

**ECONOMICS OF FATIGUE
AND UNREST**

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ECONOMICS OF FATIGUE
AND UNREST AND THE
EFFICIENCY OF LABOUR IN ENG-
LISH AND AMERICAN INDUSTRY

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INTRODUCTION

THE scientific study of industrial fatigue has in recent years gained increasing recognition and appreciation in official, academic, religious and business circles, not to mention the less circumscribable general public; but those bold enough to publish their investigations or views in the matter are inclined to neglect an essential consideration in the plan for a happier state of society.

Little progress can be hoped for in the practical application of scientific discovery if it is not susceptible to proof that the economic gains outbalance the costs of application. The economic possibilities must be strictly kept in view. Breeding a race of indefatigable Robots for instance, or reducing workmen to a restful docility impervious to the appeal of agitators, are strategical operations hardly within the range of economic action. Nor are the physiological and psychological phenomena of industrial fatigue and unrest intelligible without some orientation in modern economic organization. The fatigue—or unrest—of the mediæval handicraftsmen or of a slave in the "household" system of the Roman empire presented problems entirely different from those uppermost to-day.

In this work my aim is to traverse as thoroughly as any text-book the whole teeming ground of recent research, and yet to keep in constant view the economic landmarks and the economic soil; the sophisticated reader must excuse the brief statement in Part I of the facts characterizing our present industrial organization and distinguishing it from all predecessors. These facts are grouped logically

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rather than chronologically. A description of the distinctive features of modern technical advance (Chapter I) is followed by an appreciation (Chapter II) of the pass to which labour was reduced by this progress, and leads to a review (Chapter III) of the policies of extrication or mitigation that have been carried out by various agencies.

The intelligent control of industrial conditions first proclaimed by scientific management has gradually been extended in the interests of labour so far as to foreshadow (Chapter IV) a systematic "personnel" policy based on physiological and psychological theories. These theories rouse the hope that efficiency and human happiness may yet be found compatible. They point to fatigue as an affliction caused by industrial conditions and in its turn causing industrial inefficiency, and I have ventured to include unrest in the same category. Unrest is admittedly an affliction causing industrial inefficiency; in its turn, it may be caused by industrial conditions.

False optimism, perhaps, and word magic! But in view of the costs of industrial inefficiency (Chapter V) the facts in the case receive (Part II) exhaustive examination. Results arrived at by different methods are duly segregated: the evidence of the overt facts found in industry itself is considered in Chapters VI to XI *and is summarized* in Chapter XII, pp. 348-356; and only then (pp. 365-383) is the evidence obtained by questioning, by psychological or physiological tests and by experiments in the laboratory summarized and discussed. Part III outlines methods for collecting further evidence of scientific and practical value.

If the study of industrial fatigue and unrest has need of economic orientation, the general theory of economics certainly needs a more scientific basis.

Next in importance to the question of the optimum number of potential workers—the problem of population—must come the question how best to set a given population to work.

No conventional label has yet been attached to this class of considerations as a whole, though the admitted "problems" of unemployment and of wages are both involved. If greater care were exercised to employ men efficiently without engendering fatigue and unrest, a greater number of men would be given employment and higher wages could be afforded all round.

Is it presumptuous to claim a place for Fatigue and Unrest in the study of economics, as well as a place for Economics in the study of Fatigue and Unrest?

* * * * *

Part of the material for this work was collected while I was a member of the New York Bureau of Industrial Research, and I am glad of the opportunity of thanking the Bureau for leave to publish. I must also express my gratitude to Mr. Joseph L. Cohen, M.A., and to Miss J. E. Norton for reading parts of the manuscript and making many valuable suggestions.

My indebtedness to my wife, Lella Faye Secor, is but inadequately expressed by the dedication of this book. Authorship in the midst of University work, providing no incentive and few opportunities for research, would have been an impossibility without her unflagging toil, supervision, and advice at every stage of production.

P. S. F.

CAMBRIDGE,
1924.

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PART I

CHAPTER I

THE GROWTH OF TECHNICAL EFFICIENCY

From our present dizzy state it is startling to look back on the deep calm of the first seventy years of the eighteenth century. All the evils of society were yet manageable. . . . But tranquillity as usual bred carelessness ; events were left to take their own way uncontrolled ; the weeds grew fast, while none thought of sowing the good seed.

WHEN Thomas Arnold wrote these lines in 1833¹ he was viewing the English industrial revolution at close range. Fifty years later, when the same industrial upheaval was revolutionizing the economic life of America, D. A. Wells² ventured a prophecy :

The historian of the future . . . will doubtless assign to the period embraced by the life of the generation terminating in 1885, a place of importance . . . second to but very few, and perhaps to none, of the many similar epochs of time in any of the centuries that have preceded it.

The force of these observations is borne out by contemporary statistics of production, of consumption of raw materials, of exports and imports and of transport facilities by land and water. There comes a sudden acceleration, an upward swing in the curve of trade, out of all keeping with the previous pace, far outstripping the customary slight increase in the figures from decade to decade. This sudden acceleration, first observable in England and later in America and continental Europe, marking the rise of a new industrial efficiency which has continued to the present day, well deserves the name of Industrial Revolution.

¹ *Miscellaneous Works* ; quoted, Dicey, *Law and Opinion*.

² *Recent Economic Changes*, Appleton and Co., New York, 1898.

THE INDUSTRIAL REVOLUTION

The early pre-eminence of England in industrial efficiency is usually ascribed to her freedom from military invasion; the sea routes at her disposal; the wealth accumulated in rents and in the booty of an Indian Empire; the cheap labour released by the enclosures of the open fields; the skilled workmanship of immigrants fleeing from persecution elsewhere; the interest displayed in scientific experiments; natural resources in water power, coal and iron; and last but not least, the character of the English people themselves.

In economic terms, all the factors of production were to be had cheap. There was cheap capital, cheap labour, cheap technical ability, cheap power, and cheap raw materials. On the other hand, there was a ready market with buyers willing and able to pay for the products. In short, there was a range of prices at which goods could be supplied and at which goods would be demanded.

But whatever the underlying causes, there is no doubt that Englishmen at the time felt boundless enthusiasm for the new doctrine of efficiency, and recognized the novel and unique quality of their country's achievements which soon came to be identified as "progress." The famous declamation of Lord Macaulay in the course of the debates on the Reform Bill finds an echo in numberless contemporary writings,¹ and is no isolated judgment:

Our fields are cultivated with a skill unknown elsewhere, with a skill which has extracted rich harvests from moors and morasses. Our houses are filled with conveniences which the kings of former times might have envied. Our bridges, our canals, our roads, our modes of communication fill every stranger with wonder. Nowhere are manufactures carried to such perfection. Nowhere does man exercise such dominion over matter.

In sixteenth and seventeenth-century England the standard of efficiency was still largely mediæval. Industry as it was conceived in the Middle Ages was, in Mr. Lipson's phrase, the "limited production of a well-wrought article." Prices were fixed by authority, workshops inspected to

¹ See, for instance, *On the Economy of Machinery and Manufactures*, written in 1832 by Charles Babbage, Lucasian Professor of Mathematics in the University of Cambridge.

ensure the quality of the product, and conditions laid down for teaching apprentices. The purpose of industry was to maintain the craftsman in that standard of living to which it had pleased God to call him. There was to be no change in a man's class! And while sumptuary laws dictated what the poor and simple should eat or wear, the utmost extravagance among those fortunate enough to have been born gentle or noble was publicly approved of.

As a result, production in the Middle Ages was deliberate and unhurried. "Workers had the healthy instinct not to produce more than was necessary to lead a jolly life," and good use was made of the opportunity for relaxation offered by the Catholic calendar of saints' days. No one worried about calculating accounts or balances. Book-keeping methods were largely of this order: "Item, a box of gloves—but I do not know how much they were." Or, "Item, one owes me 19 gulden . . . but his name I have forgotten."¹

But this tranquil state scarcely survived the eighteenth century. Say, the French economist, found a quite different England at the close of the Napoleonic War. He was filled with wonder at the intense restless industry of all classes of Englishmen. "Everybody runs absorbed in his own affairs," he wrote. "Those who allow themselves the slightest relaxation in their labours are promptly overtaken by ruin."

By this time, indeed, a new force had invaded industry: the man or rather the economic function presented in human form, that for the last hundred years has appeared in our economic text-books as the entrepreneur. This French word is used presumably because the equivalent in English—the undertaker—is connected too familiarly with a particular line of entrepreneurship; but the entrepreneur is precisely he who undertakes to deliver the goods to their final resting-place, and brings together and organizes the chief elements required in their delivery.

In Adam Smith's day this individual had not yet come under academic notice. Adam Smith speaks only of land, capital and labour, without specifying how these elements were brought together except through the capitalist. But

¹ Sombart: *The Quintessence of Capitalism*.

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it was not long after the publication of the *Wealth of Nations* in 1776 that the entrepreneur thrust himself very forcibly into the public gaze and into the public life. The craftsman no longer manufactured his product in his own home with his own tools from raw materials procured by himself, and no longer sold it in finished form directly to the consumer; it was the entrepreneur who began to supply the capital and find the market. Gradually the craftsman became a wage-earning "employee" dependent on the entrepreneur, who by commissioning him to turn out certain specified products finally controlled his entire economic activity.

The entrepreneur became the evangelist and protagonist of efficiency. The characteristics indigenous in the entrepreneur and usually taken to be the necessary basis of efficiency are enterprise, thrift, and honesty, or at any rate a reputation for honesty.

English enterprise had already shown itself in the freebooting voyages of Drake and other Elizabethans. Professor Schmoller speaks of these English adventurers as a "sporting variety of men of rare bodily vigour, strong of wit, calm in deliberation and bold in action."

Thrift had been preached as a new gospel in Florence and other cities of Italy as early as the fifteenth century, but it was in England and Scotland under the Puritan tradition that it found an abiding home among the "middle classes." The exhortations of Defoe to work and save and avoid all pleasures were later taken up by Franklin, whose discourses on "holy economy" were printed and reprinted in even the most obscure newspapers. And as a result of this general Sabbatarianism, the English "Bourgeois" gradually deprived himself of all pleasures on which money *could* be spent, and saving became more or less automatic.

But his reputation for honesty, his thorough "respectability"—that was the English business man's chief source of pride. And this quality was particularly important when the entrepreneur began to rely for his capital on other people's thrift as well as on his own. English middle-class "solidity" has been aptly compared by Marshall to the qualities of wool, itself one of the chief of British products.

Now the influence which inspired the thrifty, honest,

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enterprising entrepreneur to new heights of organizing and undertaking, and made him, indeed, the guardian spirit of efficiency, was the phenomenon of "profit."

David Hume touches in his *Essays upon the foibles of the merchant entrepreneur* :

If the employment you give him be lucrative, especially if the profit be attached to every particular exertion of industry, he has gains so often in his eye, that he acquires by degrees a passion for it, and knows no such pleasure as that of seeing the daily increase of his fortune. And that is the reason why trade increases frugality, and why, among merchants, there is the same overplus of misers over prodigals as among the possessors of land there is the contrary.

Profit differs from wages or interest in increasing or decreasing not at a constant ratio to the amount worked or saved, but at an ever accelerating or slackening rate. Profit is the difference between the entrepreneur's total expenses and his total receipts, and it does not require a long mathematical formula to show that the slightest rise in receipts or fall in expenses may mean a manifold increase of profit. Suppose a manufacturer of shoes gets 30s. for each pair, but has to pay out 28s. in materials, wages, interest, rent, etc. If he can reduce his expenses by one-seventh to 24s., while holding the price at the old level he has increased his profit on each pair from 2s. to 6s. In short, a decrease of one-seventh in expenses results in threefold the profit.

To "economic man" closely calculating his gains and losses, these possibilities of profit acted as magic in conjuring up efficiency. In the place of a limited production of a well-wrought article to maintain a given status, there grew up the ideal of unlimited sales of an economically made article to obtain the maximum of profits.

THE MEASURE OF EFFICIENCY

The word "efficiency" has been much bandied about, and though it will be difficult to resist an appeal to its seductive powers, we must beware of using the word loosely.

For instance, efficiency is often used to refer simply to

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the *amount or quality of the product* without counting the cost. Product, however, is a perfectly good word and there is no reason for using any other. Again, efficiency is sometimes used to refer to some quality inherently belonging to the human organism. Yet such terms as working capacity or willingness to work suit the case much better.

But the important consideration in business which no other word expresses so well as efficiency is the *relation of product to cost*. Taken in this way, efficiency refers to the amount and quality of product obtained at any given standard cost. To be quite exact, efficiency is said to be

greater or less according as $\frac{\text{Product}}{\text{Cost of Production}}$ is greater

or less ;¹ and since the denominator in this ratio may vary just as much as the numerator, efficiency might also refer to the cost at which any given standard of production was obtained. But this reverse method of stating efficiency is what we refer to as "economy." Fundamentally, efficiency and economy refer to the same relation of product and costs, though efficiency directs attention to the possibility of varying the product, while economy considers primarily the possibility of varying the costs.

The idea of efficiency—also economy—as referring to a ratio, permits a definite reference to be assigned to other words in frequent use in business and economic circles. A *waste* is generally used to denote any rise in cost that is not balanced by an equivalent rise in product ; a *loss* any fall in product that is not balanced by an equivalent fall in costs. Both wastes and losses are unproductive costs and forms of inefficiency ; waste, like the word "economy," refers to the matter from the cost side, whereas loss, like the word "efficiency," refers to the matter from the product side.

These definitions are not as definite as might be, because the kind of units in which product and cost are to be measured are left to the imagination, or, worse still, to inference. A business man will naturally think of the relation of his

¹ This is in keeping with the use of the word efficiency in engineering. The efficiency of a machine is defined as the ratio of the useful work to the total energy exerted.

money returns to his money expenses, i.e. the total sales of his product as against the payments he must make to induce men to work for him, or to lend him land or capital. In short, efficiency means to him the rate of profit.

If, however, one goes behind the money measure to the things money is paying for—the efforts and sacrifices involved in working and lending, and the actual satisfaction or welfare derived from profits and other inducements—then indeed, efficiency becomes, in Mr. Hobson's phrase, a matter of human values, or, as Marshall (22) puts it, a matter of *real* costs and gains.

Real efficiency would thus consist of the maximum of welfare obtainable from our limited natural resources and our (poor) human stock, and is by general agreement a consummation devoutly to be wished for. But there is difficulty in its objective measurement.

Apart from its variation from year to year and class to class, maximum wealth per head of population might serve as a rough measure, but certainly when calculated over a long period, real, national efficiency will by no means coincide with immediate, private, business profitability. Nor will it coincide with the mere increase in value of output per man employed.

Yet this is the conventional measurement of efficiency used when an answer is attempted to the question so vital to the labourer immersed in industry: namely, how far the forms and methods of organization introduced by the industrial revolution are fundamentally necessary to the growth of efficiency, and how far they are merely fortuitously associated with this growth—and possibly avoidable to-day.

The revolution in industrial efficiency is usually measured in sensational statistics of increases in output per man, which tend to mislead in that they ignore the increase in costs of production other than the labour required, and chronicle only exceptional occurrences. No complete statement, for instance, seems ever to have been made of the amount of machine and equipment costs to set against increases in output per man—costs that the new efficiency has enormously increased.

Böhm-Bawerk's exposition of "roundabout" production

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probably indicates most clearly the nature of these costs.

When primitive man began to use a hammer and chisel in place of his bare fingers to quarry stone, he undoubtedly increased his output; but against this has to be set the time and effort spent on the "roundabout" journey taken in fashioning his new tools. In industry to-day the tool has given place in large measure to costly and expensively housed machines, profits from which are realized only after a long period of waiting. Unquestionably much of the saving in the cost of direct labour is offset by the growth of capital expenditure and standing charges corresponding with the cost of constructing and maintaining machinery and factories, and of organizing the so-called unproductive staff. In 1880 the annual cost of wages was reported in the United States census to have been 947 million dollars, and the capital invested 2,790 million dollars, or 2.94 times as much. In 1900 the ratio of capital to annual wages had risen to 4.23 times, and there was a corresponding increase in the ratio between the horse-power of the engines employed and the number of labourers employed. In 1880 this ratio was 1.25 (3,410,000 horse-power to 2,733,000 wage-earners); in 1900, 1.99.

The figures of increased production per man usually quoted not merely omit to set out all the increased costs; they cite only exceptional cases.

A study undertaken by the U.S. Department of Labor in 1898 (7) indicates clearly the average or typical increase of efficiency as contrasted with more sensational citations. Comparisons were drawn between "the machine method generally in use at the present day, and the primitive method of production which was in vogue before the general use of automatic or power machines, and which still exists to some extent in remote rural sections or occasionally even in towns."

Out of the innumerable examples presented in this study, it is best to pick only the hundred or so where comparison is made for the same or consecutive years, and where the level of wages and other conditions were presumably the same. It will be found that in the typical case the transition

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to machine production involves a reduction by between one-half and three-quarters in the time worked and in the labour cost. The most typical single example is the making of circular saws ("unit no." 570). Under the old methods the time necessary was 32 hours, 19 minutes, and the labour cost \$8.32. Under the new methods the time required is 14 hours, 8 minutes, and the labour cost is \$4.07.

Besides machine production this investigation reveals division of labour as a further characteristic of the new roundabout efficiency. In the typical case, machine production involves almost double the number of processes and over double the number of men. In the making of circular saws, for instance, fourteen separate operations were performed by a total of ten different workmen under the old method; but under the machine method 21 separate operations are performed by a total of 25 different men.

A third characteristic clearly observable in various industrial statistics is the growth of large-scale production. In Germany, establishments maintaining one to five persons as assistants employed 3.6 million persons in 1907 as against 2.6 million in 1882; but between these years the numbers employed in factories having 6 to 50 workers increased threefold, from 1.2 to 3.7 millions; and the number employed in factories containing over 50 persons increased more than threefold, from 1.6 to 5.2 millions. In the United States in 1914 out of 7 millions returned as employed in manufacture, 5.4 millions or almost four-fifths were employed in establishments of more than 50 workers; and from census to census a steady growth can be traced in the value of the output produced per factory.

There are two distinct phases in large-scale organization. Production on a large scale may issue from one building or block of buildings which form one unit for purposes of technical operation. When the scale of production is large enough, this unit of operation is called a factory as distinct from a workshop or mere household.

Or production on a large scale may issue from different and possibly widely scattered work places, all of which are owned and controlled by one man or body of men. Common ownership and control may be said to constitute a firm or

business unit, and when the scale of production is large enough, to constitute "big business."

These two forms of large-scale production are often confused. Indeed, it is seldom made clear in the usual citations, that the American statistics of size of "establishment" refer not to any growth in the business unit, i.e. in combinations between factories, but to the factory proper. A large-scale factory and a large-scale firm each conduces to different sorts of economy, and each is logically as well as historically independent. The two forms will accordingly be treated as distinct features of the present industrial system.

These, then, are the four main tendencies within the industrial revolution: the use of scientific invention, the division of labour, the development of the factory with the consequent factory town, and the growth of the business unit. Each will be shown to involve, both independently of the others and interrelated with them, inherent efficiencies or economies that presuppose its persistence in any future organization of industry—a persistence that will have to be reckoned with in all plans for reform and reorganization.

THE USE OF SCIENTIFIC INVENTION

Perhaps no single factor has played so important a part in increasing industrial efficiency as the invention of machinery and scientific processes, or rather, their commercialization. In most cases the practical exploitation of a scientific invention is not undertaken by the inventor himself, but by the entrepreneur—"the alert business-man," as Marshall calls him—who must decide whether any invention will "pay its way" or not.

The majority of inventions resemble mediæval alchemy or the music-hall "Tiddley Pom," and their specifications never get beyond collecting dust year after year in the archives of the patent office. For however cleverly a machine performs its task, its introduction in industry is impracticable without the prospect of a balance of saleable products continuing after the initial cost of the machine or process has been met.

Among the practical difficulties of commercializing

machinery is the necessity of having raw materials of a uniform character, and the inevitability of turning out a uniform product which may or may not suit the needs or tastes of all customers. The first great inventions were applied to the process of spinning and weaving, and this was doubtless due to the character of textile materials which "are delivered by nature in standardized primary forms. . . . Cotton, wool and other fibres are fine homogeneous cylinders of different shapes. Cotton is flat, wool is round; but both lend themselves to be laid out in orderly array by machinery, and thus to be spun into yarn. Yarn is a homogeneous cylinder of uniform diameter and unlimited length, perfectly standardized."¹ It is the desire for variety in the product which still prevents the application of machinery to many industries, such as, for instance, dressmaking (except for the actual stitching), and most work with pretensions to the artistic.² And the absence of uniformity in growing crops such as tea, cotton, small fruits and vegetables, deprives the harvester of the aid of machinery. In many of the large groups of industries such as agriculture, building, mining, commerce and personal services, machinery is far from dominating the situation.

Once these difficulties are overcome, the economies effected by the use of machinery and other scientific processes appear little short of the miraculous, and may be contemplated under three heads: the economy of labour, the economy of time, and the economy of materials.

Man's power is greatly increased by the use of levers, pulleys, and simple tools and apparatus. His strength is supplemented and a thousand times multiplied when electricity, oil, steam, water-power, or other natural forces are harnessed to do the work; and there is far less need to use the main force of massed labour.

The process of tanning furnishes a striking illustration of economy in time. Formerly hides were placed in pits in the tanning solution and allowed to remain from six months to two years before they were ready to be worked into leather goods. The application of scientific processes had reduced

¹ Marshall: *Industry and Trade*, pp. 56-7.

² On the other hand, the demand for army "uniforms" during the wars of the eighteenth century gave machinery a great impetus.

this period even in Babbage's day down to six weeks. But the saving in time is, of course, most obvious in transport. Consider a journey from London to Exeter, which can be made to-day in about three hours. In 1673 the same trip required eight days. Forty horses were necessary and only six passengers could be accommodated. Babbage made a cool reckoning in 1832 :

One point of view, in which rapid modes of conveyance increase the power of a country deserves attention. On the Manchester railroad, for example, above half a million of persons travel annually; and supposing each person to save only one hour in the time of transit between Manchester and Liverpool, a saving of five hundred thousand hours, or of fifty thousand working days of ten hours each, is effected. Now this is equivalent to an addition to the actual power of the country of one hundred and sixty-seven men, without increasing the quantity of food consumed; and it should also be remarked that the time of the class of men thus supplied is far more valuable than that of mere labourers.*

A further economy effected by scientific invention is the use of by-products, and of materials found in large quantities which were previously considered useless. The use of coal-tar for the manufacture of colours and explosives is a case in point, or the conversion of phosphorus iron ores into "basic" steel by the Gilchrist-Thomas method.

Economy in one element would have no value if it were achieved at a greater expense in another. Labour-saving devices, for instance, must not entail an added cost in materials or in time greater than they save in labour, and similarly material-saving and time-saving inventions must not lose in cost of labour more than they save in material and time. Economies of labour, time and materials are often enough *all* involved in the superior efficiency of scientific processes. And the economies effected by the use of inventions often permit of a quantity, quality, accuracy, regularity, or speed of production beyond anything that was possible with man's original resources in labour-power, materials and time.

One of the most far-reaching advantages of machinery is its capacity to reproduce intricate mechanisms without the slightest variation in measurement. When cylinders

* *Economy of Manufactures*, p. 306.

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were bored by hand, Watt was satisfied if the Carron Iron Works produced his machines correctly measured to within three-eighths of an inch, so that no more than a halfpenny would fit between piston and cylinder. But soon exact, standard machines, tools and parts of machines came to be required which only standard machines could make; thus a cumulative tendency was established for scientific invention to set up a demand for further invention.

Scientific inventions have been commercially adopted mainly in the manufacturing and transport groups of industries. Some writers, indeed, distinguish two phases in the English Industrial Revolution—one marked by the introduction about 1760 to 1800 of inventions in textile and metal manufacturing, the other a Commercial Revolution marked by the introduction, about 1830 to 1840, of mechanical transport, particularly in railways and shipping. In transport inventions are used largely without any accompanying increase in the division of labour or growth in the unit of operation. Running a motor-car requires the full time of one man just as much as driving a horse; the taxi-driver is no more specialized than the cabby. Again, a railway train employs a few men for their full time just as did the stage-coaches of a century ago. In manufacture, however, the use of inventions has generally gone hand in hand with division of labour and concentration in large units.

THE DIVISION OF LABOUR

Adam Smith defines division of labour as the reduction "of every man's business to some one simple operation," and he attached fundamental importance to this feature of the Industrial Revolution; "The greatest improvement in the productive powers of Labour, and the greater skill, dexterity, and judgment with which it is anywhere directed, or applied, seem to have been the effects of the division of labour." The advantages of division of labour and specialization² have been elaborated upon with growing intensity ever since, the most recent variation of the theme

² "Specialization" is simply division of labour viewed from the personal side. "Mr. X specializes in this part of the job, Mr. Y in that"; instead of "such a job is divided up between Mr. X and Mr. Y."

being scientific management. Two types of division of labour stand out as basic in our modern industrial organization, although some writers, notably Carl Bücher, have distinguished several others.

(a) The vertical division in which several persons are assigned different stages in the process of converting raw materials into a certain definite finished product. This is illustrated in Adam Smith's celebrated case of the pin-factory and in the American shoe-making industry of to-day (8, No. 232). A useful pair of shoes develops from a few scraps of leather after it has passed through four separate departments of the factory, and undergone no less than 239 operations. Thirty-seven operations alone are needed to deal with the upper leather, 13 with the heel, 63 with the sole leather, and 126 with the manufacturing stage, or the assembling and completing of the operations already under way. But so carefully have these specialized operations been analysed and divided, that a hundred pairs of shoes pass through the entire process in slightly more than half an hour. On an average, each pair of shoes remains under one operation not longer than nine and a quarter seconds.

(b) The horizontal division in which several persons are engaged in producing different products from the same raw materials. Leather in this case is used by the shoe-maker, the strap-maker, the saddler, the book-binder, the manufacturer of travelling bags, etc., each one producing products quite different from the other.

Though experimental proof as to their precise importance is lacking, numerous economies direct and indirect have been set forth as resulting from division of labour of either type.

(1) When work is divided up into simple elements, it is possible so to distribute the separate jobs among different individuals as to utilize their original or natural qualities. If a man works best at something requiring a steady, rhythmic motion and does not like thinking, it is highly wasteful to put him on some other phase of the work requiring, for instance, accurate and painstaking measurements.

(2) However inefficient a man may be originally at any job, continuous practice in one certain occupation finally enables some skill and dexterity to be acquired. As Adam

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Smith pointed out, making one operation "the sole employment of his life necessarily increases very much the dexterity of the workman."

(3) "The saving of time commonly lost in passing from one sort of work to another" was also adduced by Adam Smith. Apart from the delay if the work is spatially dispersed there is also the difficulty of shifting the mind quickly from one type of work to another.

(4) Babbage perceived that "the manufacturer, by dividing the work to be executed into different processes, each requiring different degrees of skill and force, can purchase exactly that precise quantity of both that is necessary for each process." He is not paying a skilled man for doing work part of his time which could just as readily be assigned to unskilled labour.

The important influence of rhythm¹ on "economies" (2) and (3) must not be overlooked. It is probable that a certain amount of time is required for "warming up" and acquiring momentum when a job is begun. If the same job is continued without interruption the operator acquires a rhythm of motion which accelerates the task and probably tends to decrease the accumulation of fatigue.

It would be difficult to find division of labour worked out more ingeniously and microscopically than in the meat slaughtering and packing industry in America, where 1,050 head of cattle can be "distributed" from the pen to the cooler, hide cellar, etc., by a crew of 230 men in the course of a ten-hour working day. Here machinery, despite current belief in the sausage machine, plays only a subordinate part.

The animal has been surveyed and laid off like a map; and the men have been classified in over thirty specialties and twenty rates of pay, from 16 cents to 50 cents an hour. The 50-cent man is restricted to using the knife on the most delicate parts of the hide (floorman) or to using the axe in splitting the backbone (splitter); and wherever a less skilled man can be slipped in at 18 cents, 18½ cents, 20 cents 21 cents and so on, a place is made for him, and an occupation mapped out. In working on the hide alone there are nine positions at eight different rates of pay. A 20-cent man pulls off the tail, a 22½-cent man pounds off another part where the hide separates readily, and the knife of a 40-cent man cuts a different texture and has a different

¹ A definitive analysis of rhythm is given in Chapter VIII D, § 3.

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' feel " from that of the 50-cent man. Skill has become specialized to fit the anatomy.'

The division of labour has been applied quite apart from scientific invention also in shops and offices; but however economical in and by itself, specialization has effected the greatest efficiency when combined with the use of scientific processes and large-scale factory production.

From the beginning, division of labour and inventions were stimulated by each other. Directly a job was divided up into simple elements, it became comparatively easy to devise a tool or machine for doing that particular work, and profitably if the market were large enough to keep the machinery in full use. Conversely, the increased effective use of machinery tended to greater and greater division of labour; and this interaction of machinery and the division of labour acted in turn on the development of the factory and the organization of big business, owing to the economic advantage of the *continuous* employment of specialists, and specialized machinery.

THE FACTORY AND THE FACTORY TOWN

A larger unit of operation—the "factory," "mill," or "plant"—followed close upon the use of inventions and the division of labour. Independently of either of these two tendencies, the factory has marked economic advantages over the household system of production, economies which were often appreciated in early times.

The Pyramids were built by massed labour without elaborate inventions or the fine sub-division of labour; and during the Middle Ages workers in different occupations were often brought together under one roof. According to Professor Meredith:

A versified history of John Winchcombe of Newbury, of which the first edition was possibly printed as early as 1597, tells us that

Within one roome being large and long
There stood two hundred Looftes full strong.

¹ John R. Commons: "Labour Conditions in Meat Packing and the Recent Strike." *The Quarterly Journal of Economics*. Vol. XIX.

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Each weaver (adult males were employed) was attended by a "pretty boy." A hundred women were carding. Two hundred girls were spinning. A hundred and fifty children were picking wool—"the children of poore silly men." There were fifty shearers, eighty rowers, forty dyers, and twenty hands in the fulling-mill.¹

Several fundamental economies are obtained by this concentration of work at one time and place :

(1) The proximity of all operations saves needless transport of goods and men, and permits of that continuity of process so essential in chemical transformations if the expense of re-heating materials is to be avoided.

(2) By planning and management the work can be routed so as to avoid hold-ups as it passes from one process to another ; beginners can be taught more readily to handle their materials and tools, and all workers can be more strictly supervised when collected under one roof ; waste of time and materials can be checked, and the output kept at a more constant rate ; the continued interruptions of domestic life are avoided.

(3) During and between working hours the stock and tools are safely housed and can be more easily preserved from damp and damage than in the crowded quarters of the home ; and the ventilating and lighting arrangements are better adapted to the work in hand than in rooms used also for domestic purposes.

(4) Finally, the appreciation of sociability by the workers and the stimulus of rivalry between them must not be overlooked.

The alternative household system where the worker is employed in his own home still survives in the "sweat shops" of the New York and London slums, and has the supposed economic advantage that the employer is saved the expense of providing floor-space and heat and light, and that he can employ women unable altogether to forsake their household tasks, and young children legally excluded from the factory—labour that is plentiful and cheap. Yet in most industries the economic advantages of the factory as such seem to outweigh those of home work, and when combined with the division of labour and the use of scientific invention

¹ *Economic History of England*. London, Pitman & Sons. See also Professor Ashley's *Economic History*, vol. I, part ii.

its advantages are overwhelming. The more complicated and costly machinery becomes, the more essential that it should be housed in proper quarters, concentrated round the engine-house or generating station. The by-products of scientific processes, owing to their weight and bulk relative to their value, must as a rule be used at or near the place where they are extracted or dumped. And the further division of labour is carried, the more important becomes the question of controlling the orderly routing of the materials from one specialist to another.

The increase in the size of work-places has occurred not merely in manufacturing but in distributive trades, where single shops such as Selfridge's or the American "department store" may employ hundreds of workers at a time. It also prevails in commercial and Governmental offices.

The "factory principle," which, in the last analysis, is the aggregation of numbers of workers in close geographical proximity, underlies also the characteristic growth of the factory town or district. In fact, in certain industries such as the manufacture of cutlery, the Industrial Revolution has had the effect of multiplying the number of workers in any one town rather than the number under any one roof. While large-scale factories yield internal economies, this localization yields *external* economies which equally support the law of increasing returns. Where several factories are gathered together, there will be established a long line of auxiliary undertakings to supply the various needs of the factory: machine and tool manufactures, banks and commercial houses, transport and information facilities. And not least in importance is a local supply of labour skilled in the particular trades employed; and the immobility of labour often keeps an industry localized when otherwise it might move.

The question why localization took place at all is logically distinct from the question why it took place at any particular spot; but since certain locations possessed differential advantages to industry, such as water-power, coal deposits, accessible markets, the process of localization in general was fostered naturally. When water-power was used, factory towns sprang up along banks of swiftly flowing streams, as in Lancashire and Yorkshire, west and east of the Pennine

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Range. Later, with the use of steam as motive power, similar localization occurred close to the coal deposits.

Statistics demonstrate how thoroughly urbanization has followed upon the Industrial Revolution. In the year 1851 there were seventy towns of *twenty thousand inhabitants* and upwards in Great Britain. "Their population had increased from 3,181,595 in 1801 to 8,803,897 in 1851, or at the rate of 189 per cent. ; whereas the population of the country and of the smaller towns had increased by only 71 per cent. In 1801 these towns formed 23 per cent. of the whole population ; in 1851 the proportion had risen to 34 per cent. The same movement has since continued at a greater pace. In 1911 towns of this size accounted for 61 per cent. of the population of England and Wales." ¹ It is no longer the village that is the typical centre of English life, but the straggling, urban district. And the American and German population seem to be tending in the same direction.

BIG BUSINESS

A factory is an establishment where several workmen are collected together for the purpose of obtaining greater and cheaper conveniences for labour than they could produce individually at their homes ; for producing results by their combined efforts, which they could not accomplish separately. . . . The principle of a factory is that each labourer, working separately, is controlled by some associating principle, which directs his producing powers to effecting a common result, which it is the object of all collectively to obtain. Factories are therefore a result of the universal tendency to association . . . by the development of which every advance in human improvement and human happiness has been gained.

This eulogy of the factory system delivered by Cooke Taylor, Senr., indicates the necessary complement of the division of labour. If work is split up and assigned to numerous individuals, it becomes economically necessary to provide some " associating principle " so that the different workers may be co-ordinated for a " common result."

But it does not follow that such association should be confined within the walls of one single factory. Factories, or any of the other work-places—the mine, the shop, the office—are but the unit of technical operation, and may

¹ Arthur Shadwell in the *Encyclopædia of Industrialism*.

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in their turn become associated for general business purposes.

The "business" or unit of organized control is rarely smaller than the unit of technical operation; and the practice, not unusual in Lancashire weaving sheds, of renting out "room and power" within one factory to several firms, is perhaps merely the exception that proves the rule. Hence, any increase in the size of the factory usually entails an increase in the proportions of the business organization. But there has also been a continuous tendency for successful businesses controlling perhaps only one factory to "swallow," or combine with rival establishments, so that the growth in the controlling "business" has been even more rapid than the growth of the individual establishments controlled. Out of this process have developed "trusts" such as the U.S. Steel Corporation, which owned, in 1914, 146 separate plants (furnaces, mills and factories), five main railroad lines, numerous iron ore and coal mines, timber properties, lime and ore quarries, natural gas territories, and a whole fleet of ships.

Big business has an economic *raison d'être* independent of the other tendencies of the Industrial Revolution; indeed, it was foreshadowed in the commission system before ever factories were the rule. The textile industry of eighteenth-century England was *organized* by large-scale clothiers; yet work was actually performed in the home with the help only of the hand-loom or the foot-driven spinning-wheel, and with only a rough division of labour.

This commission system tended to displace the handicrafts owing mainly to its economy in marketing. When materials are bought and the product sold in the bulk, the expenses involved in the process of buying and selling are—per unit dealt with—at a minimum.

Besides this economy of "bulk" transactions is that of integration, whereby consecutive or auxiliary operations can be co-ordinated and middlemen's profits avoided. A further economy is that risk can be minimized and a lower reserve held with the same "credit," if several different articles are being produced and the gains on some are likely to cancel and more than cancel the losses on others.

A special impetus is given to large-scale business with

the growing use of scientific invention and the tendency toward division of labour.

It is a commonplace that in marketing as well as manufacture practised specialists and highly specialized machinery and organization can be put to the fullest use only where standardization prevails; and standardization refers precisely to the production of identical copies of an article on a large scale usually impossible to all but large-scale business or combinations of businesses.

The increase in the size of the business as distinct from the operating unit has occurred mainly in mines and manufactures with their vertical and horizontal combination; in commerce with branch banks and chain stores, such as Boot's Cash Chemists in England and the United Drug Company in America; and in transport with the growth of railway systems. It has not applied in agriculture, and in personal connections such as the professions or in domestic service.

THE CAPITALISTIC SYSTEM

The new industrial tendencies so far described have been largely anatomical: a large number of businesses each comprising one or more work-places or factories, each, in turn, comprising numberless specialists and special scientific processes. This structure appears to possess fundamental economic advantages, without which production and wealth per head of population could not be maintained; and large-scale structures must probably be accepted as inevitable in modern industrial anatomy.

But what of the functioning of the industrial system? These structures, like the skeletal muscles of the body, must be co-ordinated by some principle of general control. In modern industry co-ordination is effected in two ways, both of them referred to as capitalistic, and neither of them to be accepted as necessarily final. There is the strict organization within the business unit, and outside this a looser, more mechanical connection on the market.

In his eulogy of the factory system, Cooke Taylor speaks of control by some associating principle. He does not enlarge upon the matter; and if he had, his picture, as Miss Hutchins

says,¹ might not be so attractive. Under the new industrial system the associating principle was none other than the will of the entrepreneur. For the new efficiency capital was indispensable to labour; but capital was owned by a special class of capitalist entrepreneur, and by virtue of this ownership the entrepreneur gained control over the whole combination of labour, raw materials, machinery and general factory equipment. He purchased his labour on the market just as he purchased his material equipment, and the joint product of the two factors belonged to him.

Organization within the business unit acts on the principle of vesting control in those who own the capital equipment. Yet during the course of the nineteenth century virtual control came to be exercised by the capital borrower, rather than by the owner and investor of capital stock. The typical unit of control is to-day no longer the one-man business or even the partnership, but the limited joint-stock company in England and the corporation in America. In 1904 70·6 per cent. of all factory workers in America were controlled by a corporation, while in 1914 the percentage had risen to 80·3. These companies or corporations offer a field for the savings of all types of capital owners from the most conservative investor to the most reckless speculator. Those investors who want the assurance of a regular income become bond holders or debenture holders; those who prefer to speculate in the hope of getting a larger income or of profiting quickly by a rise in the capital value take common or ordinary stock; and for those who favour a middle course there is preference or preferred stock.

This adaptation to the various predilections of owners of capital has been forced upon the business world owing to the constantly increasing scale of operations and the constantly increasing proportion of capital needed for the maximum efficiency in production.

Yet control has not been scattered. The controlling influence has gone with the speculative stock on the principle presumably that those who take the financial risks should have the responsibility. To-day it is not so much the capital owner in general who directs production as the

¹ *Women in Industry*. London, Bell and Sons, 1915.

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speculative capital owner; and though he may in fact hold only a small fraction of the total capital, this financier, often so-called, exercises a very real control and may bind together the largest of business combinations.

When we look outside the unit of business control, be it company, corporation, or one-man business, everything seems at first sight chaos. There is no authority vested in any body of persons to regulate the connection between these unit businesses, no conscious plan for industry as a whole. Among these businesses, working in successive stages of production and dependent on one another for their raw materials, their equipment and their market, each looks after itself, captures markets, corners materials, conducts rate wars, and lets the devil take the hindmost. Each business, individually, must "speculate" on its limited stock of knowledge and take the risk of losing its capital in the struggle. This competition, indescribable in any but military terms, may satisfy our sportive and predatory instincts, but at the same time it greatly strengthens the power of those who own the capital and who stand to lose or gain. If there are to be risks it seems unanswerable that those who take the risks should assume the control within each business. Hence the present system—or lack of system—is capitalist in the sense that whatever control exists over industry as a whole is exercised by those owning the capital of the competing businesses, or at any rate that part of the capital that is risked.

This capitalist lack of system is in marked contrast to the handicraft system under the control of the guilds (representing the whole industry in any locality), and to the mercantile system of Queen Elizabeth in England and of Colbert in France, where the law of production was set forth by constituted authority which applied to the whole industry of the nation. It is in marked contrast to the practice *within* the business unit, where each employee has his function planned out and can be ranked in a regular hierarchy as subordinate, co-ordinate or superior to any other employee.

Occasionally a single business grows so big relatively to its particular industry or market that, subject only to the

elasticity of the demand, prices and the conditions of production can be *controlled* within that industry or market without fear of competition from rivals. A monopoly is then said to be established. But such a monopoly, unless based on legal enactment or pre-eminent natural advantages, is often short-lived and always precarious. Its abuse in raising prices too high is likely, sooner or later, to bring in fresh competition or else to kill demand.

In the absence of control through organized authority, or even through a monopoly power, a sort of automatic control asserts itself over the industrial arena, exercised through fluctuations in market prices.

The final purpose of economic organization is to satisfy the requirements of the population, their needs, desires and business requisites, through the adaptation of natural resources and human abilities. The danger of anarchic organization where, owing to roundabout production, requirements must be forecasted so far ahead, is that certain requirements may be neglected, and that for other requirements the supplies may be overabundant. Under the present system the chief safeguard against this danger is the encouraging and discouraging effect of rising and falling prices.

If any consumer requires an article more urgently or in larger quantities and can afford to pay, this increased "demand" will send up the general market price. Conversely, the market price of articles in less demand will fall. When market prices rise entrepreneurs eager to reap the increased profit will bring more of the available supplies to market and undertake increased production. When prices fall entrepreneurs anxious to avoid financial loss will hold up supplies and slacken production. Thus do resources, immediate and anticipated, *tend* to be adjusted to alterations in human requirements.

The miracle of this impersonal, mechanical control through prices—of this invisible hand, as Adam Smith put it—was expatiated upon with the greatest enthusiasm by a long line of economists. Bastiat wrote addresses on the Economic Harmonies, and Bishop Whately, in describing (for the benefit of a New Zealander) how London was fed "through the sagacity and vigilance of private interest

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operating on the numerous class of wholesale and retail dealers," adopted an almost theological view of the matter.

Unfortunately the actual facts of our economic life do not always bear out these high praises.

For one thing, effective demand can only arise where men have wealth to offer in exchange for the article demanded; the requirements of men, their needs and desires, do not correspond to the means at their disposal. The poor must do without elementary physiological wants, while the rich may spend their means regardless of cost on the absurdest cravings.

Further evidences of faulty organization are the periodic crises and depressions that overwhelm industry in a fairly regular cycle. The whole course of the nineteenth century was industrially a switchback, the deepest troughs centring round 1837, 1857, 1874 and 1894; and we are now (1921-24) in the depths of another. Many and various are the facts advanced to account for these economic discords: sun-spots, the rainfall and crowd psychology, as well as the monetary and credit policy of governments and banks. But there is no question that, whatever the ultimate cause, whether natural or human, there would be no such dire results if our control over industry in general were not so casual.

THE SCOPE OF INDUSTRY

"Industry" has hitherto been mentioned somewhat provisionally, and further progress would be unprofitable without more definite indication of its capriciously variable terms of reference.

Though by derivation "industrial" might refer to every aspect of work, the word is usually restricted to its human aspect. We speak of the industrial classes and industrial insurance when referring to the people engaged in industry, and insurance as applied to their lives. And the scope of industry is most pertinently indicated by the persons engaged therein. It is soon evident how indefinite are the limits of the term as commonly used. Among those at work industry seems to embrace a wider, a narrower and an intermediate circle.

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In its widest sense, industry refers to all those who are at work for the purpose of "gain," i.e. of actual money payment or the prospect of it. In this sense industry includes all persons enumerated in the decennial occupation census as occupied. For the United Kingdom in 1911 this occupied population amounted to slightly over twenty million persons, about 45 per cent. of the total population. For the United States in 1910 the number of occupied persons was thirty-eight millions, or about 37 per cent. of the total population.

Table 1 shows in broad outline how this industrial population is occupied in the United Kingdom and the United States. The information is drawn from the British and American censuses of occupation for 1911 and 1910 respectively, but the principle of arrangement is somewhat new. The *place of work* constitutes a simple index of the conditions affecting the human factor, and the population is grouped according as it works in fields, mines, offices, factories, shops and so on.

In the official classifications, considerations as to the type of material used or the type of wants satisfied often enter in and confuse the "work-place" categories. Thus, in the British census the retailing of any article is usually not distinguished from its manufacturing stage, and whisky distillers, wine merchants, publicans and ladies keeping boarding-houses are apparently all included under the one heading, "Food, Tobacco, Drink and Lodging." Again, both in the American and British censuses, office clerks in a factory are included with the various manual occupations of the same factory. The number given as occupied in various places can, therefore, be regarded only as a rough approximation.

In its narrowest sense—and it is the sense adopted in the American census of manufactures—industry refers exclusively to persons engaged in manufacture. The English census of production includes also those occupied in mines and buildings—groups 2, 3 and 4 in the table. In this sense we speak of industry *and* agriculture, or industry, transport *and* commerce.

In an intermediate sense the adjective "industrial" is

TABLE I
CLASSES OF OCCUPATION : THEIR RELATIVE IMPORTANCE

Place of Work.	Official Designations and Millions of Persons so Occupied.	
	U.S.A. Census, 1910.	U.K. Census, 1911.
1. Fields	Agriculture, forestry and animal husbandry 12.7	Agriculture 2.3 Fishing 0.1
2. Mines	Extraction of minerals 1.0	In and about mines and quarries.. 1.2
3. Building	Subdivisions of manufacturing and mechanical industries 1.7	Building and works of construction 1.2
4. Factory and workshop	Remainder of manufacturing and mechanical industries 9.0	Classes numbered 10, 11, and 13-22 6.3 ¹
5. Transport lines	Transportation 2.6	Conveyance of men, goods and messages 1.7
6. Store (shop)	Subdivisions of trade designated as "in stores" 2.6	Subdivisions of trade designated as "in stores" 2.0 ¹
7. Office	Clerical occupations 1.7	Commercial occupations 0.9
8. Personal connection :		
(a) Commercial	Remainder of " Trade " 1.0	Remainder of " Trade " 0.8 ¹
(b) Domestic	Domestic and personal services ² 3.7	Domestic offices or services ² 2.2
(c) Professional	Professional service 1.7	Professional occupations 0.9
(d) Governmental	Public service 0.5	Government and Defence 0.6
Total of occupations	38.2	20.2

¹ These figures are estimated. The groups officially numbered 10, 11 and 13-22 in the English census include 9.1 million persons and mix up together all those occupied with specific materials, whether as manufacturers (class 4), as shop assistants (class 6), or in a commercial or personal service connection (class 8 a and b). Bowley in his *Division of the Product of Industry*, Table 2, gives 8.7 million (6,520 men, 2,155 women) as occupied in 1911 in "productive industries," including building and mining. Subtracting 1.2 for mining and another 1.2 for building, factories and workshops (class 4), are left with 6.3 million. The numbers given as occupied in classes 6 and 8 a suppose the 2.8 million remaining of the 9.1 million to be divided in the proportions disclosed by the American census, namely 2.6 to 1, and cannot be depended upon.

² The official connotation of domestic and personal service is not the same in the two countries.

applied to those persons who are occupied in all *manual* work, and under this definition groups 1, 2, 3, 4, 5 and possibly 8 in the table would all be called industrial. In practice, however, this definition "taken neat" has proved unworkable, and labour legislation such as the English Workmen's Compensation Act of 1906 has had to include with manual workers all those "whose remuneration, if not a manual labourer, does not exceed £250 a year." Moreover, this Act is confined to those "under a contract of service or apprenticeship"—in other words, to those employed by others and not working on their own. Sometimes only those employees are included who work in a factory or other large-scale unit of operation where, as for instance in the English census of production of 1907, at least five persons must be working altogether.

