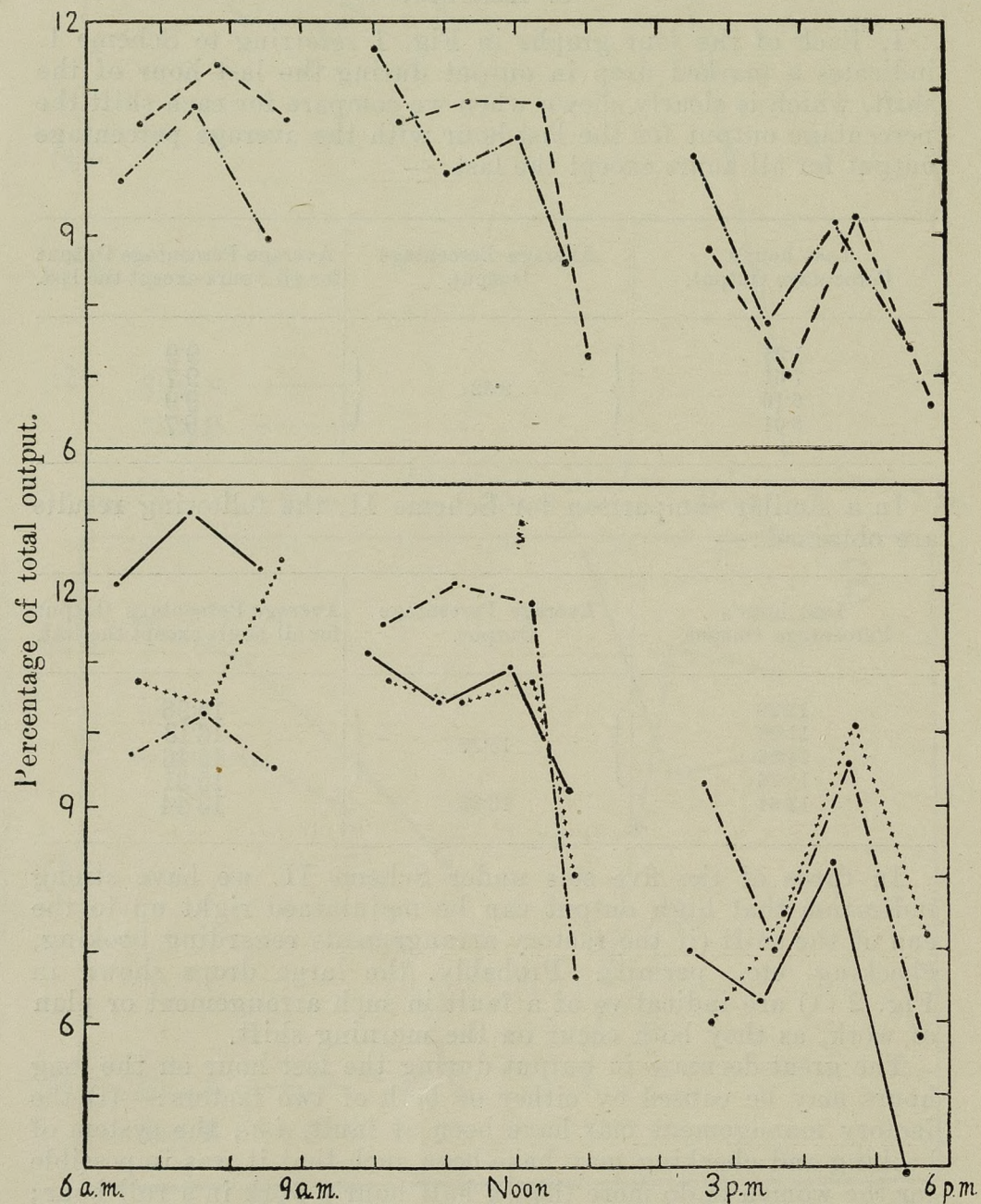


Fig. 3.—Actual hourly outputs of five operators expressed as percentages of total output. (Scheme I.)

(Each curve relates to an individual operator.)