The adjective "industrial," then, most often stands in these Acts for the whole phrase employed-on-a-largish-scale-at-a-manual-occupation-or-anywhere-where-the-gain-is-relatively-low, though the "largish-scale" feature may not be insisted on. This may seem rather an exacting definition, yet within its terms are included the bulk of the occupied population both in England and America. For instance, the English Unemployment Insurance Acts of 1920 and 1921, though neglecting outworkers, persons employed in agriculture and private domestic service, still applied to some eleven millions at the beginning of 1922. Again, in the scheme for Workmen's Compensation which refers only to parts of groups 2, 3, 4 and 5, some 8·4 million persons were included in 1919.

The fact conveniently disregarded by many is that in modern industry manual workers and all workers with relatively low incomes—persons we may group as wage-earners—greatly outnumber employers, "salaried" persons and workers on their own account. In the industries covered by the Census of Production, the Population Census of 1901 enumerates in England and Scotland 223,227 employers, 420,782 working independently on their own account, and 7,186,779 employees, among whom, to judge from the 1907 Census of Production, not more than 500,000 would be salaried.

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Thus, as against a total of not more than 1,150,000 employers, independents and salaried persons, there seem to be in the same groups of industries at least 6,650,000 wage-earning employees—a proportion of almost six to one.

Most persons occupied for gain are supporting children and other relatives, and when these are included in the sum total it is evident (unless the term is taken in its very narrowest scope) that industrial conditions affect the vital interests of a majority of Englishmen and Americans.

CHAPTER II

THE LABOUR PROBLEM

It is our business now to look behind the scenes of the triumph. The Industrial Revolution hailed by Macaulay and his contemporaries as "carrying manufactures to such perfection" appeared in a different light to the contemporary workmen. And well it might.

The industry of to-day is the product of a revolutionary century, man the growth of æons of tardy evolution. Man's organism has gradually been adapted for hunting and fishing, perhaps even for agriculture and cooking, but is he adapted to the machine work, the specialization, the factory routine and the docile subjection to organization demanded by modern business?

If outwardly he conforms to economic exigency, is he not inwardly repressing primitive instincts which may ultimately rise to rend him? Is there as yet any such type as the harmonious economic man?

These are the questions with which biology and the newer psychology have disturbed the smug satisfaction of Macaulay's pupils. And recent research in economic history and economic statistics is not calculated to allay their discomfort. Exposed to a strange environment, man was not compensated by such abundant increase in material wealth as used commonly and conveniently to be assumed. Working-class families, under the new industrial "discipline" described by the Hammonds (21), seemed to be—

a mere part of the machinery without share in the increased wealth or the increased power over life that machinery had brought. For the revolution that had raised the standard of comfort for the rich had depressed the standard of life for the poor; it had given to the capitalist a new importance while it had degraded the work-

people to be the mere muscles of industry. Men, women and children were in the grasp of a great machine that threatened to destroy all sense of the dignity of human life.

LABOUR AS A COMMODITY

The status of the manual worker and craftsman in the new and more efficient organization of industry is marked by two negations: non-participation, and lack of property.

As Professor McGregor puts it, labour to-day is only "loosely associated" in the business organization. It does not take part in, or even form a part of, the original incorporation and plan of organization: its subsequent adhesion is taken for granted as purchasable on the market like any commodity.

Human work or "labour" becomes simply one of the ingredients or factors entering into production, and the payment for this labour, like the payment for raw materials, machines and buildings, represents an element in the cost of production. It is significant of the general attitude of the employer that the employee has come to be officially rated as a "hand." Hands are hired and fired; or if one hand leaves of his own accord, another is confidently expected to be immediately obtainable on the market.

The conception of labour as a commodity has frequently received official condemnation, notably in the Treaty of Versailles. That such is the conception, or rather the practice, of the capitalist is by no means, however, a recent discovery.

"The whole system of capitalist production is based on the fact that the workman sells his labour power as a commodity," wrote Marx in *Das Kapital*. "Division of labour specializes this labour power by reducing it to skill in handling a particular tool. So soon as the handling of this tool becomes the work of a machine, then the workman becomes unsaleable like paper money thrown out of currency by legal enactment."

This observation points straight to the manner in which the labourer first learnt of his new status. So far as the workman was concerned, the immediate result of the great inventions was to throw him out of work, and almost the

earliest manifestation of labour unrest was the deliberate destruction of machines.

To-day the labourer is enlightened as to his status from a slightly different angle. He becomes unemployed not so much because of revolutionary changes in industry, but in the natural course of industrial and commercial events.

"Cyclical" business crises and depressions, whatever their origin, are commonly manifest in the reduction of the working force and the wholesale dismissal and "laying-off" of employees.

The seasonal depressions that are more easily accounted for have the same effect as far as the worker's life is concerned. Industries such as building, furnishing, metal work and printing show regular variation from month to month in the percentage of workers unemployed.

Other occupations, such as dock labour and ship repairs, offer men only a casual employment in the sense that from day to day the labourer hardly knows whether he will be at work or not, and must often wait in queues outside the gates to be hired for each separate job. And mining, with the irregular day-by-day demand for labour at each pit, may almost rank as a casual industry, too.

Unemployment without accompanying loss of the means of subsistence does not always appear to be objectionable. The *idle* rich do not usually complain, and the working-man might not complain either if he had the means of obtaining an income other than the wages from his usual employment. But in general he has not been able to save and is propertyless.

An American study of family budgets of workmen mostly earning (in 1918) between \$900 and \$2,100 a year showed an average saving of income over expense of only \$78.95 per year. In the case of families with incomes below \$1,200—and these formed 22.7 per cent. of all families studied—there was on the average a deficit.

The amount of saving by the English working-classes can be judged from Bowley's estimate of £50,000,000 per year as the total *unearned* income in 1911 of the nineteen million persons with incomes *from all sources* of less than £160 per year. This is equivalent to £2 12s. unearned income

per head per year. Moreover, the nineteen million include a million and a quarter salaried persons and over two million and a quarter small tradesmen who are likely to have more chance of saving than the wage-earners also included. Enthusiasm is often solicited on behalf of the savings accounts of the working-class in such institutions as savings banks, building societies, co-operative societies, industrial insurance companies and friendly societies, but the total capital saved (£514,045,000 in England in 1910) clearly would not yield, at the low rate of interest paid, a large annual income per head among the millions of workers; and this income is included by Bowley, together with pensions, annuities, compensation, etc., in his general calculation.

For practical purposes, then, the industrial worker may be taken as a man of no property, who must rely for his entire income on his commodity of labour.

LABOUR DEMAND AND SUPPLY

If labour must be regarded as a commodity subject to laws of supply and demand, it becomes of great importance to inquire into the actual conditions determining this supply and demand.

Demand for labour at any given price was unquestionably increased by the Industrial Revolution and the development of industrial efficiency. With increasing output per head labour became economically more valuable and could possibly have "held out" for comparatively high wages.

Concurrently, however, with increase in demand there occurred an enormous increase in the supply of labour.

In 1700 the population of England and Wales was five and a half millions; in 1801 it was nine millions; in 1851 it was close on eighteen millions; and in 1901 it was thirty-two and a half millions. During the whole of the eighteenth century the population increased by less than two-thirds; during merely the first *half* of the nineteenth century it doubled, and in the second half this rate was almost maintained, so that in course of the whole century the population nearly quadrupled.

Increase in population would not necessarily be identical with increase in labour supply except for two facts: the relatively high birth-rate among the working-class, and the difficulty of working-class children moving into other classes of occupation.

This "class immobility" cannot be disregarded. Marshall sagely observes (22) that those who produce the human article do not reap the benefit, and that this production is a long and tedious process. Consequently to obtain a satisfactory human article we must rely on "the means, the forethought and the unselfishness of parents."

But working-class parents, however unselfish, are hardly in a position to see very far into the prospects of different industries, and in the absence of the means to maintain their children during later education, they usually have no choice but to throw them on the labour market in early youth.

Marshall proceeds: Labour power is perishable. The sellers of it are commonly poor, and have no reserve fund, and they cannot easily withhold it from the market. Moreover, where sellers are poor and numerous, relatively to the purchasers, they are at *a disadvantage in bargaining*. The labourer cannot afford to refuse offers of employment. This disadvantage lowers his earnings, "this lowers his efficiency as a worker, and thereby lowers the normal value of his labour. And in addition it diminishes his efficiency as a bargainer, and thus increases the chance that he will sell his labour for less than its normal value."

A vicious circle is thus set up, foredooming one generation after another to a constantly lowered standard of life. But while Marshall regards this merely as a cumulative tendency, Malthus considered that no progress could be made in raising real wages and the standard of life from the barest minimum of subsistence if the population were to increase without "preventive check." His view, based on the natural geometric increase of population and the diminishing return from land and minerals, cannot be refuted in its main contention.

In fact, all the marvellous inventions, and all the wonderful increase in productivity per man, theoretically

constituting an increased demand for labour, seem to have been largely offset by the enormous increase in the population and consequent supply of labour. It is a matter of controversy to what degree the mass of people are very much better off now than they were in the century previous to the Industrial Revolution. It is not our total wealth that counts, but the wealth per head, and the distribution of that wealth among the heads. Nor should the different kinds of wealth be overlooked.

The word "proletariat" has become associated with city populations dependent upon the wages earned in the factory. The word is derived from the Latin *proles*, "offspring," and a proletarian was one who served the State not with property but by producing children. It is an irony of fate that the word has returned to its original meaning.

THE EARNINGS OF LABOUR

The hypothesis of a low market value deduced from the relation between the supply and demand for labour is borne out by the facts in the case.

The conclusions to be drawn from statistical investigations are that labour is poorly paid compared with the other agents in production—i.e. capitalists, landowners and managers; and that the difference in remuneration between various grades of labour is not nearly so great as the difference between labour and other agents in production.

Probably¹ out of 8,500,000 English adult male wage-earners, 6,500,000 just before the war received earnings within the limits of 20s. to 40s. a week. In America there is probably a greater difference between the wages of skilled and unskilled labourers; skilled and unskilled for the most part belong to different races whose standards of living are different. Yet in the year 1891 a remarkable continuity in American rates of wages all the way from 25 cents a day to \$4.25 is shown in a saddle-back curve reproduced by Bowley.² Out of a sample of 9,312 earning

¹ Board of Trade Enquiry 1906-7.

² A. L. Bowley: *Wages in the United Kingdom in the Nineteenth Century* p. 23.

wages across these wide limits, 6,643, or 71 per cent., earned wages within the relatively narrow limits of \$0.75 to \$2.25 per day.¹

Either there is no great gap between the earnings of skilled and unskilled labour, or the skilled are heavily outnumbered.² Both suppositions are probably true to some extent. The use of machinery and the subdivision of labour have obliterated the clear-cut distinction between skilled and unskilled workers. There are to-day large groups of so-called semi-skilled workers, and a majority of those called skilled are usually not skilled in the old sense of having undergone years of apprenticeship.

It is justifiable, then, to consider labour as a fairly homogeneous class with individual incomes concentrated within certain limits and averaging distinctly lower than the incomes of other classes, and we may proceed to gauge what this income amounts to in terms of the commodities of life.

The needs of each wage-earner must depend on the family he has to support, and the normal family has been estimated by Mr. Rowntree in England and by the U.S. Department of Labor as man, wife and three children. Taking this as the standard, Mr. Rowntree calculated the cost of living for an English family in 1914 as 35s. 3d. This estimate allowed for a mixed diet containing the minimum number of calories required by man, woman and children, and for the bare necessities in the matter of clothes, house rent, fuel, and household and personal "sundries."³

According to the wage census made in 1906-7 by the English Board of Trade, the average earnings of adult males were, in 1906, 29s. 2d. a week, which, with the rising wages between 1906 and 1914, would be equivalent at the later date to 33s. 8d. This figure is 1s. 7d. short of the sum estimated

¹ The same concentration of individual incomes low in the scale is clearly demonstrated by a report of the American Bureau of Economic Research. Incomes were recorded for 1918 stretching all the way to over \$4,000,000 a year—and 521 persons were found with an income of over half a million dollars. But those with yearly incomes within the relatively narrow range from \$500 to \$1,500 (i.e. \$1.75 to \$5.00 per working day) numbered 25 millions out of the 37½ millions recorded altogether. Exactly two-thirds of all individuals had incomes falling within a $\frac{2000}{1000000}$ part of the whole scale.

² Cf. p. 65 below; also Henry Ford: *My Life and Work*. "43 per cent. of all jobs require not over one day's training, 36 per cent. require from one day to one week."

³ Rowntree: *Human Needs of Labour*.

by Mr. Rowntree as necessary for subsistence of an average family.

All wage-earners, however, are not "bread-winners" for a family, and it may be thought inexact to take the average earnings per adult male. But Rowntree tells us that only 10 per cent. of men remain permanently single, and to balance these we have to consider the large number of women supporting dependents with wages lower than men's.

A more recent English investigation into the conditions of dock labour (1920) showed the usual wage paid by the Port of London authorities and by ocean shipowners to be 11s. 8d. and 13s. 9d. a day. According to the employers' own estimate, £3 17s. per week was then considered necessary in the London area to secure a decent standard of life. Even if the possible eleven half-days a week were worked, which is seldom the case in dock labour, such a standard would require 14s. to be paid per day instead of 13s. 9d. or 11s. 8d.

In America similar investigations were made during the war, and a very similar state of affairs was revealed. The iron and steel workers are usually supposed to have better wages than most workers,¹ but it has been shown that "all in the unskilled class fall just short of the level of living to which common labour ordinarily feels it is entitled and should attain—the level of a healthful animal existence. And all in the semi-skilled class fall just short of the level of living to which more steady workers feel they ought to attain—the level of decency and at least a few comforts."²

Reduced to figures, \$1,760 per year was estimated to be required (in 1918) for life at the comfort or decency level, but the earnings of the semi-skilled averaged \$1,683; \$1,386 was estimated as required for life at the level of

¹ The following is the evidence of Mr. Gary, President of the U.S. Steel Corporation, before a Senate Committee in 1919: "I wish to state that there is no basic industry in this country, in my opinion, which has paid larger wages to its employees than the United States Steel Corporation, and perhaps not as large. . . . We have stood for the highest wages invariably. We have been the first to increase wages and the last to decrease them."

² *The Steel Strike of 1919*: The Interchurch World Movement. Possibly it would be more accurate to speak of the *average* in the unskilled and skilled class rather than *all*.

animal subsistence, but \$1,265 was the averaged earnings of the unskilled.

These estimates of the relation of earnings to cost of living, a relation that may be expressed as the *real* or commodity earnings of labour, can be brought up to date by the usual device of index numbers. Index numbers do not in themselves show what the real earnings are, as some seem to believe, but merely the changes from time to time in economic values. In England and America it is agreed that as between 1914 and 1923 *real* earnings during employment remained more or less stationary, and what has been said above of 1914 remains approximately true of 1923, so long as the wage-earner is in employment.

Estimates of the cost of living in the absence of established standards of health and efficiency must remain somewhat vague, but there is no question that the average English and American (unskilled and semi-skilled) working-class family is grievously near to earning less than the minimum for full efficiency. And all families are not restricted to the average size, nor are all in receipt of average wages. It is cold comfort to the many larger families with subnormal earnings to be told that on the average earnings *do* just meet the costs of living.

LIFE AT THE POVERTY LINE

The industrial worker is poor relatively to other classes in the community, and poor absolutely, i.e. with reference to the cost of living; and an attempt must be made to gauge what this relative poverty involves in the worker's actual conditions of living. These conditions depend partly on the commodities purchased in the market, partly on amenities obtained without purchase, and partly on freedom from exertions and duties additional to those naturally involved in industrial work.

The proportions spent by the English and the American working-classes on the various purchasable wants are now fairly well known.

Studies of 1,944 English workmen's budgets made in 1904 by the Board of Trade revealed that among families

with an average income of 36s. 10d. and an average of 3·6 children living at home, 61 per cent. of income was spent on food. This percentage varied according to the total income. It was 67 per cent. among those receiving less than 25s. per week, and 57 per cent. among those receiving more than 40s. a week.

Various subsequent investigations showed that if 60 per cent. of income is spent on food, one-fifth of this or 12 per cent. of income is spent on clothing, 16 per cent. of income is claimed by rents, 8 per cent. by fuel and light, and 4 per cent. by sundries, which include such multifarious wants as subscriptions to trade unions and insurance societies, tramway fares, newspapers and tobacco.

Numerous investigations into American workmen's "family budgets" culminated in 1918 in an inquiry by the Bureau of Statistics of the U.S. Department of Labor, covering 92 localities scattered through the country and 12,096 white families (9, August 1919). Families with different income levels are tabulated separately, but the whole group is fairly homogeneous. Of the families studied, 32·7 per cent. have an income between \$1,200 and \$1,500; 88·5 per cent. an income between \$900 and \$2,100 a year.

The average percentage of total expenditure spent on each type of requirement was as follows:

Requirement.	By all Families.	By Poorest Families (with income \$900-\$1,200).
Food	38·2	42·4
Clothing	16·6	14·5
Rent	13·4	13·9
Fuel and light	5·3	6·0
Furniture	5·1	4·4
Miscellaneous	21·3	18·7
Total Expenditure	100·0	100·0

The apportionment of expenditures by families with a total income between \$900 and \$1,200 is given in the second column. As repeatedly observed by statisticians, the lower the total expense the greater the proportion spent on food

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and the less on comparative luxuries like clothing and furniture.

The miscellaneous items by no means consist in mere luxuries. In two extremely detailed investigations, that of the New York City Bureau of Standards and the New York Factory Investigating Commission,¹ 16.2 per cent. and 17 per cent. respectively of the total expenditure of working-class families was found distributed over these sundries as follows :

"Sundry" Requirements.	Bureau of Standards.	New York Factory Commission.
Car fare	3.6	3.6
Health	2.4	2.5
Insurance	2.7	4.1
Furnishings	2.1	0.8
Newspapers	0.6	0.6
Recreation and amusements	4.8	5.7
Percentage of all sundries to total expense	16.2	17.0

Car fare is mostly used in getting to and from work, and, with expenditure on health and insurance, forms over half the amount spent on sundries. In short, only the slightest fraction of the general expenditure can be attributed to luxury, even on the supposition that a little recreation is a luxury.

These official investigations reveal how inexorably the purchases of the working-class are restricted to the grosser necessities of life—food, clothing, housing and fuel.² Of these the most urgent necessity is food, and it forms by far the most important item in the workman's budget. If budgets were obtained of the more well-to-do families—

¹ Lauck and Sydenstricker: *Conditions of Labor in American Industries*, pp. 373-5. Funk & Wagnalls, 1917.

² Family budgets are presumably kept only in the more provident households where such "conventional necessities" as beer and tobacco would be restricted. During 1920 19,000,000 barrels of beer were consumed in the United Kingdom at an expenditure of £9 per adult per year or 3s. 6d. per week, and in 1921 the annual expenditure on *all* alcoholic drink is given as £14 4s. per adult. But this does not vitiate the argument that ordinary wages are only just sufficient for the physiologic needs of a provident budget-keeping family. The situation in other families is probably *worse*, and is likely to affect their survival value.

an invidious procedure no doubt—expenditure on food and fuel would probably recede relatively to that on house-room, clothes, and such “sundries” as travelling, recreation and doctor’s bills. In one such middle-class budget that I obtained, food accounted for only 18 per cent. of total income, clothing 20 per cent., while sundries formed 51 per cent. of expenditure, or, if we exclude furniture and savings (each involving 8 per cent. of income), 35 per cent.

In amenities which to him are beyond the possibility of purchase, the industrial worker is also heavily restricted. These amenities, which include scenery and fresh air, the possibility of recreation and facilities for education, necessarily differ in different countries. In these respects the English worker is probably worse off than the German or American of a similar class. England is more urbanized, and English towns, or at any rate the working-class quarter, are more smoky and generally sordid, and the public buildings more hideous than is the case either in America or Germany.

The Inter-Departmental Committee on Physical Deterioration,¹ in dealing with the Manchester district, heard one witness who did not mince matters :

The pollution of the air is worse than ever. I should trace much of the anæmia to the deprivation of sunlight and to the lessening of the vivifying qualities of the air. You have execrable air for the people to breathe.

Another gave similar testimony :

By cutting off much of the scant supply of sunlight which is all that Manchester at best would be allowed by its gloomy climate to receive, it injures health. The filthiness of the air makes those inhabitants of all parts of Manchester who value cleanliness most unwilling to ventilate their dwellings. By killing nearly all vegetation and by its other effects, the foulness of the air contributes much to that general gloominess of the town which led Mr. Justice Day to say in explanation of the prevalence of drunkenness in the town, that to get drunk is the shortest way out of Manchester. The foulness of the air . . . prevents well-to-do persons from living in . . . the town.

And English sabbatarianism has deprived the worker of healthy recreation, mental and physical, on his only regular whole holiday. In working-class education also

¹ Vol. I, *Report and Appendix*, 1904, p. 20, Vol. II, p. 221.

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England is behind. The proportion of working-class children who reach the University, or the "top of the ladder" generally, is more easily expressed in permillages than percentages; the usual age when children leave school to commence what otherwise might be a career is thirteen or fourteen. In the matter of leisure and opportunities for sociability, the English worker is perhaps better situated than the American. His hours of industrial employment are shorter and possibly less strenuous.

Finally account must be taken of the industrial worker's efforts and duties outside his regular industrial employment, efforts and duties for which he is not paid.

Official investigations of hours of work take no account of the time the worker must often spend in travelling to and from his job; nor do they chronicle the additional hours a woman usually has to spend in housework before and after her hours of paid employment. With increasing urbanization and the increasing employment of women these additional exertions are likely to form a growing burden in the life of the industrial community.

In one of the larger American cities I found that over 46 per cent. of the employees of a large concern lived farther than four miles from the plant, the distance averaging about five miles. The surface car (anglicé tramcar) was the universal mode of transit, and I calculated that with walking to and waiting for the car and changing cars where necessary, it would take forty-five minutes to cover the average distance. Nearly half the employees, therefore, had a full hour and a half added to their working day.

A recent study of mortality among women textile operatives in New England (8, No. 251) gives 2.8 hours per week as the average time spent in household duties, in addition to their factory work, by 814 "decedents" whose cases came under review. And such conditions are by no means foreign to England.

We are brought, then, to face hard facts: The worker is, at best, obliged to spend from 80 per cent. to 85 per cent. of his income on food, housing (including rents, fuel and lighting) and clothing—an expenditure which does not appear in excess of the amount necessary to maintain life and working

efficiency. The balance of total expenditure, 15 per cent. to 20 per cent., is used largely for insurance against sickness or death, transit to and from work, and other objects necessary to life and work, and scarcely to be classed as luxuries. The worker who has a typical family to support has small opportunity to save, and none whatever to indulge in the luxury of travel, entertainment, music or books.

CONDITIONS OF EMPLOYMENT

Another peculiarity in the supply and demand of labour, is pointed out by Marshall. When a person sells his service as a commodity, he has to present himself where these services are to be delivered; he cannot send them on like the merchant who sells material goods. The person to whom these services are sold, however, does not need to be present to receive them; and he may be entirely ignorant of the conditions under which he is repeatedly making the purchase. If suffering is inflicted, it is not the labour-buyer who knows where the shoe pinches. And yet it is he who determines the labour policy.

Anglo-Saxon democracy, we are taught, was founded on the principle of no taxation without representation—on the principle that those whose pockets are affected should have some voice in the policy of the State. Yet under the new industrial dispensation those who are affected in their very life and health have to submit to conditions without a chance of constructive suggestion.

The employer no longer rolls up his sleeves and works among his employees. He may be and often is entirely absent from the office where the work is directed. He may even know nothing whatever about the business. The original "sleeping partner" and his modern descendant, the "investing" public, constitute, legally at any rate, the ultimate authority in industrial enterprises. The managers and organizers actually in the plant are simply paid agents; in the last resort they are as helpless to change working conditions as the absentee landlord's rent collector is to alter slums.

It is true that the leaders of a democratic state are

usually as far removed from the life of the ordinary citizen as the owner of stock from the factory that pays his dividend. But at any rate the statesman can trace his authority to the citizen through some process of election, whereas the owner of stock is entirely independent.

The relation of employment and the system of competitive enterprise imply the government of the great field of national labour by those who are not under the direct industrial control of the people. . . . The wage relationship means that the risk, the legal right to the accumulated stocks, the initiative, the government, and the credit of the firm belong to those who supply share capital; while those who supply the labour have their risk discounted for a fixed weekly amount, and are paid off in this way. This fact of exclusion from the risks of capital carries with it exclusion from government.²

The normal relationship of employment has not received the public attention it deserves and has certainly been overshadowed by the pathological condition of unemployment. Industrial employment may be said to consist of being hired for a financial consideration to carry out orders under predetermined conditions.

The individual applicant must usually either accept or reject these conditions *in toto*, and where poverty is the applicant's lot, and financial consideration very urgent he will be obliged to submit. Under these circumstances the situation facing the employee in industry is not unlikely to contain elements measurably subversive to his integrity and health.

It is likely that hours of work or the intensity of work may be arranged without reference to the possibility of overstrain, and the shortening of working life. It is likely that work may be planned and divided up without reference to its monotony, and workers hired to perform it with regard only to their cheapness and immediate productivity and without thought for their fitness in the long run. And it is likely that the hygienic, disciplinary and other conditions under which the work is performed will be determined with sole regard to success in the chemical or mechanical process, and with scant attention to the possibilities of arousing the interest of the human worker.

² D. H. MacGregor: *Evolution in Industry*, chaps. ix and v, Home University Library.

In the remainder of the chapter we shall examine how far, in the sphere of the employer's deliberate determination, this likelihood of subversive conditions has actually been realized.

TYPE OF WORK AND TYPE OF WORKER

The most obvious effect of the Industrial Revolution on the condition of labour was the new type of work introduced. Work on machines replaced hand work, and the division of labour introduced a monotonously repeated drudgery. These facts have often enough been animadverted upon, but no one has yet enumerated and classified operations as they are actually found in any typical factory.

In Table 2 such a survey is attempted in the case of an American metal factory where the "revolution in efficiency" had certainly proceeded far.

The factory was making munitions of war, particularly fuse parts, when the investigation was undertaken. The same general types of occupation occur, however, in every branch of the metal industry. The full details of the various occupations included in each class are given elsewhere.¹

My general aim was to elucidate the physiological and psychological requirements of various types of factory work, and the first step was to observe the part of the body which was directly involved in any operation.

This scheme, however, was only applicable in the case of routine occupations where, by extreme subdivision of labour, one part of the body only would be used. Hence routine occupations are differentiated from "adaptive" occupations, and the parts of the body involved placed under the routine heading only. Where it is the machine that directly performs the work, sub-groups are formed according to the type of participation by the worker.

A man *drives* a machine when his own muscles supply the power; he *steers* it when he must change the direction and speed of the mechanically propelled machine; when direction is fixed he merely *operates*, and when both direction and speed are fixed, i.e. when the machine is semi-automatic,

¹ P. Sargant Florence: *The Statistical Measurement of the Human Factor in Industry* (28, chap. xii).

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he may *feed* material direct on to the moving parts or merely *stock* a reservoir. When the machine is self-driving, self-operating and self-feeding, i.e. acts completely automatically and almost like a chemical process, the man's part is but to *attend* to it in emergencies, and occasionally to bring up stock and remove the finished product.

TABLE 2
TYPES OF OCCUPATION IN BRASSWARE AND MUNITION FACTORY

Designation.	Example.	Per cent. of Employees so Occupied.
<i>Uniform Processes.</i>		
1. Brainwork	Clerks	3.9
2. Handwork	Bench-assembly	10.2
3. Sensework	Inspecting, gauging	13.7
4. Bodywork	Labour	16.3
5. Machinework—		
(a) Man-driven	Foot-presses	1.4
(b) Man-steered	Cranes	1.3
(c) Man-operated	Lathes	13.8
(d) Man-fed	Grinding-wheels	0.8
(e) Man-stocked	Dial-feed presses	2.6
(f) Man-tended—		
i. Chemical Treatment	Furnaces	9.0
ii. Mechanical Treatment	Automatics	6.9
		15.9
<i>Adaptable Processes.</i>		
6. Crafts—		35.8
(a) Stationary	Toolmakers	5.6
(b) Circulating	Toolsetters	4.1
(c) Structural	Building, maintenance	5.9
		15.6
7. Custodial	Police, watchmen	2.5
8. Administrative	Executives, foremen	2.0
All processes		100.0

The percentages of employees listed as occupied in each class of work are significant.

It will be noticed, with surprise, perhaps, that those actually working with machines or on chemical processes by no means form a majority—in fact only about one-third (35.8 per cent.) of the total employed. Even if the craftsmen engaged in setting tools on the machine or making tools by machine are added, the number of machine workers will not be more than half the total.

Monotonous work, again, does not occupy such a large proportion as is usually thought. The most regularly and frequently repeated operations occur in classes 2, 3, 5^a, 5^e, and to a less extent 5^c, employing about 40 per cent. of the total. Among these classes the extreme in monotony is reached by the man-stocked division. Here the operator simply places the material in a slot or some similar device, and thus only indirectly feeds the machine. The slots present themselves at such regular intervals that little irregularity is possible. But these man-stocked operations, though attention has been frequently directed to them (e.g. 2, pp. 28ff.), form a very small proportion of industrial operations.

The chief alteration in the type of work introduced by the Industrial Revolution is perhaps the decrease in heavy "body work," and the increase in unskilled and semi-skilled work of lighter character. In Table 3 body work accounts for only 16·3 per cent. of those employed, to which must be added, however, the heavy work often connected with chemical treatment and occasionally with man-driven machines. The only skilled occupations in the sense of work requiring an apprenticeship are those listed as crafts; though the leading man of gangs occupied in mechanical and chemical treatment should perhaps also be considered as skilled. The remainder of the occupations are either quasi-skilled in the sense of requiring a few months' training or semi-skilled. It is only body work and some of the labour (in the narrow sense of the word) employed in chemical treatment and with the structural crafts, e.g. builders' labourers, that can be classed as wholly unskilled.

In short, the tendency has been to develop the quasi-skilled or semi-skilled occupations, at the expense of the non-skilled and highly skilled occupations that involve either heavy muscular work or a long apprenticeship.

In a survey of twelve American metal-working factories employing 37,000 workers, Mr. Magnus Alexander found the following proportions in the various degrees of skill: 9 per cent. were highly skilled and had passed through an apprenticeship, 12 per cent. were skilled merely, and 34 per cent. semi-skilled, making in all 46 per cent. in the new

intermediate class. Thirty-five per cent. were unskilled and the remaining 10 per cent. were clerks.

The development of opportunities for those without muscular strength and without apprenticeship has resulted in the employment of great numbers of women and children in industry, which in turn has led to numerous special problems. In the English census of production of 1907, 1,619,202 women were counted in *manufacturing* trades employing 3,252,170 men—more than one woman to every two men. Of the men, 430,310 were under eighteen—more than one in eight. Of the women 401,317 or one quarter were under eighteen.

During the recent war women were increasingly employed to replace men, and in England at the present moment (1923) women may be said to be almost exclusively employed in dressmaking and laundries (not to mention domestic service); to predominate by at least two to one in the cotton and woollen industries, in tailoring and in hotel and club service; while a half-and-half admixture of women is found in retail shops, in commerce, and in the food and drink trades.

In America the census discloses over a million children aged from ten to fifteen occupied gainfully on January 1, 1920. The majority were occupied in agriculture, but 185,000 were occupied in "manufacturing and mechanical" industries, 80,000 in clerical occupations and 63,000 in trade.

The employment of women is often taken by (bachelor?) writers as synonymous with the employment of mothers with young children, and such cries as "the break-up of the home," "woman's double burden," constantly make themselves heard. Actually the majority of women in industry are not mothers with young children, and the real difficulty is of a different nature. Owing largely to the forces of supply, and also to some extent to custom, the wages of women employees are considerably lower even than those of men: and in the not infrequent case where women have relatives dependent on them, they are still more perilously near to the poverty line.

The employment of children implies *pro tanto* neglect of education. Besides this, if we are to believe the reports

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of competent observers, young and growing bodies may not always thrive in the industrial atmosphere.

Employment in textile mills, according to a factory inspector,¹ "if carried on in high temperatures, rarely fosters growth or development" among boys.

The stunted child elongates slightly in time, but remains very thin, loses colour, the muscles remain small, especially those of the upper limbs, the legs are inclined to become bowed, more particularly if heavy weights have to be habitually carried, the arch of the foot flattens, and the teeth decay rapidly.

The girls exhibit the same shortness of stature, the same miserable development, and they possess the same sallow cheeks and carious teeth. I have also observed that at an age when girls brought up under wholesome conditions usually possess a luxuriant growth of hair, these factory girls have a scanty crop which, when tied back, is simply a wisp or "rat's tail."

HOURS AND INTENSITY OF WORK

The number of hours worked per day and per week in various industries at the present time can be stated with some exactitude. In most civilized states limits have been prescribed by law, and the actual practice within these limits is the subject of statistical investigation.

In English coal-mines the 8-hour day was legally enforced in 1908 to be superseded by the 7-hour day in 1919.² And though not legally established³ the 8-hour day has since 1919 been a fact over the whole of English industry, including even transport, although hours cannot here always be taken in one stretch.

The 8-hour day involves a working week either of 44 or 48 hours, according to whether there is or is not a Saturday half-holiday. With the possible exception of the building industry, the tendency seems towards a 48-hour week.

In America the hours of work are as a rule longer, though there has been a gradual shortening since 1909, when 76 per

¹ Evidence of Mr. Wilson before the Committee on Physical Deterioration, vol. I, *Report and Appendix*, 1904, pp. 26-7.

² The period is reckoned from the time the *last* workman in the shift leaves the surface to the time the *first* workman in the shift returns to the surface.

³ England's failure to ratify the Washington Convention and recent pronouncements of German employers possibly foreshadow a new extension of working hours.

cent. of all factory wage-earners were found to be working between 54 and 60 hours per week. The most recent inquiry (National Bureau of Economic Research, 1922) puts the average hours worked per week at 50·3 when every type of industry is considered. Allowing for the Saturday half-holiday now usual in America, these weekly hours imply something like a 9-hour day on full working days.

Great variations are found, however. Many well-known American establishments work the 8-hour day and in some States 8 hours per day is the legal maximum for women. At the other extreme the 12-hour day still seems to flourish in certain industries, notably the iron and steel industry; and in 1910 over 50 per cent. of all persons employed on blast furnaces, sugar-refining, ice-manufacture, and glucose, starch and gas works were officially reported as working more than 72 hours per week—presumably on a 12-hour day plan with no Saturday half-holiday and possibly Sunday work as well.

The blast furnaces and the gas-making industry each occupied over 30,000 men, and there were many other industries of equal importance in which two-thirds of all employees worked a 60-hour week or longer, entailing at least six full 10-hour days. These comprised the lumber industry, canning and preserving, flour and grist mills, slaughtering, paper and wood-pulp industry, brick and tile works, steel works and rolling mills.

Exceptionally long hours were also worked in England during the recent war. In the munition and allied industries 12-hour shifts and Sunday labour for both women and men were the rule, at any rate between 1914 and 1916.

Knowledge of the daily or weekly hours of work does not specify how these hours are distributed throughout the day or week, but unless the total normal hours are more than ten, the working day usually conforms to a certain cycle of work and rest, i.e. two spells of continuous work with an interval for dinner in between. Work before breakfast is becoming unusual, while overtime adding a third spell in the evening, and night work, is only occasional. The weekly cycle normally consists in a work-phase of five and a half days, and a rest-phase of half a day and a day.

Annual holidays cannot be taken without loss of pay, so that industrial workers usually work 52 weeks in the year, unless a local institution supervenes, such as the "Wakes Week" of the English textile districts.

Extremely long hours, now the exception, were once the rule in England. The detailed cases brought as evidence in English Government inquiries leaves no doubt as to the difficulty of enforcing even a 12-hour day in textile mills. In Manchester and the Lancashire cotton district generally, the customary working day in 1825 extended over 14 hours with half an hour allowed for breakfast and one hour, sometimes less, for dinner. These working hours applied to children and women as well as men; in fact children often had to clean the machinery while adults had their meals.¹

At first sight the economic reasons for these long hours subsequent to the Industrial Revolution seem somewhat obscure. If efficiency means increased productiveness of labour, this would imply a shortening of the working time required for a given production; and since workers were paid either at a piece rate or an hourly rate, the more they worked the more they would have to be paid. The explanation lies in the employer's belief that the added sum paid in wages was not to be compared with the added gain in net value of output, and it was even maintained that the reduction of the working day from 11½ to 10½ hours would take away all the employer's net profit.

This theory, advanced in 1837 by Nassau Senior, was based on the hypothesis of a business having a fixed capital invested in mill and machinery four times the circulating capital representing current requirements in raw materials and wages. It reveals what was probably the determining factor in the mind of the employer when he insisted on long hours; namely, his relatively large amount of fixed capital due to the application of the great inventions. Senior himself put it in a nutshell:

"The great proportion of fixed to circulating capital makes long hours of work desirable."

¹ Hutchins and Harrison: *A History of Factory Legislation*, pp. 30-31. P. S. King & Son.

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If we realize that the capital invested in an industry to-day is for the most part transformed into physical properties such as raw materials, buildings, machinery and so on, and that the value of such properties to their owners must depend on their productiveness, we can see clearly the economic "urge" to keep these properties working.¹ Interest and other standing charges, such as rent, taxes, insurance, have to be paid at stated periods regardless of the amount produced in the interval. In addition, apart from the depreciation due to wear and tear, there is the physical loss of value occurring by mere lapse of time, i.e. depreciation from exposure, and the further loss of value occasioned under competitive conditions by the obsolescence of machines.

An extreme case of loss of value even where no work is done occurs in the so-called continuous industries where chemical processes are used. If the work suffered any interruption the material in process would be entirely lost and the equipment possibly damaged. Among such industries are blast furnace works, steel-making, sugar-refining, and the chemical, glass and cement industries, and in these industries a definite attempt is made to work the capital equipment all the twenty-four hours of the day. The consequence is that employees must either work three shifts of eight hours or two of twelve, and most important controversies regarding hours of work have centred about these continuous industries. Work at night and on Sundays is made necessary, but the same workers need not always work at night and two (or three) shifts may take it in turns. And there are various ways of taking turns besides that in vogue in American steel plants, whereby one shift must work twenty-four hours on end before being relieved!

As hours of labour became gradually reduced, the employer turned his attention to increasing the intensity of work. Work could be intensified either by increasing the speed of work, the constancy of work or the load of work per worker.

The speed of work depends often on the speed at which

¹ The fallacies of this position are dealt with in Part II.

machines are set, or else it may depend on the particular piece-wage system adopted. In either case the employer has the speed largely under his control.

Increased constancy of work often results automatically from greater efficiency in routing materials, and attending to machines. There is far less chance of rest on account of mechanical breakdowns or lack of materials. Recording instruments, too, can be attached to the machine and, as Babbage remarked in 1832, "one of the most singular advantages to be derived from machinery is the check it affords against the inattention, the idleness or the knavery of human agents."

The load of work can be increased by increasing the number of machines (e.g. furnaces or automatic looms) that a worker has to watch; by increasing the number of tools or the amount of work to be done simultaneously by any one machine; or by introducing inferior quality in the material, necessitating increased attention on the part of the worker.

There is little doubt that what was gained by decrease in hours was largely offset by an increase in the intensity of work, and the worker is more and more becoming concerned with questions of speeding up, as hours are gradually reduced.

PHYSICAL ENVIRONMENT AND INCENTIVES

To all the evils from which the domestic worker had suffered, the Industrial Revolution added discipline, and the discipline of a power driven by a competition that seemed as inhuman as the machines that thundered in factory and shed. The workman was summoned by the factory bell; his daily life was arranged by factory hours; he worked under an overseer imposing a method and precision for which the overseer had in turn to answer to some higher authority; if he broke one of a long series of minute regulations he was fined, and behind all this scheme of supervision and control there loomed the great impersonal system.

The rigid industrial routine thus epitomized by Mr. and Mrs. Hammond has probably imposed a greater strain on the human organism than the mere length of the working day. Man has for centuries been accustomed to long hours of toil in the fields or on his bench at home. He has no

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doubt evolved characteristics to resist mere length of work. But the task of working at a particular place and a particular time, neither of his own choosing, is one for which he is perhaps not so fully equipped. A well-known American economist has gone so far as to suggest the growth of a definite prison "complex" in the mind of the factory worker. But however that may be, the physiological hazards are clearly traceable.

When the craftsman who works at home feels tired of his task he can "knock off" for a few minutes, and gain a fresh incitement. If he feels slack in the morning he can work in the afternoon and evening, or vice versa. If his work gets on his nerves he may walk into his garden, or occupy himself about the house, away from the ordinary conditions of his work. To the industrial employee all such variations are impossible. Whether he is working in factory, office, mine or shop, he must "keep on the job"; he cannot work when work is congenial and stop when he feels the need of rest. There is a definite routine imposed from outside.

This is the outcome of the factory system with its economies of close supervision and accurate routing. The compulsion on the employee to be constantly at work in certain surroundings, physical and social, makes it imperative to understand the nature of these surroundings.

In modern industry the physical and hygienic surroundings in which the worker finds himself are dictated largely by three types of consideration. Definite conditions are required for the success of certain processes, as, for instance, humidity for cotton spinning, or a very high temperature in certain chemical processes. Other conditions are the unpremeditated results of the new technical processes such as fumes from chemicals and the heat of foundries. Finally, as the material equipment becomes more and more expensive the view develops that the factory exists solely to house this equipment and that the human worker must just adapt himself as best he can.

The physical conditions that may be singled out as most likely to be injurious to the worker are the noise and vibration resulting from machinery, the presence of noxious dust

and fumes, and hot humid and stagnant air due to insufficient ventilation;¹ the absence of seating accommodation for those working on machines, the danger of serious accidents when work is performed with and in the midst of mechanical and chemical processes, and finally the absence on premises devoted entirely to industry of the means of taking an occasional rest and often of proper sanitary conveniences. When work is done at night, artificial lighting is added to the other adverse conditions with the possibility of insufficient volume or concentration, or, on the contrary, too much glare.

The outstanding features of the social environment which is forced on the worker in modern industry is lack of any motive in work other than the financial remuneration.

Professor Wagner (22, pp. 783-4) has distinguished five main classes of motive. One is the altruistic prompting of conscience and the sense of responsibility and duty; the other four are egoistic—the desire for economic “cash” gains which indirectly lead to the satisfaction of wants; the desire for honour, approbation and fame; pleasure in activity and occupation for its own sake² as one takes up a hobby; and finally the fear of punishment and the hope of reward. The last type of motive mingled with the economic motive is possibly represented by the discipline exercised through the foreman, by the fear of dismissal and the hope of promotion; but, surprising as it may seem, little play is afforded for the other egoistic, and the altruistic motives in modern industry. The cash-nexus is the chief bond between the worker and his work, and other possible forms of incentive—the hobby-nexus, the duty-nexus and the fame-nexus—lie neglected.

Whatever he may have been “naturally,” there is no question that the average workman has been made by

¹ The importance of ventilating a room has been found to lie not in removing any excess of carbon dioxide or supplying oxygen, etc., but first of all in eliminating the superfluous heat from the bodies of the occupants, i.e. in its cooling power as Professor Leonard Hill puts it. The service ventilation performs is thus physical, not chemical.

² Three forms of this motive can perhaps be discriminated: (i) pleasures in the form of activity itself, as the pleasures of the chase or of the busy-body; (ii) pleasure in performing the activity *efficiently*, however dull it may be in itself, and (iii) pleasure in the objects acted upon, e.g. children, animals, machines, filing systems, or in the incidental circumstances of an occupation, e.g. the sociability of factory work.

circumstances into a thorough economic man. Adam Smith has pointed to the need of balancing the comparative advantages in employment beside the wages received,¹ and modern economists (in spite of popular belief to the contrary) have given form to this calculation in the term "net advantages." This term is, in the words of Marshall, based on the fact that "every occupation involves other disadvantages besides the fatigue of the work required in it, and every occupation offers other advantages besides the receipt of money wages." Yet in practice, provided the bounds of respectability are not outraged and a modicum of sociability and freedom to "see life" is allowed, it is the difference in wages and in the prospect of continued wages that seems the main influence in moving workers from one occupation to another.

Differences in inherent pleasantness, healthiness and risk, or differences in incidental requirements such as long journeys to and from work, seem to count for little. The explanation probably lies in the insignificance of the differences in interest, possibility of fame, and feeling of duty, between ordinary industrial occupations.

Any likelihood of a fame-nexus or hobby-nexus in modern industry is eliminated where an employee's work is taken from him in exchange for his wages and sunk in the product of the whole firm. The worker occupies a subordinate position, with knowledge of only a small link in the chain of production. All the thinking is done from above, and there is little or no chance of choosing between alternative actions.

The actual forms which this all-important financial incentive takes is largely a matter of circumstances. Where conditions are uniform and the output of a repetitive nature wages are usually paid by the *piece*. Otherwise, and also where the quality of production is important, wages are

¹ "The five following are the principal circumstances which so far as I have been able to observe make up for a small pecuniary gain in some employments and counterbalance a great one in others: first, the agreeableness or disagreeableness of the employments themselves; secondly, the easiness and cheapness, or the difficulty and expense of learning them; thirdly, the constancy or inconstancy of employment in them; fourthly, the small or great trust which must be reposed in those who exercise them; and fifthly, the probability or improbability of success in them."—*Wealth of Nations*.

usually paid in proportion to the *time* worked. Where changes in the prosperity of the industry or in the cost of living are easily measurable, wages, whether by time or piece, are sometimes made to *slide* accordingly, on a pre-arranged scale, or else special *bonuses* or *shares* in *profit* are arranged to be given when circumstances permit.

Different as are the forms of wages payment, their content usually amounts to much the same.

The piece-rate is fixed so that ordinary effort over the day (the fair day's work) will bring in the current, or only slightly more than the current, daily time-wage earnings; and variations in wages prearranged by sliding scale or otherwise are not very different from the changes obtained ultimately, though with greater friction, by strike or lock-out.

CHAPTER III

SOLUTIONS OF THE PROBLEM

THE labour problem has proved a highly convenient phrase in the academic world; it is so pat on our lips that the way it caught on—the etiology of the phrase—is in itself an interesting problem.

Certainly to the capitalist employer labour, with its indifference to his interests and its vague unrest, is distinctly a problem to manage, and academic and business society do not always travel such separate paths as to prevent a junction at this point of view.

Yet from the standpoint of the community as a whole—mainly consisting of “labour”—it is not labour but the predicament in which labour finds itself that is the problem.

In this sense there appear to be two fundamental problems: that of poverty caused either by low wages while employed or by periods of no wages while unemployed, and that of harmful and irksome conditions of employment. Manual workers, men, women and children, are liable to be employed during long hours at a uniformly high intensity on uninteresting work among unhealthy surroundings.

And there is a grave suspicion that this labour policy, based on the calculation of immediate profit to a single employer, is not in the long run the most effective use of the man-power of the nation, and possibly gives no indication of the industrial capacity of men when roused to enthusiastic co-operation.

Hence there is a series of problems not merely from the standpoint of the labour involved in the new industrial

system but also from the standpoint of national efficiency, and a double reason exists for seeking a solution or solutions of these problems.

When in the course of the nineteenth century the theory of *laissez-faire* collapsed and the need for action was admitted, action was taken by several agencies—by labour itself, by the State, and by the employer—and their efforts have profoundly modified the position of labour to-day.

THE RISE AND FALL OF *Laissez-Faire*

At the very moment when the new problems of industrial labour were growing insistent, a theory was arising as to the policy of the State which effectually prevented anything being done towards a solution of these problems. The policy of leaving economic forces to act unhampered by Government "interference" was formulated at first as a criticism of the restrictions on industry imposed by guild systems, mercantile policy, and other feudal or nationalistic practices; but it was applied in all its rigour against any solutions that were suggested of the newly arising problems of labour.

The pure theory of *laissez-faire* was to the effect that if business men were allowed to follow their own economic interests their activities would in the long run conduce to the greatest national prosperity. The Government was merely to "keep the ring," while entrepreneur competed with entrepreneur, and employer higgled with employee. As a result of this unhindered competition and higgling prices and wages, it was thought, would reach a "natural" level, justified by conditions of supply and demand. If wages were low, this was held to be due to an over-supply of labourers; and poverty was considered preventable only by individual sacrifice and effort, not by any Government action.

When attempts were made to popularize these notions of *laissez-faire*, it became a doctrine of the crudest fatalism. To increase wages was considered useless, since it would only lead, through an increased birth-rate or a decreased death-rate, to a further over-supply of labour, and hence

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back again to lowered wages. The possibility of restraint and the preventive checks indicated in Malthus' original theory was ignored, and the working-classes were apparently regarded as breeding automatically.

Poverty being thus inevitable, efforts could only be made to keep the poor contented with their lot. Paley, though author of *Evidences of Christianity*, yet ranked his *Reasons for Contentment*, addressed to the "Labouring Part of the British Public," as first among his works. His argument is certainly ingenious :

Some of the necessities which poverty (if the condition of the labouring part of mankind must be so called) imposes, are not hardships but pleasures. Frugality itself is a pleasure. It is an exercise of attention and contrivance, which, whenever it is successful, produces satisfaction. The very care and forecast that are necessary to keep expenses and earnings upon a level, form, when not embarrassed by too great difficulties, an agreeable engagement of the thoughts. This is lost amidst abundance. There is no pleasure in taking out of a large unmeasured fund. They who do that, and only that, are the mere conveyers of money from one hand to another.

Equally famous among the broadcasters of *laissez-faire* were Lord Brougham, who warned labour of the danger of making capital timid, and Miss Harriet Martineau, whose tales, to quote Leslie Stephen, "are now an unreadable mixture of fiction, founded on rapid cramming, with raw masses of the dismal science."

The ruling classes were not slow in acting upon the theory thus propounded. At first, indeed, they went one better ; instead of merely keeping the ring, they distinctly seconded the employing classes. The militia was concentrated in industrial districts ready for action—as at Peterloo—and all combinations among workmen were entirely prohibited. By the Combination Act of 1800 and the law of conspiracy any artisan who organized a strike or joined a trade union was a criminal and liable on conviction to imprisonment. A strike was a crime, the trade union was an unlawful association.¹ All views contrary to the interests of the employing class were summed up as Jacobinism—the Bolshevism of the day—and its expression in speech

¹ Dicey : *Law and Public Opinion in England*, p. 98.

and print suppressed with imprisonment and deportation. Spies like the famous Oliver were employed to manufacture such views if they could not otherwise be discovered.

This policy of the Government, characterized by the Hammonds (21) as rank abdication in favour of the employer, came to an end in England with the repeal of the Combination Act in 1824. Such a policy still persists in America, where many of the individual States of the Union are under the thumb of the larger employers within their jurisdiction. As recently as 1919 the strike of the iron and steel workers in Pennsylvania against a 12-hour day disclosed the existence of spies and agents-provocateurs organized under the name of detective agencies, and repeated the century-old story of suppression of free speech, illegal arrests and a military reign of terror.¹ Thanks to the exploitation of mob-psychology by modern journalism, the technique of suppression has, if anything, been improved.

The second phase in the *laissez-faire* policy, that of genuine neutrality, lasted in England well into the middle of the nineteenth century. About the time of the great exhibition of 1851, indeed, the Government seems to have arrived at the conclusion that perfection had been reached. "As a sign of the state of opinion it is noticeable," writes Dicey,² "that the only considerable legislative achievement which can be ascribed to Palmerston is the Divorce Act of 1857."

The principles of Jeremy Bentham and the Utilitarians were now established, and only here and there were voices raised against a smug contentment.

In 1838 Dr. Arnold warmly denounced the proposal "that civil society ought to leave its members alone each to look after their several interests" as "one of the falsest maxims that ever pandered to human selfishness under the name of political wisdom"; while Carlyle in 1839 delivered himself in still more forcible fashion:

That the arrangements of good and ill success in this perplexed scramble of a world, which a blind goddess was always thought to preside over, are in fact the work of a seeing goddess or god, and require

¹ *The Great Steel Strike of 1919*, Interchurch World Movement.

² *Op. cit.*, p. 182.

only not to be meddled with : what stretch of heroic faculty or inspiration of genius was needed to teach one that ? To button your pockets and stand still is no complex recipe. *Laissez-faire, laissez-passer!* Whatever goes on, ought it not to go on ? . . . A social principle which this present writer, for one, will by no manner of means believe in, but pronounce at all fit times to be false, heretical and damnable, if ever aught was.

Arnold and Carlyle were voicing a growing movement of protest against the patent results of *laissez-faire*. Men like Lord Shaftesbury and Charles Dickens with no theory of politics or economics behind them were shocked by the conditions as they saw them in the factory towns, and the evidence tendered before royal commissions opened the eyes (and mouths) of public-spirited liberals, as well as industry-hating Tories. It was found that boys working in mines, though well-versed in the adventures of Dick Turpin, had heard neither of God, Heaven, King George III, nor even the Duke of Wellington, and it came to be admitted that some modification of *laissez-faire* was necessary. Government action had been taken to abolish slave traffic and slavery in British Possessions: it was as an anachronism that Oastler attacked the "Slavery in Yorkshire" of English boys and English women. The Factory Act of 1833, the first to be something more than a dead letter, marks the beginning of the end. Regardless of the interests of employers and of all the benefits of *laissez-faire*, the working hours of women and of boys under fourteen were to be limited, by legal procedure, to twelve a day !

THE LABOUR MOVEMENT

Full credit has to be given to the disinterested protests of upper-class persons against leaving the labour problem alone. But it is doubtful how far these protests would have been effective had they not been backed by the working-classes in their own behalf. Self-help was cogently advocated by exponents of *laissez-faire* like Samuel Smiles, so long as it was only the individual who helped himself. But the working-man now took the lesson to heart in a collective capacity, and with the repeal of the Combination Act in 1824 the workers began openly to organize.

Effective organization gradually developed two forms—that of the trade unions and that of consumers' co-operation. These forms were effective because they recognized the inevitable efficiency of the new industrial system and did not attempt to return, in spite of the urging of Morris, Ruskin and others, to a mediæval system. Population had increased too rapidly to return to the inferior productivity of the handicrafts, however morally or æsthetically desirable.

The trade unions attacked simultaneously every problem confronting labour in the new industry. They fought for higher wages, the prevention or palliation of unemployment, and healthier and less irksome conditions of employment.

With the weapon of the strike in their hands, their aim was, and is, to effect a collective bargain with the employer which shall ensure to every member of the union a common standard of wages, hours and other industrial conditions. Mutual insurance against sickness and unemployment, and the assurance of benefit during authorized strikes, binds together every member of the union, and presents a united front to the employer. In this way the two parties to the employment bargain possess the equality in bargaining power without which *laissez-faire* can be only a farce.

Members of society "are not equal in natural powers, and still less have they ever, within historical memory, started with equal artificial advantages. . . . Power of every sort has a tendency to increase itself." Yet under *laissez-faire*, continues Dr. Arnold, "we stand by, and let this most unequal race take its course, forgetting that the very name of society implies that it shall not be a mere race, but that its object is to provide for the common good of all, by restraining the power of the strong and protecting the helplessness of the weak." If government did not propose to help the weak, the weak now proposed to help themselves; and the important part trade unions have played in maintaining and raising the standard of wages, in reducing the hours of work and in improving the general status of the employee cannot be gainsaid.

The membership of British trade unions has increased by leaps and bounds in the last twenty years. In 1900 the total membership was something like two million, in 1910

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two and a half million, and in 1920 seven million; and although there has since been a setback, this has probably been the result of cyclical depression in industry rather than a permanent tendency.

Not the absolute figures of membership, but the *proportion* of wage-earners organized in trade unions is the significant symptom. Briefly speaking, in coal mining, transport and cotton industries more than three-quarters of all those employed are members of the trade unions, while in building, general labour (mainly employed in public utilities), iron and steel, shipbuilding and engineering industries, at least half of all those employed are members of the trade unions. The only large group of industries where the proportion organized in unions is low is agriculture and those industries where women are in the majority. Even then, over a million and a quarter women trade unionists were reported in 1920.

In America the total membership of trade unions was by 1920 5,179,000, some 4,000,000 of whom were included in the American Federation of Labor and most of the remainder in the Railway Brotherhoods. This total of course represents a smaller proportion of the numbers employed than in England.

While trade unions are fighting for better conditions and higher wages, the other wing of the labour movement is fighting to make the wages go farther. The fundamental object of the co-operative movement is the provision of goods to consumers at the lowest possible price. This is done not by charging a lower price at the time of purchase but by being able as a result of charging "market" prices to return a dividend to all purchasers in strict proportion to their purchases.

This system, first devised by the Rochdale pioneers in the forties, has met with solid success. In 1919 the total membership of English and Scotch co-operative societies amounted to 4,131,477, and the average sales per member to about £48 in the year.

To cheapen their costs the local English and Scottish retail societies are federated into a Scottish and an English Co-operative Wholesale Society, from whom stock is obtained.

These Wholesale Societies, as well as some of the large local societies, also produce, transport or manufacture many of their leading "lines," and it is calculated that from a third to a half of all co-operative sales are articles *produced* co-operatively.

In America co-operators are few and far between. The existence of 2,600 societies is reported by the Department of Labor (8, No. 313) as scattered through the States, but among the thousand societies giving details the average membership was only 269. Practically no manufacturing is done by these societies, and only a few wholesale transactions are undertaken.

Trade unions represent the working-classes organized as producers, co-operation represents them organized as consumers; and in times of strike and of political crisis both wings of the labour movement have often helped one another, and with the increasing identity of their membership they are likely to do so more and more.

The labour movement has in England also a political organization in the Labour Party, and a political philosophy in the shape of socialism of one kind or another. The movement has its ups and downs, its quirks and failures in cohesion, but it marks a growing reaction to labour's industrial predicament and one to be reckoned with in the industrial world of the future.

STATE CONTROL IN INDUSTRY

The effect of upper-class protests and working-class organization is a definite "intervention" on the part of the State into "economic affairs." That, at any rate, is how the *laissez-faire* doctrinaire puts it in his text-books. Apart from the encouragement or enforcement of social insurance, largely palliative in purpose, this intervention takes two forms—that of control by regulation, where the State sets certain standards that are to be observed by the private employer for the benefit of the employee, and that of control by actual operation, where the State itself assumes the rôle of an employer.

Even so mild a form of intervention as the regulation

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of women and children's employment and of factory hygiene and the hours of work, is not brought about without agitation and propaganda. Text-books of economic history often give one the impression that the famous English Factory Acts of 1833, 1844, 1847, etc., were passed somehow automatically through the innate goodness and right thinking of the Government. In actual fact there was the most alarming "labour unrest," and "paid agitators" were "insiduously" at work organizing short-time committees and packing witnesses to London. Of the agitation in the seventies for a 54-hour week Hutchins and Harrison¹ remark that "Contemporary observers seem to have been struck by the admirably business-like manner in which this nine-hours movement was engineered, forming a strong contrast with the burning excitement and bitterness of the ten-hours movement of the 'thirties and 'forties."

The cabinet and legislature are, in fact, usually driven to a policy of regulation against the formidable opposition of the business interests and a large section of the Press. Often enough the "interests" have their way and legislation is withheld.

In America there is a further obstacle to regulatory legislation. Passage by the legislature does not *ipso facto* make a law valid. An employer may deliberately infringe a law in order that his trial may test its "constitutionality" before a judicial court. And until quite recently factory legislation was generally held to be contrary to the Fourteenth Amendment to the Constitution, which prohibits States from abridging the "privileges or immunities of citizens of the United States"; nor "shall any State deprive any person of life, liberty or property without due process of law." The rightful "liberty" of a citizen was held to include the privilege of working fourteen hours a day if he and his employer chose, and only conclusive proof that the conditions to be regulated were harmful to the health of the worker would reverse this interpretation. Such proof has recently been established to the satisfaction of many courts, through the labours of Mr. (now Mr. Justice) Brandeis, Mr. Frankfurter, Miss Josephine Goldmark and others. Masses

¹ *A History of Factory Legislation.* P. S. King.

of statistics and expert opinion have been presented as a "brief," to show the injury of long hours and other working conditions to the worker's health and safety. Yet social legislation adopted in many European countries is still held unconstitutional in the United States.

State regulation, it is evident, can only be effected by constant vigilance, by numerous inquiries, official and otherwise, and by ceaseless agitation.

Till quite recently the important subjects of State regulation have been three: hygiene, safety, and the restriction of employment with particular reference to women and children.

Under English factory legislation the enforcement of these regulations can be followed in the number of contra-vention notices served among the 120,000 odd factories under regulation in 1910. For instance, the dictates of hygiene demand the limewashing of walls every fourteen months (7,710 notices); the provision of sanitary conveniences (1,067 notices); and a certain standard of general ventilation (1,846 notices), of special ventilation by exhausts in case of fumes, dust, etc. (3,203 notices), of temperature (2,308 notices), and of room-space (92 notices).

The dictates of safety require the fencing of machinery (32,868 notices); reporting of serious accidents (8,932 notices); and testing of steam boilers (2,242 notices).

Restrictions on employment set a minimum age below which no employment in industry is allowed, and for young persons and women above this age certain maximum hours of work at given times, e.g. by day, not night, are prescribed. Only in the case of the Coal Mines Acts of 1908 and 1911 have the hours of employment of adult men been legally restricted.

The wage to be paid (except in so far as payment in kind or "truck" is forbidden) is usually only regulated (e.g. by Trade Boards) when sweating exists and the bare subsistence minimum must be enforced. Little is done by the State to lay down the maximum intensity of work or the limits to nervous and physical strain. Trade-union and shop-committee action is, perhaps, better adapted than any State regulation to settle such questions as to a fair day's work.

Regulation is enforced by State inspectors with power to

prosecute employers infringing the law. In England the inspectorate, in spite of foreboding to the contrary,¹ is efficient and conscientious. In America the inspectors, usually appointed "politically" by the individual States, too often constitute the weakest link of the administrative chain.

Transcending regulation, the State may intervene by taking upon itself the rôle of employer. In certain industries, notably that of carrying letters, this policy of "State operation" was usual even in the palmiest days of *laissez-faire*. With the reaction from *laissez-faire*, State operation either by the nation or the local municipality was extended here and there to a wider range of industries, notably to the provision of water, gas and electricity, to transportation, and to munition factories and all industries, such as road-making and maintenance, where the product is offered free to the consumer.

Improved conditions were predicted for the workers in these State-operated industries. In their capacity as voters the employees, it was supposed, could make their wishes felt. In practice this political control often seems too indirect, and it is significant that much of the working-class enthusiasm for State operation has been transferred to Syndicalism or Guild Socialism, systems that demand a direct industrial control by the workers' own trade unions.

Apart from schemes and projects, the actual course of events, though masked by the ups and downs of the industrial cycle, will probably lead eventually to systematic and effective division of responsibility between State Government, the Trade Unions, and the Capitalist. At this very moment such three-fold division provisionally holds in sway in numerous industries. The State, by its policy of regulation, lays down certain standard requirements with regard to factory hygiene or safety, hours of work, etc. Within these standard requirements employer and employee then bargain the matter out. The trade unions usually have a minimum wage scale and a maximum standard of hours of their own,

¹ "The inspectorships are a lumbering affair, and will turn out in practice, we suspect, a nullity; their chief recommendation with their projectors is probably the patronage they afford." *Leeds Intelligencer*, August 10, 1833. Quoted by Hutchins and Harrison.

somewhat more liberal than that of the State; and where collective bargaining prevails and the trade union represents the workers, these standards usually form the basis of discussion.

THE PLAN OF SCIENTIFIC MANAGEMENT

While the State was laying down certain minimum or maximum standards to be observed by employers in their dealings with their employees, and employees were moving against the autocratic control of industry, employers were often setting their house in order for themselves.

At the beginning of the nineteenth century isolated pioneers like Robert Owen had introduced schemes of management beneficial to labour that were actually found to pay. Toward the end of the nineteenth century the opposite process showed itself. Schemes of industrial management introduced to pay, and to pay enormously, were found to offer greatly increased advantage to labour. The movement which crystallized these claims to better the lot of labour not so much for the labourer's sake as for the employer's is known under the name of Scientific Management.

On the subject of scientific management so much has already been written that an exhaustive description at this stage is quite unnecessary. The essential novelty of the idea consists in directing the attention and the forethought of the business manager to a hitherto neglected part of industry—namely to the actual point where the worker is at work. The events occurring at this focal point had previously been left entirely to the control of the foreman, who fulfilled a rôle somewhat parallel to that of the sergeant in the army.

One of the best-known exponents of scientific management gives the following account of the duties expected of the foreman by the ordinary manager.¹ A new-fashioned expert is supposed to be criticizing old-fashioned inefficiency:

Your foremen, under the conditions you describe, are so busy that they are in no position to run their departments efficiently. . . . Take your speeds and feeds as an example. It requires considerable analysis

¹ C. E. Knoopel: *Installing Efficiency Methods*, The Engineering Magazine Publishing Co., New York, 1915.

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and experimenting to determine proper combinations of speed, feed and cut; the best angles and shapes of tools; the best cooling agents; the kind of steels to use. Yet you expect your foremen to do this efficiently.

Piece-rates cannot be set without careful study. It needs infinitely more than a look and a guess. You look to your foremen to set fair rates. Unless there is a careful advance planning, machines are bound to be either idle or congested. You expect your foremen to keep work running through the plant in a proper manner with reference to relative importance. You keep no data on idle equipment time because this, you say, is up to the foreman. They must also break in new men, adjust differences as to wages with them, look after quality of production, keep up discipline, keep down rejections. On top of all this you expect your foremen to exercise the functions of an order department in ordering their material, and then act as chasers in keeping the work flowing through the plant.

Organizing the flow of materials and products in course of manufacture through the plant has always exercised the ingenuity of the foremen and works manager. It is in the application of ingenuity and forethought to the remaining duties of the foreman that scientific management is initiating a new movement in industry. In dealing with these hitherto neglected duties of the foreman, four distinct principles are distinguished by Dr. Taylor, the founder of scientific management. The fourth principle, which concerns the organization and division of labour necessitated by the other three, will be discussed later; but this is Taylor's enunciation of the first three principles so far as applicable to the familiar operation of bricklaying (24, p. 85) :

First.—The development (by the management, not the workman) of the science of bricklaying, with rigid rules for each motion of every man, and the perfection and standardization of all implements and working conditions.

Second.—The careful selection and subsequent training of the bricklayers into first-class men, and the elimination of all men who refuse to or are unable to adopt the best methods.

Third.—Bringing the first-class bricklayer and the science of bricklaying together, through the constant help and watchfulness of the management, and through paying each man a large daily bonus for working fast and doing what he is told to do.

In theory, the method of work is supposed to be scientifically thought out, the worker to be scientifically selected and trained to perform it, and the most efficient speed, i.e. the

best time in which to perform a given task, to be scientifically determined. In practice, most attention seems to be paid to the method of work and the speed of performance. The central instrument for doing this has always been the Time and Motion study.

Time and motion study may be described as a minute observation and timing of all the various "elementary" movements or rests involved in a given industrial operation. Several repetitions of the operation are usually observed, and the best times for such of the elementary motions as are considered to be necessary are then added up to form a selected minimum time for the whole composite operation.¹

This study forms the basis for developing an ideal method of performing an operation at an ideal speed, with the unnecessary motions duly expurgated.

When delay allowances are added for human shortcomings, the selected time forms the basis of the piece rates. It solves the besetting difficulty of all systems of payment by result, namely, what is the result—the fair day's work—that should secure the fair day's wage? The fair day's wage, curiously enough, is usually regarded as fixed; it is the customary time wages paid in the given locality for the given class of skill. There is no difficulty, therefore, where time rates are concerned, but where piece rates are to be set, the question of exactly how many pieces shall count as one day's work is incalculable without a careful study of the pieces a man can turn out within the given time.

This besetting difficulty has led more timorous employers to adopt the so-called premium bonus system, whereby the rate of piece wages falls "degressively" as the total output increases. Under the ingenious Rowan system, for instance, the employee can never earn more than double the standard wage, however great his output. But so certain is scientific management of its measurements of working capacity, that a progressive system of piece rates is advocated, such as Taylor's differential wage or Gantt's task and bonus, by which the rate increases with increasing total output. If a man exceeds his carefully measured task, it is felt he deserves

¹ The most complete account of methods in actual practice is given in Dwight Merrick's *Time Study as a Basis for Rate Setting*.

(almost) every penny of the time (and overhead charges) he saves.

The method adopted by scientific management of inducing the worker to achieve his daily output is, then, to hold out an additional increase in pay either in the form of a bonus or an increased rate of piece wages. Much thought has been spent on devising the form of remuneration most likely to appeal, and many rival plans have been advanced into which we need not enter. The general principle is similar to the well-known device of holding out a carrot before a donkey attached by a pole to his head. In the words of Knoeppel:^{*} "Each man should see an ideal ahead of him that his mentality can readily comprehend, for just as surely as he attains this ideal it is automatically replaced by one still higher. Thus standardization becomes not crystallization but evolution."

In order to introduce such a "scientific" system it is obvious that a great change must be made in the whole organization of the industrial establishment. Scientific management proposes an increase in the ratio of supervisors, foremen and indirect labourers to the direct labourer, and a thorough division of labour or functionalization among these supervisors and foremen. The more mental functions of the direct labourer are mostly taken away from him and transferred to this specialized hierarchy. This principle, the fourth in Dr. Taylor's bricklaying programme, is somewhat euphemistically expressed (24, p. 85) as

an almost equal division of the work and responsibility between the workman and the management. All day long the management work almost side by side with the men, helping, encouraging and smoothing the way for them, while in the past they stood one side, gave the men but little help, and threw on to them almost the entire responsibility as to methods, implements, speed and harmonious co-operation.

The fact is that in thus "smoothing the way" for the men the management are liable to increase the uniformity, puerility and "skilllessness" of the operation, and in this respect, as well as in its improvements in material technique, scientific management, marks merely a continuation of the tendencies of the Industrial Revolution, and certainly cannot

* C. E. Knoeppel: *Installing Efficiency Methods*.

be viewed as offering any solution of the labour difficulties raised thereby. Rather does it add to them, as will be seen presently.

SCIENTIFIC MANAGEMENT AND LABOUR

The aims and methods of scientific management were in the first instance designed to increase efficiency, but as a result of their application the exponents of the movement claim to have improved the lot of the industrial worker (24, p. 10).

Scientific management . . . has for its very foundation the firm conviction that the true interests of the two [employer and employee] are one and the same; that prosperity for the employer cannot exist through a long term of years unless it is accompanied by prosperity for the employee and vice versa; and that it is possible to give the workman what he most wants—high wages—and the employer what he wants—a low labour cost—for his manufactures.

And yet scientific management, while taken up eagerly by many employers, is by no means popular with labour either in America or England. So strong has been the feeling in America that, under pressure of labour interests, Congress passed a Law in 1915 providing that in United States Army workshops no appropriations should be available

for the salary or pay of any officer, manager, superintendent, foreman or other person having charge of the work of any employee of the United States Government while making or causing to be made, with a stop-watch or other time-measuring device, a time-study of any job or any such employee between the starting and completion thereof or of the movements of any such employee while engaged upon such work; nor shall any part of the appropriations made in this Bill be available to pay any premium or bonus or cash reward to any employee in addition to his regular wages, except for suggestions resulting in improvements or economy in the operations of any Government plant; and no claim for service performed by any person while violating this proviso shall be allowed.¹

This unfavourable reaction on the part of labour has been variously explained. Professor Hoxie, for instance, maintains that the opposition of the trade unions is largely due to their innate conservatism. Trade unions stand as bulwarks

¹ Muscio: *Lectures on Industrial Psychology*. Routledge.

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of the customary wage, the customary working speed and the customary division of labour, and they naturally fear the revolutionary innovation of scientific management.

If the accusation of changing customary industrial conditions were the only count against scientific management the case might be dismissed. The present conduct of industry, even on its technical side, is not so efficient as to exclude further progress. The industrial revolution must go on. But further technical progress must bring with it further progress on the human side of industry, further progress in "*personnel*" administration, and this, for two fundamental reasons, scientific management fails to ensure.

Scientific management "experts" fail to grasp what the labour problem is, and in their ignorance claim to "solve" more than any social science possibly can at this date; and secondly, even where scientific results are possible, scientific management fails to be really scientific.

(A) Where scientific solutions are impossible scientific management makes extravagant claims.

According to authenticated statements of Dr. Taylor,¹ scientific management

seeks to substitute in the shop discipline natural law in place of a code of discipline based upon caprice and the arbitrary power of man. . . . It substitutes joint obedience of employers and workers to fact and law for obedience to personal authority.

As Professor Hoxie points out, this type of claim is of very wide scope. The idea is that, on the basis of scientific studies mainly of the "time and motion study variety," laws will be evolved to solve all such difficulties as the equitable division of the product. Collective bargaining on this subject, according to Dr. Taylor, is no more reasonable than "bargaining about the rising and setting of the sun."

Wages certainly have often been increased as the result of scientific management, but this is very far from predicating that the increase occurred through some scientific law operating automatically. What the bonus or other reward for the task shall be is settled by the management, and usually on *the basis of some idea as to what a workman of a*

¹ R. F. Hoxie: *Trade Unionism in the United States*, p. 300.

given class ought to get. Numerous passages in Dr. Taylor's *Principles* make this plain. One instance may be quoted.

Some ore-handlers under Dr. Taylor's supervision, though paid at a *piece* rate far below what was offered elsewhere, were yet found, owing to their high productivity, to earn some 60 per cent. more per day than the ruling rate of wages in the district. Now, Dr. Taylor tells us (24, p. 74),

a long series of experiments, coupled with close observation, had demonstrated the fact that when workmen of this calibre . . . receive much more than a 60 per cent. increase in wages, many of them will work irregularly and tend to become more or less shiftless, extravagant and dissipated. Our experiments showed, in other words, that it does not do for most men to get rich too fast. After deciding for this reason not to raise the wages of our ore-handlers . . .

This decision is referred to later (24, p. 138), where it is stated that

a long series of careful experiments [were] impartially made to determine what compensation is really for the man's true and best interest when all things are considered.

The gesture is magnificent, but this is hardly "science." Though neither the results nor the methods used in these "long series of careful experiments" has ever to my knowledge been published, we will not dispute Dr. Taylor's word for them. What we do dispute is the existence of any objective measure of a man's "best interest" and the possibility of any scientific law of distribution being framed on that basis. The difficulties that generations of economists have grappled with are not so easily solved: These claims of scientific management are, so far as the state of science at present is concerned, *ultra vires*.

(B) Where scientific solutions *are* possible, scientific management is not scientific enough.

Dr. Taylor claims that "scientific management guards the workers against over-speeding and exhaustion nervously and physically," but the following facts seem to warrant the conclusion that the human element is not scientifically studied at all.

(1) Time-study is often carried out without any concomitant motion-study. Motion-study may be distinguished as the attempt to work out the most economical form of move-

ment on the part of the worker for any given operation, and the most economical appliances for him to use. Quite apart from time-study (the study of the fastest time it is possible to attain on the given operation) motion-study is destined to play an important rôle (as will be shown in Chapter VIII) in the further development of industrial efficiency. Shorn of its motion-study features, time-study is inclined to become a mere question of speeding up.

And if the actual practice as applied in factories be examined, there are, according to Professor Hoxie, seventeen factors that may vary subject to human will, and that affect the results of time-and-motion-study. These factors include "the intelligence, training and ideals of the time-study man"; but we might assume the staff to be actuated by purely scientific motives and yet find many flaws in the procedure.

(2) The danger of speeding up is increased by the peculiar technique, advocated by exponents of scientific management, of basing the task for a group of workers on the fastest record of the fastest man under the most propitious circumstances.

It is true that minute care is taken to avoid errors of observation, and that a delay allowance is introduced in all cases to allow for human frailty and imperfection. Yet in spite of the complicated formulæ often adopted,¹ this allowance seems a somewhat arbitrary, unscientific device, and, judging from the results of a very large series of observations I recently carried out, the amount of allowance (usually about 20 per cent.) seems often quite inadequate. Such an allowance has to cover the difference between the capacities of different operators at the same time, and of the same operator at different times.

Though the extent and form of variation in the output of different individuals must be very different in the several types of operation, reference to Table 27, recording the variation among a group of button-chargers (working apparently at high pressure), should prove illuminating.

The maximum hourly outputs from any one individual in the group (over 3.6 lbs.) are more than 40 per cent. faster than the average hourly output of the group (2.5 lbs.);

¹ Cf. Dwight Merrick, *op. cit.*

and more than twice as fast as the instances of slowest hourly output (less than 1.4 lbs.).

Moreover, while 1,489 observed hourly outputs (out of a total of 2,080 observations) fell within half a pound of the average rate, there were comparatively few observations to attest the possibility under normal circumstances of the faster speeds. If fewer than 2,080 observations had been taken these speeds might never have been obtained at all, and it seems the reverse of logical to deduce a feasible speed from fast records, the observation of which is largely a matter of chance.

If the time-study of any operation is taken for less than one hour, there is a further source of error. Great rapidity of motion is often economical on short runs of a quarter of an hour or so, in order to obtain a rhythm, but in that case long rests must supervene for the worker to recover from fatigue. The whole question of rhythm and output, however, must be postponed for later discussion.

(3) It is clear also that the method of selecting, training and stimulating employees has not been given the scientific attention originally advocated by Taylor; nor do we find in the literature of the movement since Taylor's writings many published cases of scientific investigation applied to hours of work and physical or social working conditions. Interest in work on the part of the workers has not been aroused except through the money motive, and the additional division of labour, routine, discipline and red tape often necessitated is liable to enmesh what little feeling of freedom the worker has left.

In practice, it is evident, scientific management has not paid that attention to the efficiency of the human factor in industry which has been lavished upon the efficiency of the material factors. As an engineering proposition there is no question of the success of scientific management. It has greatly increased material efficiency and increased it by a conscious direction of attention to points where the human factor is increasingly involved. But beyond this its claims are either outside the ken of science or have not a sufficiently scientific foundation. The economic world and the human factor are more complex than is dreamt of in the philosophy of scientific management.

CHAPTER IV

THE THEORY OF FATIGUE AND UNREST

THE predicament of labour in the new industrial efficiency has gradually come to be recognized as a problem, and the several parties concerned have each tried their hand at a solution: the labourer naturally as a measure of self-help, the State and the employer to some extent for humanitarian reasons, but perhaps also in fear of a possible catastrophe.

In the course of the nineteenth century some of the conditions favouring the further growth of technical efficiency ceased, at any rate in England. The more favourably situated mineral resources were largely worked out and the more favourably situated soil fully employed. The qualities required for successful entrepreneurship no longer remained the monopoly of Englishmen, and without additional recompense labour was no longer sufficiently docile and fecund to stand or survive the additional burdens of the new efficiency.

To this the twentieth century added the destruction of capital by war on the grand scale, and it is not surprising that captains of industry—private and public—turned in compensation to the more efficient use of the human factor.

The solution by scientific management suggested itself, and has undoubtedly marked a great advance in engineering practice by recognizing the human worker as a "variable" requiring special consideration. Dr. Johnson's remark that "Trade could not be managed by those who manage it if it had much difficulty" seems thoroughly deserved by the practice of employers in the pre-scientific Victorian era. The British War Office, a large employer of labour directly (in arsenals) and indirectly (by contract), carried Victorian

ideas up to the outbreak of the recent war, and took it as axiomatic that output was a multiple of the number of hours worked. If a gang could produce a hundred shells in an 8-hour day, it followed that in a 12-hour day they could produce a hundred and fifty, and orders to increase hours were issued accordingly.

Scientific management is an improvement, yet as actually practised it consists more in the application of Victorian efficiency to the new field of "handwisdom" than in any new development. It fails to alter the essentially autocratic control of industry, nor does it really introduce scientific research into the "labour problems" of industry. Yet democracy and applied science are not incompatible. An industrial democracy, to be efficient, would require full scientific information, and could not dispense with scientific management on the labour side of industry.

In this chapter a scientific basis is outlined for developing such labour or "personnel" efficiency. Ever since the Industrial Revolution many forces have contributed towards the working out of such a basis. The most notable contributions have been the practical policies of such enlightened employers as Robert Owen, Ernst Abbé, Cadbury Brothers, Rowntree and Lord Leverhulme; the welfare work movement in one form or another; and the gradual development of an industrial physiology and psychology taking cognizance of industrial fatigue and unrest as facts with causes to be investigated scientifically and thus, if possible, to be prevented. It still remains, however, to piece these contributions together into a general system of scientific labour administration.

THE "HUMAN FACTOR," "FATIGUE" AND "UNREST"

Literature concerning the human factor in industry has been abundant recently, but no very clear analysis of the term is usually made. Since factor is used in connection with industrial production, the phrase refers presumably to the degree of *capacity* and *willingness* to produce exhibited by any set of human workers. Further, the term usually seems to be applied to a *given number* of men. Unlike the

word man-power, the human factor could not be said to be increased by the mere addition of more men.

Degrees of capacity or incapacity to produce may be distinguished, on this assumption, according as they are variable or not variable in the course of the act of production itself. Where the muscularly weak are asked to lift excessively heavy materials, or the maimed to use parts of the body they have lost, the same degree of incapacity would invariably be displayed. Variable incapacity can be analysed into incapacity due to excessive activity previously undergone under certain conditions (capacity tending to decrease with increased work) and incapacity due to insufficient previous activity (capacity tending to increase with increased work). The former case may be denoted fatigue, the latter lack of practice or inexperience.

Degrees of willingness or unwillingness to produce are represented by such expressions as mental fatigue, boredom, monotony, lack of interest, indifference; but, particularly where the unwillingness to produce is variable in the course of production, the expression in most common use to-day is industrial or labour "unrest." In recent investigations of labour unrest the word is used mainly to refer to certain direct manifestations of antagonism to production, such as lost time, strikes, restriction of output, seizure of factories and sabotage, or else manifestations of a political and occasionally military nature. Unrest is also extended to refer to the growth of organizations such as trade unions and Socialist parties, which are largely committed to this antagonism to the present system of production. In effect, "labour unrest" is used to indicate a feeling of unwillingness, dissatisfaction or balked disposition (as Graham Wallas puts it) which directly or indirectly tells against production under given conditions—a feeling which may or may not have some actual physiological concomitant in the individual organism.

The human factor in production may then be represented to include the following elements:

- A. The degree of willingness to produce on the part of a given number of men. Labour unrest.

B. The degree of capacity to produce on the part of a given number of men.

- (1) Not variable by the act or conditions of production itself.
- (2) Variable by the act or conditions of production itself.
 - (a) Inexperience or lack of practice: capacity tending to increase with increased production.
 - (b) Industrial fatigue: capacity tending to decrease with increased production.

Among the elements affecting capacity to produce the most important, according to the generally accepted theory, is that denoted industrial fatigue.¹ Marshall (22) called fatigue the main discommodity of labour and one of the "real" costs of production, and since then engineers like Mr. Gilbreth have made "fatigue study" or fatigue "control" practical factory politics, while publicists such as Mr. J. A. Hobson have given fatigue a prominent place among the human values affected by industry. That lengthy holidays and week-ends are necessary to effect recovery from fatigue has been a tenet, indeed, acted upon by the English upper classes for several generations.

The significance attached to fatigue by economists, practical engineers and those solely engaged in "keeping fit" is not difficult to explain. A state of *absolute* incapacity that cannot be varied by the act or conditions of production itself is not an *industrial* problem, while a state of incapacity due merely to insufficient previous activity tends to right itself. Hence it is chiefly in the case of fatigue that there is an obvious need for industry to adopt corrective measures. The phrase "industrial fatigue and unrest," therefore, may be adopted *provisionally* to cover all the more pressing problems of the human factor that arise in industry and that may largely be solved by industry.

Whether or not fatigue and unrest are accepted as the leading constituents in the human factor in industry to-day, it is generally agreed that this human factor is variable,

¹ As is usual with words that have come into popular use, "fatigue" symbolizes several related things, just as "unrest" was found to do. Particularly we must distinguish the *feeling* of fatigue or tiredness, the outward *manifestation* of fatigue in reduced efficiency, and a probable inward physiological *state* of fatigue. How far these three things are concomitant is still under investigation.

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not to say temperamental and even wilful, and it is often concluded that this variability precludes scientific investigation. Such scepticism is not justified if it can be shown that the variability of the human factor is definitely determined by certain variations in its environment, e.g. the hours of work or the hygienic condition of the work-place, and in its turn definitely determines certain outward variations capable of measurement—e.g. the amount of lost time, accidents, and deficiencies and defects in output.

The belief in the possibility and the importance to industrial efficiency of a scientific study of the human factor with its liability to fatigue and unrest, is based on two propositions :

1. That variations in the human factor result in certain variations in industrial efficiency and certain losses in production. —
2. That variations in the human factor are largely caused by variations in conditions of employment that are largely determined by the employer.

In short, the theory of fatigue and unrest constitutes a belief in the possibility of so adjusting the conditions of employment that capacity and willingness will possess the human factor sufficiently to ensure increased efficiency and decreased costs. The wise employer will experiment by varying the conditions of employment and make due note of the concomitant variation (if any) in productivity and costs.

This process of adjustment, if it determines practical policy, may be called one of control. Where efficiency and costs on the one hand, and employment conditions on the other, are capable of numerical measurement, the process may be called one of statistical control. In studying the work of loading pig-iron, for instance, Taylor, by adjusting experimentally the load taken and the hours worked, found (24) that "when pig-iron is being handled (each pig weighing 92 pounds) a first-class workman can only be under load 43 per cent. of the day . . . and as the load becomes lighter [i.e. when only half pigs are handled] the percentage of the day in which the man can remain under load increases." Applying this law, Taylor got Schmidt, his Pennsylvania Dutchman, to load $47\frac{1}{2}$ tons of pig-iron per day instead of

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12½—i.e. he increased the output 276 per cent. Taylor, in short, controlled conditions of load and hours in the light of their result on output and output costs.

The various resultant costs besides loss of output that should control the adjustment of conditions will presently be specified, and also the various conditions of employment that may be adjusted besides hours and load of work. Before entering on these details, however, attention must be directed to certain drawbacks and pitfalls in the use of the words "fatigue" and "unrest."

THEORY AND INVESTIGATION

The theory of fatigue and unrest embodied in our two propositions must not commit us to any assumptions previous to investigation as to the incidence of fatigue and unrest; nor yet does it aim at establishing the existence of any particular physiological or psychological state of fatigue or unrest.

Most current definitions of industrial fatigue certainly involve a specific assumption. Fatigue was distinguished above as the case in which capacity to produce tended to decrease with increased production, and this is in keeping with the definition adopted by the British Association Committee (12). The Health of Munition Workers Committee defined fatigue as "the sum of the results of activity which show themselves in a diminished capacity for doing work."

I have pointed out elsewhere (18) that all such definitions imply "a coupling of two occurrences in the relation of cause and effect"—on the one hand a variation in certain industrial conditions such as an increase of hours or intensity of activity, and on the other hand a variation in the human factor as shown in deficient output or otherwise. Fatigue thus defined is a theory positing a whole process; it holds that a specified result is found associated with a specified set of conditions. But it is dangerous to assume before investigation that such a process really takes place.

The use of the word fatigue by definition implies the existence of the very process that we are trying to demonstrate. The word, in the earlier stages of argument, must be dropped altogether; and

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to avoid begging the question in the final demonstration two distinct steps are called for: first, to show and measure the fact of a definite diminution [or indeed any variation] of working capacity, and secondly, to associate this diminution with the fact of a definite increase in the length or intensity of activity [or indeed any variation in conditions of production] (18).

Industrial unrest might similarly be defined as the sum of the results of certain industrial conditions which show themselves in a diminished willingness for doing work; and the acceptance of such a definition would involve the same danger of *implying* "the existence of the very process that we are trying to demonstrate."

In view of these dangers the words "fatigue" and "unrest" will at first be entirely eliminated and the discussion in Chapters V-XI carried on without them. This will ensure our investigating whatever associations or correlations exist between various industrial conditions and variations in efficiency, without seeking to prove any specific theory. Subsequently, in Chapter XII, we may consider the conclusions that can be reached as to a physiological or psychological state of fatigue or unrest.

After an exhaustive review of the several psychological tests that have been tried, Muscio reported to the English Industrial Fatigue Research Board that "owing to the impossibility of eliminating will in the subject, there is little probability of devising such a test suitable for practical application." Physiological tests and experiments seem to be no more successful at present. Though the more severe degrees of exertion met with in warfare may be accompanied by easily observed physiological data,¹ our present knowledge of physiological processes accompanying ordinary industrial activity and behaviour is too limited. "What possible good does it do when discussing bricklaying," asks Watson (27).

to guess at what goes on in the synapse, in the efferent or afferent leg of the reflex arc or in the muscle itself? These are all worthwhile problems, but they belong to the realm of physiology, and this section of physiology has not yet been written. . . . The total known facts are pitifully meagre. For students of behaviour to devote

¹ See the experience of Dr. Maitland during the retreat of the Serbian Army in 1914-15 (13).

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hundreds and thousands (literally) of pages to the "physiological aspects" of fatigue problems tends in no way to the advancement of the study.

What the investigator is at present called upon to do is "to name the function he is measuring and specify the conditions under which the act is taking place. The function studied may be bricklaying, typewriting, multiplying subvocally or any other function." The scientific advantage of such a method is that it takes account only of "overt acts." Hours of labour or temperature and lighting of work-room, for instance, are overt or "objective" in that different people observing variations in them—possibly with the help of recording instruments such as watches, thermometers or photographic appliances—will be found to agree as to the nature or amount of variation. Similarly with the industrial "results." Here also are overt events—the production of output, the occurrence of lost time, accidents—such that different people making accurate records will agree as to their nature and amount.

From the practical business man's point of view variations in the human factor itself may be entirely omitted from consideration. If it can be shown in any factory that a decrease in the daily hours of work is connected with an increase in the quantity of daily output, the explanation does not matter practically to the management—whether fatigue has been reduced, good-will increased, or what. It is enough that a policy of shortening the hours of labour will result in the increased efficiency desired.

Once the correspondence between variations in production costs and variations in industrial conditions is established we may then proceed to determine how far the correspondence can be traced through the human factor and can definitely be attributed to fatigue and unrest.

To sum up. If industrial fatigue and unrest are defined for practical purposes as diminutions in human capacity and willingness to work associated with certain industrial conditions, the definition must not be taken to imply belief in any particular psycho-physiologic state of fatigue or unrest, nor yet must the definition be taken as more than a hypothesis still to be tested by the facts as to its truth and industrial

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importance. These facts will be investigated in Chapters V-XI without any use of either the words "fatigue" or "unrest" (unless they appear in quotations or references), until in the final chapter of Part II (Chapter XII) the theory is reconsidered in the light of the facts and association of facts disclosed.

THE COST AND CONTROL OF HUMAN INEFFICIENCY

The first proposition in the theory of fatigue and unrest is that variations in the capacity and willingness of the human factor (i.e. mainly in fatigue and unrest) result in variations in efficiency and unproductive costs.

Inefficiency in industry is not confined to low output, and will be used to refer to any or all of six forms of unproductive cost.

A given production is the more costly the greater the labour turnover—that is the more frequently the producing organization must replace its (human) members. Maintenance of organization is essential if the cost is to be avoided of training fresh employees merely to replace those who have severed their connection.

Secondly, a given production is the more costly the greater the absence from work and the time lost by strikes and otherwise. Even if any member of the organization maintains his connection, it does not follow that he will always present himself at the proper time and place. Yet regular attendance is essential if the cost of broken squads, idle equipment and general uncertainty is to be avoided.

A given production is the more costly, thirdly, the greater the restriction or deficiency in the quantity of output per hour or per man; and, fourthly, the more severe the defects in the quality and economy of output. Even if any member of the working force maintains his connection and attends regularly, it does not follow that his output will always be up to standard in amount or that the proportion of spoiled work or broken tools and machines will be at a minimum.

A given production is the more costly, fifthly, the greater the frequency and severity of accidents occurring

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to members of the working force; and, sixthly, the more frequent and severe their ill-health, whether in the form of occupational disease or otherwise. Maintenance of connection, attendance and output may all be satisfactory, and yet a large loss be incurred through the disabilities of employees and the liability of the employer to pay compensation. Prevention of industrial accidents, occupational disease, etc., is essential if the costs of interrupted operations and high insurance rates against compensation claims are to be avoided—not to mention the physical suffering of the victim.

These six types of costs, being unproductive, may, in strict accord with definition, be called losses, and since they are by hypothesis connected with variations in the human factor, they may be named the six types of labour loss.

These labour losses are, of course, not responsible for all industrial inefficiency. Full efficiency in industry depends on the successful interplay of the human and the material elements, and the losses that vary with the capacity and willingness of labour are only one side of the story. Indeed, for each type of labour loss there is a corresponding type of loss varying in extent with the *production manager's* capacity or willingness. Just as the worker may be absent when the work is awaiting him in the plant, so the worker may be waiting in the plant because of delays in bringing up material from the stock-room, or because of a temporary breakdown of his machine or a failure of power.

Corresponding to the loss by labour turnover is failure in plant maintenance: the wearing out or obsolescence of the machinery and buildings necessitating premature replacement, complete exhaustion of stock-room materials, or complete breakdown in the sources of power supply. Corresponding to the loss by reason of the workers' low output is the retarded functioning of machinery, owing to lack of lubrication, improper tool-setting, faulty repairing, etc., and inferior quality of materials and a poor supply of power. And corresponding to the loss by injury and sickness are accidents to machines, stock or power. In short, the "matériel" factors—stock, equipment and power—like the

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human "personnel" factor, must be physically present at the required time and place, must be kept fit and in good operating and "running" order, and should not be subject to continual replacement.

An American committee of engineers appointed by Mr. Hoover recently drew up a report on Industrial Waste. On its "release" for publication startling headlines appeared in the Press. More than 50 per cent. of the responsibility for waste was laid at the door of management and capital owners, and less than 25 per cent. was charged to labour. Management was charged with deliberate restriction of production, by collusion in bidding and by unfair practices in order to maintain high prices. Incapacity to produce resulted partly from "faulty labor control," but also from lack of cost control and technical research, from faulty sales policy, and from failure to standardize the product, to use raw materials economically, or to plan the flow of materials effectively.

Disorganization and mismanagement of the "matériel" factor, when compared with the disorganization and mismanagement of the labour or "personnel" factor, has probably received more than its share of attention. The field of industrial research is now become so vast that concentration on one issue is imperative, and in studying the human factor we are merely selecting the issue hitherto most neglected.

It has been the gradual recognition of these labour losses in production, and the belief that they could be prevented, that has led to the institution in large industrial establishments, or among groups of smaller establishments, of a special labour or personnel department.

In the unregenerate factory, untouched even by scientific management, industrial policy is usually considered as entirely concerned with the direction of technical processes and the conditions of supply and demand affecting material goods. The efficiency of the labour employed on these processes is supposed in some manner to adjust itself automatically. In practice, there is an enormous amount of work connected with the employment of labour, but it is relegated to subordinates. Arrangements must be made for

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hiring men and for "firing" them when unsatisfactory, methods and scales of payment must be devised to supply the maximum of incentive, and discipline must be exercised where this natural incentive fails. The safety, sanitation and hygiene of the factory, the hours and speeding up of work, must all be considered. Finally, it must be determined what type of worker to employ at the various jobs, whether skilled or unskilled, men or women, adults or adolescents—how far, that is, dilution of labour is to go.

This "employment" side of industrial management, which in America is coming to be called personnel administration, obviously involves much work: unfortunately it has hitherto not involved much thought. While technical experts are thoroughly at home in a factory, anyone called in as a specialist to look after employment efficiency will be classed as a welfare worker, and considered somewhat superabundant. Personnel work has been carried on up to the present absent-mindedly and by rule of thumb through the foreman and sub-manager, simply as a by-occupation to the real business of technical production.

The new labour or personnel department is often planned to be co-ordinate with the works or production department. While the production department controls the conditions of efficiency in the material, technical processes, the new department is to control the conditions of efficiency of the human factor. Tead and Metcalf (25) suggest six divisions within the new department devoted respectively to Employment, Health and Safety, Education, Research, Employees' Service or "Welfare" Work, and Joint Control.

Virtually, such a personnel department has long existed in several well-known English works. In successive chapters of his account of the Bournville "experiment in welfare work," Mr. Cadbury¹ covers much the same ground as Tead and Metcalf: Selection of Employees, Education of Employees, Provisions for Health and Safety, and Recreation and Social Institutions, i.e. Employees' Service (Welfare Work); while further chapters on Discipline, Organization and Methods of Remuneration correspond to some of

¹ *Experiments in Industrial Organization*. Longmans & Co., London, 1912.

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the functions of Tead and Metcalf's Joint Relations Division.