A special instance is operator 74, who was an experienced worker, and had worked on both the long and the short hours. In Fig. 4 are plotted her hourly percentage output for the two shifts. There is little need to point out the strong indication of fatigue with the long hours and its entire disappearance in the short hour shift.

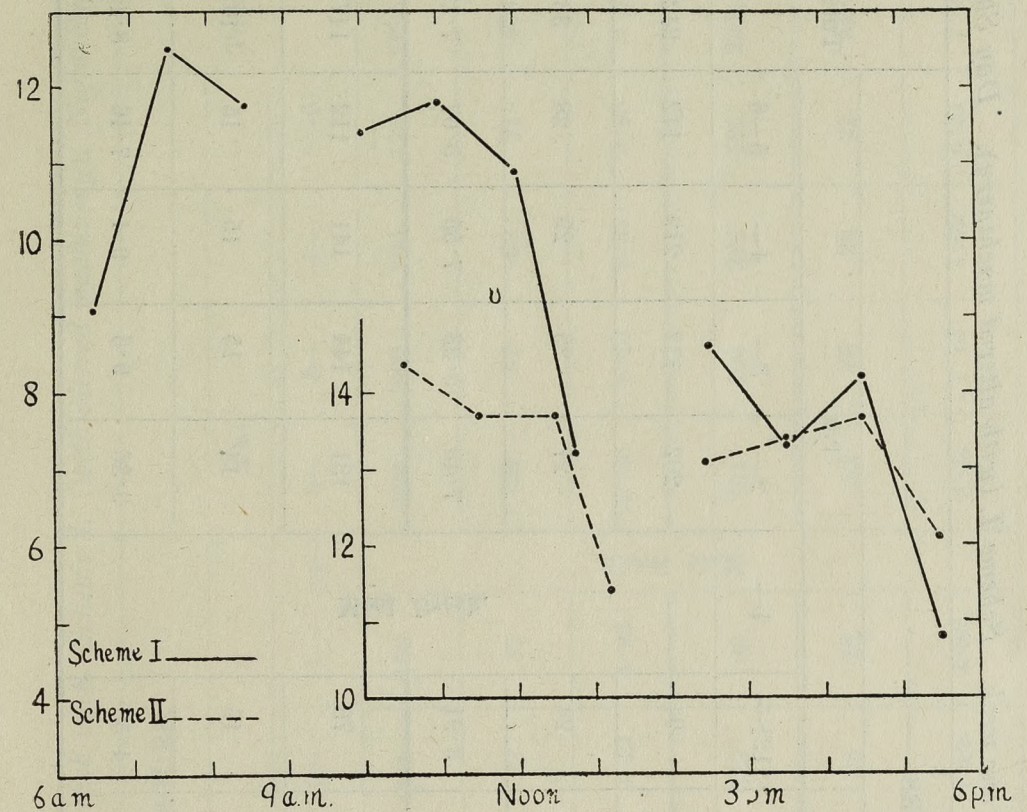


Fig. 4.—Actual hourly output (expressed as a percentage of total output) of a single operator under Scheme I, compared with the output of the same operator under Scheme II.

III. Comparison of Fig. 1A, which is a record of day work, with Fig. 1B, which is a record of night work, gives no evidence of any adverse effect of night work, and, moreover from Tables VIII.A and VIII.B (to be explained in the next section) the average number of shells per operator per machine per hour for the shifts is as follows:—

| | Day Shift. | Night Shift. |
|----------------|------------|--------------|
| Shop A. | 7.19 | 8.39 |
| Shop B. | 8.40 | 7.24 |

For the short hours unfortunately there is only a record of one shift's work, which shows evidence of evenness of output, a feature which I have previously noted in such hourly output records of women's night work.

IV. The data of Tables VIII.A and VIII.B show the actual number of shells made in each hour for the whole week for each shift under Scheme I. These totals divided by the number of hourly bookings for each period give the average actual number of shells turned out per period per operator.