In discharging its special functions the personnel department tends to make repeated use of statistics. Tead and Metcalf draw special attention to the statistics of labour turnover and absence, while at Bournville figures are given year by year showing the percentage of employees discharged, the percentage of accidents to employees, even the percentage of suggestions from employees that were accepted under the special suggestion scheme. It is in the light of these minutely calculated ratios that control is exercised and successful adjustments are made in the underlying conditions of employment.

THE ADJUSTMENT OF INDUSTRIAL CONDITIONS

The second proposition in the theory of fatigue and unrest is that variations in the human factor are largely caused by variations in industrial conditions under the control of the employer.

As the worker faces his task conditions naturally divide themselves into those confronting him in the task—the working conditions; and those of his own being and his life at home—the worker's personal and living conditions.

Among working conditions great variety prevails in the nature of the operations the worker is required to perform. And even where the purpose of any operation is given, the possible methods to be adopted often show the widest variations. The most varied adjustments may be made in the equipment used, the sequence and timing of motions, the motions themselves, and the posture of the operator; and the various possible adjustments in methods of work will call upon very different physiological and psychological processes within the human organism.

That most of these conditions of the operation itself can be controlled by the management has been abundantly shown by advocates of motion study, among whom Gilbreth is the pioneer. Unnecessary and wasteful motions have been cut out, seats of approved pattern provided, and appliances designed to make the handling of the materials easier.

A second group of working conditions refers to the intensity of work and the hours during which work of any given type is to be performed. The length of the normal day, the working of short time, over-time, night work and Sunday work have all been the battle-ground of reform and readjustment. Intensity of work depends mainly on variations in the speed of work and in the load carried—whether the load is a definite weight or a number of machines to attend to—and here also almost infinite adjustment is possible on the part of the employer. The speed at which any given automatic and semi-automatic machine is run is by no means fixed and immutable, and where the worker himself sets the pace, methods and scales of wage payment can be devised to produce within limits a great variety of speeds. The time study and the payment of bonuses or progressive piece-wages introduced by scientific management have the adjustment of speed to capacity for their very object.

The possibility of varying the load of work in heavy muscular labour is also familiar to scientific management (24). "For a first-class shoveller there is a given shovel load at which he will do his biggest day's work. What is this shovel load? Will a first-class man do more work per day with a shovel load of 5 pounds, 10 pounds, 15 pounds, 20, 25, 30, or 40 pounds?" By experiment Taylor found that "a first-class man would do his biggest day's work with a shovel load of about 21 pounds," and in this and other experiments (e.g. the case of Schmidt's pig-iron handling cited above) Taylor conceives the adjustment of the load to be on exactly the same footing as the hours of work and the speed of work.

A third group of working conditions refers to the physical and social environment in which the work is performed. Where there is a fully developed personnel or labour administration the division of health and safety will here assume responsibility. The possibilities of combination and permutation in the physical environment or hygiene of the establishment are almost infinite, but the factors most important to the human body can conveniently be grouped under five or six heads:

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1. Air : temperature and humidity ; ventilation and room-space ; dust and fumes (exhaust systems) ; smell.
2. Light : volume, concentration, glare.
3. Noise : volume, irregularity, vibration.
4. Accident and fire hazards ; safety devices ; first aid.
5. Sanitation and tidiness ; cleaning and drinking water ; lavatories.
6. Seating and rest rooms.

A good deal of the physical environment depends, of course, on the easily ascertainable fact whether work takes place out of doors or indoors, or possibly underground ; and whether it is performed by day or night.

The social environment is undoubtedly quite as important as the physical, and the possibility of social adjustments by the employer has been popularly demonstrated in the welfare-work movement. All the relations between employer and employee are involved, as well as the relations between employee and employee.

The social relation of employment falls logically into the appointment of the worker for a given job, his training for the job, his subjection to orders about the job, and his remuneration to encourage him to do the job ; and at all these stages the treatment of the employee is capable of almost infinite variation at the hands of the employer. Remuneration, for instance, is not merely a question of the amount and method of payment in money, but can also involve so-called " non-financial " incentives, such as depend on the hope of promotion and the recognition of good service generally, or the fear of discipline and ultimate discharge. Remuneration may also include payments in kind, such as the so-called welfare work or employees' service division provides ; for instance, facilities for dining, recreation and medical treatment on or near the premises.

The relation subsisting between employees may be thought to be more a matter of chance ; but even here the all-important issue of the kind of foreman appointed is largely in the hands of the employer, as is also the " grouping " of the working force. The kind of people who read—and write—books do not always realize the importance of sociability in the life of the less-educated population. A working force divided into small groups may entirely

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lose the thrill of the large but crowded and buzzing work-room.

The characteristics of the worker himself and his living conditions may at first sight appear to be outside the control of the employer. This is emphatically not the case.

In the first place the employer is at liberty to select the type of worker required, and modern practice has parted with the hiring-at-the-gate system. Instead, a special Employment Division is instituted to deal with the selection of new employees (as well as to review the cases of those leaving), and all the resources of industrial physiology and industrial psychology are brought to bear on the consideration of the special aptitudes of the candidates for any vocation. In America the very building and lay-out of the employment department is sometimes elaborately planned for interviewing and physically examining all candidates, and for recording their past history and experience.

Once the worker has been selected for employment his or her working capacity can, secondly, be increased by training or proper supervision. The policies adopted by employers in this matter vary all the way from the "let-them-alone-they'll-soon-pick-it-up" idea, to the most thorough-going schemes under a special Educational Division, for vocational guidance, for training apprentices, or for rehabilitating those crippled in war or by industrial accidents.

On the policy of the employer will depend, thirdly, variations in the efficiency of the human factor as determined by the standard of living. The standard of life of the average working family has been described (Chapter II) as providing only a bare sufficiency of food, clothing and housing. No saving is possible, and few wage-earners have any source of income beside their wages. Two corollaries follow: (1) The adequacy of the worker's standard of living for industrial efficiency is usually measurable in the wage he is paid; (2) Inadequacy of the worker's standard of living is by no means to be dismissed as a thing altogether unavoidable by the management.

The truth of these corollaries is admitted when, as a result of monetary policy, the cost of living fluctuates

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violently. During the rise in prices that occurred between 1914 and 1920 governments saw to it that adequate adjustments were made in rates of wages. In England the Corn Production Act, 1917, empowered District Wages Committees to recommend minimum wages "adequate to provide efficiency"—recommendations which were acted upon by a Central Wage Board; and in all industries repeated additions were made to wages by means of bonuses, sliding scales and so on. In America commissions such as the Shipbuilding Labor Adjustment Board, the Board of Railroad Wages and Working Conditions, the Emergency Construction Wages Commission, and the National War Labor Board, were entrusted similarly with the task of adjusting wages to changes in the cost of living.

Usually these adjustments were designed to reproduce the standard of living prevalent before the war, regardless of whether this had or had not been adequate for efficiency; and the period of a falling cost of living commencing in 1920 has seen the same process of adjustment of wages, but this time downwards.

The burdens imposed on workers in addition to their industrial employment can usually be mitigated to some extent by the employer, and he cannot entirely escape responsibility even here.

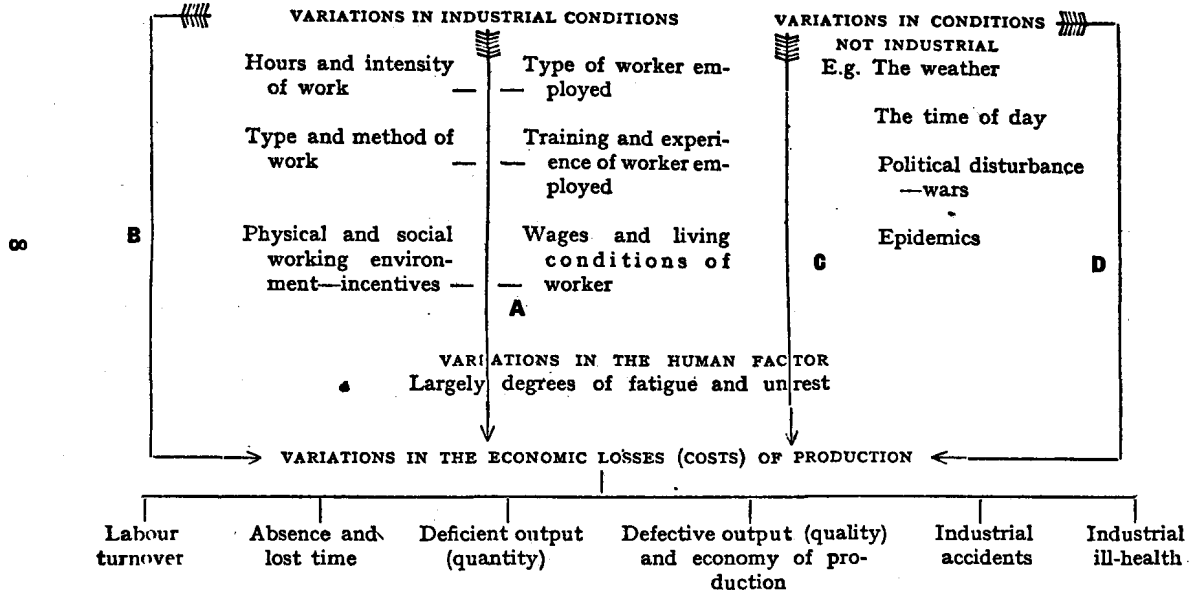
Adjustment in wages may often affect the prolongation of the working day. When women employed in factories are responsible for managing a house as well, additional pay would enable them to hire domestic "help" and to devote more of their energy to their industrial efficiency. Again, to avoid long journeys to and fro between home and factory, employers have often aided in securing houses for their employees nearer to the factory, or else have provided (or urged the existing transit companies to provide) special transit facilities.

THE SCHEME OF INVESTIGATION IN PRACTICE

The relations held to subsist between industrial conditions, the costs of production and the human factor can best be summarized in a diagram

TABLE 3

POSSIBLE RELATIONSHIP BETWEEN COSTS OF PRODUCTION, THE HUMAN FACTOR AND INDUSTRIAL OR NON-INDUSTRIAL CONDITIONS



This diagram may be viewed in perspective with the costs of production considered in the foreground. Looming in the background are the industrial conditions. In the midst of the whole landscape is the human factor, which, according to our two theoretical propositions, is influenced by the background conditions, and influences in its turn the foreground costs. (Line marked "A.")¹ This intermediate human factor is to be neglected at first, and associations or "relationships" are to be traced directly between variations in the foreground costs of production and variations in the controllable industrial conditions represented in the background.

This, in graphic form, is the course to be pursued in Part II. By investigation that combination of workers and working conditions is to be sought which will conduce to minimum turnover, lost time, deficiency and defectiveness of output, and industrial accidents and sickness. It is a scheme which the ordinary business man need not dismiss as utterly fantastic. It includes several types of inquiry that are undoubtedly by this time the stock-in-trade of his favourite trade paper. Their names may, therefore, strike familiarly and pleasantly on his ears: Time and motion study, safety-first work, vocational tests, industrial hygiene, and if not cost-of-living studies, at least the phrase "index numbers." Incidentally, a few titles can be added that will soon invade the business world and come into fashion, if they have not done so already.

Most of these inquiries aim to elucidate the effect on efficiency of varying particular industrial conditions. For example, motion study is the attempt to trace relationships between efficiency (mainly quantity and quality of output) and method of work; and vocational and trade tests constitute an attempt to determine the relationship to efficiency

¹ The background conditions sometimes influence the costs in the foreground directly without passing through the human factor (line marked "B" in the diagram). This implies that the influence cannot be one of fatigue or unrest on the part of the worker. For instance, owing to natural or mechanical forces, a dry physical environment will cause the output in cotton spinning to fall, or increased speed in the operation on a lathe will result in more broken tools and greater wastefulness in output, quite regardless of the human factor. Short circuits like this are foreign to our problem and must be guarded against. Cf. Chapter XII for explanation of lines marked (C) and (D).

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of the (innate) type of worker and his (acquired) experience and training.

The place of these familiar forms of inquiry within the general scheme of investigation can, therefore, best be indicated by placing their more fashionable titles in a parallel column opposite the particular industrial conditions into which they inquire.

Particular Group of Industrial Conditions under Inquiry.	Title of Inquiry.
A. Working Conditions—	
1. Type and Method of Work ..	Motion Study
2. Length and Intensity of Work (Hours, Speed and Load) ..	Fatigue Elimination, Time Study
3. Physical and Social Working En- vironment	Industrial Hygiene, Safety First Work, Social Psycho- logy, Study of Incentives
B. Worker's Condition—	
1. Type of Worker Selected	Tests for Vocational Selec- tion
2. Training and Experience of Worker	Trade Tests and Methods of Vocational Guidance and Training
3. Living Conditions of Worker ..	Change in Cost of Living Studies (Index Numbers), Minimum Wage and Cost of Living Studies

In America phrases have already been invented to include the scheme of investigation in all or most of its ramifications. "Job Analysis" and "Labor Audit" may serve as specimens. In a bulletin published by the Federal Government,¹ the "Labor Audit" is defined as a "reasonably exhaustive and systematic statement and analysis of the facts and forces in an industrial organization which affect the relations between employees and management and between employees and their work."

The studies indicated in these phrases are being carried out by Government departments, by associations and societies of scientists and business men, by special "experts" in "human engineering" setting up business on their own, or by the research divisions of firms engaged in industry in the ordinary way.

¹ Federal Board for Vocational Education, Washington, Bulletin 43.

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Government departments can usually devote more time and money to long investigation than private firms who work for immediate profit. Cost-of-living studies, surveys of hours and wages and hygiene in whole industries, and methodical investigation of the effects of such conditions, tend (in the apparent absence of academic interest) to be a monopoly of research endowed by the State.

This tendency is illustrated in England by the memoranda and reports of the Health of Munition Workers Committee and the reports of the Industrial Fatigue Research Board; and in America by the *Monthly Review* and the Bulletins of the Bureau of Statistics attached to the Department of Labor, and also by the publications of the United States Public Health Service.

Among the societies which have recently grown up, devoted to investigation of the human factor in industry, mention may be made of the American Personnel Research Federation and of the English National Institute of Industrial Psychology of which Dr. C. S. Myers is chairman. The American Federation was founded in 1921 for the "collection and dissemination of information" and for the "stimulation and initiation of research through individuals, organizations, and Governmental agencies." That such investigation is a matter of deeds, not words, is attested by the perusal of a recent Government report¹ which counts 250 organizations as engaged in "personnel research work" in America alone.

The National Institute of Industrial Psychology "undertakes investigations on behalf of industrial and commercial firms," and its work is to include "the encouragement and co-ordination of research work on industrial psychology and physiology throughout the kingdom, and the publication of the facts established by such research in a form which will indicate their practical value."

Investigations by and for private firms are not usually published, but range over a wide field, extending even to studies of changes in the cost of living.²

¹ (8, No. 299) "Personnel Research Agencies. A Guide to Organized Research in Employment Management, Industrial Relations, Training and Working Conditions."

² Some studies of this type have been published, notably the studies conducted at the Holt Manufacturing Company in 1919 (Bulletin of the

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Tead and Metcalf (25), indeed, recommended a permanent Research Division to which personnel problems arising in any of the other divisions of the department could be referred.

THE NEED FOR JOINT CONTROL

In controversies it is customary sooner or later to draw a contrast between theory and practice, and prudence bids the rash enthusiast forestall criticism of this character from the start.

The practical result of any scientific study can only be to point out the consequences that follow any given variation in conditions; the whole question of the desirability of such consequences is left open. Apart from the scientific experts, there must always be some person or body of persons using their judgment as to the consequences to be desired and to question whether the conditions necessary to those consequences are always worth while.

Any positive recommendation of the investigator is likely to meet criticism from several "practical" points of view, among which may be distinguished the viewpoint of Capital, of the technical Management and of Labour.

The purely capitalist attitude is not easily found in print. There is often, however, a good deal said about the danger of "coddling the workers," of "flouting inexorable economic laws"; fatigue is ascribed to being born tired, and unrest to unscrupulous "paid agitators." Drink figures largely, as well as "fatigue from the effort to work slowly." There is obviously a strong undercurrent of *laissez-faire* still flowing; but it is flowing up a backwater. "It is a distinct gain," writes Stanley Kent,¹ "that the study of industrial fatigue must always in future be recognized as an essential factor in a right determination of the conditions of labour, and that never again will the fortunes of tens of thousands of workers hang entirely upon the will of uninstructed and often unsympathetic employers."

Taylor Society, October 1919), and at the Franklin Manufacturing Company in 1918 ("Industrial Management," September 1918). As a result of both studies, wages were substantially advanced.

¹ *Nature*, September 13, 1917.

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The technical expert is suspicious of recommendations coming from psychologists or other investigators not thoroughly conversant with the technical details of the industry; he naturally insists that production must be the primary consideration, and condemns costs that do not involve an equivalent increase in production. The *Engineering Supplement* of *The (London) Times* legitimately pokes fun at an American scheme to cure industrial unrest by attaching to works or groups of works a psychiatrist or "physician of the mind" to impose a standard of "industrial mental hygiene." The list of types under which candidates for psychiatric examination are to be divided runs, verbatim: "Queer guys, eccentrics, disturbers, querulous persons, unreliable and unstable fellows, misfits, the irritable, the sullen, socially disgruntled, unsociable, negative, conscientious, litigious, bear-a-grudge, peculiar, glad-hand, gossipy, roving, restless, malicious, lying, swindling, sex pervert, false accuser, abnormal suggestibility and mental twist types."

"There are doubtless psychic conditions," runs *The Times* comment, "that can be treated and relieved by qualified psychiatrists, and in default of such treatment would go from bad to worse. But a list such as this amounts practically to treating all industry as a vast asylum for the mentally abnormal."

The *Engineering Supplement* of *The Times* has also kept up a running fire of criticism on the publications of the Industrial Fatigue Research Board.¹ These criticisms are reasonable in urging the greater participation of technical experts in the planning of investigations, to ensure that all the complex conditions of the industry are duly considered, and to question how far the costs of readjustments or novelties—such as the mental hygiene scheme—are worth while; but they seem to err in supposing that the technical expert is always willing to come in or that State-directed research should be entirely devoted to increasing immediate cash returns to the employer. It is true that the factor of costs is sometimes lost sight of by the enthusiastic psycho-

¹ *Times Engineering Supplement*, August 1920, February 1921, June 1921, etc.

logist or physiologist, but it is true also that a "long-run" national or communal efficiency does not always march with immediate business profit.

Actually, as things are in most industries to-day, it is only the employers who decide at the end of some more or less scientific investigation how far its conclusions are to be acted upon; and the mere thought of the trouble or risk usually involved in any change too often outbalances the hope of gain to themselves and to their employees.

Where employers do bestir themselves the technical point of view is usually adopted in making readjustments and some form of scientific management is the outcome, with the human factor largely neglected. Here lies the point of the criticism of industrial investigation advanced by Labour. As Mr. Clynes puts it: "The workman does not look with favour upon methods designed scientifically to speed him up in order that, without making him either a more skilled workman or a more contented human being, he should be a more effective producer of marketable goods."

The technical standpoint must enter into the planning and methods of investigation, but it does not need reinforcement when the results and recommendations of the investigation are to be acted upon. Usually the technical standpoint is fairly represented in the decisions of the board of directors, or whoever is the chief executive. The standpoint of labour, on the other hand, is admittedly not so represented and yet—though this is not realized—it is no more to be identified with the standpoint of the independent investigator than is the technical view.

A timely illustration of the ineligibility of the results of a special inquiry, even when this is conducted by thoroughly impartial and well equipped authorities (and not, as so often under scientific management schemes by *ad hoc* "experts" in the pay of the employer), is afforded by a recent controversy as to the means of preventing accidents.

The British Health of Munition Workers Committee, a Governmental body appointed by the Ministry of Munitions, published in 1918 a Memorandum (No. 21) in which the following passage occurs:

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Accidents depend, in the main, on carelessness and lack of attention of the workers, and so the more one can eliminate this lack of attention and increase the concentration of the worker upon his work, the more will accidents be reduced. As has already been pointed out, one wants to induce in all the workers throughout their hours of labour the same mental outlook as is present in the night-shift workers in the early hours of the morning. These workers have for the most part forgotten the pleasures and excitements indulged in shortly before coming on to night shift, and they have nothing but an unexhilarating breakfast and bed to look forward to. Such a mental state is impossible of achievement by the day-shift workers, but something in the way of mental calm and equilibrium can be attained by stopping all conversation except that relating to the work in hand. If the workers would consent to it it would be a good plan to induce temporary deafness by plugging the ears, and so shut out the noise of the machinery, which is in itself an important cause of distraction and fatigue. Again, if it were practicable—though it is seldom that it can be so—it would be of value to shut out the sight of surrounding objects by separating the lathes or other machines from one another by partitions. The worker, left to himself without sounds or sights to distract his attention, could then concentrate himself entirely on the work in hand. It might be said that the monotony would be so great that nobody would stand it, but would it not be better to work for, e.g., two 3- or 3½-hour spells every day under such conditions if the worker could thereby earn as much as he does under present conditions in two 4-hour spells? However, these conditions are mentioned only as an ideal, which should be aimed at whenever possible.

One commentator² observes that the Memorandum “describes a condition of things which at this moment can be found in every gaol where the ‘silent system’ is in vogue, and each prisoner picks oakum in his cell.” It is evident that before such recommendations can be practically adopted many factors have to be weighed besides the one factor of increased concentration on work. A committee where labour was represented would certainly resent these restrictions on personal liberty, and might well consider the increased immunity from accident not worth the price.

What is really wanted is a non-partisan investigation acted upon by a bipartisan board of control. Without this the labour policy of even the most sympathetic employer will appear as paternalism, if not as the merest charity.

² *New Witness*, May 24, 1918.

THE PLAN OF INFORMED JOINT CONTROL

The opinion is widely held that the use of scientific information as to the conditions of human efficiency is less consistent with a thoroughly democratic control of industry than with autocratic "capitalist" rule. It is true that a lamentable preference for closed windows and many other unfashionable practices prevails among the working-class; but in view of the facts brought out in Chapter II it seems probable that participation in control by workers who know "where the shoe pinches" will aid rather than hinder scientific investigation. Indeed, we find Lenin, during his dictatorship of the proletariat phase, actually accepting a part of the scientific management advocated by Taylor.¹

A socialist state can come into existence only as a net of production and consumption communes which keep conscientious accounts of their production and consumption, and economize labour, steadily increasing its productivity and thus making it possible to lower the working day to seven, six or even less hours. . . .

We should immediately introduce piece work and try it out in practice. We should try out every scientific and progressive suggestion of the Taylor system. . . . To learn how to work—this problem the Soviet authority should present to the people in all its comprehensiveness. The last word of capitalism in this respect, the Taylor system—as well as all progressive measures of capitalism—combine the refined cruelty of bourgeois exploitation and a number of most valuable scientific attainments in the analysis of mechanical motions during work, in eliminating superfluous and useless motions, in determining the most correct methods of work, the best systems of accounting and control, etc. The Soviet Republic must adopt valuable scientific and technical advances in this field. The possibility of Socialism will be determined by our success in combining the Soviet rule and the Soviet organization of management with the latest progressive measures of capitalism. We must introduce in Russia the study and the teaching of the Taylor system and its systematic trial and adaptation. . . .

Our aim is to attract every member of the poor classes to practical participation in the management, and the different steps leading towards this end (the more diverse, the better) should be carefully registered, studied, standardized, verified on broader experience and legalized.

¹ *Pravda*, April 26, 1918. Translated in the Bulletin of the Taylor Society, New York, June 1919.

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In countries still capitalistic there are many examples of a joint control of industry by workers and capital owners where the two parties are both well informed and eager to apply their information.

The American clothing trades, largely concentrated in New York, Rochester, Chicago and other large cities in the East and Middle West, are particularly fertile in experiments. There is in New York a Joint Board of Sanitary Control; and even the determination of a fair day's work is not shirked. A trade-union leader, Mr. Sydney Hillman, President of the Amalgamated Clothing Workers of America, was recently interviewed¹ as the chief exponent of the plan of joint control:

In one of our largest factories, in which 3,000 workmen are employed, a system of production standards has been in force for some time. The standards were worked out by committees of workers in consultation and co-operation with the management. It was not an easy task, as there are about 150 operations that had to be standardized. But experimentation and good-will on both sides permitted us to solve the question to the satisfaction of all concerned. We proceeded on the basis of definite principles. We analysed and timed each operation and determined the normal speed. We then set a maximum speed above the normal and a minimum below. We provided for grades between the normal and the maximum, and set special standards of wages for each grade of work as determined by quality and output. All workers were then classified into grades. Each worker who delivered the output of his respective grade is entitled to the corresponding wage. The grading of workers is not done arbitrarily, but on the basis of capacity as proved by the average output of the worker over a long period of time, and is subject to approval by the union and the management.

"Do no differences of opinion arise?"

"Quite frequently," replied Mr. Hillman, "but they are settled as other disagreements are. The necessary machinery is provided by our collective agreement. A case in point which comes to my mind occurred at the factory which I just referred to. A new method of making pockets was introduced. The management analysed the new process and determined that it enabled a normal worker to turn out 100 pockets a day. The workers claimed that they could make only 70. The case was carried to the impartial chairman, who acts as permanent arbitrator in all controversies. Experts were put on the job, time studies were made, the evidence was carefully gone over, and a compromise reached."

¹ Dr. Louis Levine in the *New York World*, July 11, 1920.

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Informed joint control also marks the activities of the National and Works Councils in various English industries,

The National Council of the Pottery Industry in 1920, for instance, invited the assistance of the Industrial Fatigue Research Board to indicate "a means of grading potters' shops (with stoves) in accordance with their relative characteristics as hygienic workshops or the reverse," and a report was issued (4, No. 18) under the supervision of a committee partly composed of representatives of the industry nominated by the Council and partly of members or nominees of the Research Board.

At the Bournville Works of Cadbury Brothers most of the social environment of the worker is controlled jointly by workers' and managers' representatives. There are two welfare and recreation sub-committees of the Works Council for men and women respectively, and also two rules and discipline sub-committees; in addition, there are several discipline tribunals on which workers are represented equally with the management, and these have power to suspend, put on probation, or recommend dismissal.¹

These few examples show how the adjustment of industrial conditions to ensure greater human efficiency need not be carried out solely by the capitalist employer. The method of paying wages, the intensity of work, the methods of work, the physical and social environment of the factory, have all formed subjects of investigation under joint control, and this procedure may well be extended to all the other conditions of employment.

The selection of an employee, for instance, might be determined by physical examination and psychological tests at least partially under the control of his putative fellow-workers. Or the Employment Exchange or even the trade union itself might conduct the necessary examinations and tests and only present duly qualified men.² A great part of the workers' objection to being stripped, "tagged" and classified would certainly be removed in this way.

It is well known that the trade unions' antagonism to

¹ *A Works Council in Being*, Publication Department, Bournville Works.

² Cohen suggests that employment exchanges may ultimately be able to make a complete scientific analysis of the various types of work for which labourers are required. *Insurance against Unemployment*, p. 435.

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dilution of labour arises from their objection to the lowering of standards of skill and workmanship. In the New York silk ribbon industry (11, September 1921) examinations for candidates to enter certain classes of operatives are given by joint committees representing equally the management and the workers in the shop. In this industry the principle is admitted that "the responsibility for the training of new workers" lies equally with the employer and the employees.

Through collective bargaining trade unions are playing an increasing part in deciding the sort of workers to be employed (especially where employees will only work with fellow unionists) and in determining the hours to be worked and the wages to be paid. There is also taking place a devolution of the functions of management into special "matériel" and "personnel" departments. This personnel department is often planned, as in Tead and Metcalf's scheme (25), to contain a "joint control" division and a linking up of expert knowledge and democratic administration is thus foreshadowed.

The next step is to base the collective bargain on the investigations of a jointly controlled research department into the conditions necessary for efficiency—conditions that depend not on this or that particular economic system, but on the fundamental and permanent character of physiological and psychological phenomena.

PART II

CHAPTER V

THE BUSINESS COSTS OF INDUSTRIAL INEFFICIENCY

INEFFICIENCY is measured by lowered production with no equivalent fall in costs, or, conversely, by a rise in cost with no equivalent increase in production. For purposes of argument we may suppose inefficiency to take the latter form ; we shall suppose the volume of production to be given, and concentrate on the fluctuation in cost.

BUSINESS COSTS AND REAL COSTS

In a business enterprise costs may fall on any of the agents of production ; but here we need distinguish only the costs that fall mainly on the business taken as a unit—costs that are usually measurable in terms of money ; and the costs that fall on the human agent alone—sometimes measurable in terms of money, but none the less real when they are not.

Among the immeasurable human costs are sensations of weariness, tiredness and boredom ; the physical suffering and pain from industrial accident, sickness or semi-starvation ; worry over danger of accident, as also over economic insecurity ; and feelings, often present, of ill-will and exasperation. Few human beings like to harbour malice, fewer still perhaps prefer monotonous and uninteresting work to congenial co-operation. If the wage-earner feels he is stigmatized and treated as a " wage slave " with no hope of advancement, if he feels his faculties blunted and all his powers of appreciation balked, just so far he will be demoralized and miss certain pleasurable emotions.

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Whether or not his feeling is justified is beside the point in this connection.

Costs that fall on the human worker and that are measurable in terms of money are the loss of earnings resulting from absence and, where piece wages are paid, from deficient or defective output, and also the loss of earnings resulting from periods of unemployment associated with turnover; and the actual expense incurred in medical and surgical treatment of accidents and sickness.

When the human agent is more or less poverty-stricken, a measurable money cost will fall, not on him, but on the community as a whole. The unemployment "dole," hospitals maintained by public subscription, indoor and outdoor relief of paupers, are all to some extent chargeable to industrial inefficiency. The cost of premature death or permanent disability might also be calculated in terms of working days lost to the nation.

But on the whole we must recognize the impossibility of assessing accurately most of the "real" costs involved in labour turnover, absence, sickness, accidents and fluctuating output. Real cost will not be overlooked, but for knowledge in objective terms reliance must be placed mainly on the analysis of financial losses as they fall on the business unit.

It is here that the *economics* of the question lies. Contrary to the almost universal assumption, economics is not confined to the satisfaction of material wants; but it is confined to the measurement of any and all wants and satisfactions in terms of money or other means of exchange. Human beings are often found willing and able to give something in exchange for learning, for art and the amenities of life, for power, and even for the opportunity of religious exercises. Consequently there is an economics of education, of dramatic production, travel agencies and book-publishing, as well as an economic side to politics, and economics—perhaps even profits—of religion. But there can be no economics without some kind of objective measuring-rod such as modern society provides by money.

And money is not necessarily connected with the employer's profit. The factory or business can be regarded as

a form of organized society, and attention can be concentrated on the losses and gains of the whole unit rather than on the losses of its constituent members. Under the present regime it is true such gain as there is over and above a certain amount goes in the shape of profit to the employer in his capacity as entrepreneur or owner of the capital equipment. But this is not a necessary accompaniment of large-scale industry, and we may measure the efficiency of production by its money gains independently of the ultimate distribution of these gains.

Inefficiency's cost in money will be detailed (Sections A) in each of the chapters devoted successively to turnover, absence, deficient and defective output, accidents and sickness. Yet two elements in these costs common to all labour losses may be pointed out here. These are the expenses of "repair" involved in replacing men or restoring their productivity, and the expense involved in excess charges (mainly overhead) per given product, which will continue until the men are completely replaced or restored.

These two elements of cost—repair and excess charges—bear a peculiar relation to one another. The total cost may be almost entirely composed of one element or almost entirely of the other, or partly of one and partly of the other, but usually the greater the part of one the less will be the part of the other. Total cost includes as a rule a certain proportion of both, but if expenditure is stinted in the repair element, i.e. if there is almost complete neglect, expenses from excess overhead alone may well make a larger total in the end.

For instance, if a large proportion of output is spoiled; and no attempt is made to teach the workers better, the cost of training and supervision will have been saved; but only at the expense of excess charges for materials and labour to make up for the output wasted and of excess overhead charges for the equipment engaged in making defective output. Again, if no record of absence is kept, and no reserves are at hand to repair vacancies, certain direct expenses are saved, but there will be much greater overhead loss from idle equipment. If no hospital is set up to render first-aid during working hours, so much repair

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expense is saved ; but what of the diminished productivity of the injured and ailing and those contracting septic infection ?

Many overhead charges are constant, whatever the amount of the product, so that the less produced the higher is the burden of overhead expense relatively to the product.

OVERHEAD COSTS ANALYSED

This brings us to a closer examination of the term "overhead expense" which figures so prominently in industrial accounting. Overhead is generally used to cover all operating expenses except those of direct labour and the raw materials converted into the product. In the production of any article the cost of the labour time actually spent on it and the cost of the material used up in it are easily ascertained ; but the remaining expenses—the wear and tear of machines, the foreman's time in supervision, etc.—are not easily distributed in the right proportion between each of the different articles produced.

It is the usual practice to assume that these overhead expenses form, for all articles, the same fixed percentage of the direct expense of labour and material, and invariably to add this percentage to the direct cost in arriving at the total cost. Overhead, in short, is a convenient term to cover all expenses not directly chargeable to the product.

Modern scientific practice, however, has moved beyond such rough, if convenient, estimates. The different items in the overhead have been analysed to show the exact amount each contributes to the total cost of making any single article.

For our particular purpose the important distinction lies between those expenses (1) that continue constant whatever the production, so that lessened production involves an excess in the overhead charges ; those expenses (2) which can be modified in the long run by reorganization such as changing the scheduled hours of work ; and the expenses (3) which vary proportionately to variations in production and are automatically less when production is less.

These distinctions have proved important in many other branches of economic activity. Of the expenses of main-

taining a railway plant, for instance, some are due to the wear and tear from the traffic and vary proportionately to the amount of traffic ; others, like the repair of stations and buildings, are mainly the result of exposure to wind and weather, and have little or no relation to the traffic borne.

TABLE 4
OVERHEAD COSTS

I. FACTORY OR ESTABLISHMENT EXPENSES.

(Charges kept within the organization.)

1. *Tools and Supplies (Lubricants, Fuel, etc.) Consumed in Work.*
 "Expense Materials."
 (a) For heating, lighting, ventilating plant M
 (b) For keeping machinery "in condition" whether idle or not M
 (c) For stores, transport (conveyors, etc.).. .. M or B
 (d) For driving the machine-shafting M
 (e) For the actual work of the machines (i.e. consumption of tools) B
2. *The Plant.*
 (a) The land or "Site" C
 (b) Buildings, machines and equipment :
 Wear and tear* (depreciation)—
 Due to work [1 (e) above] B
 Due to exposure C
 Obsolescence † C
3. *Labour of Supervision and Service.*
 (a) Salaries of foreman, office staff and executives paid by week or longer periods C or M
 (b) Wages of indirect labour, firemen, watchmen, police, utility men, etc., paid by hour or day .. M

II. FINANCIAL, BUSINESS OR CAPITAL EXPENSES.

(Charges in the form of annual obligations to outside interests.)

1. Interest on loans (bonds, notes, debentures, etc.) .. C
2. Taxes, local rates, etc. C
3. Insurance premiums (fire, etc.) C
4. Compensation for accident where insured outside .. M or C
5. "Rents" where land, machines, power, etc., are hired at a fixed sum from outside interests C

* This may appear either immediately as upkeep (maintenance) and repairs, or may be averaged over the year in the Depreciation Account.

† This is usually included in the Depreciation Account.

In Table 4, which gives a systematic list of overhead costs, costs under head (1) are marked C for Constant under all conditions of plant operation ; these costs are analogous to the expenses of mere exposure. Costs under head (2) are marked M for Modifiable by changes in organization, scheduled hours, etc. Costs under head (3) are

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marked B; their growth is Balanced by greater production, just as greater wear and tear of plant is balanced by higher traffic returns. Conversely, where production falls because a full labour force either is not hired, present, or producing to capacity, the expenses marked B will be remitted in proportion.

The characterization of B, M and C given in the table is not by any means final. For instance, it has been observed that an increase in the number of hours worked probably has a strong influence in increasing the number of accidents per hour. If this be so, an increase in the amount paid in accident compensation does not necessarily imply a balancing by increased production; it may have been due to increase in hours regardless of production.

Again, in the case of the cost of lighting, the reduction in expense may be more than strictly in proportion to the reduction in hours, since in winter at any rate the hours dropped would presumably be those requiring full lighting.

THE IMPORTANCE OF OVERHEAD COSTS

Before the relative efficiency of any industrial policy can be estimated it is necessary to know the proportion that overhead expenses bear to the direct expenses of labour and raw material, and also the relative importance of each of the items within the overhead cost. It is obvious that a manufacturer does not spend as much on fuel for lighting his factory as he does on the wages for the direct work on his materials. But the exact percentage contributed by each item to the total factory cost varies enormously for different industries, and unfortunately no research has been undertaken on the subject.

Thanks to the devotion of Economics to pure theory and the secrecy business men insist on when costs—and profits—are in question, it is at present impossible to tell in any single industry, in any single factory, or in the production of any single article, what proportion of the total cost is constant, what proportion balances and offsets labour losses, and what proportion is modifiable. All we can do is to quote the opinions of business men.

For purposes of argument, manufacturers¹ often take the balancing items in the overhead cost (B) as about equal in value to the constant items (C). More exact figures that I was able to obtain in a highly organized English engineering plant bear this out. Here the overhead expense fell into four shares equal in amount. One share was due to consumption of tools—a “balancing” cost; another share was due to general office expense—a constant cost; a third share was due to general works service, inspection and departmental supervision—mainly constant costs; and a fourth share to depreciation and repairs of equipment, power, etc.—again mainly “balancing” costs. If the modifiable items (M) are considered as half constant, and half balancing any fall in production, then half the total overhead remained in this factory a constant burden, however much labour losses might reduce production.

But how does the total of overhead items compare in cost with, say, the direct labour cost, i.e. the wages paid to the direct producers? There exists only the scantiest information to answer even such a broad question as this.

For this information, such as it is, we have mainly to thank Governmental investigations, particularly those of the U.S. Federal Trade Commission. The fragments vouchsafed are given in Table 5; in most cases the overhead that is quoted does not include financial expenses (Group II, Table 4), such as interest and taxes.

The evidence shows clearly enough that the relation of overhead cost to direct labour cost is extremely variable for different industries. It is as low as 20 per cent. in coal-mining, where comparatively little mechanical equipment can be used, and as high as 160 per cent. in such industries as canning, where mechanization has gone far.

Excluding mining, and concentrating on manufacturing industry, it is obviously within the limits of truth to take overhead factory expenses (Group I) as being almost equal to direct labour cost, certainly 80 per cent. to 100 per cent. of it. Canning and tanning have an overhead ratio above this, pottery and shoe-making below; while the two

¹ See, for instance, Mr. J. M. Williams' assumption, p. 143 below; also those of Mr. Alexander, p. 139, and Lord Leverhulme, p. 215.

TABLE 5
THE RELATIVE BURDEN OF OVERHEAD EXPENSES IN AMERICAN INDUSTRIES

Industry.	Time.	Units of Output.	Cost per Unit.		Percentage Overhead to Labour.	Reference.
			Direct Labour.	Overhead.		
<i>Tanning.</i>						
"Company 1," upper leather	1917	Square feet	\$ 0.030	\$ 0.034	113.3	Federal Trade Commission Report (a)
<i>Coal Mining.</i>						
S.W. Pennsylvania	1918	Per \$ of retail price	0.17	0.04	23.5	Summarized from Report Federal Trade Commission (b)
Central Pennsylvania	1918		0.22	0.04	18.2	
<i>Canning.</i>						
Average of canneries packing over 50 per cent. total production of country	1917	Case of 48 lb. cans	0.705	1.148	163.0	Summarized from Report Federal Trade Commission (b)
<i>Textiles.</i>						
Blue denim cloth	1919	100 Yards	4.70	4.20	89.3	Summarized (b)
Grey sheeting	1919	100 Yards	2.07	1.85	89.3	Summarized (b)
<i>Shoe Manufacturing.</i>						
(Random selection by Federal Trade Commission)						
Men's shoes (8 kinds)	1917	Per pair	0.551	0.271	49.2	Federal Trade Commission Report (a)
Women's shoes (5 kinds)	1917	Per pair	0.677	0.439	64.9	
Children's shoes (6 kinds)	1917	Per pair	0.244	0.135	55.3	

(a) Cost Reports; Report on Leather and Shoe Industries, Washington, 1919.

(b) W. J. Lauck, Bureau of Applied Economics, Washington, 1920.

instances of textiles quoted in the table are well within the estimate.

The "financial" overhead charges (Group II) are all constant. When these are added, the assumption that overhead expenses exactly equal direct labour cost will be near enough the truth at any rate in discussing manufacturing industry.

The examples in the table are all drawn from America ; but English industries with the same degree of organization will probably show similarly variable results. In the English engineering works cited above, direct labour cost accounted for 27·5 per cent. of the conversion cost, i.e. of the total cost of production minus cost of raw materials. This would make overhead $\frac{72\cdot5}{27\cdot5}$, or 263 per cent. of direct labour cost, and this high overhead is in conformity with the experience of similarly organized American machine shops. On the other hand, in the British iron and steel industry, the ratio of fixed charges and repairs to wages is often quoted as about 60 per cent.

If, to strike a rough average, the total overhead cost is taken as equal to the direct labour cost, and if the variable part of the overhead charges that balances any fall in production is accepted as equal to the fixed part that is constant however severe the fall in production, it follows that these constant costs are equal to half the direct labour cost.

THE INDUSTRIAL BALANCE SHEET

For every increase in the turnover, absence, accident and sickness rate, and for every fall in quantity and quality of output, a financial expense is incurred either through the cost of repairing the loss or through the constant overhead cost that will accrue if the loss is neglected. A third policy, not always distinguishable from repair, is that of preventing the occurrence of loss, i.e. the policy of modifying or adjusting the original industrial conditions that are found to underlie the several labour losses. In choosing between these three policies, neglect, repair or prevention, the wise employer will

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use his expenses as a signpost and institute a sort of actuarial control.

Against the direct and initially heavy expenses of prevention or repair, he will balance the excess overhead cost per unit of product resulting from neglect. If the cost of prevention or repair seems to him too high, he should look upon it as an investment and consider the recurrent costs that the prevention or repair will be saving.

A policy of repair or prevention may, of course, be carried too far and a point reached when the direct expenses involved outbalance the saving in the constant overhead cost per unit of output. This suggests the existence of an economic minimum which is implicit in every type of labour loss, a loss which the employer cannot, economically speaking, avoid.

In each of the chapters (VI to XI) devoted to the several labour losses, the procedure will be systematic and uniform.

In Section A the cost of each unit of loss will be analysed.

In Section B the average loss experienced in various English and American industries will be recounted so far as the figures are available.

In Section C an estimate will be made as to what part of this experience can be considered a minimum economically unavoidable.

In Section D the statistical evidence will be reviewed as to how variations in industrial conditions affect excess losses, i.e. those over and above the unavoidable minimum. This reveals how much of the loss could have been avoided by adjustment of specific conditions and indicates the precise form that repair or prevention should take.

CHAPTER VI

THE LOSS BY LABOUR TURNOVER

LABOUR TURNOVER, alternatively called Labour Maintenance, Labour Recruitment or Labour Wastage, is the fluctuation in the personnel of an organization. It is measured, for any given year, by the number of persons hired to replace persons leaving the working force, taken in relation to the total number employed on the average. Thus, if four hundred persons were hired during the year to replace persons who were leaving or had left a factory employing five hundred on the average in a given year, the turnover rate would be said to be 80 per cent.

This method of calculating the turnover rate from the replacements is not the only plan. Many prefer to calculate turnover from the total number of persons leaving, regardless of whether they were replaced. The results of the two methods do not differ greatly unless the total working force is being much increased or diminished, as may happen in times of a boom or a slump in business.

Where the working force is being reduced those who are discharged merely on account of the general business policy, and not replaced, are said to be laid off; and the method recommended is, therefore, equivalent to counting all those leaving, minus those laid off. For the detailed steps in recording turnover reference must be made to Part III, Chapter XIII.

A—THE COST OF TURNOVER

One of the earliest business estimates of the loss suffered through labour turnover, which may still claim to be one of the most thorough, is that made by Mr. Magnus Alexander

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in 1912. Economic conditions in that year were, after all, about as normal as they have ever been since, and no apology is needed for going into this estimate in some detail.

A General Analysis

Mr. Alexander investigated twelve engineering and metal-working factories, representative in size and character, and situated in different parts of America, in which some 40,000 men and women were employed. He subdivided the employees under investigation into five groups, and studied the requirements of each group as to the quantity and quality of instruction needed by new employees, and the effect of the work of new employees upon the economical conduct of the business as a whole.

Into *Group A* he put highly skilled mechanics who must have practised their trade for a number of years in order to have attained the required degree of all-round experience and proficiency; into *Group B* mechanics of lesser skill and experience occupied in work where an average degree of proficiency could be acquired within a year or two; into *Group C* the large number of operatives usually known as piece workers, occupied in work where, without any previous skill or experience, fair efficiency could be attained within a few months; *Group D* included all unskilled directly and indirectly productive labourers who could readily be replaced in the course of a few days; and *Group E* comprised the clerical force in the shops and offices.

Mr. Alexander then analysed the factors which contribute mainly to the cost of hiring and training new employees (8, No. 227, pp. 13-27):

- (a) Clerical work in connection with the hiring process.
- (b) Instruction of new employees by foreman and assistants.
- (c) Increased wear and tear of machinery and tools.
- (d) Reduced rate of production during early period of employment.
- (e) Increased amount of spoiled work by new employees.

The hiring expense applies to all groups of labor to about the same extent. It consists of interviewing applicants, taking their records, making out their engagement cards and other necessary papers, and placing their names on the payroll books; sometimes also advertising and travelling expenses will have to be incurred. . . .

The instruction expense, on the other hand, will vary largely

according to the experience and skill of the new employee and the nature of his work. It will be lowest for Group D and highest for Group C employees, for the latter must be instructed most and watched longest. The expense for Group B employees will be nearly as large as that for Group C employees, not because they need as prolonged supervision, but because higher-priced foremen will have to give the instruction. . . .

The value of increased wear and tear of machinery and tools by new employees is difficult to estimate. It will be little, if anything, for Groups D and E employees . . . while it may reach thousands of dollars for damage to expensive machinery used by Groups A, B, and C employees. . . .

The loss due to reduced production is entirely dependent upon the value of the article produced and the experience and skill of the employee required for its production. It will be lowest for Group D employees. It can be estimated with approximate correctness for other employees by considering their average wages and the average loss of productivity during their initial period of employment. . . .

The expense due to spoiled work will similarly vary with the value of the raw material worked upon and the labor expended in such work . . . practically nothing may be lost by Groups D and E employees. . . .

These cost items must be reduced materially when they are applied to re-hired employees. The cost of training old employees will, of course, be smallest when these employees are put back on the same, or on similar work to that on which they were engaged before they left employment in the same factory. Many re-hired employees, however, are put on entirely new work, and their training will therefore involve an expenditure which will more or less approximate that needed for the training of entirely new employees.

The relation of overhead charges to the wage bill is also an important variable, particularly in assessing the loss due to reduced production. Mr. Alexander estimates these overhead charges as 100 per cent. of the wages of Groups A and B, 75 per cent. of Groups C and D, and 40 per cent. of Group E.

As a result of these calculations Mr. Alexander arrived at the Table of Costs given on page 140.

From Mr. Alexander's figures it is not difficult to arrive at the average cost per case of turnover for the factories he has investigated as a whole. Since the five groups by no means contain an equal number of employees this average must be a weighted average, i.e. due weight must be given to the relative numbers "turning over" in each group of

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employees (A, B, C, D or E). The proportion re-hired must also be taken into account.

Though he does not give the actual numbers involved in turnover as defined above, Mr. Alexander does tell us that the number of new engagements during the period was 3,393 in Group A, 4,583 in Group B, 10,512 in Group C, 10,426 in Group D, and 2,077 in Group E; and that the number re-hired was in each group respectively 1,268, 1,713, 3,928, 3,895 and 776. From this it is clear that the cost of turnover in Groups C and D should have a much greater influence or "weight" in forming the average, than the cost of turnover in other groups.

TABLE 6
ANALYSIS OF COSTS OF LABOUR TURNOVER

Group.	New Employees.						Re-hired Em- ployees.
	Hiring.	Instruc- tion.	Wear and Tear.*	Reduced Produc- tion.*	Spoiled Work.	Total Cost.	Total Cost.
(a) Apprenticed	\$ 0.50	\$ 7.50	\$ 10.00	\$ 20.00	\$ 10.00	\$ 48.00	\$ 10.00
(b) Skilled ..	0.50	15.00	10.00	18.00	15.00	58.50	20.00
(c) Semi-skilled	0.50	20.00	10.00	33.00	10.00	73.50	35.00
(d) Unskilled ..	0.50	2.00	1.00	5.00	—	8.50	5.00
(e) Clerical ..	0.50	7.50	1.00	20.00	—	29.00	10.00

* The figures are those quoted by Slichter (23, p. 131) from Alexander's original paper on "Hiring and Firing," given before the National Machine Tool Builders' Association. Slightly different costs—usually higher—appear in these two columns in subsequent papers. Cf. 8, No. 227.

The final average cost for a typical case arrived at by accurate weighting and with allowance for re-hiring is \$36.04. Thirty-six dollars in 1912 may be considered as equivalent in 1923 to about \$56, of which the equivalent English value is from £6 to £12.¹

¹ Between 1915 and 1920 the wages and materials of which turnover cost consists rose considerably in terms of dollars, and fell between 1920 and 1921. The net rise between 1913 and 1923 is measurable in index numbers, and amounted in May 1923 to 56 per cent. for wholesale prices,

These calculations are given to illustrate the method of computation and to show the relative importance of the several items in the turnover costs, and too much reliance should not be placed on the final figures arrived at. They are useful merely as supplying some idea of the order of magnitude of the turnover cost.

Other estimates recently made in England are of the same order. Professor Collis prefers to err on the safe side, and puts the cost to the employer at £2 10s., adding another £2 10s. as the cost to the employee. Dr. G. N. Miles,¹ Secretary of the National Institute for Industrial Psychology, considers that,

each worker may cost a firm from £2 to £50 to train, and the period of training, even in the simplest occupation, before a worker reaches full output, is as much as three months. This turnover, therefore, means that throughout the year places are occupied by persons who are considerably under average skill. The loss of potential output from this cause is tremendous, and if you will add to this the cost of spoilt work, which often represents not only the loss of the faulty worker's time but the time of all those who have brought the material to the state at which the incompetent is spoiling it, you will see that we are every year from this cause alone throwing away vast amounts of time and effort which could be much better utilized.

A modification of these figures must be made to allow for the fact that every case of turnover was not that of a fully experienced employee. From the tables given below (14 and 15), showing the greater liability to turnover of "green" hands, it is clear that many men who leave do so before they have learnt their job, and the full expense of replacement is, therefore, not incurred. Unfortunately, and probably about the same for wages. In 1923, therefore, the average cost of turnover in America would be 156 per cent. of \$36 or \$56.

Translation into English currency is complicated by the fact that English wages never had the same gold value as American wages. Even if we neglect the fluctuation of the exchanges, translation therefore cannot be made on the basis of the mint par of roughly 4s. to the dollar. Judging from the Board of Trades' report on Living Conditions in England and America, the gold value of English wages seems to have been in 1913 roughly about half that of American wages (i.e. \$1 translated 2s.). Thus in 1913 a cost of \$36 in wages and materials would be equivalent to something between 72s. and 144s., £5 8s. being about the mid-point. Between 1912 and June 1923 English wholesale prices and wages rose between 50 per cent. and 75 per cent., so that the cost in 1923 would seem to range from £5 8s. (72s. × 150 per cent.) to £12 12s. (144s. × 175 per cent.) with a mid-point just at £9.

¹ *Westminster Gazette*, January 10, 1923.

information as to the proportion of full cost incurred on the average at each replacement is not available; for the present we must use the full cost figure with the caution that it is undoubtedly subject to a sort of rebate for the turnover of men not fully broken in.

The expensiveness of green hands is much greater in the first and greenest days of employment than later on; expenses, in fact, follow a steep curve downward. This rebate, therefore, will not amount to a large sum unless there is a high proportion of semi-skilled men leaving, say, within a week of being hired, and of skilled men leaving, say, within a month.

The Factor of Reduced Production

An element in the costs which requires further illustration is that of the "loss due to reduced production." In Chapter V it was pointed out that all costs could be analysed either as costs of repair and replacement or as excess costs, mainly in overhead. The expense of hiring and instructing the new employee to take the place of an employee who has left is clearly a cost of replacement, but the expense of reduced production while this new employee is learning the job is mainly one of excess overhead. This element in cost is indirect and all too often unobserved by the employer.

Yet it clear that, although his output is lower, the newcomer must be provided with the same amount of heating, lighting and ventilation as the experienced worker; his machinery requires the same care; his machine has its power transmitted over the shafting with the same loss in friction, regardless of the amount of his output. And all the time exposure and obsolescence and the general organization of executives, foremen, watchmen and utility men continue unchanged, and so do the financial charges—interest, taxes and insurance, and the rent of the land.

A business-like account of the way excess charges occur through labour turnover is given by Mr. John N. Williams of the Fayette R.Plumb Inc.¹ The case Mr. Williams takes

¹ "An actual account of what we have done to reduce our Labour Turnover." *Annals of the American Academy of Political Science*, Philadelphia, May 1917.

as an illustration is "a position that is only semi-skilled, in fact such a position that with average intelligence a man becomes an effective worker in twelve weeks." This type of work would probably come under Group C in Mr. Alexander's classification. In the particular department Mr. Williams deals with,

the overhead expense is 130 per cent, or for every dollar we pay in actual productive labor we pay \$1.30 for unproductive expense, such as foremen's wages, instructors' wages, inspectors' wages, power, heat and light, repairs to machinery and fixtures (belts, shafting, benches, frames, etc.), oils, grease and kindred items, and expense materials that have no connection with the actual material in the tools, such as emery, grindstone, files, hand tools, etc.

This brings into the question the loss to any employer that is not realized because it does not appear in the pay envelope, but is hidden in the cost of doing business and is assumed to be a necessary evil in the expense of conducting such a business.

This is hard to express in terms of dollars and cents, but from our records I believe I have found a way to make it clear. In this department a skilled employee makes \$24 per week and (on the basis of unproductive factory expense of 130 per cent) it costs \$31.20 additional expense for his production. Our records show that a new man will have an average earning power of only \$10 per week over a period of the first six weeks. For each skilled man who turns out \$24 worth of productive work per week we have an overhead expense of \$31.20 in this department. Now for this \$31.20 we secure from a skilled worker a certain number of pieces of productive work represented by his earnings of \$24 per week. From a new man the average for six weeks is less than one-half the work turned out by a skilled worker, as shown by his average earnings of \$10 per week.

It is not fair to say that this man turning out only \$10 of productive labor will cost us as much in unproductive factory expense as the man who turns out \$24 of productive labor, but there are certain charges that must be assumed that can properly be figured on the basis of a man charge, rather than a charge to a unit of production.

The only credit the new man would have would be in expense materials, that is, materials such as emery grindstones and kindred items, where the greater the production the greater the consumption of such expense materials should be.¹ This is based on the assumption that the learner will not use more of such expense materials in proportion than the experienced man, although it is a well-known fact that this is not correct. A learner always uses more expense material per unit of production than an experienced man.²

¹ Items marked B in Table 4, particularly Group I, 1 (e).

² This additional cost of the learner would presumably be assessed by Mr. Alexander under the heading "Wear and tear of machinery and tools."

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In this department the factory expense materials are 50 per cent of the total factory expense charges and in our figures we are going to disregard any excess charge for the extra amount of materials used by the inexperienced men. This, however, leaves us with 50 per cent of the unproductive expense of \$31.20 which we pay for the \$24-production of the experienced man, or \$15.60 which we must charge to the \$10-production of the new men. This charge of \$15.60 covers only such expenses as foremen, instructors' and inspectors' wages, power, heat and light, repairs of all kinds, etc., or such expenses as must be assumed by the man unit no matter what his production is. In other words, it costs as much in such expenses for the \$10-production as it does for the \$24-production.

On the basis of an expense of \$15.60 for a \$10-production the percentage is 156 per cent instead of the 130 per cent we pay for the \$24-production or a net excess cost to us of 26 per cent or \$2.60 per week, or for six weeks an excess of \$15.60. During the following six weeks, which complete the twelve weeks we figure are necessary to produce an experienced man, this excess cost becomes less due to increased production, but if we cut it in half it is six weeks at \$1.30 or a total of \$7.80.

For the twelve weeks, therefore, the overhead cost alone of reduced productivity would be, on Mr. Williams' estimate, \$15.60 + \$7.80 equal to \$23.40. Even then he has, in our opinion, omitted an important item. He says: "The only credit the new man would have would be in expense materials . . . where the greater the production the greater the consumption of such expense materials should be." This is correct, and since the new man's production in the first six weeks is only $\frac{10}{24}$ that of an experienced man, he may be credited accordingly with $\frac{14}{24}$ of the expense materials—exactly proportional to his lower production. But Mr. Williams credits him with the *entire* cost of expense materials: he makes no charge for the $\frac{10}{24}$ part of an experienced man's consumption which the new man is said to consume. This is surely a grave omission, amounting to $\frac{10}{24} \times \$15.60$, i.e. \$6.50 on the first six weeks' production, and following Mr. Williams' own estimate of increased production to *at least* as much on the last six weeks' production. Our own calculation on the basis of his figures would therefore make the excess overhead charge for diminished productivity as much as \$23.40 + \$6.50 \times 12, i.e. \$101.40 per case of turnover.

In addition to this there is also the direct cost of maintaining the learner in the first six weeks before he is able to make enough at piece rates to support himself. Thus, for the type of worker Mr. Williams is considering, \$42 was paid out in time wages to make up deficiencies in the piece wages ; yet at the same time in return for this \$42 there were no "pieces" produced. It is a direct dead loss to the firm.

The total cost in reduced production alone due to this single case of turnover thus appears to be \$101.40 plus \$42, equals \$143.40. This is a considerably higher sum than the \$33 estimated by Mr. Alexander for the same group of employees. Mr. Alexander, to be sure, wrote in 1913 when wages and prices generally were lower than in 1917, but apart from this he counted on a 75 per cent. overhead for this semi-skilled group instead of 130 per cent., and he does not seem to have made a very liberal allowance for time-wages maintenance while learning. There is also great uncertainty as to the period necessary for the achievement of full efficiency. I found this period surprisingly protracted in a few isolated operations (18, pp. 132-4), and a systematic study of the learning curve is clearly called for in the interest of accurate industrial accounting.

A Summary of Costs

The elements in the business cost of a representative unit of turnover may, in conclusion, be grouped as follows :

A. Direct costs :

1. The small expenses of the hiring procedure—largely clerical.
2. The expenses of training the newly hired worker up to the level of the worker replaced.

B. Overhead costs during replacement.

These are due to the failure, at first, of the newly hired worker to reach the level of the worker replaced, and the need of paying wages merely to maintain him. This "lag" in production may be felt in

- i. The quantity of output.
- ii. The quality of output, and spoiled work.
- iii. The economy of production—wear and tear ; and to some extent, increased accidents.

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C. Overhead costs before replacement has been started.

Hitherto we have supposed the vacancy caused by turnover to be immediately refilled. If, however, this is not the case and the position remains vacant through failure to find a substitute, this "lag in replacement" involves expenses actually similar to those of absence. These are analysed in Chapter VII.

The cost to the worker must not be overlooked. Corresponding to the B Group of business costs there are the lower wages received by the newcomer while learning to replace the former employee. Maintenance wages are, of course, not so high as "earned" wages. Corresponding to the C Group of business costs there is the complete loss of wages in the period of unemployment between jobs. If, however, as often happens, the worker does not leave one "berth" until he has found another, unemployment will not occur. Finally, corresponding to Group A of business costs, there may be expenses connected with the actual process of securing work. Where, as in England, there are free Labour Exchanges these expenses are largely eliminated.

B—THE AVERAGE LOSS BY TURNOVER

The total turnover as distributed between "lay-offs," "discharges" and "quits," the actual experience in turnover rates in America and England, and the probable total cost of this experience in relation to the total wages bill, have now to be examined.

An employee is "laid off" when he leaves at the request of the employer for business reasons; he is "discharged" when he leaves at the request of the employer owing to his personal conduct—either his physical incapacity or his failure "morally." When lay-offs and discharges are excluded there remain the employees who leave voluntarily at their own request, or, more frequently, without giving any notice. We shall refer to these cases in American workshop slang as "quits."

We have advised that the numbers laid off for business reasons be subtracted from the total number of employees leaving; but in recounting the general experience we must use the figures available which all too often include the

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lay-offs. Wherever the information is supplied the proportion formed by lay-offs will be indicated, though it is only on rare occasions that lay-offs amount to anything more than a small minority of the cases. The proportion of employees discharged will also be indicated when possible.

American Experience

The most important source of information as to actual rates of turnover experienced in America are the studies undertaken by the U.S. Department of Labor,¹ extending over the years 1910-19. The number of establishments studied each year and the average turnover found in these establishments are given in Table 7; particularly intensive investigations were made in 1913-14 and 1917-18, and their general results are quoted as a separate item.

Since results are likely to be influenced by the state of

TABLE 7
RATE AND MANNER OF TURNOVER IN AMERICA IN SUCCESSIVE YEARS

Year.	Number of Establishments Studied.	Average Percentage of Total Hired to Number at Work.	Total Leaving. Percentage of Number at Work.	Manner of Leaving. Percentage of Total Leaving.			Index of Physical Production. †
				Discharged.	Laid-off.	Quitting.	
1910	16	105	102*	15	3	82	166
1911	24	87*	87	19	10	71	158
1912	54	111	96*	20	6	74	181
1913	113	135	135	17	7	76	187
1913-14	84	93*	99	—	—	—	171-187
1914	162	81*	87	20	31	49	171
1915	51	78	63*	16	20	63	187
1916	20	138	108*	—	—	—	219
1917	27	138	129*	—	—	—	215
1917-18	176	207	201*	14	8	79	214-215
1918	29	174	150*	—	—	—	214
1919	19	90	84*	—	—	—	195

† Professor E. E. Day, Quarterly of the American Statistical Association, March 1921. The production in 1899 is taken as 100.

* The true turnover or replacement rate. The lesser of the two, hired or leaving.

¹ Summarized in article on "Mobility of Labor in American Industry," by Paul F. Brissenden and Emil Frankel (11, June 1920), and somewhat expanded by the same authors in their book *Labor Turnover in Industry*, New York 1922.

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trade, we have added to this table the index number of physical production worked out by Professor Day of Harvard University, and also the proportion of the number hired to the average working force. Strictly, the true turnover can only be found by subtracting the lay-offs from the total leaving ; or else by comparing the total number leaving with the total number newly hired, and taking the lesser of these two numbers.¹ In the table this chosen number for each year has an asterisk placed against it.

Roughly, it may be said that heavy production as shown by the index number is accompanied by a high turnover. But when there are two years of heavy production in succession, the turnover seems to be high in the second year rather than the first ; for instance, in 1913 rather than 1912. Similarly, when two years of light production have succeeded one another, turnover is lower in the second year rather than the first, i.e. in 1911 rather than 1910. The year 1915 forms an exception, since the turnover is low and the production relatively high. It was a year in which American industry slumped at first owing to the disorganization resulting from the European War, but revived suddenly in the second half owing to orders for munitions placed by such belligerents as possessed the freedom of the seas. An average index number for that year is therefore somewhat misleading.

Within each year there is evidence for suspecting a seasonal fluctuation in the turnover. At any rate, monthly figures reported by a considerable proportion of the plants surveyed in 1910 to 1919, enabled the Department of Labor to construct a table showing turnover 20 per cent. above average in March, April and May ; 8 per cent. above average in June, July and August ; 15 per cent. below average in September, October and November ; and 13 per cent. below average in December, January and February.

The investigation conducted by the Labor Department

¹ As a rule the U.S. Department of Labor uses the total number leaving in calculating its turnover rates. With the violent fluctuations in business and in the numbers employed, occurring between 1919 and 1921, it became evident that those laid off for business reasons must be eliminated from this total ; and the plan gradually recommended itself of taking either the number leaving or the number hired according to which was the lesser—that is, of subtracting the number leaving who were not replaced by hiring

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in 1917-18 covered so wide a field that more detailed results may be given for different localities and different industries.

The results of these investigations originally appeared locality by locality.¹ They are summarized in Table 8.

TABLE 8
RATE AND MANNER OF TURNOVER IN DIFFERENT AMERICAN CITIES. ONE
YEAR, JUNE 1, 1917 TO JUNE 1, 1918

City or Place.	Number of Plants in each Type of Industry.(a)	Average Percentage of Total Leaving to Number at Work.	Manner of Leaving.(b) Percentage of Total Leaving.			
			L.	S.	D.	Q.
Cincinnati ..	26 F 2 P	166	0	7	12	81
Detroit ..	37 F 5 T	272	7	9	11	73
Cleveland ..	34 F 3 P	217	5	5	9	81
Chicago ..	18 F 4 H 3 P	184	10	5	22	63
Milwaukee ..	20 F 1 P	192 (c)	2	6	8	83
San Francisco (d)	8 F 2 St 1 M 3 P	236	23	6	7	64
Average ..	27.8, All types	211	7.8	6.3	11.5	74.2

(a) F = factory or manufacture, P = public utility, T = telephone department, H = mail order house, M = mine, St = store.

(b) L = laid off, S = left for military service, D = discharged, Q = quit (left of own accord).

(c) Monthly rate multiplied by 12.

(d) Includes whole San Francisco Bay Region.

The average percentage of turnover is obtained by taking the percentage in that establishment having the median rate—that is to say, the rate which would come in the middle of a list formed by arranging rates in order of their amount. The percentages of turnover due to lay-offs, discharges and quits are averaged in the ordinary way, i.e. the arithmetic mean, for those establishments (by no means all) that give this information. During these years of war the proportion of workers who left to undergo compulsory military service must also be distinguished.

others. For the detailed technique of this plan, and some of its advantages and disadvantages, the reader may be referred to my manual (18, pp. 89-95), where the plan was, I believe, first suggested.

¹ See *U.S., Monthly Labor Review* during the year 1919: January, "Labor Turnover in Cleveland and Detroit," by Boris Emmet; February, "Labor Turnover in San Francisco Bay Region," by P. F. Brissenden; March, "Labor Turnover in Cincinnati," by Emil Frankel; April, "Labor Turnover in Milwaukee," by W. F. Kirk; September, "Labor Turnover in Chicago," by Emil Frankel.

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It will be seen that in no city was the total rate of turnover less than 166 per cent., or the proportion of quits less than 63 per cent. It will also be noticed that where the proportion discharged seems to be high, the proportion laid off tends to be low, so that the combined proportion is fairly constant.

The turnover experienced in different establishments *within the same industry* has also been averaged. The results were unfortunately expressed as rates per 10,000 labour hours, but multiplying by 30 will (on the assumption of 300,000 hours per hundred employees in the American working year) convert these rates into the more usual and more simple annual percentage of turnover.

These rates, averaged for different American industries, are compared in Table 9.

TABLE 9
RATE OF TURNOVER IN DIFFERENT AMERICAN INDUSTRIES

Industry.	1913-14.			1917-18.		
	Number of Est.	Percentage of Number at Work.		Number of Est.	Percentage of Number at Work.	
		Hired.	Leaving.		Hired.	Leaving.
<i>Factories.</i>						
Automobiles and parts ..	15	156*	162	30	231	228*
Chemical Industries and Refineries	3	120	105*	15	297	252*
Clothing and Textile	6	62*	66	8	126*	141
Furniture and Millwork ..	—	—	—	3	249*	306
Leather and Rubber	6	159	135*	4	240*	246
Machinery Manufacturing ..	16	81*	108	31	165	159*
Miscellaneous Metal Products ..	20	81*	93	45	318	303*
Printing and Publishing ..	5	69	66*	5	177*	189
Slaughtering and Meatpacking	2	255	240*	4	255	219*
Gas and Electricity Manufacturing	1	15*	30	10	138*	141
<i>Stores.</i>						
Mercantile, Retail and Wholesale	5	72	66*	7	138*	144
<i>Offices.</i>						
Telephone	2	39*	48	10	93*	102
<i>Transport.</i>						
Street Railways	3	27	27	4	81*	96

* True turnover or replacement rate, whichever is the lesser of the two, hired or leaving rate.

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To this list may be added American experience in different branches of industry drawn from various sources.

OFFICE WORK.—Among telephone operators in New York State the turnover in 1919 was 3,224. Since those at work numbered approximately 12,326 (possibly less, but not more) this would mean an annual turnover of at least 26 per cent. Of those leaving 5·8 per cent. were discharged, 83 per cent. quit, and 11·3 per cent. were transferred, pensioned, or died.

TRANSPORT.—On the Great Lakes an investigation by the U.S. Department of Labor in 1917 (11, June 1918) found a turnover (based on replacements) of 380 per cent. on the bulk freight steamers, 243·8 per cent. on the lumber steamers, and 818·5 per cent. on the passenger-and-freight steamers!

On railroads the turnover varies enormously with the exact class of occupation. Investigating ten to fifteen railroads with a staff of some 170,000 men, Slichter (23) found engineers (anglicé engine-drivers) and conductors had a turnover of only 4·8 per cent., composed of 53 per cent. lay-offs, 26 per cent. discharges and 21 per cent. quits; firemen and brakemen a turnover of 35·7 per cent. (24 per cent. lay-offs, 26 per cent. discharges, 50 per cent. quits); station agents a turnover of 64·2 per cent. (18 per cent. lay-offs, 7 per cent. discharges, 75 per cent. quits); maintenance of equipment men a turnover of 106·2 per cent.;¹ and the men engaged in maintenance of way and structures 199·8 per cent. (45 per cent. lay-offs, 5 per cent. discharges, 49 per cent. quits).

MINING.—In a California copper-mining and smelting plant investigated in 1917-18 for the U.S. Department of Labor (11, May 1919) the turnover (measured by number leaving) was 363·3 per cent.

AGRICULTURE AND BUILDING.—In a vivid article on the casual labourer, the late Professor Carleton Parker² calls attention to what he calls the "strike in detail" in California harvest and construction camps.

¹ The component percentages given for this class fail by a long way to add up to 100 and cannot be accepted.

² *The Casual Laborer and Other Essays.* Harcourt Brace & Howe, New York, 1920.

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Resistance by the worker to an employer's labor policy takes one of two forms: either an open and formal revolt such as a strike; or an instinctive and often unconscious exercise of the "strike in detail"—simply drifting off the job. The latter phenomenon is called by the employers "undependable labor," and ideas concerning this wilful unreliability constitute the laymen's usual version of the California labor problem. . . .

A large ranch with a fruit season of nine weeks reported a monthly turnover of 245 per cent. One power-house construction job in the Sierras gave figures showing that to maintain a force of 950, over 1,500 men a month were shipped to them.

Most of the statistics quoted by Professor Parker give only the "average duration of the job," i.e. the average number of days worked per man. In lumber camps, for instance, investigation showed that a man tended to stay only fifteen to thirty days; in construction work, ten days; in harvesting, seven days; and in orchard work, seven days. However, as we are not told the possible duration of the job, e.g. the length of the harvesting season, we are not able to judge how much this casual migration is due to economic circumstances and how much to labour turnover proper.

TRADE.—Among a group of agents canvassing for a New England life insurance company, Dr. John B. Watson reports the survival of only 56 per cent. (33/59) at the end of their first year and 22 per cent. (13/59) at the end of their second.¹

GOVERNMENT SERVICE.—The Civil Service Reports for 1903 to 1917 show turnover rates among federal employees ranging from 5.5 per cent. in 1903 to 19.4 per cent. in 1917, the average being about 9.6 per cent. Of this turnover about five-sixths was due to resignation and death (quits), and one-sixth to "removal" (discharge). More recent and more detailed investigation by the Commission on Reclassification showed a turnover of 10 per cent. in 1915-16, of 16.4 per cent. in 1916-17, of 36.4 per cent. in 1917-18 and 40.5 per cent. in 1918-19.² The possible reasons for

¹ *How to Break down Resistance to Life Insurance.* J. Walter Thompson Co., New York.

² This experience includes that of compositors and pressmen in the Government printing office, who, strictly speaking, should be classified under manufacturing industries. However, judging from the more detailed figures for 1915 to 1919, these printers formed only a small proportion of the Government servants (about 10 per cent.), and their turnover rates did not vary much from the average for the whole group.

this remarkable increase in these years is discussed below in Section D.

It is evident that loss by turnover arises in almost all the branches of industry distinguished in Chapter I, though scarcely any figures are to hand for industries of the personal connection type. Many of these, indeed, are one-man businesses, where the phenomenon of the employee does not occur. Yet judging from the worry of servantless weeks not unknown to the well-to-do mistress of a household, from the execrations heaped on maids who will not stay, and the copious advertisements for "help," quite sensational turnover rates could undoubtedly be found in domestic service.

To sum up the relative showing of different branches of industry. Many industries have a higher, and some a lower, turnover rate than manufactures. The lowest rates occur among the soft-handed industries, such as the Government service, and work in offices and shops generally. The highest rates occur in the hard-handed industries, "below the collar line," such as mining, and some branches of transport, building and agriculture. As regards different forms of manufacturing, the turnover rate seems to depend largely on market conditions.

For instance, in 1913-14 turnover was relatively low in metal (and munition) factories, but in the war period it was as high as 300 per cent. In gas and electricity, as well as in clothing and textiles, turnover seems uniformly low, whereas in stock yards, slaughtering and meat packing it is uniformly high.

English Experience

Though the term mobility of labour is much favoured by the English economists of the theoretical school, the conception of labour turnover which is one form of labour mobility—namely, mobility between factories—is somewhat novel in England. This has probably been due to the comparatively slow growth of scientific interest in the concrete facts of industry, rather than to the absence of any such phenomenon. The English Industrial Fatigue Re-

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search Board have made up a good deal of leeway recently by a report (4, No. 13) dealing with the turnover of employees—mainly women—in English munition works during the war. Unfortunately, the method adopted for computing the turnover rate is somewhat different from that generally used in America,¹ and indeed by business men in England.

TABLE 10
RATE AND MANNER OF TURNOVER AMONG WOMEN IN INDUSTRY:
ENGLISH EXPERIENCE. WAR PERIOD

Factory and Industry.	Annual Percentage Rate of Loss.	Percentage of Total Loss Leaving in Specified Manner.		
		Laid Off.	Discharged.	Quitting.
<i>Married Women.</i>				
Shells A and B	45·8	14·5	21·3	64·2
Shells C	98·8	17·6	19·4	63·0
Shells E	139·3	18·8	17·9	63·3
Shells F*	212·0	27·0	22·2	50·9
Fuses G	73·0	0·9	12·2	86·9
Fuses H	—	—	—	—
Biscuits J:				
Dayshift	176·5	10·4	9·0	80·6
Nightshift	256·9	13·2	7·3	79·5
<i>Single Women.</i>				
Shells A and B	27·4	16·0	16·0	68·0
Shells C	65·3	22·2	13·0	64·8
Shells E	108·2	29·8	14·2	56·0
Shells F*	172·5	28·8	27·0	44·1
Fuses G	49·4	1·9	16·5	81·6
Fuses H	69·4	22·9	18·4	58·6
Biscuits J:				
Dayshift	116·8	15·0	9·0	76·0
Nightshift	185·9	8·8	8·6	82·5

* Later period only.

A three-monthly period is taken as a basis instead of a yearly period; but in spite of the differences in method we shall not go far wrong if, for purposes of comparison, the English rates are multiplied by four.

¹ See § D3 for conditions under which the results of the two methods are comparable, and for a brief outline of the English method. For practical business purposes this method is difficult to compute, and though unquestionably useful in furthering the scientific interpretation of variations in turnover, it is liable to complicate the direct assessment of the costs of turnover per given wages bill.

In Table 10 is given the percentage rate of loss (total over all periods of service) for single and married women. Since the experience of all factories is omitted where the period studied was less than twenty-one months (i.e. D, F 1st period, I, K, and all factories in the postwar period) these "overall" rates¹ are fairly comparable for the different factories. The proportion laid off, discharged or quitting is also distinguished. In the table of the original report lay-offs may be recognized under the title—more becoming an official report—"reduction of staff," and quits under the titles "left of own accord" and "left owing to ill-health." "Dismissed owing to incompetency" and "unsuitability" are clearly equivalent to discharged.

In the prewar period one factory—J, employing women in biscuit-making—was studied for a period sufficiently long to justify quoting turnover rates over all lengths of service. One year's investigation of this factory was also made in the postwar period. Single women were chiefly employed and the "overall" percentage rate of loss was 100·8 per cent. in the two years preceding the war, and 75·4 per cent. during the year following the Armistice.

In the prewar period women were laid off at the rate of 7·80 per cent. annually per number employed and discharged at the rate of 8·10 per cent. The rate at which women quit on their own accord, however, was 84·90 per cent. In the postwar period the rates were 13·88 per cent. laid off, 8·44 per cent. discharged, 53·08 per cent. quitting.

The turnover among male employees is given in the case of two factories, J (making biscuits) and K (making leather goods) in the postwar period. The annual rate works out at 68·8 per cent. at factory J, of which 4 per cent. was due to lay-offs, 10 per cent. to dismissals, and 86 per cent. to quits. At factory K the annual rate is 35·7 per cent.—35 per cent. of it due to men laid off, 11 per cent. to men discharged, and 54 per cent. to men quitting. At both of these men's factories and at the women's factory J in the postwar period, the maximum service of the cases studied was twelve months; we are dealing with industrial

¹ The figures are taken from the "general" Table XXXVII of the Fatigue Board's Report. Figures from Factory M (drugs); where single and married women were not differentiated, are also omitted.

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“infants” more liable to turnover. A more normal length of service would probably have yielded lower turnover rates.

Another way of expressing the amount of labour turnover is to compute the survival rates of a group of workers at different periods after their engagement. Convenient periods, chosen by the English investigators, are three

TABLE II
SURVIVAL RATES AMONG WOMEN IN INDUSTRY: ENGLISH EXPERIENCE.
WAR PERIOD

Industry and Factory.	Married Women.		Single Women.	
	Percentage Surviving After		Percentage Surviving After	
	Three Months' Service.	One Year's Service.	Three Months' Service.	One Year's Service.
Shells A and B	82·1	58·0	88·2	72·2
Shells C	68·6	33·8	79·8	49·3
Shells E	62·1	20·0	73·6	28·8
Shells F*	30·6	13·2†	39·1	22·8†
Fuses G	77·0	48·9	83·3	61·8
Fuses H	—	—	80·9	61·1
Biscuits J:				
Dayshift	36·8	16·7	54·7	27·6
Nightshift	24·1	6·3	37·5	14·7

* Second period.

† Nine months' survival rate.

months and one year after engagement. The proportion of employees surviving on the average after these periods of service is given in Table IX, for the same factories as in Table 10.¹

Experiences Compared

If anyone is rash enough to desire a comparison of English and American “overall” turnover rates, it must be pointed out immediately, that the length of service in the English factories was on the whole much shorter than

¹ The figures are drawn from Table XXXVIII in the Fatigue Board's Report. *Yearly* survival rates for factory F are not given.

in the factories investigated in America. Nobody whose turnover was recorded in England had served more than two years or at most 27 months, whereas in the American groups studied in 1913-14 and 1917-18, 59.0 per cent. and 45.8 per cent. respectively had been employed for two years or more, and indeed 32.9 per cent. and 27.8 per cent. respectively for five years or more.

Luckily, the American statistics of turnover in relation to length of service are presented in such a way that the old-stagers of more than two years' service may be omitted from our purview. When this is done the average turnover rate in the 34 and 53 American factories reviewed in 1913-14 and 1917-18 respectively is 138 per cent. and 218 per cent., instead of the 63 per cent. and 130 per cent. given for all periods of service in Table 14. The average (median) turnover among the English factories given in Table 10, omitting H, is 108.2 per cent. among single women, and 139.3 per cent. among married women, so that comparing rates in war periods only, the turnover in England seems to be considerably lower than in America, even when only those American factories are considered that keep records of length of service. On the other hand, only women were studied on any large scale in England, and in 45 American factories where (in 1917-18) the comparison was made, men were found to have a considerably higher rate than women—168 per cent. as against 111 per cent. Possibly if we compared the English experience with the turnover among American *women* who had served less than two years, the differences in the rate would not be so great. In any case, the differences shown between individual English factories are greater than between the American and English averages, and at least two of the English factories show a higher turnover rate than the American average.

A point of similarity which must not pass unnoticed is the high proportion of those who quit, i.e. leave of their own accord, as compared with those discharged, or laid off for business reasons. English experience during the war (Table 10) showed that of all women leaving factories those quitting on their own account usually constituted about 60 per cent. to 80 per cent., and the proportion is, if any-

thing, higher among women and also men in the prewar and postwar periods. American experience over a series of years (Table 7), and a series of cities (Table 8), shows much the same proportions. In none of the years where the proportion of quits is given is it less than 49 per cent., and in none of the cities surveyed in 1917-18 is it less than 63 per cent. In short, both in England and America labour turnover is largely a matter of a voluntary act on the part of labour itself.

This is a disclosure which has hitherto failed to permeate economic thinking. The phrase "hiring and firing," for instance, which has caught on like a disease, gives an entirely false impression. Men are usually not fired but, to preserve the metaphor, go off spontaneously.

Again, I suspect that much of the "reserve of labour" distinguished by Sir William Beveridge among other causes of unemployment, consists of men who have quit one employment voluntarily and are temporarily unable to attach themselves to another.

Turnover has not inaptly been termed the strike in detail. It is, in fact, the only orthodox method by which the individual workman can to the best advantage market his commodity of labour. If he is not paid enough (either in wages or decent working conditions) in one factory, he must, by all the laws of supply and demand, remove his labour to a higher bidder. And this he may do even at the risk of a period of unemployment. In which case it is not the temporary unemployment that is the ultimate problem, but the rejected terms of employment, and these we shall presently investigate.

The Aggregate Cost of Average Experience

The rates of turnover experienced, multiplied by the cost per *unit* of turnover, will not mean very much to the employer until this *cost of the total number of units experienced* is expressed in terms of the total payroll. The employer may then calculate the cost of this labour loss as a definite percentage of the total paid out *normally* for labour, and the turnover will appear as a sort of "friction load" telling

against the economical use of labour-power. It is the precise wastage in such friction that the employer wants to discover.

For America let us take 180 per cent. as a not unusual rate of turnover. This figure means that for every man employed 1.8 men are hired every year. If the cost of each new hiring is \$36.04, as Mr. Alexander's figures would show, then for every man on the payroll $\$36.04 \times 1.8$ must be paid for turnover every year or \$64.87.

How much, on the average, is each man on the payroll paid in wages per year? Mr. Alexander's figures of cost were obtained in 1912 when the value of the dollar was nearly double its value to-day (1923), so that we must either take the wage level of 1912 or multiply his figures of cost by one and a half to two. Mr. Alexander tells us himself that the annual payroll of the twelve factories he studied in 1912 was nearly \$29,000,000 and that the total employed was 37,274 initially, and 43,971 at the end of the year. Taking the average of the two as 40,622 employees, this makes the yearly wage per man about \$720, a sum probably quite normal for 1912.

The figures, then, are :

Wage cost per man .. .. .	..	\$720	- (a)
Turnover cost per man on the payroll ..	..	\$64.87	- (b)

Turnover Cost ($b \div a$) = 9.01 per cent. of the wage cost or payroll.

This supposes the turnover rate to be 180 per cent. per year. If the turnover is less the cost will be less in exact proportion; and without taking account of the "rebate" necessary when men leave before their training is fully paid for, Mr. Alexander's experience indicates *that in manufacture every 20 per cent. of turnover costs 1 per cent. of the total payroll*; 100 per cent. turnover will cost 5 per cent. of the total payroll, 200 per cent. turnover will cost 10 per cent., and so on.

Calculations made in England based on a turnover rate of 100 per cent. and a loss per case of turnover of £2 10s. to the employer and £2 10s. to the worker, bring out the aggregate loss among the twenty million employed in industry as £100,000,000. If the average wage is taken as about 45s. to 50s. a week, say £125 a year, this would

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indicate a loss of 4 per cent. of the payroll equally divided between master and man. The loss to employer is here very conservatively assessed, and the American experience of 5 per cent. of wage bill gone in "friction" for a 100 per cent. turnover is probably in fact approached.

C—THE MINIMUM LOSS BY TURNOVER

There is, of course, a certain amount of turnover that is not within the power of any industrial establishment or any industrial community to alter. The death or permanent sickness of employees from "natural" causes is an obvious case in point. How large a turnover such unavoidable sources may produce depends, as Mr. Alexander points out,¹ on the "substitution of fair numerical values" for sources such as the following:

- (a) The replacement of employees who die.
- (b) The replacement of employees on prolonged sick leave for whom others must be substituted temporarily or permanently.
- (c) The replacement of employees who, although they had been selected for their positions with good judgment, are found to be unsuited to the work or unfit on account of personal characteristics, or who leave of their own accord, because they do not find the work congenial, the climatic conditions agreeable, or who for other reasons remove from the locality.
- (d) The engagement of extra employees required for a short period, either on account of a temporary piece of construction work, or usually on account of the high peaks of a fluctuating production.
- (e) The recognized fact that no employment department can be run on a 100 per cent. efficiency basis.

From the average age of employees in the factories he surveyed, and the death rates established for these ages in mortality tables, and also from the experience of mutual benefit associations in factories, Mr. Alexander assumes that 1 per cent. die.

For the value of the other items the evidence is less certain. Based on statistics of Government employees in Washington, he estimates that "4 per cent. are sick for sufficiently long periods to necessitate their replacement

¹ Paper on "Hiring and Firing," read in 1915 before the American National Association of Manufacturers.

temporarily or permanently." A further 8 per cent. are estimated to withdraw from service for unforeseen or unavoidable reasons or to be discharged for justifiable causes; "8 per cent. are temporarily needed on account of normal fluctuation of production; and 80 per cent. constitutes a readily attainable efficiency of an employment department."

The complete minimum turnover which cannot economically be avoided and which may serve as a practical ideal and standard at which to aim is, therefore, according to Mr. Alexander, $\frac{100}{80} \times (1 + 4 + 8 + 8)$ per cent. = 26½ per cent.

That this theoretical minimum is by no means impracticable is shown by the actual experience of several typical establishments both in their ability to decrease their turnover very greatly and in the actual low level of turnover obtained. Dr. Slichter (23) gives figures for a metal-working plant in Chicago with an average force of 4,831 employees. This plant seems to have maintained an average turnover rate for nine years (1908-16) of 40.9 per cent. The 8-hour motor plant investigated by the U.S. Public Health Service showed a turnover (replacement) rate for the year 1916-17 of only 30 per cent. (9). And turnovers as low as 28.0 per cent. and 28.1 per cent. are given in section D, §2 below, outlining the reduction of turnover due to changes in personnel organization.

The English inquiry into turnover during the war (4, No 13) exhibits the excessive losses over and above Mr. Alexander's estimates that are likely to occur when conditions are abnormal. Detailed information is given of the proportion of women leaving on account of ill-health and physical incapacity. Exclusive of the exceptionally high figures in the night work at Factory J, turnover rates from this cause (Table 12) range, among single women, from 9.2 per cent. to 20.6 per cent., and among married women from 28.4 per cent. to 44.4 per cent. instead of the 4 per cent. estimated [group (b)] by Mr. Alexander.

It is impossible to distinguish the justifiable from the unjustifiable discharges in the English records, but in the case of women "domestic reasons" are prominent among

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unavoidable quits, and Table 12 shows Mr. Alexander's estimate of 8 per cent. for his group (c) of unavoidable sources of turnover to be again greatly exceeded. Even if the

TABLE 12
REASONS FOR EMPLOYEES QUITTING ON OWN ACCOUNT
English Experience among Women

Period, Industry and Factory.	Annual Rate of Turnover.			
	All Reasons for Quitting.	Specified Reasons.		
		Ill-health and Physical Disability.	Domestic Reasons.	Dissatisfaction.*
<i>Married Women.</i>				
<i>War Period.</i>				
Shells C	62·2	28·4	13·8	16·0
Fuses G	63·5	17·6	28·9	9·1
Fuses H	—	—	—	—
Biscuits J :				
Dayshift	142·3	44·4	57·9	33·0
Nightshift	204·3	62·3	73·3	58·0
<i>Prewar Period.</i>				
Biscuits J	—	—	—	—
<i>Postwar Period.</i>				
Biscuits J	—	—	—	—
<i>Single Women.</i>				
<i>War Period.</i>				
Shells C	42·4	13·9	13·0	5·2
Fuses G	40·3	11·8	15·6	8·1
Fuses H	40·8	13·8	14·8	11·5
Biscuits J :				
Dayshift	88·7	20·6	27·8	36·9
Nightshift	153·6	43·8	43·6	62·7
<i>Prewar Period.</i>				
Biscuits J	84·9	14·9	24·0	38·2
<i>Postwar Period.</i>				
Biscuits J	53·1	9·2	18·5	25·0

* Cases where the reason was not stated have been subtracted. These constitute the difference between the rate for all reasons and for the three specified reasons added together.

exceptional rates on night work at Factory J are omitted, the turnover from this cause ranges among single women from 13·0 per cent. to 27·8 per cent. ; and among married

women from 13·8 per cent. to 57·9 per cent. Thus, the figure for one cause of turnover alone usually exceeds Mr. Alexander's estimate for the whole group of unavoidable causes.

Under group (d) a larger rate of turnover than Mr. Alexander's 8 per cent. might also be expected in the case of shipyards, repair shops, factories handling perishable goods and subject to seasonal production, and indeed, in the case of all industrial establishments during years of cyclical disturbances in business, i.e. booms or depressions.

This element affects mainly the lay-offs, and where lay-offs can be cut out of the final turnover rate, different establishments and industries can be compared with greater fairness. Yet even so, when there is an exceptional demand for labour, as in the war years 1917-18, there is likely to be competition between establishments in the terms offered, and a constant movement of labour from one establishment to another as a result. The "quitting for better opportunity" will be particularly high in all towns where different establishments carry on exactly the same industry.

The following sections give the results of investigation into the underlying conditions of such excessive turnover, wherever it has been found possible to isolate the specific condition successfully.

D—CONDITIONS OF EXCESSIVE LOSS

§ 1. *Effect of Different Physical Working Conditions and Types of Work*

A definite attempt to associate turnover with specific physical conditions in the factory was undertaken by the U.S. Public Health Service when comparing plants working the 10-hour and 8-hour day (9). Though the investigation included other factors besides physical environment as affecting labour losses other than labour turnover, one of the problems attacked was the effect on the turnover and on the allied "transfer rate" of such conditions as noise, bad light and air, and all the physical accompaniments connected with night work.

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Quoting from the Bulletin (9, Chapter 7) itself:

In the attempt to gauge the effects of environment, the physical conditions of labor in 68 departments of the 8-hour plant were examined and judged by the investigators in relation to six special factors: muscular strain, eye strain, noise, bad lighting, bad air conditions such as fumes, smoke, etc., and the prevalence of night work.¹ . . . While obviously such factors could not, for the most part, be rated by exact measurements, yet they indicate roughly the physical demands of the work. The effect on the workers of these conditions is suggested by certain objective indices in each department, that is, the relative amount of labor turnover per month, the average number of transfers asked and granted monthly through the medical department, the number of headaches reported at the hospital, and the number of days absent.

The various indices, such as turnover, requests for transfer, etc., were compiled from records kept at the 8-hour plant. . . . In the summary table (Table 13) the departments characterized by any one

TABLE 13
SUMMARY OF COMPARATIVE STANDING OF DEPARTMENTS MEASURED BY
LABOUR TURNOVER, REQUESTS FOR TRANSFER AND TRANSFERS GRANTED
American Eight-hour Motor Plant

Departments Grouped according to Undesirable Conditions.	Percentage of Working Force per Month.			
	Requests for Transfers.	Transfers Granted.	Turnover.	Turnover plus Transfers Granted.
All departments (65), average rate ..	7.76	0.38	1.12	1.50
Bad air (13 departments), average rate	11.73	0.43	1.39	1.82
Noise (5 departments), average rate..	10.37	0.40	1.28	1.68
Eye strain (9 departments), average rate	9.13	0.50	1.14	1.64
Night work (17 departments), average rate	7.73	0.40	1.19	1.59
Bad lighting (14 departments), average rate	7.62	0.41	1.04	1.45
Muscular strain (9 departments), average rate	6.79	0.28	1.20	1.48

of the physical factors mentioned above are grouped together and given in the extreme left-hand column. Each column representing turnover, etc., gives the monthly average for each group of departments in percentages of the number employed. . . . In each column the

¹ The investigators, when rating the departments, were unaware of the purpose of the ratings (to explain the turnover, etc.) so that no bias entered into their judgments.

average rate . . . for each group may be compared with the average rate . . . for all 65 departments given at the top of the table.

To avoid complications which might arise from the inclusion of women, this table omits the three departments employing women at the 8-hour plant. . . .

Taking each column separately we find turnover highest in the group of 13 departments in which the conditions of the air are worst, involving heat, smoke, fumes, gases. The average turnover in these departments is 1·39 per cent (of the working force per month) as contrasted with a rate of 1·12 for all departments. . . .

Second to the group with bad air conditions, turnover is next highest in the five departments in which there is the greatest noise, averaging 1·28 per cent per month of the force as against a turnover of 1·12 per cent for the factory as a whole. In these departments . . . requests for transfer are also next to highest, 10·37 per cent per month as against 7·76 per cent.

Exactly similar methods were adopted at the 10-hour plant.

Owing to the larger number of women employed at this plant in various departments an effort has been made to show the differences between departments which are predominantly masculine or feminine. Departments employing more than two-thirds men are grouped together and listed as men's departments; the five departments employing more than two-thirds women were too few from which to draw conclusions, and hence are grouped with mixed departments, in which the proportion of one sex to the other is less than two-thirds. Since women predominate in this combined group, it is they who are the variants, accounting for the lesser rate of turnover, 9·9 per cent monthly, as against a turnover of 12·8 per cent in the men's departments.

The physical factors most distasteful to the men at this plant, as indicated by a turnover above the average (of 12·8 per cent monthly) are as follows :

	Per cent.
Departments with night work, turnover averaging . . .	.. 15·8
Departments with muscular strain, turnover averaging . . .	.. 14·9
Departments with bad light conditions, turnover averaging . . .	.. 14·6
Departments with bad air conditions, turnover averaging . . .	.. 13·8

The factors most distasteful to the combined group of workers in which women are present in large numbers are as follows, as indicated by a turnover above the average rate of 9·9 per cent monthly :

	Per cent.
Departments with great noise, turnover averaging . . .	.. 12·4
Departments with bad light conditions, turnover averaging . . .	.. 12·3
Departments with bad air conditions, turnover averaging . . .	.. 10·6

Just as the several groups of industries differ very greatly in their turnover showing, so will the several occupations and crafts within any industry. Among these different occupations, groups may be formed such as Mr. Alexander's five divisions quoted above, and in the twelve American metal plants investigated, Mr. Alexander distinguished (23) the following rates of turnover: for Group A (apprenticed tradesmen) 104.2 per cent.; for group B (skilled men) 112.3 per cent.; for group C (semi-skilled men, pieceworkers) 87.5 per cent.; for group D (labourers) 84.0 per cent.; for group E (clerks) 57.2 per cent.

Slichter considers the comparative turnover showing of the several groups to be distinctly exceptional in this case. He holds, and most authorities are in agreement with him, that the more skilled the occupation the less is the liability to turnover. The experience of a large car-building establishment in Chicago (11, October 1918) confirms this view; the rate of turnover among 466 semi-skilled machinists, drill press and lathe operators was only 172.3 per cent. and among 517 painters only 208.1 per cent., while it was 542.6 per cent. among the 1,140 unskilled labourers employed.

The general result of the investigation by the U.S. Department of Labor (11, June 1920) of 22 plants in 1913-15 shows an annual turnover rate of 60 per cent. among skilled men, but 129 per cent. among the unskilled. A further investigation of 10 plants in 1917-18 disclosed an annual rate of 135 per cent. among the skilled and 435 per cent. among the unskilled.

Further experience on a large scale is certainly required as to the effect of occupation on turnover rates within the same industry, or better still, within the same plant. Where different types of work are segregated in different departments the various departmental rates of turnover could be usefully compared.