TABLE VIII A.—Total and average output for each hour during one week. Scheme I. (with altered machinery). Day Shift.

| | HOURS. | | | | | | | | | | | | | Totals. |
|---------------------------------|--------|------|------|-------------|------|------|------|------|-------------|------|------|------|------|---------|
| | A.M. | | | | | | | P.M. | | | | | | |
| | 6— | 7— | 8— | 9— | 9½— | 10½— | 11½— | 12½— | 1— | 2— | 3— | 4— | 5—6 | |
| <i>Shop A.</i> Total Shells. | 251 | 278 | 266 | Meal Break. | 270 | 265 | 265 | 94 | Meal Break. | 202 | 172 | 219 | 142 | 2424 |
| Observations. | 34 | 33 | 34 | | 33 | 33 | 33 | 24 | | 27 | 29 | 29 | 28 | 337 |
| Average Shells per hour. | 7.38 | 8.42 | 7.82 | | 8.18 | 8.03 | 8.03 | 3.91 | | 7.48 | 5.93 | 7.55 | 5.07 | 7.19 |
| <i>Shop B.</i> Total Shells. | 144 | 147 | 148 | | 146 | 144 | 142 | 73 | | 131 | 144 | 141 | 112 | 1472 |
| Observations. | 17 | 17 | 17 | 16 | 16 | 16 | 16 | 14 | 15 | 15 | 15 | 174 | | |
| Average Shells per hour. | 8.47 | 8.64 | 8.70 | 9.12 | 9.0 | 8.87 | 4.56 | 9.35 | 9.6 | 9.4 | 7.46 | 8.40 | | |

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TABLE VIII B.—Total and average output for each hour during each week. Scheme I. (with altered machinery). Night Shift.

| | HOURS. | | | | | | | | | | | | | Totals. | |
|---------------------------------|--------|------|-----|-------------|------|------|------|------|-------------|------|------|------|------|---------|-----|
| | P.M. | | | | | | | A.M. | | | | | | | |
| | 6— | 7— | 8— | 9— | 10— | 11— | 12— | 1— | 1½— | 2— | 3— | 4— | 5—6 | | |
| <i>Shop A.</i> Total Shells. | 263 | 235 | 230 | Meal Break. | 279 | 297 | 301 | 158 | Meal Break. | 296 | 302 | 300 | 174 | 2835 | |
| Observations. | 31 | 26 | 25 | | 32 | 32 | 32 | 32 | | 32 | 32 | 32 | 32 | 32 | 338 |
| Average Shells per hour. | 8.48 | 9.03 | 9.2 | | 8.71 | 9.28 | 9.40 | 4.93 | | 9.25 | 9.43 | 9.37 | 5.43 | 8.39 | |
| <i>Shop B.</i> Total Shells. | 225 | 235 | 231 | | 229 | 240 | 220 | 88 | | 231 | 199 | 222 | 184 | 2304 | |
| Observations. | 30 | 30 | 30 | 30 | 29 | 28 | 28 | 28 | 28 | 28 | 29 | 318 | | | |
| Average Shells per hour. | 7.5 | 7.83 | 7.7 | 7.63 | 8.27 | 7.85 | 3.85 | 8.25 | 7.10 | 7.92 | 6.31 | 7.24 | | | |

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TABLE IXA.—Total and average output for each hour during one week.

Scheme I. (with old machinery). Day shift.

| | HOURS. | | | | | | | | | | | | | Totals. |
|-------------------------|--------|------|------|-------------|------|------|------|------|-------------|------|------|------|------|---------|
| | A.M. | | | | | | | | P.M. | | | | | |
| | 6— | 7— | 8— | 9— | 9½— | 10— | 11— | 12— | 1— | 2— | 3— | 4— | 5-6 | |
| <i>Shop A.</i> | | | | | | | | | | | | | | |
| Total shells | 263 | 266 | 272 | Meal break. | 103 | 256 | 247 | 238 | Meal break. | 215 | 180 | 201 | 139 | 2380 |
| Observations | 40 | 40 | 38 | | 35 | 35 | 36 | 36 | | 31 | 31 | 32 | 31 | 385 |
| Average shells per hour | 6.57 | 6.65 | 7.15 | | 5.88 | 7.31 | 6.86 | 6.61 | | 6.93 | 7.74 | 6.25 | 4.48 | 6.19 |

Tables IX.A and IX.B have been similarly prepared, but for an earlier period of one week, before the alterations in plant described on p. 4 had been effected.

TABLE IXB.—Total and average output for each hour during one week. Scheme I. (with old machinery). Night shift.

| | HOURS. | | | | | | | | | | | | | Totals. | |
|-------------------------|--------|------|------|-------------|------|------|------|------|-------------|------|------|------|------|---------|-----|
| | P.M. | | | | | | | | A.M. | | | | | | |
| | 6— | 7— | 8— | 9— | 10— | 11— | 12— | 1— | 1½— | 2— | 3— | 4— | 5-6 | | |
| <i>Shop A.</i> | | | | | | | | | | | | | | | |
| Total shells | 248 | 237 | 236 | Meal break. | 242 | 261 | 250 | 118 | Meal break. | 247 | 183 | 277 | 152 | 2451 | |
| Observations | 38 | 36 | 36 | | 36 | 37 | 36 | 36 | | 36 | 36 | 36 | 36 | 32 | 395 |
| Average shells per hour | 6.53 | 6.58 | 6.55 | | 6.72 | 7.05 | 6.91 | 6.55 | | 6.86 | 6.69 | 7.69 | 4.75 | 6.21 | |
| <i>Shop B.</i> | | | | | | | | | | | | | | | |
| Total shells | 263 | 244 | 199 | Meal break. | 242 | 207 | 134 | 105 | Meal break. | 153 | 181 | 167 | 140 | 2035 | |
| Observations | 32 | 31 | 31 | | 28 | 27 | 20 | 20 | | 21 | 26 | 27 | 26 | 289 | |
| Average shells per hour | 8.22 | 7.87 | 6.42 | | 8.64 | 7.66 | 7.9 | 7.28 | | 6.96 | 8.2 | 6.11 | 5.38 | 7.04 | |

The results have also been plotted in Fig. 5 (A and B), which gives evidence of the increase in output due to the new type of machine, but there is practically no change in the tailing off characteristic of output on long shifts where the work is heavy.