It is difficult, however, to separate the type of work from the type of worker. The labourer type usually has a high comparative turnover, but whether this is because of the strain of the heavy work or because the labourer is, comparatively speaking, a shiftless—or is it shifty?—individual, or because he is not trained to any special work,

or because his wages are comparatively low and his hours long, it is impossible to say. These factors are usually found inextricably bound up with and interacting upon each other, and the resulting turnover cannot easily be attributed to any one of them.

§ 2. *Effect of Organized Employment Policy*

Many American firms have adopted the policy of centralizing the hiring of new employees in the management. The central management may also see to it that newcomers are adequately introduced and educated, and will usually make full inquiry before discharging employees or laying them off for want of work. Occasionally the results of such a policy on turnover are duly measured and chronicled.

The Dennison Manufacturing Company for instance, adopted selection, training and promotion schemes, a transfer system between departments, regularization of work through busy and slack seasons, and also followed up the reasons given for leaving. The rate of turnover was reduced from 68 per cent. in 1911 and 61 per cent. in 1912 to 52 per cent. in 1913, 37 per cent. in 1914 and 28 per cent. in 1915.

Again, by careful inquiry into the reasons for discharging employees and by reviewing the decisions of their foremen, a printing and binding establishment reduced turnover from 36.8 per cent. in 1912 to 31.5 per cent. in 1913 and 28.1 per cent. in 1914; while a motor manufacturing company reduced turnover by similar means from 73.7 per cent. in 1911 to 36.3 per cent. in 1915.

The U.S. Department of Labor (11, June 1920) has traced the histories of ten establishments selected for introducing "definite labor policies and centralized employment machinery," and has in successive years compared their average annual rate of turnover with the average turnover of all other establishments that were surveyed. In 1913, the first year studied, the turnover in the selected establishments averaged 162 per cent., considerably higher than in the other plants where it averaged 129 per cent., so that their employment machinery and labour policies seem to

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have been introduced under a distinct handicap. In 1914 the average turnover rate of the selected establishments was, however, down to 33 per cent., while in all other establishments it remained as high as 84 per cent. In the subsequent years 1915, 1916, 1917, 1918 and 1919 the turnover rate was 24 per cent., 42 per cent., 51 per cent., 81 per cent. and 72 per cent. respectively in the selected establishments, but 78 per cent., 135 per cent., 171 per cent., 186 per cent. and 102 per cent. in all other establishments. The effect of a special "labor policy" in reducing turnover seems, therefore, to have remained fairly permanent.

When psychological or other tests of fitness are given before hiring employees, the workers thus specially selected usually show a much lower turnover rate than those hired at random.

Link¹ introduced tests consisting of number-group checking, cancellation and card-sorting in order to select inspectors of fuse parts in a large American munition works. Among 94 women inspectors who had left and whose term of service could therefore be ascertained, inspectors recommended by the tests were found to have averaged 9.56 weeks' employment, while inspectors not so recommended averaged only 1.05 weeks'. The average term of those who were recommended and hired on the basis of the tests was almost ten times as long as the average term of those who were hired regardless of the evidence of the tests.

Of all the schemes introduced under a revised personnel policy, that which is likely to affect turnover most directly is the system of transferring an employee at his own request from one department of the plant to another. In the investigation for the U.S. Public Health Service we were able to show statistically the value of the transfer system as a deterrent to turnover. The workers leaving a department by transfer would probably have left the plant entirely had there been no transfer system. Hence the distastefulness of certain departments and kinds of work is indicated not by the turnover alone, but by turnover plus transfers granted.

¹ H. C. Link: *Employment Psychology*. New York, Macmillan & Co., 1920.

And by adding these two rates in the fourth column of Table 13 and comparing the total with the rate of *requests* for transfer given in the first column, we see that, with one slight exception, the order of *demerit* is identical. In both columns departments with poor air conditions have the highest average rate, noisy departments the next highest and so on. Neither the turnover rate nor the transfers-granted rate taken singly, however, is thus correlated to the requests-for-transfer rate.

This implies a compensating action between turnover and transfers granted. Thus in the departments with eye strain, the request-for-transfer percentage (9.13) is third in order, and the transfers-granted-plus-turnover percentage (1.64) also third; but the rate of transfers granted, taken alone (0.50) is first, and the rate of turnover taken alone (1.14), fifth. Thus a high transfer rate seems to compensate for a low turnover rate.

Relatively frequent requests for transfers in any department, which undoubtedly denotes many grievances and complaints, are connected with correspondingly frequent departures from that department. These departures occur through one of two channels: the safety valve of transference, or the bursting boiler of turnover, and where the safety valve is used it prevents much bursting of boilers.

§ 3. *Effect of Employees' Length of Service*

A fact that must be faced by all employers considering whether or not to introduce a systematic employment policy, is the excessive rate of turnover among employees more recently hired.

Most industrial organizations seem to consist of a nucleus of tried hands who have served their employer like old family retainers, surrounded by a floating and fleeting population of newcomers. A factory, indeed, is rather like a boarding-house that takes "transients." Possibly the newcomers are unable, without systematic training, to pick up the mystery of their craft rapidly enough to earn a decent living; possibly the unaccustomed working conditions are too much for them. At any rate, it is fatuous to assume that the floating

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population will soon get used to deafening noises or over-bearing foremen, no matter how trying these new conditions are at first. Such a theory quite ignores the risk of a newcomer leaving before conditions are ever given the chance of getting him acclimatized.

Where conditions are beyond his control, the wise employer might try to give new hands special consideration and, in particular, a systematic training. It is admittedly a risk to the employer to spend money in training when there is constant danger that the newcomer may shortly leave and take his newly acquired knowledge to another employer. But the vicious circle must be broken somewhere; inexperience favours instability, instability inexperience, and the only immediate remedy lies with the employer. It is ignorance, indeed, that often prevents the employer from taking action; the first step is for him to realize the extent of turnover among the newly hired.

The statistics of turnover in relation to the average length of service at the plant show so clearly that those who have recently entered a plant are more liable to leave than those who have already stayed some time, as to suggest a striking analogy with infant mortality. For it has long been known that those who have recently entered this world are, up to the age of five at any rate, far more liable to leave it than those who have already stayed five years.

Table 14 summarizes the evidence gathered in America by the U.S. Department of Labor in 1913-14 and 1917-18, from such plants as kept the necessary records. Comparison is made of the number leaving after a service of one month or less, three months or less, three to six months, six months to a year, and any length of service, as against the number who are in employment, i.e. "on the payroll," at any given time, and have the same periods of service behind them. Thus, selecting any employee who has a given length of service to his record, it is possible to estimate his liability to leave.

Taking as a standard the liability to turnover among those who have served between six months and a year (109 per cent., and 104 per cent. in the two periods respectively) we find the liability of those having served less than a month to be (in the 1917-18 study) five and a half times as great,

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and the liability of those who have served three months or less almost two and a half times as great in the 1913-14 study, and almost four times as great in the 1917-18 study.

So important did the factor of length-of-service appear to the English investigators of labour turnover, that they criticize the simple measure of turnover generally used because it "assumes that the average number of workers

TABLE 14
COMPARISON OF TURNOVER AMONG GROUPS WITH VARIOUS LENGTHS OF SERVICE
American Experience, 1913-14 and 1917-18

Length of Service Groups.	1913-14: 34 Establishments.			1917-18: 53 Establishments.		
	On Payroll at End of Year.	Left during Year.	Liability to Turnover (Annual).	On Payroll at End of Year.	Left during Year.	Liability to Turnover (Annual).
<i>Months.</i>			Per cent.			Per cent.
1 or less	—	—	—	6,356	37,681	593
3 or less	11,365*	28,407	250	13,411	56,593	422
3 to 6	6,396	8,516	133	6,019	11,770	196
6 to 12	7,188	7,497	104	9,018	9,813	109
All lengths up to over 5 years ..	86,450	54,618	63	71,769	93,092	130

* This figure was printed incorrectly 13,365 in the original.

employed in the period considered were all at work for the whole period, while actually they entered the factory at different dates and so were exposed to the risk of leaving for different lengths of time. It also ignores any difference that may exist between the rates of leaving at different stages of a worker's factory service."

In order to take proper account of the length-of-service differential, the English investigators worked out an entirely new system for measuring labour turnover. This method "calculates separately the rates of leaving at different times in a worker's service." Length of service is—usually—divided up into quarterly (three-monthly) periods. "The rate of leaving in any three months is the number who

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leave during that three months of their service divided by the number exposed to the risk of leaving during that three months."

This number "exposed to risk" used as the denominator is not the same as the American denominator, "number on payroll at end of year." It includes those who may have left any given length-of-service group *during* the period studied. It excludes those who came *before* the period started. "An arbitrary period between the two definite dates is chosen and only those workers who entered the factory during that period are considered."

Now if the composition of the working force of a factory remains fairly constant these differences in method are unimportant. On this supposition, the numbers in various length-of-service groups are the same at the beginning and end of the period, and those who left groups during the period are, as far as length of service is concerned, similarly constituted as those who came before the period. For instance, if the period of study was from January 1st to March 1st, and the number on January 1st who had served a month or less, i.e. had been hired in December, was 200, a stable length-of-service constitution of the working force would mean that on March 31st there were also 200 who had served a month, i.e. had been hired in March. Within each given length-of-service class the number leaving during the period thus balances the number hired before the period began.

The more complicated English method is important for comparative purposes¹ therefore, only where the constitution of the working force in regard to length of service is different in different plants, and at different periods in the same plant.

We may therefore present (Table 15) the English experience for the two factories (C and F) where the data seems sufficient, in much the same form as the American

¹ Such differences arise in periods of trade boom or trade slump when an unusual increase or decrease in employment will occur. As I pointed out in 1918, "when using the total number employed as a basis, it is plainly unfair to compare the rate at a factory which is increasing the number of its employees and under the necessity of trying out new hands, with the rate at a factory which is regularly dismissing its hands." By comparing turnover among groups with much the same length of service the English method partly gets over that difficulty.

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experience. Incidentally, the detailed figures for single women in factory C show how the over-all percentage of 65.3 quoted in Table 10 was arrived at, and may serve as a useful example.

The English method of working out turnover rates allows us to trace a sort of life history of a group of workers. We can see the members of the group dropping out of sight one by one like the ten little nigger boys sitting in a row. And we shall find that the process of dropping out is faster at first than toward the end. For instance, in factory C, where the largest amount of material was collected, we are

TABLE 15
COMPARISON OF TURNOVER AMONG GROUPS WITH VARIOUS LENGTHS OF SERVICE
English Experience, 1916-18

Length of Service Group.	Factory C. Single Women.			Factory J (2nd period). All Women.		
	Number exposed to Risk of Leaving.	Total Number Leaving.	Percentage Rate of Loss (Annual).	Number exposed to Risk of Leaving.	Total Leaving less Reduction of Staff.	Percentage Rate of Loss less Reduction of Staff (Annual).
<i>Months.</i>						
3 or less	3,611	729	80.76	4,377	2,479	226.4
3 to 6	2,653	444	66.96	1,536	442	114.8
6 to 9	2,081	342	65.72	920	167	72.4
9 to 12	1,693	191	45.12	598	79	52.8
All lengths up to 24-27 months	14,237	2,325	65.32	8,175	3,241	163.2

told (see Table 11) that only 79.8 per cent. of the single women survived three months, whereas 49.3 per cent. survived a year. Had the rate of "mortality" found in the first three months—roughly 20 per cent.—continued, the percentage dropping out within the year would have been something like 59 per cent.,¹ leaving 41 per cent. to survive.

¹ Twenty per cent. plus, in the second three months 20 per cent. of 80 per cent. (or 16 per cent.), plus, in the third three months 20 per cent. of the surviving 64 per cent. (slightly less than 13 per cent.), plus, in the last

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Instead of the "death" rate of 20·2 per cent. throughout a year's service, we learn that it was, in fact, only 16·7 per cent. in the second quarter, 16·4 per cent. in the third quarter and 11·3 per cent. in the final quarter. There is clearly a specially heavy "infant" mortality in the first three months of employment.

This fact can be established in the figures given in Table 11 for married as well as single women in all the other factories studied with the exception of factory E, single women, where the rate of turnover appears to be higher in the later months of the first year of employment.

§ 4. *Effect of Type, Experience and Wages of Workers Employed*

Where other conditions are sufficiently stable, the turnover of different races and age-groups may occasionally be distinguished as determinant factors.

At the American Pulley Company, Philadelphia,¹ Americans showed a turnover rate of 215 per cent., Italians of 180 per cent. and negroes of 310 per cent. The turnover of the different races occurred at different seasons. In the spring the Italians chose to migrate West, in the autumn the negroes went South for the cotton-picking; so a wise management took on Italians in the autumn and replaced them with negroes in the spring.

As to age-groups, it is generally agreed that adolescents will show a higher turnover than adults. Looked at from a different angle the turnover liability may be calculated as the number of changes in jobs a year. Figures compiled by the Chicago Bureau of Vocational Guidance (23) show how American boys and girls between the ages of fourteen and sixteen will, on leaving school, only gradually settle down to industrial stability. As the industrial experience increases, i.e. as each child getting older advances farther in his industrial career, the jobs are held longer and turnover

three months, 20 per cent. of the surviving 51 per cent. (slightly more than 10 per cent.). The total of the four quarterly "death" rates is 59 per cent. and the survivors of a year's employment could be expected to be 41 per cent. or rather less, if 20·2 per cent. had been taken instead of round figures.

¹ W. A. Sawyer in *Industrial Management*, January 1919.

is reduced. Thus if the total industrial experience of a boy or girl was less than three months, he had already changed jobs at the rate of 5.1 changes per year and she at the rate of 4.5. When industrial experience had lasted from three to six months, the rate for boys was 3.1, for girls 2.6; six to nine months' experience yielded rates of 2.2 and 2.0; nine to twelve months' experience rates of 1.9 and 1.9, and so on, till with two to three years' experience boys tended to change jobs but once a year and girls but 0.9 times.

That in the middle years of life a critical age is reached when a man tends to "quit his job with especial readiness" is a thesis recently advanced by Kitson (16, September 1922). The figures cited are not very striking, nor is the interpretation in terms of sexual development very convincing. It is, however, quite probable that when his children are young and his wife is unable to work independently, a man is less likely to move from one locality to another than later on when his family is grown up.

As to the relative liability to turnover of *men and women* evidence collected by the U.S. Department of Labor during 1917-18 showed that in 45 factories men had an average turnover of 168 per cent. as against only 111 per cent. among women, and that in the 28 factories where records of service were kept women were the more stable employees.

Among 41,686 men leaving any of these factories 41.8 per cent. had been employed less than a month and only 14.9 per cent. over one year; but among 14,371 women only 30.9 per cent. had been employed less than a month and 24.7 per cent. over one year. And this in spite of the fact that (1) women *in* the employment of these factories had as a whole been taken on more recently than the men; (2) that women, as seen above, are in general more liable to leave employment through ill-health or domestic reasons than men. In short, women show markedly lower excess turnover over and above the unavoidable minimum. The assumption that women get lower wages than men for the same output because they cannot be relied upon to stay in industrial employment is thus brought in question, and theoretical economists would be wise to examine this assumption further.

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A striking though not unexpected discovery is the high turnover experienced when *heavy work is assigned to married women*, encumbered as they are with household duties and responsibilities.

Greenwood compared several munition factories in England engaged on work of various degrees of severity (14, 1919). He calculated in all cases what percentage of all the women hired were able to "survive" in the factory after three months of factory work. He selected two factories in the same part of the country, both possessing "welfare organizations of the highest type" so that as far as possible the character of the work alone should differentiate them. At the ages of 18 to 22, when only 5.92 per cent. of the girls were married, the light-work factory showed 85.75 per cent. of the girls "surviving"; in the heavy-work factory, 87.91 per cent. survived. At the ages of 23 to 27, when 28.08 per cent. of the girls were married, the light-work factory showed 81.50 per cent. surviving, the heavy-work factory only 78.80 per cent. And at ages above 28, when 50.59 per cent. of the women were married, the difference between the two factories widened still further; at the heavy-work factory 78.50 per cent. only survived, while at the light-work factory the survivals were 86.07 per cent. of all the women hired. Heavy work thus seems to tell especially on married women—a fact employment managers should take into consideration when "diluting" their labour or otherwise assigning work to women.

Other things being equal, the turnover rate also seems to vary with the previous occupation of the worker.

Survival rates (4, No. 13) of women coming from different occupations into English munition factories during the recent war are given in Table 16. It will be seen that a smaller percentage survived the given periods among those having no previous occupation and probably coming straight from school, and also among those who had previously worked in other munition factories and had perhaps "got the habit" of moving on. The more stable employees were, in general, those coming from shops and laundries.

Where groups with different levels of wages are compared in the same factory those paid less are usually found to

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have the higher turnover. In an American oil refinery (II, June 1922) the rate of turnover among a group of men receiving 40 to 49 cents per hour was 18·4 per cent. during the first five months of 1921; but among the 888 men receiving 50 to 59 cents per hour the rate was 15·6 per cent. and among the 540 men receiving 60 to 69 cents it was only 6·5 per cent. In other wage groups the men employed numbered less than five hundred and the evidence carries insufficient weight. However, these results certainly

TABLE 16
SURVIVAL RATES IN RELATION TO PREVIOUS OCCUPATION
Women in English Munition Factories, 1916-18

Previous Occupation.	Factories F, G and I. Single and Married Women Remaining out of 1,000 3 Months after Hiring.	Factories C and E. Single Women.	
		Remaining out of 1,000 3 Months after Hiring.	Remaining out of 1,000 a Year after Hiring.
Factory	577	820	582
Munitions	588	762	407
Domestic service	620	787	456
Shop assistant	729	838	571
Laundry	681	815	528
No previous occupation ..	520	775	437
Total	697	792	469

raise the question whether the higher turnover found in unskilled occupations may not be due largely to the lower scale of wages.

And how greatly turnover is affected by changes in the relative wages paid by different establishments or different industries is demonstrated by the increasing turnover occurring between 1913 and 1919 among Government servants at Washington (II, December 1920).

Governments are notoriously slow in adjusting themselves to changing conditions, and when the cost of living suddenly rose during the war period the U.S. Government ran, or rather stood, true to form. The money salary of Govern-

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ment clerks, printers, etc., was not raised, as it was for workers in other occupations, with the consequence that the *real* salary in terms of commodities fell. By 1917 it was calculated that though the average salary was \$1,184 per year as against \$1,065 in 1905, the retail price of food had meanwhile almost doubled and the 1917 salary could buy only a little over half as much as that of 1905. In the years 1903 to 1907 the turnover was, according to the Civil Service reports, 7·6 per cent. ; in 1917, according to the same authority, 19·4 per cent.

In 1919 the average dollar value of Government salaries was only slightly increased, and their purchasing power fell yet further to 8/9ths of the 1917 level and 5/8ths of the 1915 level. According to the Commission on Reclassification, who conducted a particularly detailed inquiry, the turnover in 1915 was 10·0 per cent. ; in 1919 it was computed on the same basis as 40·5 per cent.!

There is no doubt here of a flight from the unstable dollar !

CHAPTER VII

THE LOSS BY ABSENCE

ABSENCE, to avoid the less distinctive term "lost time," differs from labour turnover in that the worker is not taken to have severed his connection with the plant. He is still an employee, but fails to attend at the required time and place. Suspension on account of discipline or lack of work is usually not included. This is unlike turnover which, although excluding lay-offs by the employer, is taken to include dismissals.

Different kinds of absence may be distinguished: individual or organized, and absence lasting long or short periods. Organized absence is familiarly known as a strike. Striking employees do not intend to sever their connection with their employer permanently, and under the conditions and within the limits explained below (p. 190) it is a mistake to confound the strike with labour turnover. The business costs involved are similar in nature to those of absence.

Individual lost time for longer periods, i.e. for whole days or whole spells, may be referred to as full absence; for shorter periods, i.e. before the factory gate closes or within an hour of the scheduled time for starting work, as lateness or tardiness.

The method of measuring absence is described in Part III. The usual practice is to express the amount of time lost as a percentage of the total scheduled or "nominal" hours, if possible, including overtime.

A—THE COST OF ABSENCE

The costs of labour losses have been shown (Chapter V) to be of two types: the cost of repair or replacement, and the cost of excess overhead. These types are so related that

the more that is spent on repair the less is lost in the excess overhead. In the case of absences "repair" consists in filling up the place of the absentee at the shortest notice. It is a matter of a temporary re-alignment.

The quickest re-alignment will be possible where a definite reserve of men is held against the emergency of absence. It would manifestly be a great expense to have a special understudy for every job in the plant; but where there are many jobs of the same nature and the policy of training employees to do more than one job is adopted, the expense of reserves is greatly reduced. A reserve force of ten would probably be ample to cover possible absence among a hundred similar jobs, and these ten reservists, if not called upon to act as substitutes, could be doing the other jobs for which they had been trained. Reserves are particularly important where work is done in gangs. Here the cost of individual absence which holds up the work of the entire team is so obvious that some method of re-alignment is usually found, however crude. The whole question of absent "gangsters" resulting in "broken squads" was very urgently discussed in British shipyards during the war. A definite instance of a reserve force held against absence is reported from Bamberger's large department store in Newark, New Jersey, where 5 per cent. more employees are kept on the payroll than would be necessary if no emergencies ever occurred.

This reserve represents one of the costs of re-alignment. Re-alignment also involves additional clerical expense to cover the notification of the absence, and to mobilize available substitutes.¹ When the employee gives notice that he expects to be absent, delay in re-alignment and consequent costs are, of course, greatly reduced.

Re-alignment, however prompt and efficient, cannot entirely obviate excess overhead expense. The reserves that are brought up are not likely to be as skilful as the absentee or as familiar with the work. But it can soon be demonstrated that the money spent on re-alignment avoids a far heavier expense, if we examine the probable excess overhead cost *where no re-alignment takes place.*

¹ See Chapter XIII (Part III) for details of the records required.

Let us suppose an absence rate to be 15 per cent. when it could be reduced to 5 per cent. What are the prima facie results on cost of this 10 per cent. of superfluous absentees ?

- (1) 10 per cent. less wages have to be paid.
- (2) Output is reduced 10 per cent.

These two items might at first glance seem to balance one another, i.e. returns are 10 per cent. less, but costs are also 10 per cent. less.

Indeed, I have heard American superintendents and foremen stoutly maintaining an "I-should-worry" attitude; if employees want to lose their pay that is their concern—it makes no difference to the company.

The fallacy in this view lies in assuming that the wages of direct labour constitute the only cost entering into the production of any article. The nonchalant foreman would certainly have changed his tune if *all* his men had stayed away, as they would be doing if they struck. It would then be clear that he himself and his brother foremen, all the administrative staff, all factory buildings, stores, machinery and equipment of all kinds were lying idle. And staff, talent and capital lying idle is expensive.

There are obviously further results on costs of a 10 per cent. increase in absence :

- (3) An additional 10 per cent. of the physical equipment is rendered idle, and is depreciating by exposure and obsolescence.
- (4) An additional 10 per cent. of the administrative staff is rendered idle though salaries run on.

Equipment and the administrative staff must be maintained up to the normal working standards and cannot be reduced at short notice in proportion to a smaller attendance. The costs of these factors may therefore be considered to be constant over a certain period, regardless of decreased attendance and consequent decrease in output. Where this decrease is 10 per cent., it is clear that the cost *per unit of output* of the physical equipment and the administrative staff will be increased some 10 per cent.

Besides these constant cost factors there are other elements involved in production which are constant or variable (or partly one and partly the other), according to

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the type of labour loss discussed. In the case of a 10 per cent. increase in absence the following changes in costs would probably occur among these modifiable elements :

- (5) An additional 10 per cent. of the heating, lighting and ventilation gone to waste.

Where machinery is involved—

- (6) An additional 10 per cent. of the supplies used in keeping machinery in condition gone to waste.

Where the absentee was on "direct" labour—

- (7a) An additional percentage (probably not quite 10 per cent.) of "indirect" labour's wages gone to waste.

While the same force of watchmen, police, etc., would have to be maintained, utility men and helpers might possibly be reduced or put on to other jobs in proportion to the direct labour absent.

Where it is "indirect labour" that is absent—

- (7b) An equivalent loss would probably occur either through the "direct" labourer having to help himself or through a general disorganization. This disorganization would certainly take place where a gate-keeper or time-keeper or a foreman was absent.

To illustrate the exact way these further losses occur let us take the case of the heating installation of a plant. A workroom must be kept at the same temperature in winter whether there are 85 men present or 95. A certain fixed amount of fuel has to be burned therefore, whatever the rate of absence; but the greater the absence the higher the consumption per man present and consequently per unit of product made. And it is relative to the unit of product that all costs must finally be assessed. The same may be said of lighting and ventilating the rooms, supervising the work and keeping the machinery in condition. All these functions have to be performed and paid for by the management regardless of the number of workers that are absent. But obviously the fewer the number of workers present the greater is the portion of this fixed total with which each worker's output is burdened.

This burden is spoken of most usually as the overhead

cost. Its constituent items are arranged in a standard system in Chapter V. The items were lettered (B) if the reduction in output through the labour loss was balanced by a reduction in costs, as in the case of direct wages which are not paid to absentees. The items were lettered (C) if the costs were constant, as in the case of idle equipment whose depreciation by exposure and obsolescence runs on whether it is worked or not. The items were lettered (M) if they did not balance losses in product but did not necessarily remain constant and could sometimes be modified. Thus in the absence of a machine worker it might be possible to disconnect his machine so that power would not be wasted in driving the shafting. But it is difficult to see how heating, lighting and ventilation could be reduced in a given set of workrooms just because the attendance in each was lower.

In our present state of ignorance as to what proportion of the total overhead cost in any industry is constant, what proportion balances and offsets labour losses, and what proportion is modifiable, we can only take it as not unlikely that in many industries half the overhead is reduced proportionately to the rate of absence, and half must remain constant.

The total amount of overhead costs is better authenticated, and we may cite a known example where the relation of direct labour to overhead is fairly typical. A great deal of information is given by the U.S. Federal Trade Commission¹ about shoe manufacturing, and although the overhead is relatively low in this industry as a whole, we can find at least one well-known style of shoe, in the manufacture of which the overhead is slightly more than 100 per cent. of direct labour.

Now let us compare (Table 17) the items in the cost account under the actual conditions of 1917 and under our supposition of a 10 per cent. higher rate of absence. We will suppose that half the overhead cost varies with the decreased output and half is constant. The values in 1917 are given per 100 pairs of shoes. In our suppositious case, absence being 10 per cent. greater, production would presumably be down to 90 pairs of shoes.

¹ U.S. Federal Trade Commission. "Cost Reports; Report on Leather and Shoe Industries," Washington, 1919. See especially p. 72.

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The profit in the table is a gross profit. That is to say, it includes any taxes, rates, and interest on the capital that must legally be paid—usually constant sums. Let us suppose, what is purely hypothetical, that \$10 covers fixed interest and taxes on the capital required to make 100 shoes where absence is normal; we are left with a net profit of \$28.60 under the 1917 conditions, \$21.47 under the conditions of a high rate of absence. By this time, it will be noticed, the financial loss as a result of the excess overhead on a 10 per cent. increase in absence is $\frac{\$28.60-21.47}{28.60}$ or approximately 25 per cent.

TABLE 17

EFFECT OF INCREASED ABSENCE ON BUSINESS COSTS
Recorded Cost of Women's Shoes "Brown Calf, Polish," made by Company "428," and Hypothetical Cost if Rate of Absence Increased.

	Recorded in 1917. Cost per 100 Pairs.	Rate of Absence increased 10 per cent. Cost per 90 Pairs.
Leather ..	\$223.20	\$200.88 (= 90 % of 1917 cost)
Other material ..	38.10	34.29 (= 90 % of 1917 cost)
Direct labour ..	53.20	47.88 (= 90 % of 1917 cost)
Overhead ..	65.40	32.70 (= constant half of 1917 cost) 29.43 (= 90 % of reducible half of 1917 cost)
Total cost ..	379.90	345.18
Selling price ..	418.50*	376.65 (selling price 90 pairs)
Profit (gross) ..	38.60	31.47

* 100 pairs.

The example illustrates the increasing proportion of loss as absence makes itself felt on profits. This is due to—

- (1) The fact that part of the overhead *factory* expenses are not reduced (i.e. do not balance) with the amount of absence on the part of the working force.
- (2) The fact that there are *financial* overhead charges which are also not reduced, such as interest and taxes on capital.
- (3) The fact that profit is a remainder that is left after total expenses are subtracted from total revenue from sales. The same absolute loss may be small proportionately to total sales but large proportionately to the margin of profit.

B—THE AVERAGE LOSS BY ABSENCE

Apart from statistics of strikes, information as to the rates of absence in industry, whether full absence or mere lateness, is by no means as abundant as the information concerning rates of turnover.

§ 1. *Full Absence*

In America, the most extensive series of published absence rates are those for 90 shipyards during the first nine months of 1918, as collected by the Industrial Relations Division of the Emergency Fleet Corporation.¹ The rate is not worked out on an hourly basis but covers only full days lost. The final averages for all the steel-ship and wood-ship yards are given separately in the following table. They amount to 17.8 per cent. and 13.2 per cent. respectively. The averages for the various local groups of yards vary all the way from 8.0 per cent. to 23.7 per cent., the Eastern groups of yards having the highest rates of absence (none below 15.1 per cent.), and the Pacific groups of yards the lowest (none above 12.4 per cent.).

For manufacturing industry there is nothing corresponding to the extensive researches of the U.S. Bureau of Labor Statistics made in the case of turnover. We have to rely on the publications of individual plants and occasional community surveys. One very ambitious survey undertaken by the Pennsylvania State Chamber of Commerce covering the whole state unfortunately coincided with the great epidemic of influenza in the autumn of 1918, and the results cannot be used as a *normal* experience.

The American experience of absence in *manufacture* appears from Table 18 to vary all the way from 1.35 per cent. to 11.30 per cent. On analysis, however, the normal experience will not appear quite so indeterminate as this wide range suggests.

There are two factories given with extremely low absentee records: the Joseph and Feiss Company (Item 6) and the large plant at Rochester (Item 3). Both these

¹ Douglas: "Absenteeism in Labor," *Political Science Quarterly*, New York, December 1919.

TABLE 18
AVERAGE RATE OF ABSENCE IN VARIOUS INDUSTRIES
American Experience, 1915-1922

Item.	Industry, Firm, Period of Study and Reference.	Sex Employed and Proportion of Working Time Lost.
	<i>Manufacturing.</i>	<i>Per cent.</i>
1	8-hour plant (motors), 1917-18 (g)	Mostly men, 5.11
2	10-hour plant (metal-working), 1917-18 (g)	Men and women, 4.95
3	Large plant, Rochester, New York, November 1917 (a)	Men, 1.35; women, 2.77
4	6 "men's" plants, Rochester, New York, November 1917 (a) averaged	Men only, 4.70
5	8 "mixed" plants, Rochester, New York, November 1917 (a) averaged	Men, 2.64; women, 3.52
6	Clothing manufacturing, Joseph and Feiss, Cleveland, Ohio	1915, 1.50; 1916, 2.50
7	Paper box manufacturing, Dennison Co. (b)	Men, 3.50; women, 5.20
8	8 textile mills, Philadelphia (11, XVI, 1):	
	A. April 1920-June 1922	Men and women, 4.60
	B. January 1921-June 1922	Men and women, 4.95
	C. July 1921-June 1922	Men and women, 6.45
9	Hood Rubber Co., 1919-21 (11, XIII, 4)	Men (2/3), women (1/3), 5.49
10	Plant of U.S. Steel Corporation, 6 years (b)	Men, 6.20
11	Cotton mills, 7 towns, South Carolina (b)	Men and women, 11.30
	<i>Shipbuilding.</i>	
12	48 steel shipyards, January-September 1918 (c)	Men only, 17.80
13	42 wood shipyards, January-September 1918 (c)	Men only, 13.20
	<i>Shops-Retail.</i>	
14	Bamberger's, Newark, New Jersey (b)	Mostly women, 5.20
	<i>Offices.</i>	
15	Dennison Co., clerical sales department (b)	Men, 1.10; women, 2.60

(a) Report of Rochester, N.Y., Chamber of Commerce, June 1918.

(b) John S. Keir: "The Reduction of Absences and Lateness," *Annals of American Academy*, Philadelphia, Pa., May 1917.

(c) Paul H. Douglas: "Absenteeism in Labor," *Political Science Quarterly*, New York, December 1919.

plants had taken extreme precautions against absence, the former by visiting all absentees in the home, and the latter by a most liberal bonus system for perfect attendance, so that they may be taken as somewhat exceptional "model" establishments.

A further condition differentiating absence rates in manufacturing plants is, probably, the proportion in which they employ men and women. It will be shown later that women's rates of absence are consistently higher than men's rates.

Another source of difference may be the general type of work in the factory. The rates in factories employing men only (presumably engaged on heavier work) apparently tend to be higher than the men's rates (when distinguished) in mixed factories, where the work might be supposed on the whole to be rather lighter.

Yet in spite of these different conditions, if we except the two "model" plants (Items 3 and 6) and the mills in the Southern States (Item 11) where working hours are still abnormally long and conditions generally rather primitive, all the rates fall within the limits 2·6 per cent. to 6·4 per cent., and the majority of them within the narrow limits 4·6 per cent. to 5·6 per cent. In America a fairly representative average experience of absence would therefore seem to fall at about 5 per cent. of the total time worked.

It must be emphasized that even if these figures can be held to establish a representative rate of absence, this would be representative only in so far as the period from which the experience was drawn was a period of normal business conditions. As a matter of fact, the years 1916-1920, when most of the experience was gathered, were somewhat abnormal as to labour conditions, owing to the heavy war demands and the postwar boom lasting until the middle of 1920. Labour was scarce, and workers were not likely to be discharged immediately for a heavy absence record.

It is at any rate suggestive to notice that at the Hood Rubber Works absence from all causes fell greatly in the last half of 1920, when it averaged 4·23 per cent. as compared with the last half of 1919, when it averaged 5·43 per cent. ; and these lower rates persisted in the first four months

TABLES 19 AND 20
AVERAGE RATE OF ABSENCE IN VARIOUS INDUSTRIES

Factory Number.	Description of Work.	Source.	Number and Period Studied.	Percentage of Working Time Lost.		Hours of Work per Week.
				Total.	Unavoidable.	
<i>TABLE 19: English Experience. Men in War Period.</i>						
1	Light work	Loveday	270 for 15 weeks	5.5	3.6	52½
2	Heavy engineering	Loveday	1,200 for 14 weeks,* April to July 1916	10.6†	7.0†	55-59
3†	Heavy engineering	Loveday	21,250 for 1 week	13.7	4.3	52½
4	Very heavy	Loveday	200 for 8 weeks	14.3‡	4.0‡	49-51‡
5	6-inch shells	Vernon	1,300-700, July 1916 to December 1917	9.6	6.0	63-61
6	9.2 and 15-inch shells	Vernon	1,500-900, August 1916 to December 1917	11.3	5.3	63-61
7	9.2-inch shells	Vernon	1,300-900, August 1916 to April 1917	11.8	7.0	63‡
7	9.2-inch shells	Vernon	1,300-900, June to December 1917	6.0	4.0	54
8	6-inch shells	" Scotch § Factory "	8 weeks, March 3rd to April 21, 1917	5.3	3.3	12-hour shifts
<i>TABLE 20: English Experience. Women in War Period.</i>						
1	Light work	Loveday	290 for 15 weeks	7.6	5.7	52½
3	Shell shops	Loveday	3,770 for 1 week	11.3	1.7	42‡
5	6-inch shells	Vernon	750-1,340, July 1916 to December 1917	12.3	6.4	63-61
6	9.2 and 15-inch shells	Vernon	700-500, August 1916 to December 1917	10.9	3.3	45-42
7	9.2-inch shells	Vernon	400-850, August 1916 to April 1917	7.9	2.8	44‡
7	9.2-inch shells	Vernon	400-850, June to December 1917	7.8	4.3	54
8	6-inch shells	" Scotch § Factory "	March 3rd to April 21, 1917	7.8	6.0	12-hour shifts

* Figures for eight other weeks are also given by Loveday, but these weeks are either scattered or holiday periods.

† Mostly men—includes the women in shell shops referred to in Table 20.

‡ Average calculated, not given by Loveday.

§ See note, Table 21.

of 1921, when the average was 4.10 per cent. in spite of the higher rate of sickness usual at that time of year.

Available English experience is confined to munition factories, and was gathered during the recent war when long hours were generally worked. Tables 19 and 20, summarizing Loveday's (2) and Vernon's (26) findings, show that rates of absence for all reasons fall within the comparatively high limits of 7.6 per cent. to 12.3 per cent. for women and 5.3 per cent. to 14.3 per cent. for men. The wide range of variation in the men's experience appears bound up with the heaviness of the work, and with the total hours of work. Rates from 9.6 per cent. to 14.3 per cent. prevailed in factories 2, 3 and 4, where the work is described as heavy, and in 5, 6 and 7, where the working week was one of over sixty hours. Where the work was lighter and the working week shorter, as in factories 1 and 7, the rates were as low as 5.5 per cent. and 6.0 per cent. The effect of changing hours in any one factory will be taken up in section D, §1.

§ 2. Lateness

As to the actual experienced prevalence of lateness or tardiness, there is little scientific work published. In the U.S. Public Health Service investigation (9) everybody was counted "late" who did not qualify as absent but yet entered the gates after time, or at least after a three-minutes' grace. This investigation found as a result of a census averaged over three days that 1.56 per cent. of the working force was tardy in the 10-hour metal-working plant; and as a result of eleven months of records (September 1916 to July 1917) that 0.71 per cent. were tardy on the average at the 8-hour motor-plant.

The most complete series of figures on tardiness, however, are those obtained by the Rochester Industrial Management Council¹ in 15 local plants during a given month. It was found "by comparing the number of tardiness offenders with the average number on the payroll" . . . that "taking the plant as a whole, there were 10,753 cases of tardiness for a combined average payroll of 12,124 employees." The

¹ Report of Committee of Rochester, N.Y., Chamber of Commerce, June 1918.

ratio of all employees tardy each day to the total working force would thus be approximately 3.5 per cent., on the basis of 25 working days to the month.

§ 3. *Time Lost by Strike and Lockout*

The amount of time lost by strike on the part of employees is properly included in absence. The strike is a *general* absence from the plant, agreed upon beforehand. The strikers themselves hope to return to the plant under some altered condition, and have, indeed, in some recent American strikes spoken of themselves as "vacationists." It is therefore not a case of turnover. Unless the management actually—not merely as a gesture for publicity purposes—discharges all the strikers and does not take them back in the end, the strikers must logically appear on the records as absentees. The strike is, in fact, an absence due to the workers' ill-will, and must take its place beside absence from ill-health and accident.

There is no reason, however, why absence by strike should not be excluded from the general percentage rate of absence. The lost time from this cause is, of course, extremely unevenly distributed. Like the mine explosion which may cause hundreds of deaths in one plant, a strike as it affects any one organization tends to be cataclysmic. For this reason, as also because of the difference in causation, days lost by strike are probably best set apart from the general percentage rate of absence.

For certain purposes, lockouts, where the worker is kept away on the initiative of the *employer* but is not discharged, are distinguished from strikes initiated by the employees. Lockouts in the strict sense of the word are, however, numerically unimportant. In America in the 25 years between 1881 and 1906 there were 36,767 strikes, but only 1,546 lockouts, and although lockouts tend to last two or three times as long, they are still relatively negligible. Nor is the exact origin of disputes always clearly definable; the two forms of dispute will therefore be considered together as "strikes" unless otherwise stated. Both are a temporary absence from the plant organized either by

employee or employer, and are to be sharply distinguished from the turnover due to discharges or "quitting."

In the United States during the 25 years 1881 to 1905 (7, No. 21) 199,954 establishments were affected by a strike or lockout which involved 7,444,279 workers directly and a further two millions indirectly. The average number of workers involved per year directly or indirectly would therefore be roughly twenty-five into nine and a half million, or 380,000. What proportion was this of all workers in industry during these years? The strike statistics refer to groups 2, 3, 4, and 5 in Table 1 (i.e. manufacture, mines, building and transport), and in these groups the total number occupied was, in 1910, 14.3 millions and in 1890 (at the centre of the period), probably some 30 per cent. less. Taking ten millions as a rough estimate, the number involved per year in strikes and lockouts is only 3.8 per cent.

We are told, further, that the disputes lasted on the average 30.8 days, which is roughly one-tenth of the working year. Hence it may be said that in the years 1881 to 1905, only some 0.38 per cent. of total working time was lost by strike or lockout in the United States. Further data provided by the U.S. Bureau of Labor Statistics (11) for the years 1916 to 1921 show that an aggregate of 10,742,738 employees were involved by strike or lockout. The average number per year is 1,790,456 or 12.5 per cent. of the total occupied population in the groups concerned, which numbered in 1910 some 14.3 millions. The average duration of a dispute was in three years still roughly one-tenth of a working year (30.3 days instead of 30.8), so that even in the hectic years 1916 to 1921 approximately only 1.25 per cent. of total working time was lost by strike or lockout in the United States.

By much the same process of arithmetic figures have been arrived at to show "the percentage of aggregate working time occupied by disputes" during the seven years 1901 to 1907 in several English industries.¹ These percentages are as follows: In building 0.07 per cent., in mining and quarrying 0.45 per cent., in metal engineering

¹ *Encyclopædia Britannica*, 12th Edition.

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and shipbuilding 0·13 per cent., in textiles 0·09 per cent., in clothing 0·05 per cent.

In English industry as a whole during the period 1899 to 1913 some 111 million workdays were lost by disputes, including 41 million in 1912 due to the coal strike. The industries involved were Groups 2, 3, 4 and 5 in Table 1 employing in 1911 some 10·4 million workmen, so that the percentage of time lost per year per man averages for the fifteen years 0·7 days, equivalent to 0·23 per cent. of working time. Since the war the proportion of days lost by strikes has greatly increased in England just as it has in America. In the four years 1919 to 1922 approximately 167 million working days have been lost.¹ Calculated on the basis of the 10·4 millions employed in the industries concerned this amounts to some four days per man per year, or one and one-third per cent. of working time. It is clear that the proportion of time lost by strikes, which was relatively so small before the war, has increased very greatly recently.

C—MINIMUM LOSS BY UNAVOIDABLE ABSENCE

Lost time is usually considered to be unavoidable when it is due to *bona fide* sickness of the worker or to a disabling accident, or possibly to circumstances in the family of the employee which necessitate his attendance away from the factory.

But such a use of the word "unavoidable" must not be taken to mean that the employer is quit of all responsibility in these cases. If a machine is left unguarded and an employee receives injuries which lay him up for a month, he loses time "unavoidably" in the sense that once the accident has happened the rest is inevitable; but the cause of the lost time was far from unavoidable. Similarly, a good deal of time lost "unavoidably" by illness might have been saved by improving the hygienic and other conditions of the plant.

In the present section minimum absence is used in the sense that unavoidable lost time is currently used; and that without prejudice to the further inquiry (undertaken in

¹ Ministry of Labour Gazette, January 1923.

Chapters X and XI) as to how far the accidents, sickness, etc., "unavoidably" causing absence, are themselves unavoidable.

§ 1. *Insufficient Evidence of Factory Records*

Direct calculations of these unavoidable causes of lost time have been made in several factories, notably the Hood Rubber Company (11, October 1921), and the factories investigated in England by Loveday (2), Vernon (26), and others. The unavoidable lost time for these English factories was given in Tables 19 and 20, and is seen to vary, in the case of women, all the way from 1.7 per cent. to 6.4 per cent. of scheduled working time, and in the case of men from 3.3 per cent. to 7 per cent. A further and more detailed analysis was made in the case of the "Scotch" shell factory investigated by a Committee of the British Association, and the results may be placed side by side in Table 21 with the equally detailed results from the Hood Rubber Company in America, and some data quoted by Dr. Farr referring to British dockyards as far back as 1854.¹

These records, collected in factories, do not tally as closely as might be wished, and the proportion of hours likely to be lost unavoidably by reason of the workman's accidental injury or his ill-health must be sought indirectly through our knowledge of sickness and accident among the industrial population at large.

The application of this knowledge to the practical purposes of the factory will prove a complicated operation, and readers anxious for the bare result may skip to the summary on page 203. The number of estimates that are hazarded as to the unavoidable minimum, and the wide variation between these estimates, is evidence of the need for such an undertaking. The determination of a "normal" rate of unavoidable lost time will give the costs to be normally allowed on the score of sickness and disability from accident, and will indicate the scale of curative measures that would pay, in the way of reserve workers,

¹ Newsholme; *Elements of Vital Statistics*. London, 1899.

TABLE 21
 PERCENTAGE OF WORKING TIME LOST BY CAUSES SPECIFIED IN FACTORY RECORDS

Cause of Lost Time.	Hood Rubber Company 1919-21.			Scotch Shell Factory.† Average of 8 weeks ending April 21, 1927.		Portsmouth Dockyard, Farr, 1854.	Woolwich Dockyard, Farr, 1854.
	Men.*	Women.*	Men and Women.	Men.	Women.	Labourers.	Labourers.
Sickness	1.48	2.78	2.036	2.68	5.24	1.26	1.29
Industrial accidents ..	0.12	0.04	0.139	0.34	0.39	0.73	1.05
Non-industrial accidents ..	0.07	0.09	0.079	—	—	—	—
By leave	—	—	—	0.22	0.44	—	—

* Days given as lost per employee per 300-day working year are reduced to a percentage through division by 3. These two columns do not entirely tally with the third (given as it stands), which should contain intermediate values.

† British Association Reports, edited by Professor A. W. Kirkaldy. Pitman & Sons.

medical examination, hospital treatment at the factory, etc. The investigation will also disclose what variations are abnormal, suggesting the presence of adverse conditions many of which may be preventable at small cost.

If, for instance, any employer in any given industry, finds the rate of lost time in his plant to be 7 per cent., he is, in the present state of knowledge and advice, quite at sea whether to regard this with equanimity as the inevitable consequence of human frailty, or whether to be terrified at such "excessive" lost time and spend money and energy in the attempt to suppress unnecessary accidents, occupational disease, labour trouble, public-houses or paid agitators.

His doubts can be resolved only by determining how much of the 7 per cent. of lost time is due to the normal prevalence of accident and sickness, how much to an abnormal prevalence, and how much to a further margin resulting from indisposition not amounting to certifiable sickness, or from an apathy making workers unwilling rather than incapable of attendance.

§ 2. Sources and Limits of Unavoidable Absence

The wide divergence in current estimates of unavoidable lost time is due largely to failure in practical analysis. It is useless to estimate unavoidable absence from the disability suffered by the general population, only a proportion of whom are industrially employed; and even "industrial" experience is often taken to include that of the home-keeping wives, daughters and sisters of working men. Again, rates of so-called unemployment due to disability have been quoted in America, but seem to include chronic invalids unemployed for many years.

More subtle forms of misunderstanding arise in two ways:

- (a) Failure to distinguish lost time consequent on ill-health, from lost time consequent on industrial accident.
- (b) Failure to set any limits to the extension of absence, combined with the failure to reject cases of ill-health and accidents not occasioning any absence from work.

(a) The rate of industrial accident varies enormously as between different industries, while the rate of sickness is fairly constant. When the statistics of days lost collected by the Leipzig Sick Fund are analysed for men of a given age-group according to cause as well as industry, the extreme variability of lost time because of accident¹ is at once apparent (Table 36).

The days of disability from sickness, yearly, vary from 5,485 per thousand members in offices and shops to 10,476 in printing and publishing works. The days of disability from accident vary from 345 per thousand members in offices and shops to 3,305 in transportation. The maximum disability from sickness for any industry is less than double the minimum; the maximum disability from accidents for any industry is almost ten times the minimum. In fact it is impossible to speak, for industry in general, of any normal proportion of lost time as a result of accident. Each industry must be considered separately.

In Table 36 days lost owing to accidental injury not sustained in industry are included under accidents. These non-industrial accidents are, however, likely to show a fairly constant rate regardless of particular industries, and may be included in what follows with ill-health and sickness. This is in accordance with the practice of the English National Health Insurance Scheme. In any case the non-industrial accident is not a large source of lost time.

(b) Not all cases of accidents or sickness will result in absence from work in the usual sense. Some cases will not be so serious as to prevent the patient from going to work; others will be so extremely serious that the patient will have to abandon work more or less permanently. Cases in the latter class will swell the factory turnover rate rather than its absence rate.