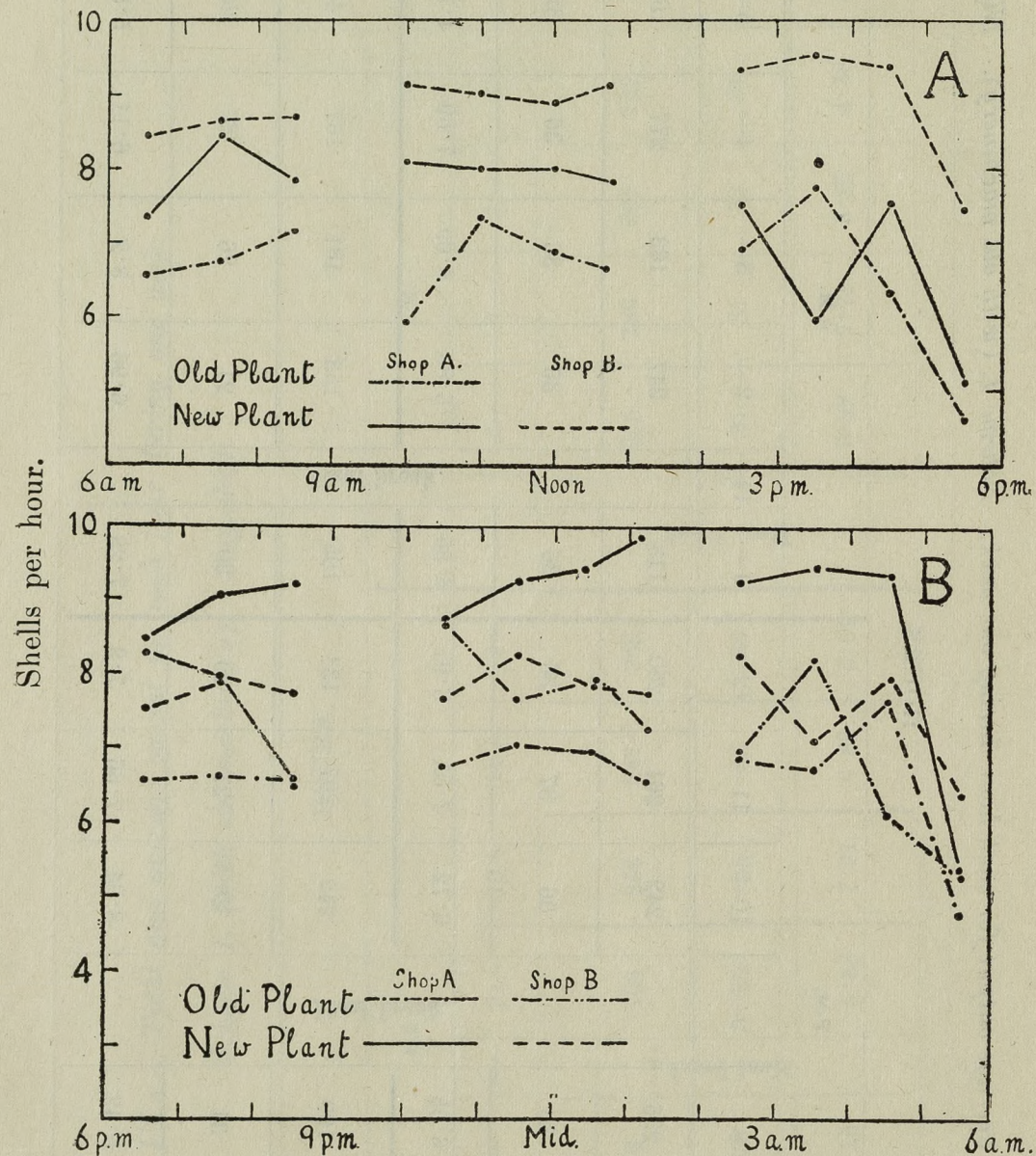


Fig. 5.—Average output for each hour during one week, under Scheme I with old and new machinery.

A = Day Shift; B = Night Shift.

SUMMARY.

(1). The investigation was based on data of the hourly output of 43 women in a National Shell Factory engaged on the "ripping" or "part off" operation in the turning of six-inch shells, during the periods of one week under two different systems of employment, namely, two shifts of twelve hours each and three shifts of 7 to 8 hours each.

(2). Direct comparison of the average hourly output for all shifts under the two systems shows a decided increase in favour of the short-shift system (8.70 compared with 8.17). This difference is further accentuated when the effect of the time of actual cutting (a machining operation the speed of which is constant) is eliminated; in the work of fixing and removing the shells, over the speed of which alone the operator has control, the time required for a fixed amount of work shows a decrease of 19.5 per cent. in favour of the shorter shift.

(3). Higher efficiency of the machinery and less idle time, the short-shift system are shown by comparing for the two systems the average output per *possible* hour of work and the average output per *actual* hour of work. The output computed on the latter basis shows a decrease of 3.43 per cent. on the long-shift system and of only 0.58 per cent. on the short-shift system.

(4). A similar comparison for the two systems of the average output per hour *in the factory* and the average output per *actual* hour of work indicates by the smaller decrease in the case of the short-shift system (7.59 per cent. compared with 14.67 per cent.) the advantage of a shift of such duration as to require only one meal-break.

(5). The uniformly low efficiency for the long shifts of the last hour is strongly indicated in the curves of average hourly output; no such uniformity exists in the case of the short shifts, on the contrary, several sets of curves exhibit no falling off.

(6). The curves of output for the short shifts give evidence of the possibility of running at full output right to the end of the shift; but the curves for the long shifts give no such evidence.

(7). A comparison of the same worker's output records for the long and short shifts shows inferiority in hourly output during the later hours of the long shifts.

(8). No evidence of detrimental effect of night work in comparison with day work is traceable.

May, 1919.

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