The duration of disability before a temporarily disabled worker is transferred from the list of absentees to that of turnover depends on the policy of the particular factory employing him. Some factories take the worker's name off

¹ In these figures are included the relatively small proportion of accidents not incurred in industry; but this inclusion would tend to reduce the variation between industries, since outside the place of work employees would be about equally exposed to injury.

the books if his disability lasts, or is likely to last, more than a week. In other factories a month is allowed for recovery or perhaps six months.

It has been necessary to face this same vagueness of definition in health insurance schemes, and it may be noted that 26 to 34 weeks is the limit to temporary sickness in the Leipzig Sick Fund, and 20 weeks in the Austrian Health Insurance scheme; and this definition was roughly copied in the English Health Insurance plan under which invalidity or disablement benefit begins after 26 weeks.

A thorough analysis might, therefore, go so far as to distinguish five degrees of seriousness in sickness or accident, according to the length of disability: (1) No disability, i.e. minor ailments; (2) temporary disability for a week or less; (3) temporary disability for a week to a month; (4) temporary disability for a month to six months; (5) disability for more than half a year—sufficiently serious to be termed "invalidity."

Degree (1) of seriousness affects, if anything, output not absence. Since it is impossible to set up a definite standard to determine how slight an illness or accident must be to justify entire neglect, statistics concerning such cases are more or less meaningless and are for the present best ignored. But the question as to the proportion of accident and sickness cases that fall into the other four classifications is of the utmost importance in estimating the amount of unavoidable absence to be expected in different factories. and it is a question which hitherto has not been satisfactorily tackled. An attempt will be made in spite of the rather complicated calculations involved.

§ 3. *Absence from Industrial Accidents*

The distribution as to length of duration of the disability is not difficult to determine in the case of industrial accidents. The so-called "accident table" gives the probable distribution among 100,000 accidents of fatal and permanent cases, and of cases of all possible durations.

Such tables have been worked out from European and American experience, and have appeared in archives, manuals

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and statistical journals.¹ The proportions given in these standard tables may be roughly summarized for our purposes by "distributing" a hundred accident cases instead of a hundred thousand. This is done in columns (1) and (2) of Table 22.

TABLE 22

CLASSIFICATION OF CASES OF INDUSTRIAL ACCIDENT ACCORDING TO LENGTH OF DISABILITY AND COMPUTATION OF THE PROPORTION OF DAYS LOST BY EACH CLASS OF CASES

	Percentage of Cases Lasting Specified Length.		Average Duration of Cases.	Percentage of Days Lost by Cases of Specified Length.
	(1) American Experience.	(2) European Experience.	(3) American Experience.	(4)
Temporary Disablement:			Days.	
Of less than a week	40	37	3·1	6·8
Of a week to a month * ..	40	43	14·4	34·3
Of a month to half year ..	15	14	70·6	58·9
Fatalities and Disablement of over six months † ..	5	6	—	—

* That is, up to and including disability of four weeks.

† Fatalities do not number at most more than one-fifth of these cases.

The American table goes into great detail as to the frequency of accidents of various lengths, so that it is possible to estimate the average days of disability suffered in each of the length-of-disability classes. This estimated average length is given in column (3) of the table. The average length of disability from accidents lasting from a day to a week is 3·1 days; from a week to a month 14·4 days; and from a month to a half-year 70·6 days.

With this information it is possible to calculate for what proportion of all days of disability, disabilities of the stated

¹ Blanchard, *Liability and Compensation Insurance*, Appleton & Company, 1917; the *Quarterly of the American Statistical Association*, December 1920.

lengths are responsible. Of all disabilities from accident, 37 per cent. to 40 per cent. last on the average 3.1 days, 40 per cent. to 43 per cent. last on the average 14.4 days, and 14 per cent. to 15 per cent. last on the average 70.6 days. It follows that among the 100 accidents of all kinds, the 94 or 95 temporarily disabling accidents will result in some 1,750 days being lost by disability; and that 6.8 per cent. of these days lost will be due to disability lasting a day to a week, 34.3 per cent. to disability lasting a week to a month, and 58.9 per cent. to disability lasting a month to a half-year.

We are now in a position to find the actual proportion of time lost in comparison with total working time as a result of accidents that disable for various periods.

If we turn to Table 33 in Chapter X we find that in 1912 when the nine-hour day was the rule, English metal factories (three groups) suffered accidents disabling for over a week at the rate of 67 per thousand employed. If all accidents disabling for a day or more are to be considered, the rate can be estimated with the help of the accident table (Table 22) at 107.0 per thousand employed. In the American metal industries tabulated in Table 31, Chapter X, the number per thousand temporarily disabled for over a day is 114.1 for 194 machine-building plants, and 120.6 in the iron and steel industry in 1915-19. This is so close to the English experience under a similar length of working day, that we may take 110 disabled per thousand nine-hour day workers as a rough but well authenticated measure of the frequency of temporarily disabling accidents in a very large group of manufacturers. Indeed, while bearing in mind the enormous variation of the accident frequency rate in different industries, it may simplify matters if the metal industry, which is in America the best "documented" industry, is taken as a basis for calculation.

If 110 per thousand employed is the frequency of all temporarily disabling accidents, it follows from our standard table: (1) that $\frac{37 \text{ to } 40}{94 \text{ or } 95}$ of them, i.e. about 45 accidents per year per thousand employed, will probably disable from a day to a week, resulting in a loss of about 45×3.1 days

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in the year per thousand employed, i.e. 139.5 days, which is 0.0382 per cent. of the total time of any one employee (13,950 divided by 365 divided by 1,000).

(2) That $\frac{40 \text{ to } 43}{94 \text{ or } 95}$ of the accidents, i.e. about 48 per year per thousand employed, will probably disable from a week to a month and result in a loss of some 48×14.4 days or 691.2 days in the year per thousand employed, which is 0.19 per cent. of the total time of any one employee.

(3) That $\frac{14 \text{ or } 15}{94 \text{ or } 95}$ of the accidents, or about 17 per year per thousand employed, will probably disable from a month to a half-year and result in a loss of some 1,200.2 days in the year per thousand employed (17×70.6 days), which is 0.33 per cent. of the total time of any one employee.

These percentages of total time lost per man are entered in Table 24, page 204, to two places of decimals.

Table 22 will allow similar calculations to be made as to the accidents in any other industry. The table was formed from the experience of industry as a whole and can therefore be applied fairly generally, though particular industries, of course, show wide deviation from the distribution standardized.¹

§ 4. *Absence from Sickness*

A table dealing with sickness among the industrial classes, exactly similar to that given for accidents, can be based on the proportions found by Heym between cases of sickness lasting longer and shorter periods. Heym's results are based

¹ Under the English accident compensation scheme, accidents disabling for less than a week are not considered and the degrees of seriousness are measured somewhat differently than in our plan. Yet the English statistics are adequate to show that accidents resulting in longer temporary absence (i.e. 4 to 26 weeks) are, relatively to less serious accidents, considerably more numerous in shipping and docks than among factories, mines, quarries, construction and railways, where the relative proportions are much the same. Fatal accidents in the railway industry were, in 1920, 2.2 per cent. of all accidents causing more than a week's disability, and were in construction 1.4 per cent., in docks 1.2 per cent. In shipping and factories the proportion of fatal accidents was much lower, 0.7 per cent. and 0.6 per cent. respectively. Mining also ranked among the lowest, with a percentage of 0.9, though owing to cataclysmic disasters occurring irregularly a wide divergence may be found in any one year.

on twenty-five years' experience of the "Mutual" Insurance Company of Leipzig, and refer to sickness sufficiently severe to necessitate absence from work. The classes of duration used by him are not quite the same as those we require,¹ but by a slight adaptation the distribution of cases of sickness can be given as in columns (a) and (b) of Table 23. The

TABLE 23

CLASSIFICATION OF CASES OF SICKNESS ACCORDING TO LENGTH OF DISABILITY, AND COMPUTATION OF THE PROPORTION OF DAYS LOST BY EACH CLASS OF CASES

	Percentages of Cases Lasting Specified Length.*		Average Duration of Cases (in days).		Percentages of Days Lost by Cases of Specified Length.	
	Men. (a)	Women. (b)	Men. (c)	Women. (d)	Men. (a) × (c) †	Women. (b) × (d) †
1st to 6th days	17.0	8.6	3.5	3.5	2.5	1.0
Week to month	55.6	53.0	14.3	15.8	33.2	26.4
Month to half-year ..	25.1	35.6	61.6	65.1	64.3	72.6
All lengths up to 6 months	97.7	97.2			100.0	100.0
Half-year or more ..	2.3	2.8				
All lengths	100.0	100.0				

* Adapted from Heym, quoted by Prinzing, *Handbuch der Medizinischen Statistik*.

† Expressed as a percentage of 2,392 for men, or 3,182 for women, being approximately the days lost by 97.7 cases of sickness for men (97.2 for women), resulting in all lengths of disability up to a half-year.

¹ To make Heym's table conformable, it is only necessary to find out the percentage of cases lasting from three to four weeks. These cases are probably less numerous than those lasting two to three weeks, which Heym gives, for men as 16.4 per cent. of all cases, and for women as 22.2 per cent. The difference between the number of cases lasting three to four weeks, and the number lasting two to three weeks, is probably about the same as the difference between the number of cases lasting two to three weeks, and those lasting one to two weeks, namely 46 per cent. less for men and 22 per cent. less for women. The proportion of cases lasting three to four weeks may then be estimated as: for men, 54 per cent. of 16.4 per cent. or 8.85 per cent.; and for women, 78 per cent. of 17.3 or 13.50 per cent.; and these proportions may be added to the proportions of cases given in Heym's original table as terminating in the second and third weeks. As a result of this addition, we obtain 55.6 per cent. for men and 53.0 per cent. for women, as the proportion of cases lasting roughly a week to a month.

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low proportion of cases lasting less than a week is noticeable, particularly among women; but when cases of accident and indisposition without medical certificates are subtracted, this does not appear contrary to general experience.

The figures in the last two columns are calculated precisely as those in the last column of Table 22, namely by expressing the product of columns (a) and (c) in the case of men, and (b) and (d) in the case of women, as a percentage of the total days lost in cases lasting less than half a year. For instance, since 17 per cent. of all men's cases last on the average 3.5 days, 55.6 per cent. last on the average 14.3 days, and 25.1 per cent. last on the average 61.6 days; it can be shown that for men, among a hundred cases of sickness of all lengths, the 97.7 cases lasting less than a half-year will result in some 2,392 days of absence; and that 2.5 per cent. of these days of absence will be due to disability lasting a day to a week, 33.2 per cent. to disability lasting a week to a month, and 64.3 per cent. to disability lasting a month to a half-year. These last columns enable us (as in the case of accidents) to calculate the actual proportion of time lost as a result of sickness that disables for various periods.

The evidence collected under the English, German and Austrian National Insurance Schemes points to a loss due to sickness lasting not longer than a half-year of 1.85 per cent. and 2.2 per cent. of all days among men and women respectively. These percentages are entered in column 5 of Table 24. In the case of men it follows from the figures in Table 23 (1) that 2.5 per cent. of this lost time, amounting to 0.05 per cent. of all days, is due to absence from work of less than a week. (2) That 33.2 per cent. of this lost time, amounting to 0.61 per cent. of all days, is due to absence from work lasting a week to a month. (3) That 64.3 per cent. of this lost time, amounting to 1.19 per cent. of all days, is due to absence from work lasting a month to a half-year. These percentages are entered in columns 2, 3 and 4 of Table 24. In these columns percentages are also given for women; they follow in the same way from the figures in the last column of Table 23.

§ 5. *Supplement and Summary*

The percentage of absence that may be taken as unavoidable in the sense defined above depends on the interpretation placed upon "absence." An employee prevented from working for a period longer than six months would *certainly* not be classed as absent, and *probably* would not be so classed if he stayed away longer than a month, and *possibly* would not be so classed if he stayed away longer than a week. The method of classification actually adopted by employers varies so greatly that all these possible limits to absence—six months, one month and one week—have been considered in calculating, in Table 24, the minimum unavoidable absence from sickness and accidents. The results, even where average latitude is allowed in interpreting absence, show a much lower unavoidable absence than is usually postulated, leaving an unexpectedly wide margin of absence possibly avoidable.

If it is the policy of any firm to consider lost time up to six months as absence, then the time lost "unavoidably" by sickness and accident is shown in Table 24 (column 5) to be 2.41 per cent. in the case of men; and it would be 2.76 per cent. in the case of women if they suffered the same proportion of lost time from accident.

These figures must be supplemented by a proportion of lost time due to absence by leave of the management. Such leave is usually granted when the employee is called away unavoidably to attend to family and business emergencies. The proportion of time lost in this way has been calculated from factory records as about 0.4 per cent. for women and 0.2 per cent. for men; and all the time lost in this way can be entered as temporary absence granted only for short periods well within a month.

In the Scotch factory, Table 21, absence by leave accounts for 0.22 per cent. of working time for men, and 0.44 per cent. of working time for women. Studying 1,200 men in a metal-working department for twenty-two weeks, Loveday presents in two separate columns of a table (1) "the percentage ratio of time lost by bad time-keeping to gross normal time, less time lost by leave," and (2) "the percentage

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ratio of time lost by bad time-keeping to gross normal time." The only difference between these two columns is the absence and presence respectively of time lost by leave; and hence, by comparing the figures in the two columns, we can derive the exact amount of leave. The average absence on leave for the twenty-two weeks comes to 0.19 per cent. or roughly a fifth per cent. of the gross normal time, which tallies almost exactly with the men's percentage at the Scotch factory.

TABLE 24
ESTIMATE OF TIME LOST BY TEMPORARY ABSENCE DUE TO PHYSICAL
DISABILITY

Source of Disability. (1)	Percentage of Total Working Time Lost by Temporary Disability of Specified Duration.				
	One Day to just less than a Week. (2)	A Week to a Month. (3)	A Month to a Half-year. (4)	Total all Periods from One Day up to a Half-year. (5)	
By sickness and non-industrial accident, varying mainly according to sex and age	Men	0.05	0.61	1.19	1.85
	Women	0.02	0.58	1.60	2.20
Industrial accident varying mainly according to in- dustry. Metal industry (men)		0.04	0.19	0.33	0.56
All physical disability (men)		0.09	0.80	1.52	2.41

Judging from the increased amount of leave in times when a greater amount of sickness is reported,¹ a frequent cause of leave of absence would be sickness in the family, and the higher estimate for women is not unreasonable in view of the convention that it is the womenfolk of a family who must abandon their work if anything untoward occurs at home, particularly if nursing is required.

The proportion of time lost by unavoidable absence will then, as in Table 25, columns (c) and (d), add up to 2.61 per cent. for men, and 3.16 per cent. for women—supposing

¹ See parallelism in month-by-month rates of absence for sickness and for personal reasons reported by Hood Rubber Company (11, October 1921).

women to suffer the same rate of accident. This amounts in the case of men to 9.53 calendar days or 7.83 out of the (approximately) 300 working days in the year; in the case of women to 11.53 calendar days, or 9.48 working days, lost in the year.

A narrower interpretation may, however, be placed upon absence. One month's disability is probably nearer the limit where the employer replaces the disabled employee, making the case one of turnover rather than absence. This does not mean that a man disabled for more than a month cannot return to his employment later, but simply that he will then appear on the books as re-hired rather than absent, and may very possibly be placed on another job.

On this strict interpretation of absence to exclude all time lost above a month's duration, the total unavoidable absence adds up as in Table 25, columns (a) and (b).

TABLE 25

ESTIMATE OF UNAVOIDABLE ABSENCE FROM ALL CAUSES

	Exclusive of Time Lost over One Month.		Exclusive of Time Lost over a Half-year.	
	Men. (a)	Women. (b)	Men. (c)	Women. (d)
On account of sickness and non-industrial accidents (all industries)	0.66	0.60	1.85	2.20
On account of leave (all industries)	0.20	0.40	0.20	0.40
On account of industrial accidents (metal industries)	0.22	0.22	0.56	0.56
Total unavoidable absence..	1.08	1.22	2.61	3.16

The 1.08 per cent. of time lost unavoidably by men in absence of not more than a month is equivalent to 3.94 calendar days or 3.24 out of the (approximately) 300 working days in the year. The 1.22 per cent. of time similarly lost by women is equivalent to 4.45 calendar days or 3.66 working days.

It must be emphasized that we have been dealing through-

out with absence due to sickness, not sickness itself; and though malingering has been excluded, the possibility of its opposite, the practice of shamming good health, has not. Where the loss of a few days' pay may mean an approach to starvation, this practice should occasion no surprise. Indeed there is some remarkable evidence indicating that absence from work owing to sickness is considerably less among the industrial classes than among classes more well-to-do. Yet however unfortunate and important such a revelation, it does not affect the question of the proportion of time actually lost unavoidably in industry, and its discussion is therefore postponed.

The total proportion of time lost by absence unavoidably and avoidably is very considerably higher than the 1, 2, or 3 per cent. found to be lost unavoidably. If the experience of American and English firms quoted above is to be trusted, time lost by absence is more of the order of 5 per cent. to 8 per cent. The wide margin between total and avoidable absence points to the importance of avoidable causes. These causes may lie either in conditions peculiar to the firm, which tend to increase its record of sickness and accidents, or more probably (since more or less model conditions usually prevail at the few factories that do keep adequate records) these avoidable causes lie in the vague indisposition of employees to work under the conditions of employment offered them in factories generally.

D—CONDITIONS OF EXCESSIVE LOSS

§ 1. *Effect of Hours and Other Working Conditions*

An increase in the nominal or "scheduled" hours of work has usually been found associated with increased rates of absence. An example I collected in England during the early years of the war, but hitherto not published, is particularly striking. The figures were obtained at a large shipyard and munition factory employing 11,096 workers at the end of 1914, and 14,025 at the end of 1915. At the outbreak of war in 1914 the hours were enormously increased. Instead of employing men almost exclusively, on a 9½-hour day six days a week, the plant now employed men and

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women on two shifts, day and night. The men's dayshift consisted of $9\frac{1}{2}$ hours' full work and the nightshift $11\frac{1}{2}$ hours; for the women both shifts lasted $10\frac{1}{2}$ hours. Some seven hours were also worked on Sunday.

Before this increase in hours the plant had been accustomed to an absence rate less than 6 per cent. Table 26 enables us to follow the course of absence as the long hours were persisted in.

TABLE 26
PERCENTAGE OF WORKING DAYS LOST FOLLOWING INTRODUCTION OF
TWELVE-HOUR SHIFTS
Large English Shipyard and Munition Plant

	All Departments (25 in number).		Twenty-one Departments employing Men only.			
			Dayshift.		Nightshift.	
	1914.	1915.	1914.	1915.	1914.	1915.
In the midmost week in :	/					
September ..	7.9	11.3	9.8	14.1	3.1	6.9
October ..	9.4	11.6	—	—	—	—
November ..	10.6	12.9	—	—	—	—
December ..	9.4	12.8	11.6	16.5	4.8	7.2
Average ..	9.3	12.2				

To eliminate seasonal variation we should compare the same month for the two years 1914 and 1915. The rate begins in September 1914 much higher than normal, and in every month and shift there is a considerable increase in the course of 1915. The average increase in absence between the same months of the two years in all departments was from 9.3 per cent. to 12.2 per cent., almost one-third again.

Referring to Tables 19 and 20, further evidence is found of the effect of hours of work on absence. In Factory "7," quoted by Vernon (26), the men's hours per week were reduced in the spring of 1917 from $63\frac{1}{4}$ to 54, while the

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women's hours were increased at that time from $44\frac{1}{2}$ to 54. Before this time the men lost 11.8 per cent. of their time, the women 7.9 per cent.; after the reduction of the men's hours and the increase of the women's, the men lost only 6.0 per cent. of their time, while the women lost 7.8 per cent. Taking 11.8 per cent. from $63\frac{1}{2}$ leaves 56 hours, and 6 per cent. from 54 leaves 51 hours; so that, in the case of men, a nominal week of 54 hours meant only 5 hours less of actual work than a nominal week of $63\frac{1}{2}$. Sometimes it actually happens that a decrease in nominal hours results in an increase of actual hours of work. Thus, when between April and November the nominal hours of 56 men sizing fuse bodies (Table 28) were reduced from 62.8 to 56.5 per week, actual hours worked after the change were 51.2 as against 50.5.

Where the schedule of hours of work is not changed, and observation is confined to the effect of consecutive days of work, a remarkable similarity in the week's curve of absence has been shown in the most widely different places of work. Records were kept for 1919 and 1920 at the Hood Rubber Company, an American factory employing men and women (11, October 1921), and for June and August 1918 in coal mines in South Wales (25). In both places, and in each investigation in each place, the curve starts very high on Monday, forms a trough in the middle of the week, and turns upwards again on Saturday. The lost time on Saturdays, however, is never as high as that on Mondays. In the case of the coal mines, the absence on Mondays is almost double that on Fridays. At the rubber factory the differences are not so great; the percentage of time lost for the consecutive days of the week were in 1919—6.34, 5.83, 5.33, 5.30, 5.51, 6.03; in 1920—5.77, 5.65, 5.29, 5.30, 5.18, 5.43.

Lateness, at the American 8-hour motor plant constantly referred to, was found to follow much the same rule. On Monday the number of men late was the highest (8.2); the record from Tuesday to Saturday then took the following course, 7.4, 6.8, 7.2, 6.8, 6.4.

In the different departments of the same motor plant absence rates were recorded and related to comparative

physical conditions in the same way as were turnover rates.²

It was found that whereas the rate of absence for all men's departments was 6.13, the rate averaged 6.29 per cent. in the nine departments where eye strain was greatest, 6.38 per cent. in the nine departments where muscular strain was greatest, 6.45 per cent. in the thirteen departments where the air conditions were poorest, and 6.82 per cent. in the five noisiest departments. Bad lighting and night-work seemed to carry no excessive absence hazard.

§ 2. *Effect of Sex, Living Conditions and Affiliations of Workers Employed*

The rate of absence for men and women is quoted separately in Table 18 for several American plants. In all cases the women's rate of absence is considerably higher than the men's in the same plant: 2.77 per cent. as against 1.35 per cent. (item 3); 3.52 per cent. as against 2.64 per cent. (item 5); 5.20 per cent. as against 3.50 per cent. (item 7); 2.60 per cent. as against 1.10 per cent. (item 15).

Comparisons between the rate of absence of men and women were made, for six months only, in the Philadelphia textile mills (item 8). In mills A, B and C, and a fourth (D) not hitherto mentioned, the time lost was, for men, 3.2 per cent., 3.4 per cent., 4.5 per cent., and 3.7 per cent. respectively of normal working time; for women the corresponding rates in the four mills were 5.9 per cent., 5.4 per cent., 6.4 per cent. and 7.6 per cent. respectively.

In their survey of fifteen local plants (items 3, 4 and 5, Table 18) the Rochester Industrial Management Council reports as follows:

There has been more dispute as to whether the common impression that absenteeism is more prevalent among women than men is actually true. In order to get statistics on comparative bases which are accurately weighted, differentiation has been made as to the hours lost by males and by females. The returns show that 51,357 hours were lost by men and 18,387 by women. The average number of males, however, was 9,410, and the average number of females 2,714. This makes the average length of time lost by each male 5.46 hours and for each female 6.78 hours, so absenteeism is actually greater among women than among men.

² See Chapter VI, p. 164.

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In the matter of tardiness, 9,410 men were found to have 7,026 cases in the month which, on the basis of twenty-five working days to the month, makes a rate of $\frac{7,026}{9,410} \times \frac{100}{25} = 2.9$ per cent. approximately; 2,714 women were found to have 3,059 cases of tardiness in the month, equivalent to a rate of approximately 4.5 per cent.

English experience also shows higher rates of absence among women. Comparison where the hours worked by the sexes is the same, is possible in the case of factories 1, 5 and 8 in Tables 19 and 20. In each case the women's percentage rates are higher: (1) 7.6 as against 5.5; (5) 12.3 as against 9.6; (9) 7.8 as against 5.3.

Women, as we know, have a greater liability to unavoidable absence from temporary sickness not lasting more than six months (see above, Table 24). But this, the usual interpretation of their heavier rate of absence, is not sufficient to account for the whole difference between the rates of absence of the two sexes. The conventional sacrifice of women, particularly married women, in family emergencies has already been alluded to; and the inferior wages of women may also be partly responsible. Where a single woman puts her earnings into a family pool, her day's work is usually of less account than that of the menfolk; and where a woman is on her own, she may prefer to take a day off for doing her own housework and laundry rather than pay out more than a day's wages in employing someone else to do it.

If our analysis of unavoidable absence is correct and physical disability is of less importance than is usually supposed, more attention should certainly be devoted to the psychological, social and economic conditions. The dependence of living conditions on the amount of wages earned suggests a study of the relation between wages and absence as a profitable undertaking.

The theory of the economy of high wages receives a severe blow in the fact noted by Vernon among the English shipbuilding crafts, that lost time increases with increases in the scale of pay and falls with a decrease in the scale. For instance, in the case of drillers, "time-keeping was poor

in 1900 to 1902 when pay was fairly good, whilst it was good from 1904 to 1909 when pay was low. Then it gradually got worse again as pay improved, and it was specially bad in 1912 to 1913 when pay was at its maximum" (26).

If it is assumed that a worker's object is merely to attain a given standard of living, these facts would be explicable. The more the worker receives per piece or per hour, the fewer pieces or hours he need have to his credit in order to earn a given weekly sum of money. The only remedy, if indeed one wishes to remedy an increase in the worker's leisure, is to attract the wage-earner to a higher standard of life. More statistical data are required before one can accept a theory assuming a fixed standard of life, though it is interesting to note the similarity of such a theory to the observation of Sargant (22) that classes of investors who require merely a stationary income will save less when the rate of interest is raised.

Time lost by strikes is usually associated with the worker's affiliation to trade unions; but this should not be taken as a universal rule. In America from 1881 to 1905 10 per cent. of strikes are tabulated as not ordered by a labour organization, and during six months of 1917 the National Industrial Conference Board (Report No. 3) found that in 13.9 per cent. of the establishments affected by strike there were no trade unionists at all among the strikers.

Though success is, according to H. L. Moore,¹ more likely to attend *an organized* strike, particularly if the *whole* industry is well organized, employers barring trade unionism under the American open-shop (*sic*) policy cannot be considered by any means immune from industrial disputes and stoppage of work.

¹ *Laws of Wages*. Macmillan, New York, 1911.

CHAPTER VIII

THE LOSS BY DEFICIENCY OF OUTPUT

DEFICIENT output implies to the piece worker a loss of wages, to the time worker possible discharge ; and it is often bewailed by business men as nothing short of a national calamity.

Vernon (26), quoting Lord Leverhulme, tabulates the " value of goods produced by each worker " in 1886, 1906 and 1912 in the United Kingdom, the United States and certain British Dominions, much to the disparagement of the Mother Country. Fortunately for her these figures are of very doubtful authenticity. The only year for which anything certain is known of English productivity is the year 1907, when the first, and as yet, the last Census of Production was taken, and the higher output per head given for earlier years must have been calculated on an altogether different basis.

There are pitfalls enough for the unwary when comparing different countries merely for any one year. Industries included in one country are omitted in the other. The English Census includes mines, the American does not ; and the *gross* output per head (the measure apparently used) is exceptionally low for mines in all countries.

To give the value of output per head rather than the physical quantity, and to translate one currency into another at mint par, is also to be deprecated. A dollar in America does not buy, and probably never has bought, the same quantity of commodities as 4s. 1½d. in England.

Lord Leverhulme, followed tentatively by Vernon, proceeds to lay the blame for this questionable inferiority in output on the greater prevalence in England of deliberate restriction of output—a still more questionable inference.

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The only evidence produced is the bare statement of Mr. Gompers that "there has not been any restriction of output for over thirty years in America." And this in the face of the statistical evidence presented by the U.S. Public Health Service (10) and quoted by Vernon himself! "Soldiering," a purely American term, has the precise connotation of the English—or Scotch—"Ca'canny."

The difficulties of comparing human productivity are mainly difficulties of isolation and enumeration.

The mechanical factor often cannot be eliminated, and it is impossible to estimate the relative importance of the part played by machinery and men in different countries, factories or departments of a factory.

Technical progress in design of machines and equipment, and in labour-saving devices is the pre-eminent reason for increased output per head employed. Under the present industrial regime labour and labour administration is not responsible for this.

The varieties in form of product and raw material prevent enumeration in uniform units. Extractive industries such as mining and agriculture result in a fairly simple and often gradeable product, but have variable fertility or accessibility to contend with. Finishing trades such as the clothing, engineering, boot and shoe, publishing, and building industries, use fairly uniform materials, but yield a great variety of products, rendering comparisons impossible.

Industries in the middle stages of the productive process are perhaps the most amenable to measurement. Textile industries, for instance, make graded wool or cotton into uniform cloth; the iron and steel group make uniform homogeneous pigs or ingots out of ore of given quality, and a similar conjuncture of homogeneous measurable material and product is presented in paper-making, tanning, rolling, saw and flour mills, etc.

Generally, however, comparable statistics of output cannot be presented *en masse*. Attention must be concentrated on the specific effect of adjusting specific conditions, rather than dissipated in the contemplation of average results over a wide range of industries.

Section B, therefore, falls behind Section D in impor-

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tance, and will in fact be combined in this chapter with Section C.

A—COST OF DEFICIENT OUTPUT

There is little need to labour the aspect of cost where deficient output is concerned. Given a certain equipment—buildings, power installation, machines and organization—it is obvious that the more that can be got out of the equipment, the greater will be the gains, and that once the expenses of the equipment ("the overhead") are covered, additional increments of product will result in a more than proportionate gain. If it takes a hundred units of product per day to cover the overhead, an increase in gross productivity from 110 to 120 units (i.e. some 9 per cent.) will increase the net gain from 10 to 20, i.e. 100 per cent. Contrariwise, a fall in productivity from 110 to 105, i.e. only some 4½ per cent., will mean a net loss of 50 per cent.

In fact, in estimating the costs of deficient output, the element of excess overhead assumes a greater importance than ever; the other element, the cost of repair, dwindles in comparison. If employees have all reported at the plant and are present at bench or machine, there is no cure for low output to be found in replacement or re-alignment; the places and the lines are filled. If more workers must be employed and brought into line to make up deficiencies in production, new buildings, new machines and a larger organization must first be provided; and if longer hours are imposed in the hope of yielding a larger output the plan, as we shall see, is likely to defeat itself.

One solution of the repair type is proposed, however, by Lord Leverhulme,¹ who puts forward a powerful plea, based on considerations of cost, for working two dayshifts, each of six hours' duration. His argument consists of two distinct stages, one supporting the two-shift scheme, the other supporting the reduction of hours. Leaving for the moment the effect on productivity of reduced hours, Lord Leverhulme first takes the case that the productivity of each man will be reduced exactly in proportion to the reduction of his hours.

¹ *The Six-Hour Day*. George Allen & Unwin, London, 1918.

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This lowered productivity per man, he then shows, can be entirely offset by the additional use made of the machinery when two shifts are worked or, in other words, when the number of men is "reinforced."

The argument runs somewhat as follows :

Assume (1) that overhead expenses are equal to the cost of direct wages. In Lord Leverhulme's opinion this is actually the case in the textile industry, and in "most workshops and factories the cost of production in the form of overhead charges is double or more than cost of wages."

Assume (2) that no increase in productivity per man per hour takes place as a result of shortened hours.

Assume (3) that, in spite of this, the same wages are paid for the shorter work-day as for the longer.

Assume (4) that the overhead is not affected by the change in hours. This assumption discounts the possible additional repairs and depreciation by wear and tear that might be expected when increasing the period of plant operation, but Lord Leverhulme states that "machinery almost invariably becomes obsolete before it is worn out."

Now take the case of the production of a thousand items on a 48-hour week, one-shift basis, and suppose the cost of wages and of overhead to be £1,000 each according to assumption (1). We then obtain the following statement of the cost of converting raw material into the finished product :

Cost of overhead	..	..	..	..	£1,000
Cost of wages	..	..	..	..	£1,000
					£2,000
Total " conversion " cost	..	..	..	..	£2,000
Items produced	..	..	..	..	1,000
Conversion cost per item	..	..	..	..	£2

Now take the case of production on the basis of two shifts, each working 36 hours, the plant thus being in operation 72 hours per week. We then obtain the following financial

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statement where the employees are paid the same for 36 hours as for 48, according to assumption (3).

Cost of overhead	£1,000
Cost of wages of two shifts	£2,000
	<hr/>
Total "conversion" cost	£3,000
	<hr/>
Items produced by double shifts	
$100 \times \frac{72}{48} =$	1,500
Cost per item	£2

Double the number of workers have produced only one and a half times as much, productivity per man per day has fallen 25 per cent. ; yet the cost of production per item is still the same.

Thus the working of shifts, or "reinforcement" as we have called it, is to a certain extent a cure for the expenses of low production ; yet, as in all cases of repair (replacement, realignment or reinforcement), no real prevention of labour losses takes place.

To show the effect of real prevention on cost the conclusions arrived at in Section D must be anticipated to the extent of admitting that a reduction of hours tends to increase the hourly output. This anticipation enables us to follow the argument to its second stage, that supporting the reduction of hours for its own sake.

If, abandoning assumption (2), we assume with Lord Leverhulme that a reduction of hours from 8 to 6 will increase the productivity per man per hour to such an extent that the productivity per man per day will not suffer,¹ then the financial results of the one-shift and two-shift system may be contrasted as follows :

	One-shift 48-hour week.	Two shifts each of 36 hours per week.
Cost of overhead	£1,000 ..	£1,000 ..
Cost of wages.. .. .	£1,000 ..	£2,000 ..
	<hr/>	<hr/>
Total "conversion" cost	£2,000 ..	£3,000 ..
Items produced	1,000 ..	2,000 ..
Cost per item	£2 ..	£1.5 or £1 10s.
Saving in cost per item	£0.5 or 10s.	

¹ The actual experience of the effect on hourly productivity of shortening hours is given in Section D § 1.

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Employers, however, may not choose to meet a fall in output by reinforcement (i.e. working shifts) or by prevention. What, then, is the extent of the costs that will pile up through excess overhead or otherwise? When discussing the cost of absence, we assumed an increase in absence of 10 per cent. and in consequence a fall of 10 per cent. in the output. Offsetting this, however, was the fact that 10 per cent. less in wages need be paid, leading not a few to suppose that absence cancelled its own cost. In the case of deficient output even a surface view such as this would not fail to detect a loss. Once men are present in the plant *all time wages are paid regardless of productivity*. Hence all deficiency in output on the part of men paid on a time basis is obviously a dead loss to the plant. Besides this loss peculiar to deficient output, the same costs result from deficient output as from absence. Though the output has fallen, there are, nevertheless, the following overhead expenses to keep up at their full level:

- (1) The expense of maintaining the physical equipment in condition, or else allowing for depreciation on account of exposure and obsolescence.
- (2) The expense of maintaining the administrative staff.
- (3) The expense of heating, lighting and ventilating; for the working force needs the same warmth, light and ventilation whether producing much or little.
- (4) The expense of running the shafting and belting connecting the power house with the machines.

Where the workers are all present there is not the same chance of reducing the number of foremen or the amount of heat, light and ventilation, or of shutting off the shafting to any set of machines, as exists when a proportion are absent, so that retrenchment in items (2), (3) and (4) is even more difficult to set against deficiency in output.

The maladjustment between the direct producer whose pay is chargeable in full to the product, and the indirect producer "about" the plant, is also likely to be costly if either the one or the other fails in productivity. This maladjustment would appear in an increased overhead per given product chargeable to indirect labour. For if it is the direct producer whose output has fallen, then there is

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less product to show for each indirect producer ; and if it is the indirect producer whose productivity has fallen, he will get behindhand as the product accumulates, and an additional force of indirect producers will have to be taken on.

For an estimate of the total cost of any given degree (say 10 per cent.) of deficiency in output, reference can be made to the estimates put forward in connection with the cost of absence. Since deficient output is probably more costly than absence of the same degree, these estimates will tend to understate the case against deficient output.

BC—AVERAGE AND MINIMUM LOSS BY DEFICIENT OUTPUT

A detailed analysis has been made of the minimum rate of absence to be expected, taking into consideration the physical disability prevalent among the industrial population. This minimum is largely unavoidable by any particular industrial establishment ; a similar minimum could also be calculated for deficiencies in output. Output suffers equally from man's physical disability, and it is just as important for the practical business executive to know how much he can expect to reduce deficiency in output, as deficiency in attendance. The data for such a calculation are, however, too fragmentary. Without any attempt to estimate their extent and force we can but indicate the general principles involved.

Deficiency may be found when comparing the output of one individual with that of another, or when comparing the output of the same workers at different times ; or again, the deficiency may be measured by some ideal standard of output occurring under specified conditions.

The Existence of Variation

The first principle to be insisted upon is that uniformity of output must not be expected as between individuals, or as between different occasions in the case of the same individual. So far from a normal uniformity among individuals there is, in fact, a well-established normal "error." We

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do not expect all men to be of the same height; on the contrary we should expect individuals among a group of "normal" men to vary considerably. Most will be near the average height of, say, 5 feet 7 inches, but quite a few will be below 5 feet 3 inches and above 5 feet 11 inches. Similarly we may expect that the majority among a group of men and women selected at random, will show a working speed close to the average, but that a few will be extremely fast and a few extremely slow.

Continuous uniformity, too, in the output of any one individual must be taken as somewhat supernatural. It is known that the human being varies in temperature, pulse-rate, etc., in the various hours of the day, and it is taken for granted also that he will have off-days—be in better health on some days than on others. Apart from the general condition of the worker, minor ailments such as headaches, and minor accidents such as cuts or scratches, do not entail lost time, but are yet unquestionably responsible for lowered working capacity.

Indeed, a strict uniformity in output among different individuals at different times should actually make an employer anxious. It is an almost positive sign of deliberate restriction of output. Any figure of output appearing over and over again—almost stereotyped—such as I found in certain English and American munition factories¹ is probably a "stint" or "doggie" tacitly or openly agreed upon by the workers.

Yet in spite of these sinister examples and the insistence on natural variation by physiology, psychology and anthropology, employers of labour have been led by certain enthusiasts to expect rigid standards of output among their employees. There is talk of 80 per cent. efficiency, 150 per cent. efficiency, the standard time of operation, the standard task, the "one way" to perform an operation. The reader will perhaps recognize some of the slogans of "scientific management." But what is this standard, this 100 per cent. efficiency, or task, or "one way"?

Too often we shall find the one standard of output calculated—with percentage allowance for "fatigue" no

¹ See 2, p. 72, and 9, Chapter 4.

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doubt—from the efforts of one or two of the more efficient workers on one or two special occasions, and everybody at all times is expected to conform to this standard. Yet it seems a perversion to estimate the rate of output which an average man can maintain, by studying the speed of the most productive worker at one or two (possibly the most productive) periods. The relation of this probably extreme speed to a speed possible to the average man is unknown. If a dozen men are picked at random, their average height will probably not be far from the well-known average height for men in general; but it will be hard to predict from the height of the tallest man a probable height for the average. For any one worker, too, readings taken at different times will show a few extremely slow and a few extremely fast records, and it is difficult to infer from his fastest record what the worker can do on the average.

This idea of "standard," which was originated mainly by engineers, was no doubt obtained from the mechanical world. A machine may be expected to act fairly uniformly at different times (though even here there is a theory of the fatigue of metals), and innumerable machines and tools can be turned out in replica. It is necessary only to test a machine once or twice, or to take a sample of machine products, to be sure that standards are satisfied. But the behaviour of human beings cannot be measured by simple laboratory tests. Statistical methods are essential. Unless the conception of a normal variation in working capacities is understood, and the amount and form of variation investigated in different types of work, the standard set will, in the long run, be found to be outside the bounds of human capacity.

The practical question to ask is, how far any actual deficiencies in output are in conformity or not in conformity with variations and sequencies to be normally expected of the human being.

The facts as to the human being are :

1. The normal existence of variation in the average output of different individuals.
2. The normal existence of variation in the daily or hourly output of the same individual.

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Individual Variations

Recent discoveries in the matter of variation between individuals are discussed fully in a paper which I read before the British Association meeting at Liverpool in 1923, and only a brief summary can be given here.¹

In an American metal factory I was able to observe in detail the work of fourteen women painting a solder mixture

TABLE 27
VARIATIONS IN DAILY AND HOURLY OUTPUT OF INDIVIDUALS

Hourly Rate of Output.	Fourteen Women Charging Buttons over a Period of 4 Weeks to 4 Months.	
	Number of Records showing Output at Specified Rate.	
	Among Daily Records of Individual's Output, Whole Period.	Among Hourly Records of Individual's Output, Selected Period.
Less than 1.4 lb.	—	23
1.4 lb. and less than 1.6	2	35
1.6 lb. and less than 1.8	16	59
1.8 lb. and less than 2.0	25	128
2.0 lb. and less than 2.2	86	245
2.2 lb. and less than 2.4	128	319
2.4 lb. and less than 2.6	139	351
2.6 lb. and less than 2.8	126	322
2.8 lb. and less than 3.0	58	252
3.0 lb. and less than 3.2	3	194
3.2 lb. and less than 3.4	—	101
3.4 lb. and less than 3.6	—	35
3.6 lb. or more	—	16
All rates of output	583	2,080

by hand on the backs of buttons. No machinery was employed in this operation, and there was a total range of variation in each individual's average output as between 78.1 per cent. and 117.8 per cent. of the average output for the group. The mean variation² was 8.8 per cent.

¹ See 19, "Individual Variations in Efficiency and the Analysis of the Work Curve," published (in English) in the *Archiv. für Weltwirtschaft*, Kiel. Much of the summary given here appeared in my "Recent Researches in Industrial Fatigue," published in *The Economic Journal* for June 1923.

² The variation shown by averaging all the individual variations.

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A variation no less wide is found by the Fatigue Research Board (4) in cotton weaving on automatic looms. Wyatt (Report No. 7) finds a total range of variation from 73 per cent. to 126 per cent. of average weekly output among 752 plain weavers; of 75 per cent. to 119 per cent. among 46 winders, and of 65 per cent. to 132 per cent. among 423 fancy weavers. The mean variation in these three operations was 6.0 per cent., 8.3 per cent. and 10 per cent. respectively of the average output. In silk weaving (Report No. 17) Elton finds mean variations ranging from 8.2 per cent. of average output to 16.8 per cent. among nineteen groups weaving varieties of plain cloths on automatic looms.

Other operations in the textile industry such as ring and mule spinning show (Report No. 7) only the slightest variations, e.g. a mean variation of 2.0 per cent. and 1.9 per cent. It is evident that the machine is here setting the pace, and that output forms but an inadequate measure of the functioning of the human body.

In the observations carried out in America I found as an additional characteristic of output obtained from machines that the distribution was negatively skewed. The probability is that the speed of the machine prohibited a greater output per hour than a certain amount, but set no limit at the lower end of the scale. A similar negative skew was also observed wherever there was a tendency to the deliberate restriction of output (9, pp. 89-91), and the same interpretation is possible, though here it is the human will, not the machine, that places limits at the fast end of the scale. In fact the uniform stereotyping of one figure of output is probably the limiting case, i.e. a complete negative skew.

Report No. 17 of the Fatigue Research Board carries the matter yet further. It is shown that the "efficiencies" with which silk weavers finish similar warps distribute themselves approximately in a curve of "normal error." Studying the individual outputs in the button-making operation mentioned above, I arrived some years ago at the same result. Not merely did the hourly and daily outputs of the whole squad form a curve approximating that of normal error, but the same was true for the daily outputs of each individual worker, and indeed of their hourly records.

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The variations of individual's daily and hourly outputs in the case of the button-chargers are set forth in Table 27 reproduced from the paper read to the British Association;

The *daily* outputs of individuals in this group vary from a rate of less than 1·6 pounds per hour, to a rate of more than 3 pounds, with an average rate of about 2·45 pounds. The maximum is almost double the minimum, and the extremes deviate from the average value some 25 per cent. to 35 per cent.

The *hourly* outputs in the selected period vary from less than 1·4 pounds to more than 3·6 pounds, with an average value of about 2·5 pounds of buttons per hour; i.e. the maximum is over two and a half times the minimum and each extreme is about 45 per cent. from the average value. Yet some 72 per cent. of all records (1,489 out of 2,080) have values between 2·0 and 3·0 pounds per hour and deviate not more than 20 per cent. from the average value.

The form of distribution, particularly in the case of the hourly output, seems to approximate to the normal curve, e.g. of men's heights, and it is the absence of this variation without any mechanical justification that should put an employer on the alert. Indeed the expectation of a normal distribution of daily outputs among individuals hired at random may serve as a basis from which to assess the value of any bonuses or psychological selection he may introduce, or to detect restriction of output. He may be guided by the following rules:

(1) If the daily output distribution of a squad of workers in any operation has a narrow dispersion, is not symmetrical or normally distributed, but is greatly skewed negatively, and the operation is not mechanically limited, the deliberate human restriction of output is indicated.

(2) If the daily output distribution in any operation has a relatively narrow dispersion and is skewed positively, after the introduction of selection of employees by test or examination, this would indicate the elimination of the less productive workers from a random group, and is a sign of a successful system of selection.

(3) If the daily output distribution in any operation has a relatively wide dispersion after an "efficiency" system of

wage payment is introduced, this would indicate success in increasing incentive and stimulating the departure of individuals from a common dead level.

Daily and Hourly Variations

Work and rest are not the only events in the life of the human being, and as work is continuously engaged in the worker is at the same time moving away from and toward the periods of sleep, meals, excretion, entertainment, etc., occurring at more or less definite times of day. Even if no work were performed and life were all rest, these other events might be expected to influence the average curve of output, and hence this curve cannot be entirely attributed to the occurrence of work and rest.

Unfortunately, though the unemployed and the idle rich offer an ample field, the life of idleness has not been impartially investigated. Not merely would such an investigation tell us what precise part of the variation in the output curve was due to continuous work, but an answer might be obtained to the practical question as to *when* man is most productive in contradistinction to the question of *how long* he can remain productive. A 6-hour shift working from 6 a.m. to 12 noon may or may not yield more output than a shift working an exactly equal term of hours, say from 1 p.m. to 7 p.m.; and similarly night work as a whole may or may not be more deficient in output than day work of an equal length.

In comparing the different hours of continuous work by day or night, however, the effects of pure duration of work are distinguished in one particular from the effects attributable to the mere time of occurrence.

In the course of the day events other than the continuation of work usually occur only once. In working-class families, as a rule, there is only one heavy meal, only one time for entertainment (the evening) and one period of sleep. Periods of continuous work (i.e. spells) on the other hand are at least two in number. Hence the variations not due to work should fall into one diurnal curve, while variations that are due to work should effect several curves

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according to the number of spells of continuous work. In this way the excess loss by deficient output owing to industrial conditions such as hours of work, can be distinguished from the minimum loss to be expected from the variability of the human organism as such.

A further variation that is normally to be expected in the daily (if not hourly) output of any individual occurs in the course of learning. Through learning, as distinguished from practice or warming up, a man increases the quality or quantity of his output by the acquisition under certain conditions (e.g. teaching, example, experience) of new bodily or mental habits. The tendency is far from regular. At first his deficiency in output is filled in fast, but later, as the limit of learning is approached, there is merely a negligible levelling up; when, moreover, the conditions for learning cease, the degree of proficiency acquired is retained by a sort of "motor" memory.

D—CONDITIONS OF EXCESSIVE LOSS

§ I. *The General Effect of Changed Hours of Work*

Industry offers two types of opportunity for tracing the effect of hours of work on output. One (which will be dealt with in the next section) occurs "where observations can be made during consecutive divisions throughout some definite or continuous working period." The opportunity utilized in this section occurs, again to quote my manual (18),

where the length or intensity (of activity) in any given factory or district has been changed and the resultant working capacity in the period before and after can be contrasted. Particularly in the same factory contrasts are possible where, owing to strikes or trade conditions, there is short-time or over-time, or owing to a definite reorganization (1) the total length of hours has been reduced or increased, or (2) rest periods have been introduced or cut out and the distribution of hours altered, or (3) activity generally has been intensified or slackened.

Among these possibilities conclusive results have been obtained as to the effects on output of (1) a general reduction of hours, (2) a general increase of hours, (3) an increase in hours by occasional overtime, (4) the introduction of short recess periods.

(1) In 1900 Abbé altered the scheduled hours at the Zeiss Optical Works at Jena, from 9 to 8 per day, and carefully observed the power consumed actually in driving the machinery for four weeks before and after the change. This power was found to have increased some 12 per cent. per hour. As a further check Abbé compared the piece-rate earnings of the employees for a year before and after the change, and found them to have increased 16.2 per cent. per hour. Factors other than the hours of work had been kept constant, and Abbé felt justified in attributing the former low productivity specifically to the longer hours. It will be seen that this increase in hourly output compensates for the reduction in the number of hours worked, so that the total daily output remained about constant.

Similar experiences of a low daily output associated with long working days have been found in many other classical experiments. We need only mention the work of L. G. Frommont at the Engis Chemical Works at Liège (20) in reducing the working day from a 12-hour basis to an 8-hour basis;¹ the experiment of Sir William Mather, M.P. (20), at the Salford Iron Works in England in reducing his working hours from a 54- or 53-hour week to one of 48 hours; and the experience of the British Government (6, July 1905) when a 48-hour week was introduced in 1894 by an average reduction of $5\frac{3}{4}$ hours at Woolwich Arsenal, and of $2\frac{1}{2}$ hours per week in the Admiralty dockyards. In none of these practical experiments in reducing hours to 8 a day or 48 a week did the total daily output fall, and sometimes it rose slightly.

Subsequent to these experiments an important series of records from single operations were collected during the recent war by Vernon, acting as investigator to the Health of Munition Workers Committee. In Table 28 are presented his results as summarized in the final report of that committee (3). The observations refer, broadly speaking, to a reduction of hours from a 12-hour-day basis sometimes with work on Sunday, to a full 10-hour day, usually with a week-end holiday.

¹ A 12- or 8-hour basis does not imply that exact number of working hours, since it includes intervals for meals. A 12-hour basis usually involves $10\frac{1}{2}$ hours actual work, an 8-hour basis $7\frac{1}{2}$ hours actual work.

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Of the four operations listed, (A) is performed on a lathe and falls in the "man-operated" class in Table 2; (C) involves muscular power in turning a handle and falls in the "man-driven" class; and (B) and (E) are semi-automatic (i.e. fall in the "man-stocked" class), and are limited by the machine in their possible speed of performance.

TABLE 28
EFFECT ON OUTPUT OF REDUCTION OF HOURS *

Type of Workers and Operation.	Weeks Ending	Average Weekly Hours.		Relative Hourly Output.	Relative Total Output.
		Nominal.	Actual.		
(1)	(2)	(3)	(4)	(5)	(6)
<i>(A) 95 or 80 Women Turning Aluminium Fuse Bodies.</i>					
First period	Nov. 14-Dec. 19	74.8	66.2	100	100
Second period	May 14-July 2	61.5	54.8	134	111
Third period	Nov. 11-Dec. 23	54.8	45.6	158	109
<i>(B) 40 Women Milling a Screw Thread.</i>					
First period	Nov. 21-Dec. 19	71.8	64.9	100	100
Second period	July 16-Aug. 6	64.6	54.8	121	102
Third period	Oct. 14-Nov. 18	57.3	48.1	133	99
<i>(C) 56 Men Sizing Fuse Bodies.</i>					
First period	Nov. 14-Dec. 19	66.7	58.2	100	100
Second period	Feb. 27-April 16	62.8	50.5	122	106
Third period	Nov. 11-Dec. 23	56.5	51.2	139	122
<i>(E) 15 Boys Boring Top Caps.</i>					
First period	Nov. 15-Dec. 19	78.5	72.5	100	100
Second period	May 1-May 28	61.5	54.7	117	88
Third period	July 3-Sept. 23	60.5	54.5	129	97

* Figures are quoted from (1, No. 20) Tables A, B, C and D.

Column 3 gives the nominal scheduled hours which are seen to be lowered gradually for each operation; column 4 gives the actual hours worked, i.e. scheduled hours minus hours of absence, which also fall with the scheduled hours. The result on the hourly output rate is expressed in column 5 as a percentage of the output during the longer hours. This hourly rate of output, it will be seen, increases universally with the decrease in hours. In other words, the low hourly output of the earlier periods in each of the operations studied

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seems to be due to the length of hours of work. In the 6th column is shown the total daily output. If the hourly rate of output rises while the actual number of hours worked falls, it remains of course undetermined whether the total result will be a rise or fall in output.

Vernon's results show that, on the whole, as a result of reducing hours from about 70 per week to about 55, i.e. roughly from a 12-hour-day basis to a 10-hour-day basis, the increasing hourly rate of output more than outbalances the reduction in hours, and the total daily output is increased.

Investigations into a further reduction of hours were made by Vernon (4, No. 1) in the tinsplate industry of South Wales. In millmen's work the *hourly* output rate increased 4.7 per cent., 8.5 per cent. and 10.6 per cent. in three factories, when hours per day were reduced from 8 to 6, and increased 11.5 per cent. in one factory when the hours were reduced from 8 to 4. It is clear that in no case was the total daily output quite as high under reduced hours.

Vernon shows that a reduction of hours may not be followed immediately by a rise in the rate of output. There is usually a period of "adaptation" to the altered hours. (4, No. 6.)

When the hours of work are reduced, there is often no change in the hourly output for several weeks. Then it begins to mount slowly, but it takes a long time before it attains a steady value in equilibrium with the altered hours. The adaptation period was found to be about two months when the hours of tinsplate millmen were reduced from 8 to 6 per shift, but 13 months when those of open-hearth steel melters were reduced from 12 to 8 per shift. In fuse operations it varied from two to four months, and in big shell operations from two months to six months or more. The time required cannot be predicted, but it is usually shorter in the simpler operations than in the more complex ones.

In recent years the hours of work have been reduced in all English and in many American industries, but the opportunity has been missed of studying on a large scale, and yet scientifically, the effect on output. Results can be quoted only in a few isolated cases. It is true that the American National Industrial Conference Board have issued "research" reports on the effect of hours on output in several industries and have summarized the various results

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obtained. But the data tabulated in these reports are at worst only opinions, and at best statistics provided by the management, and likely to be biased by the hopes and desires of the informant. These results cannot be cited as of equal scientific validity with the results of the experiments and observations mentioned above.¹

As far as the evidence goes the effects of reducing hours of work can be summed up somewhat as follows :

Reduction from a 12-hour to a 10-hour basis results in increased daily output ; further reduction to an 8-hour basis results in at least maintaining this increased daily output ; but further reduction while increasing the hourly rate of output, seems to decrease the total daily output.

These results were obtained mainly in the type of work where the speed of operation depends fairly equally on the human and the mechanical factors. Probably where machinery predominates in setting the pace, a reduction of hours would result in less rise or greater fall in output ; and where the human factor predominates, as in sizing fuses, there would be greater rise or less fall.

Machinery and technical processes, for instance, tend to set the pace in steel-making by the open-hearth process, and here, from the evidence of four years' records, Vernon found that three shifts of men working 8 hours each were able to increase output at times 18 per cent., but on the average only 7 per cent. over that of two shifts of men working 12 hours each. Actually this means that one 8-hour shift produced considerably less than one 12-hour shift.

It is not possible to estimate the course of events for whole industries. An industry consists in a group of firms all attempting to satisfy some particular need or engaged on some particular material, and each employing innumerable

¹ These specious methods did not pass uncriticized at the time. The Lancashire *Cotton Factory Times* of June 14, 1919, finds in one of the reports on the cotton industry " a distinct suggestiveness of a desire to minimize the importance of cases where production was maintained in spite of reduced time," and thinks " the statistics are admittedly to be taken with a grain of salt." *The Times* points out, further, that the manufacturers interviewed . . . " are the men who in the past have fought tooth and nail against the time reductions that the legislature has been prevailed upon to enforce, and that in view of a possible further reduction it is easy to understand why the manufacturers have no particular incentive to report favourably on past results of shortened hours."

operations, occupations and types of work ; and it is the specific type of work that will determine the effect of changes in hours on output, not the heterogeneously composed "industry." There is much more in common physiologically between the work of a common labourer in a steel mill and a common labourer in a textile mill, or on a railway, or in building operations, than between the work of the steel-mill labourer and the steel-mill mechanic or draughtsman.

(2) The investigations quoted so far have all dealt with the results of a reduction of hours. Since there is always the chance that the resultant improvement in the hourly rate of output of given workers may be due simply to the later stages of learning, a more satisfactory experiment, scientifically, is to observe whether hourly output will fall with an increase in hours. Vernon found that when tinsplate mill men were changed back from 6-hour shifts to 8-hour shifts, their output fell without delay to approximately the old level found on the 8-hour shift ; i.e. it fell some 11 per cent. to 14 per cent. There was, in fact, little or none of the gradual adaptation observed in the reverse change of shifts.

Results (hitherto unpublished) that I obtained in a highly organized English munition and engineering factory are worth quoting in this connection. In the first year of the war, hours of work were increased from $8\frac{1}{2}$ to $10\frac{1}{2}$ hours per day, and a heavy fall in the output rate was experienced. Among eight girls who happened to be engaged on the same operation for a sufficiently long period before and after the increase in hours, I found the hourly output of five to have fallen by 14 per cent. on the average, while that of two girls remained constant and that of one rose 2.5 per cent. On the average, the fall in the hourly output as a result of the addition of $1\frac{1}{2}$ hours of work was equivalent to the loss of about one hour's output at the old rate of efficiency.

(3) In American munition plants the normal hours worked were not, as a rule, increased on the country's intervention in the war, but overtime became more frequent. To disclose the effect of this overtime I compared the average rate of output during a normal 10-hour day following a normal day, during days when overtime was worked, and also during

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normal days after days with overtime.¹ The operation on which these observations were made was that of loading the ring of the fuse with powder trains. Seven operations were successively performed, each by a different man; placing the ring in a jig covered by a housing, pouring in the powder, distributing the powder, fitting on the rammer, ramming in the powder, taking the ring and jig out of the housing, and, finally, taking the ring out of the jig.

Two groups of observations were distinguished. Records of 34 men for an average of 26 days each (Group A) were more complete as to normal days after days of overtime, and were taken at a time when the working force was stationary and new workers were not hired except to replace the old. Records of 49 men for an average of 20 days each (Group B) were taken at a time when gaps among overtime workers were filled in by new workers. This might have tended to lower the relative output of all men during overtime, but would not affect the relative output on normal days after overtime.

It was found that when overtime of $2\frac{3}{4}$ hours was added to the 10 hours normally worked, the *hourly rate* of output throughout the day of the two groups of workers, (A) and (B), loading the powder ring of the fuse fell 6.5 per cent. and 5.6 per cent. respectively from the level obtained on normal working days of 10 hours following upon a normal working day. In these same groups it was also found that there was a fall of 3.9 per cent. and 4.9 per cent. in the hourly rate of output of the same individuals when working a day of normal hours after a day with overtime.

The wages cost of overtime can be measured as the relation between the additional output obtained by the increased number of hours worked and the excess wages paid, and estimates are worth making in the case of the Group A records.

As compared with the output and cost on normal 10-hour days following a normal day, the *total daily* output of days when overtime of $2\frac{3}{4}$ hours was worked was increased by 18.4 per cent., but the cost (time and a half being paid

¹ This investigation was first summarized at the Liverpool meeting (1923) of the British Association for the Advancement of Science. Cf. (19).

during overtime) was increased by 40 per cent. On a normal day after an overtime day the output was 3·9 per cent. less.

It follows from this that if overtime was worked on two days of the week, one of these days immediately preceding a normal day—an arrangement that seems to correspond to the facts in the department investigated—the increased output for the week would be 5·48 per cent. but the increase in wages cost would be 13·33 per cent.

Or again, if we isolate one day with overtime and a normal day following it, and compare the output and wage costs with that of two normal days following a normal day, we find an increase of 7·25 per cent. in the output, but an increase of exactly 20 per cent. in the wage cost. In short, the increased output is paid for not, as appears at first sight, at a rate of $1\frac{1}{2}$ the normal rate, but at slightly more than $2\frac{1}{2}$ times the normal rate.

(4) Direct comparison may also be made of the productivity before and after the introduction of short recess periods. Thus the U.S. Public Health Service (9) tried the effect of a recess period of ten minutes inserted in the middle of each of the 5-hour spells at the 10-hour plant. These were introduced as soon as a series of control observations were completed to find the rate of output *before* the change. After the change was made observations were continued on the same set of workers for several weeks.¹

In the first few weeks of the innovation, if we consider only such operations as employed more than two persons, we find an average rise in total daily output for the different operations of from 0·86 per cent. to 7·9 per cent. This means that the increased efficiency entirely compensated for the twenty minutes lost during the day, and secured some benefit in addition. In one operation only was there a fall. In the largest group—fourteen women painting a solder mixture on the back of small army coat buttons—the rise was 1·96 per cent. In a group of men on three operations, buffing and colouring safety razor parts on a revolving wheel, the rise was 0·86 per cent., 1·1 per cent., and 1·1 per cent., and this in spite of such a strong opposition on the part of the men to "being coddled" that recess periods had soon to be abandoned in their case.

A second period of observation of the recess periods was obtained in some of the operations, when larger increases were registered in the

¹ This summary is quoted from my article in the *Economic Journal*, June 1920: "An Official American Investigation into Industrial Fatigue."

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output. The one operation where a fall had been found before, now showed a rise in output over the control period of 7.1 per cent. The other operations varied in rise from 3.26 per cent. to 18.3 per cent. In one soldering operation a third period of observation was possible, when the rise over the control period was 25.9 per cent.

It should be stated that in all cases the workers were thoroughly experienced, and that the date of their first working at the operation studied is tabulated. The fact of learning, cannot, therefore, account for the rise in output.

Recess periods were also introduced at the eight-hour factory, but met with little success in increasing output. Since the departments given recesses here contained machine operations where the state of the human working capacity is less easily read in the output than is the case with pure handwork, the results may not be significant. In so far as they indicate anything to our purpose, it is that continuous four-hour spells are harmless where continuous five-hour spells are not.

§ 2. *The Cyclical Effect of Continuous Hours and Days of Work*

The second and more indirect method of tracing the effect of hours of work is by means of the hourly or daily curve of output. The course of output is traced throughout the day or week by hourly or daily measurement, on the theory that the effect of continuous hours of work unrelieved by appropriate rests will show itself objectively as the working spell, day or week proceeds.

The "work curve" is the expression generally adopted to describe the results of this type of investigation, but the true inwardness of the matter is not realized until we think of the work curve as only a part of a whole cycle containing within itself a phase of rest. Elsewhere (18) I have defined this cycle as "an alternation of activity and relaxation which recurs over and over again in the life of the worker." The day forms such a cycle and also the week, the "phase" of relaxation being in one case the night's rest, and in the other a whole week-end. Months and years—unless the wage-earner is fortunate enough to obtain a yearly holiday of sufficient length—are not cycles, and a very different interpretation must be put on a fall of output during, say, a month or a year than during a day or a week. In the one case there is an opportunity to recover and to make good the

fall; in the other case there is no such opportunity. The fall, as far as can be judged, is cumulative.

The method of the output curve is described in detail in my manual (18), and I have used it extensively in reporting for the British Association Committee on Fatigue from the Economic Standpoint (12) and in investigating the 8-hour day motor plant and the 10-hour day metal plant for the U.S. Public Health Service (9). This method has the advantage that there is no necessity of waiting for a change in the schedule of working hours, and that other industrial conditions besides hours are not likely to change from one hour to the next or one day to the next.¹ A mass of evidence has accumulated which it is impossible to give in full. For details reference must again be made to the paper cited above (19).

The general type of *hourly* output curve is one that rises and then falls during the course of each spell of continuous work. Where the spell is of four hours or more the peak usually occurs in the second or third hour. This curve cannot be attributed to any physiological fluctuation that would occur even if no work were done, since such fluctuations as have been measured seem to be diurnal in span, i.e. form a curve spread over the whole day and not over particular hours corresponding with the spell of work in the factory. Further, this curve can be spoken of as typical; it is not a mere compromise between two or more divergent curves but tends to be the curve most frequently shown. Deviations therefrom shown by particular workers and particular days seem distributed around it as might be expected from chance errors. Nor, as far as my evidence goes, do the less productive individuals have the more precipitous curves (19, V, § 3).

Now this typical work curve, as it may be called, is a result of variation not merely in the speed of work while at work, but it is also a result of variation in the time taken off from work voluntarily by the worker.

Time wasted involuntarily by the worker owing to machine stoppage, starting up, etc., is allowed for as explained in Chapter XIII and does not affect the curve.

¹ See "Methods for Field Study of Industrial Fatigue" (10, No. 458).

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But the curve is affected by the time voluntarily spent in resting, chatting, and in other relaxation which, among night workers, will probably include sleeping.¹ Though to some extent scattered throughout the working spells, these rests occur mainly in the first and last hours and account partially for the low output in these hours, but only partially. The actual speed of work seems also to be lower in these hours. Table 29 is summarized from unusually detailed

TABLE 29
PAUSES AND RATE OF WORK IN THE FIRST, LAST AND MIDDLE HOURS OF
THE SPELL

Grinding Springs: American Ten-hour Plant

Hour of Day.	Average Hourly Pauses in Minutes.		Rate of Work, Minutes per Piece.
	Involuntary.	Voluntary.	
7-8	6.00	0.36	0.45
8-11	1.94	1.35	0.44
11-12	11.40	1.70	0.45
1-2	4.02	0.06	0.50
2-5	1.36	0.80	0.46
5-6	10.98	3.51	0.47

observations of the operation of grinding springs² when account was taken of pauses of even less than three minutes' duration.

The rate of work while working was obtained in the case of each hourly observation on each day for each worker, the method being to subtract the minutes lost from the sixty minutes constituting the hour, and to divide the resultant minutes actually worked by the number of pieces made. The rate of speed is thus expressed as minutes spent per piece; it is seen to be slow in the first and last hours of each spell,

¹ Observations which I and my associates made in America of 74 men every quarter of an hour through a 12-hour nightshift disclosed the following interesting data: 3.30 a.m. 5 men asleep; 5 a.m. 5 men asleep (not necessarily the same); 5.45 a.m. 4 men asleep; 6.15 a.m. 14 men asleep: 42 per cent. of the men were found asleep at one time or another between 5 and 7 a.m.

² The full table appears elsewhere (15, vol. I, No. 5) and a description of the operation of grinding springs is given in Chapter IX.

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i.e. a larger fraction of a minute was required per piece quite apart from any increase in pauses.

Moreover, it is/the involuntary and unavoidable pauses that are high in these hours rather than the voluntary, avoidable pauses. It is probable, therefore, that the low points in the hourly output curve found at the beginning and end of each work spell of the daily cycle are not due merely to the increase of voluntary pauses. A slowing-down seemed to occur contemporaneously in the actual working rate.

As far as the evidence goes, the shape of the hourly work curve is influenced mainly by three factors: (1) The total length of the working day and the total length of the spells of continuous work; (2) the type of work engaged in; (3) the presence of any tendency to deliberate restriction of output.

(1) The longer the total working day the greater will be the variation between the output of the several hours, and in particular the greater the fall toward the end of each spell. Vernon has shown (4, No. 1) that in tinsplate manufacture hourly outputs vary less from one another during a 6-hour working day than during an 8-hour day, and that the middle period of low output is less prolonged. And the 8-hour day shows the same advantages when contrasted, in turn, with the 10-hour day.

Furthermore, when a 12-hour nightshift was worked by the 10-hour plant the average output dropped 39 per cent. below possible efficiency in the last hour but one, and dropped practically to *nil* in the last hour.

Composite curves *representative of the same types of operation* in the motor plant working the 8-hour day and the metal plant working the 10-hour day (9) showed that on the average the hourly output at the 10-hour factory fell 9.8 below the possible efficiency* of the plant and at the 8-hour factory only 6.0 per cent. below. The fall in output towards the end of each spell was considerably greater in the 10-hour plant. In the last hour of the day, even when allowance was made for stoppage of machinery,

* For methods of representing the same types of operation and of calculating the possible efficiency of each plant, reference must be made to Public Health Bulletin 106 (9), pp. 11-15.

etc., the 8-hour plant had an output rate 10.2 per cent. below its own possible efficiency, but the fall was 20.9 per cent. in the 10-hour plant.

A composite curve of output for the 10-hour plant is presented graphically in Table 40, which is formed by taking the average of the output curves for muscular handwork, the output curve for dexterous handwork, and the power consumption curve for all machine work.

The average level of output of the afternoon spell is usually lower than that of the morning spell, where the hours of work are ten or more, and this in spite of the very low output often found in the first hour of the morning. If overtime is worked or a spell before breakfast, the level of output in these additional periods is markedly low and the superior productivity of the so-called one-break system is evident.

(2) That differences exist in the curves of operations of different type suggested itself to me when collecting evidence for the British Association Committee. In drawing up the report in 1915 I showed that operators working on machines such as stamping presses maintained their rate of output almost up to the end of the working day in contrast to those engaged in handwork such as confectionery making, and soldering, straightening and labelling of tins, where the fall at the end of the day was most marked.

Evidence gathered since then at the American 8- and 10-hour plants confirms the view that the shortest initial rise, if any, and the greatest fall in the curve of output during the spell and the day, is seen to occur on muscular, and next on dexterous, handwork; and the least rise and least fall on machine work in both 10-hour and 8-hour plants. The hour of maximum output is the second on muscular handwork in both plants, and the third on dexterous handwork again in both plants. On machine work, however, the maximum hour comes later; it is the fourth in the 10-hour plant and the third or fifth in the 8-hour plant. The hour of minimum output is the last in all handwork, muscular or dexterous, but in all machine work the first hour is that of minimum output.

Comparing the average output of the second spell with

that of the first, there is a further remarkable agreement on the relative standing of the four types in both the factories. In the 8-hour plant lathe machine work shows on the average a rise of 2 per cent. in the output of the second spell, miscellaneous machine work a rise of 1 per cent., dexterous handwork a fall of nearly 3 per cent., and muscular work a fall of nearly 5 per cent. In the 10-hour plant the order is precisely the same. Lathe machine work shows the same 2 per cent. rise in the output of the second spell as compared with that of the first; in miscellaneous machine work the output of the spells is the same (when combined with lathe work, as in Table 40, the rise is 0.7 per cent.); in dexterous handwork the second spell is down about 6 per cent.; and in muscular handwork it is down almost 10 per cent. In spite of some exceptions, there is also a striking uniformity in the output curves of the individual operations within each type.

The hourly output curves in the 10-hour plant for combined machine work, for muscular, and for dexterous handwork are presented graphically in Table 40. These types of work do not, of course, exhaust the varieties of work to be found in industry, nor do the individual operations by any means represent all the species within the type.

Muscular handwork includes operations of the type marked 4 and 5*a* in Table 2, i.e. body work and man-driven machines; dexterous handwork corresponds to the handwork numbered 2, and lathe machine work to the man-operated type marked 5*c*. Among miscellaneous machine work are chemical treatment (5*f*), man-fed (5*d*), and man-stocked types (5*e*). Output from chemical treatment, as represented by furnace work, can be isolated at the 8-hour plant (19); it shows a continuous rise throughout the first spell, and throughout the second spell a continuous though much slower fall.

Lathe work, when isolated as in Bulletin 106 (9, p. 59), or as by Vernon during the nightshift, shows a buoyancy in its curve surprising for operations often so heavy. This may be connected with the pauses exhibited throughout the spell. On larger lathes the operator must remain inactive

for long periods while the machining is being completed ; on the smaller lathes, possibly to secure a rhythm (see p. 246), the work seems to be done voluntarily in a series of runs with intervals between.

I have also obtained work curves in the "sense work" (type 3 of Table 2) of women weighing brass samples (9, p. 186), and craft work (type 6) of printers setting type (13) ; and Baumberger and Martin have obtained curves for the clerical work (type 1) of telegraphists. On the whole these curves conform to the general rule of a rise followed by a fall in each spell, and a lower general level in the later spell.

Quite recently also, a thorough investigation has been made by Wyatt (4, No. 23) of the work of tending automatic looms weaving cotton (type 5f). Since on "automatics" the rate of output is so largely determined by the machine, measurement was concentrated on the time spent by the operative attending to loom stoppages. "An initial rise and final fall in efficiency" was then "discernible in the daily work curves," and these were "not due (as is sometimes alleged) to extraneous causes such as lateness in starting, etc., but are of subjective origin and represent a real quickening up and slowing down. . . . The time required to attend to loom stoppages is greater in the afternoon than in the morning spells of work, and increases progressively throughout the day." In fact, under constant conditions of temperature and humidity the morning spell shows a fall from maximum "working capacity" of 1.0 per cent. in the third full hour and 4.8 per cent. in the fourth ; but the afternoon spell shows a fall of 5.1 per cent. in the second full hour, 7.2 per cent. in the third, and 12.7 per cent. in the fourth.

It is evident that a curve exists even in the apparently most cut-and-dried mechanical operations, and that differences of curve on different types of operation are largely a matter of degree.

It must be realized, however, that "owing to the statistical necessity of securing a frequently and regularly repeated output" (12), the varieties of work for which an hourly output curve can be obtained are limited. For the output, however variegated, of power-driven machines the curve

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of power consumption is an effective substitute; but for much muscular work such as sweeping up or carrying materials there is no measured output curve obtainable.

(3) In operations where evidence of restriction of output is found in the narrow and skew distribution of outputs or the wide divergence from the average rate of output during spurts,¹ a peculiar hourly output curve occurs. The curve is marked by a distinct maximum in the last hour but one of each spell. The possible explanation is that working just fast enough in the first three hours of the spell to get their daily stint accomplished, workers will, in the last hour but one in the spell, and especially in the last hour but one in the day, increase the pace in order to pile up a reserve. For should there be no reserve, loss of time through mechanical breakdown or other unavoidable cause in the last hour would entail irretrievable failure to accomplish the "stint."

As regards variations in output in the course of the weekly cycle, most investigators seem to agree in finding a relatively low output on Monday, a high output in the middle of the week, and a fall towards Friday. On Saturday a new factor is introduced in that there is usually a half-holiday, and the effect of the position of this day at the end of the work phase of the weekly cycle is partially obliterated.

As, a rule, however, the variation in the output of the several days or nights of the week is only slight, and is distinctly less than the usual variation between the output of the several hours of the spell or the day. The one heavy fall in weekly curves of output is that recorded (1, No. 18) among women and girls making rifle cartridge cases on a 12-hour shift, six nights a week. On four separate operations the output of the last working night of the week (Friday) was 96.9 per cent., 91.0 per cent., 89.0 per cent., and 85.1 per cent. of the average level of output throughout the week. In the latter case girls are stated to have been employed, in the other cases women.

In cotton weaving Wyatt has recently (4, No. 25) managed to collect a weekly curve of efficiency in dealing with loom stoppages ² *measured hour by hour*, and he finds that the

¹ These spurts usually occurred after time had been lost involuntarily through breakdown of machinery, etc. See 9, pp. 84-93.

² See above, p. 239.

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daily curves vary according to the day of the week in which they were collected: "There are signs of a progressive change in the shape and direction of the morning curves during the course of the week. The point of maximum efficiency tends to move from the end of the morning spell on Monday to the beginning of the spell on Friday, and occupies intermediate positions on the other mornings of the week. Under normal conditions, undisturbed by temporary incentives to work, the efficiency on Monday morning is relatively low."

Monday has, however, the highest afternoon record and Tuesday the highest record for mornings; after that the fall in efficiency is continuous both for the afternoon and morning spells of the successive days of the week, and the rule holds that as the daily output falls from a high level on Tuesday down to a low level on Friday, the hourly output begins falling earlier and earlier in the day.

§ 3. *Effect of Different Methods of Work and of Rhythm*

Motion-study was defined in Chapter IV as "the attempt to determine the most economical form of movement on the part of the worker for any given operation, and the most economical appliances for him to use." It was pointed out that motion-study may be separated from time-study; and in fact the recent work of Mr. Eric Farmer for the Industrial Fatigue Research Board shows how, in practice, output may be increased by motion-study apart from time-study.

Mr. Farmer was particularly successful in increasing output in sweet-dipping and metal-polishing operations (4, No. 14—summarized in 5, No. 2).

Sweet-dipping (which is a completely manual process carried out by girls) consists in dipping a "centre" (an almond, walnut, etc.) in a basin of melted sugar with the left hand, covering it with the sugar by working it with a fork held in the right hand, and placing the finished article on the tray. On being photographed, the paths travelled over by the hands of several workers were found in most cases to assume roughly the form of straight lines, and to involve several reversals of direction. A method of doing the work was then introduced, in which the hand moved entirely in curves instead of in straight lines, the continual change of direction being thus avoided and the maximum momentum being utilized

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for the most tiring part of the work. The advantage of the new method was indicated by the fact that it had been unconsciously adopted in modified form by three of the most proficient workers in the factory. It was found impossible to induce the older workers to change their habits and to adopt the new method, but for the younger members of the department a training class was instituted, and after a short course of instruction the output increased by 27 per cent.

More striking results were obtained in another room where the process was about to be started, and after three months' work the workers were on the average producing 88 per cent. more than workers of the same standing, who were adopting the old method in the original room. This difference in output may, however, have been partly due to the better conditions in the new room.

In metal-polishing operations, Mr. Farmer dealt with the buffing of spoons and forks (4, No. 15—summarized in 5, No. 2).

The chief processes studied were outside grease dollying and roughing, both of which involve the manipulation of the article against a rapidly revolving wheel. . . . The standard methods adopted for the two processes differed to some extent. In the case of outside grease dollying it consisted of a detailed scheme showing the sequence of individual operations; in the case of roughing it merely indicated the maximum number of strokes demanded by each part of the article.

Definite training schemes were adopted in these polishing operations. Novices were taken in hand instead of being left alone "to pick it up," and even workers of long experience were induced to take instruction.

The net result of learning by training apart from learning by experience is best illustrated by the change in output of these workers already fully experienced.

In outside grease dollying among three workers handling table forks, one reduced the time required for the operation by 8 per cent. ; another, of nearly nine years' experience, by 27 per cent. ; another with three years' experience ("somewhat conservative and very sceptical when first spoken to") by 39 per cent. ; while another worker dealing with teaspoons cut the time by 35 per cent.

Again, after instruction in the new method of roughing, twelve workers on the average reduced the number of strokes made on three dozen Baguette dessert spoons from 119 to 83, and the time spent from 126 minutes to 89. The previous experience of these twelve workers ranged from five to sixteen

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months (five of them had an experience of exactly ten months), and much further improvement by learning was not to be expected without systematic training.

These improvements in output were effected on the following principle :

Motion-study was used, not to determine which were the movements that took the shortest time to perform, but to discover those movements which when properly learnt the worker would find easiest to perform. The ease with which a movement could be performed was regarded as more important than the shortness of the path followed or the time taken.

Other methods, notably those of Mr. Gilbreth, aim at standardizing motions which are found to take the shortest time for any given operations, and all motions that do not appear to yield results are often cut out as positive "waste" motions. As a result of such methods Mr. Gilbreth claims quite sensational increases in output. Unfortunately his results are so presented that the factor of changed methods of work is not isolated from such factors as changed methods of pay, changed hours of work, and changed workers, and the specific effect of motion-study on output is not clear.

It is doubtful, however, whether the fastest motions are always the most economical and efficient in the long run, or yet whether certain motions that seem to have no positive results are not in fact a very important part of the whole performance. As I have pointed out elsewhere (18) "one speed, if it is in consonance with the rhythm of the workers, may well produce double or treble what a speed only a little too fast or a little too slow may produce," and the factor of rhythm must also be taken into account as forming the basis for many otherwise inexplicable movements. In signing a large batch of circulars under pressure, I have found myself introducing what Mr. Gilbreth would possibly deem unnecessary flourishes and twirljigs, but which seemed to make for ease of movement. Nor would a blacksmith consider the tap superfluous which he gives to his anvil, between the strokes of his hammer actually necessary to accomplish his work.

With the gradual recognition of the industrial significance of rhythm and the importance of *facilitating* rhythmical movement, it is becoming only too evident how elusive

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is this conception of rhythm. Subjectively, some sort of "pleasurable feel all over" is agreed to, but in objective terms two separate definitions occur among the reports of the same Industrial Fatigue Research Board (4). While Mr. Farmer refers to rhythm in connection with the path and sequence of movements in an operation (Report No. 14), Messrs. Wyatt and Weston speak of rhythm as "the ratio between the duration of the rest pauses or muscular relaxation, and the duration of the spells of work or muscular movement" (Report No. 18).

Possibly both these conceptions of rhythm, which at first sight seem so far apart, may be taken as partial statements of the same thing. One definition is blind to all except the rhythm of different types of motion, the other to all except rhythm in the timing of motions and pauses. The definition which I adopted in 1918 takes both aspects into account. I used rhythm to signify the regular and frequent repetition of a group of differentiated motions and pauses, and I specified that motions might be differentiated in the comparative stress of each motion, the path or direction and the rapidity of each motion, and by the part of the body performing the motion. Karl Bücher,¹ in his examination of the rhythm of work among primitive occupations, seems to have adopted a somewhat similar conception, though it is nowhere fully stated. He speaks of regularizing our movements in time and space in order to avoid the strain of attention: "Regularization is made considerably easier owing to the fact that every motion is formed of at least two elements, one stronger and the other weaker, such as a rise and a fall, pushing out and pulling in, etc. The movement thus appears articulated, and as a result of this the regular repetition (*regelmässige Wiederkehr*) of vigorous movements taking place within the same time limits must always appeal to us as rhythm."

This type of definition has the advantage that the terms regularity and frequency of repetition are measurable statistically. In fact, statistical measures on the basis of this definition have already been made on a large scale by Dr. A. H. Ryan and myself, and in view of the recognition of rhythm as a factor likely to increase output per given effort,

¹ Karl Bücher: *Arbeit und Rhythmus*. Leipzig.

it is important to summarize the methods we used and such of the results as have been published.

The regularity of repetition is measurable by the degree of deviation in the times of successive repetitions of an operation. In the lathe operations that were studied, fifty to a hundred repetitions were usually made without interruptions. These "runs" were then followed by short intervals for rest, machine adjustments, etc.

In any "run," the median time was chosen as that more nearly representing the typical speed than the arithmetic mean speed. From this median time or speed the *average* deviation of successive repetitions of the operation was obtained, and this divided by the median gives a coefficient of dispersion which will be the lower the more rhythmical the operation or operator.

A method was devised by Dr. Ryan of fitting up the machine to be studied with electrical contacts so that each step in the operation could be recorded automatically on a kymograph. Chronometer records were obtained simultaneously, and by means of a signal magnet, records were also made of any variations in working conditions or in the worker's behaviour.

By these means a very large series of most accurate measurements were made on lathe operations, such as bevelling and facing and scoring fuse rings, and on various footpress operations also.* Only a fragment of the results are as yet available for publication, but the evidence which we collected tends to support the following conclusions:

1. In the operations that were studied the regularity of repetition is marked. A "control" was formed by a simple repeated action designed to obtain a high degree of rhythm, namely, tapping on a tambour. Comparison of the coefficients of dispersion showed that experienced lathe operators were almost as rhythmical in machining fuse rings as though they were simply tapping with one finger.

2. Experienced operators who can be depended upon to make the highest output are more rhythmical than the

* For description of these operations, illustrations of an actual kymograph record, details as to the statistical method, and graphical presentation of results, reference should be made to Public Health Bulletin 106 (9, pp. 200-207).

inexperienced. A learner, "M.D.," showed an average coefficient of dispersion of 7.15 per cent. in the time taken for successive repetitions of the machining operation, as against a coefficient of 4.24 per cent. and 5.93 per cent. by experienced workers.

3. Different parts of an operation, i.e. the various movements or steps which comprise a complete operation, may have very different degrees of rhythm. The more rhythmical parts of an operation were those concerned in the actual machining operation on the fuse, where conditions are fairly uniform and there is less call upon the faculties of the operator. The part of the operation showing less rhythm was the interval between machining one fuse and the next. In this interval the operator has to take out the fuse ring from the machine and put in another, and care must be taken that the rings do not drop or jamb.

The practical importance of this point in conjunction with motion-study is evident. If the degree of rhythm is determined by the conditions of the operation, and conditions can be adjusted to be more favourable to rhythm, then motion-study must lend itself to the facilitation of rhythm.

In current industrial literature the method of inducing rhythm is often too crudely conceived. Tead and Metcalf (25), for instance, speak of "the use of rhythm and music to make work more interesting," and add that "the conscious mental content of the job is of course unaltered by the use of rhythmical activity"; but it is doubtful whether rhythm can ever be arrived at by music in the factory, if the "content of the job" is unfavourable. The degree of rhythm attained depends chiefly on the type of work engaged in and, as Mr. Farmer insists, on the type of the motions used.

4. On these rhythmical operations, the median speed during the runs, had it been kept up all day, would have been much faster than necessary to allow the operator to make her daily output. Thus in Table 6 of Public Health Bulletin 106 the average number of rings faced and scored by a group of experienced workers is shown to be 347 per hour, but the median speed for facing and scoring one ring during a run is given in Table 43 as 4.32 seconds for one experienced worker and 4.92 for the other. At this speed it is evident

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that 732 to 833 rings could be faced and scored in the hour.

5. Rhythm did not seem to decrease towards the end of the day, nor did the median speed of a run of operations.

6. Correlation of the speed and rhythm in the same run (i.e. fifty to a hundred consecutive repetitions of an operation) gives evidence in certain cases of an optimum speed for rhythm which is not usually the fastest nor yet the slowest speed.

7. But though not the fastest, the median speed adopted during a run is very close to the fastest. During the course of over two thousand repetitions of the operation, the shortest time in which operator E. M. was ever found to complete the facing and scoring of the ring was 3.4 seconds; she only accomplished this record six times, but took 3.5 seconds nine times, 3.6 seconds twenty-one times, and 3.7 seconds on twenty-two occasions. Her average time of 4.5 seconds during the same series of observations is not very far from these exceptional speeds, particularly when compared with the distance between it and the speed—some ten seconds, or six rings in a minute—necessary to maintain the actual hourly output rate of 347 rings.

In fact, when the times taken to complete each ring are plotted as a frequency curve, a steep fall is observable on the fast side showing a clear limit to the speed; on the slow side the curve tapers off very gradually, and the median speed is far closer to the fast limit than to the slow, if indeed we can distinguish any slow limit.

Similar conclusions were arrived at for other operators and quite other operations. M.Ph. assembling parts of a gas mantle on a foot press, for instance, averaged 2.5 seconds in the midst of a run to complete the whole operation; but in the course of thousands of observed repetitions of the operation she took more than 2.2 seconds on only four occasions.

Points 4, 5, 6 and 7 appear to hang together if we adopt the following hypothesis, which, however, in our present state of knowledge must not be taken as anything more than a hypothesis. The worker consciously and unconsciously chooses a speed during a run of operations faster than is

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necessary to complete the day's output (Point 4) and close to the fastest speed possible (Point 7), in order to obtain a speed on which the optimum rhythm may develop (Point 6). As a result there will be many longer or shorter pauses between runs, and this (Point 5) would seem to apply throughout the different times of the day. Pauses amounting to such a large proportion of working time would destroy the significance of the hourly output curve as a record of the effect of continuous work, and would explain the unusually even distribution of output found in lathe operations in consecutive working hours.

§ 4 *Effect of Physical Environment and Night Work*

In America, Huntingdon has shown that the output of factories varies with the weather.¹ He considers that when the temperature passes below 45 and above 70 degrees work falls off sharply, and when the temperature returns within these limits work increases.

In England, Vernon's results show (5, No. 2) that, "in heavy work, especially when it involves exposure to high temperatures, output undergoes a consistent seasonal variation, being with very few exceptions greatest in winter, least in summer and intermediate between the two in spring and autumn." Investigating four groups of steel melters, three groups of rolling-mill men, a group of tinplate mill men and groups charging blast furnaces and puddling wrought iron, Vernon shows that the relative output in winter ranged, according to the groups,² between 102.5 and 124.0, but in spring and autumn ranged between 98.4 and 118.0, and in summer between 88.5 and 111.0. Decrease in hourly output can often be traced step by step as the weather grows warmer. In five tinplate factories Vernon found a mean weekly temperature between 40 and 44.9 degrees, accompanied on the average by a relative output of 102.3 to 105.7, according to the factory. As temperature rose output fell, until a mean weekly temperature between 60 and 64.9 degrees was found,

¹ *Harper's Magazine*, January 1915. Quoted (7).

² Relative output of the steel melters at Works D should be quoted only for the uniform period when all the furnaces were machine-charged. See (4, No. 5, p. 42).

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accompanied on the average by a relative output of only 93.4 to 98.1.

The difference in the seasons is mainly one of temperature, but temperature is not the only air condition affecting human output. Account must also be taken of the humidity and the movement of the air. Humidity is measurable in the difference between an ordinary "dry-bulb" thermometer and a thermometer whose bulb has been wrapped round with wet muslin. The damp wrapping makes the reading recorded by the "wet-bulb" thermometer the lower of the two, and when this reading on the wet-bulb thermometer approaches that on the dry-bulb it is a sign that the air is not much drier than the damp wrapping. The "degree of humidity" is thus measurable by a comparison of wet-bulb and dry-bulb reading. A relatively high wet-bulb temperature indicates moisture as well as heat.

This combination is particularly fatal to output. Vernon found (5, No. 2) in a tinplate factory, for instance, that during sixty weeks with a mean temperature of 60 degrees or more, the mean output fell by about 3 per cent. when the relative humidity was above 80 per cent. In fine linen weaving two sheds investigated by Weston (4, No. 20, and summarized by Vernon in 5, No. 3)

had a practically constant humidity corresponding to 88 per cent. saturation during the period of the inquiry, and it was found that, as a rule, the output varied proportionately with the wet-bulb temperature. Taking the maximum output as 100 (for looms running continuously), the usual efficiency was about 60, and it rose or fell roughly 1 per cent. for each rise or fall of 1° in wet-bulb temperature. Above a wet-bulb temperature of 75°, however, the output fell rather than rose with increasing temperature. For instance, on the afternoons of three consecutive days the temperature in one shed averaged 74.1°, 75.6° and 74.8°, and the efficiency was respectively 3.3, 1.8 and 1.6 per cent. less than in the morning, when the temperature averaged 68.9°, 69.0° and 69.3°. This was the immediate effect of the high temperature on the productive capacity of the weavers, but there appeared to have been a deferred effect as well, as a night's rest did not enable the weavers to recuperate completely after they had been subjected to such trying conditions. Thus, on the second of the three days in question the efficiency averaged 0.8 per cent. less than on the first day, and on the third day it averaged 1.3 per cent. less.

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Weston's general conclusion is that up to a certain limit of wet-bulb temperature (73°F.) productive efficiency increases with the temperature, but above that limit efficiency falls notwithstanding the favourable physical effects upon the warp.

Much the same conclusion is arrived at by Wyatt (4, No. 23) for cotton-weaving sheds that are artificially humidified: "Under existing regulations the best conditions for productive efficiency in weaving sheds seem to be obtained with a dry-bulb temperature of 70-75°F. and a relative humidity of 80-85 per cent."

Both in cotton and linen weaving breakages of the warp are less frequent at a high temperature and a high humidity, and in humidified sheds at any rate output tends to vary directly as the product of the two. For human efficiency high temperature and humidity is by no means so favourable, and Wyatt concludes that,

When the average temperature for the afternoon spell is comparatively low, the efficiency in humid sheds tends to remain at a fairly uniform level throughout the spell. When the average temperature is high, the efficiency decreases as the afternoon advances. The great decrease in efficiency when the higher temperatures prevail, is due to the effects of the atmospheric conditions upon the weaver. Thus, atmospheric conditions which are best for the warp are unsuitable for the weaver, and if maximum efficiency is to be maintained, the warp must be placed in a different atmosphere from that which surrounds the weaver.

Movement of air, i.e. ventilation in the strict sense, may rectify the effects of heat and humidity. In a tinplate factory where a good ventilation was effected by means of large vertical fans or paddles, the mean output in the summer months (May to September) was found by Vernon to be only 2.9 per cent. less than in the winter months (December to March). In two other factories where a moderately efficient ventilation was effected by cold-air douches, the summer output was 5.2 per cent. less than that of the winter, while in two other factories which had no artificial ventilation at all, it was 6.8 per cent. and 9.2 per cent. less. When comparison was made week by week, the contrast was still more striking. In the two unventilated factories the average

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output was, respectively, 11 per cent. and 18 per cent. less in the hottest weeks of the year (when the mean temperature was 65 degrees or more) than in the coldest weeks (when it was 40 degrees or less). In the ventilated factories it was only 8 per cent. less. It is probable that thoroughly efficient ventilation may increase the average output of a previously unventilated factory by 12 per cent. or more; the seasonal variations in output, extreme enough in old-fashioned works, are almost absent where labour-saving devices are adopted and buildings are suitably planned and ventilated.

The effect of lighting on output has been studied in silk, linen and cotton weaving. In these processes the worker must be constantly on the look-out for breakages in the yarn, and his output is likely to be peculiarly susceptible to variations in illumination.

Elton's investigation into silk weaving (4, No. 9) was based on hourly output data recorded automatically on a large number of looms in two weaving sheds over a period of three months. When artificial light had to be used early and late, the first and last periods of work showed a fall in output far greater than the fall observed at a later season when artificial light was no longer needed.

Elton concludes that under artificial illumination production falls, even if electric light of sufficient intensity is provided, and that the magnitude of this fall is of the order of 10 per cent. of the daylight value of the rate of output. He also points out that after natural lighting is resumed some time elapses before the output becomes normal and the operative accommodates himself to the new conditions. (5, No. 2.)

In fine linen weaving Weston (4, No. 20) concludes that the use of artificial light under the conditions observed reduces efficiency approximately by 11 per cent. of its normal daylight value, and that so far as this effect was avoidable it depended probably on glare, shadow effects and absence of general lighting rather than on amount of illumination.

Again, in one cotton-weaving shed Wyatt (4, No. 23) found that the increase in output as the proportion of work done under artificial light decreased was, in the hours most affected, from 4 per cent. to 6 per cent. In other sheds, however, the effect was less marked, and differences in

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construction, e.g. roof-lights, prevented any general conclusion. The less pronounced and less certain effect of artificial light on the cotton-weaving output may have been due to the coarser yarns used in the operations under observation.

The advantage to output accruing from daylight-saving time is demonstrable from these conclusions, as also the disadvantage of a soot-laden atmosphere and fogs.

Night work combines several different physical conditions that may affect productivity, particularly artificial lighting and the reversed and unnatural times of eating, resting and sleeping on the part of the workers. The Health of Munition Workers Committee (2, pp. 26 ff.) investigated discontinuous night work where the nightshift alternates with the dayshift at stated intervals, usually a week or fortnight; and also continuous night work where the shift remains on night work without interruption. Their results are summed up as follows:

Women:

1. In monotonous processes which call for little physical effort, such as those concerned with cartridge-making, discontinuous night work of women gives an output which rarely falls much more than 10 per cent. below, and usually approximates closely to, that obtained by day.
2. Continuous night work is productive of definitely less output than is the discontinuous system; and the Committee have failed to obtain evidence that the output of the continuous dayshift balances this inferiority.

Men: The conclusions arrived at with respect to women are true, with slight modifications, for men.

1. There is no significant difference between the rate of output in night and day shifts managed on the discontinuous system.
2. With men, as well as with women, the discontinuous system is preferable to continuous night work.

The inferiority of continuous night work can probably be traced to the failure to secure proper rest and sleep in the daytime. Women on continuous night work are likely to perform domestic duties during the day, but when they work alternately in the two shifts, they must obtain the help of others for the home tasks. Plenty of evidence exists of women employed in permanent nightshifts who still

carry on their ordinary daytime avocations and whose sleep during the day is quite inadequate.

Kelley (16, Oct. 1919) secured answers from 156 married women working at night in American textile mills, and found that only 17 obtained eight hours' sleep or more, while 50 obtained six or seven hours' sleep, 64 four or five hours', and 25 less than three hours'. If anything, Kelley considers the answers likely to have overstated the amount of sleep, since the women were for the most part in favour of night work and felt apprehensive that the investigators might object to it.

Among the many difficulties of measuring the net effect of night work on output is the probability that the harmful influence of night work "lags" into the dayshift week, and thus precludes definite conclusions being drawn by a simple comparison of the output on day and night shifts respectively.

Vernon (26, p. 94) presents the output on several operations in a large factory to show that "as a rule the output was distinctly lower in the second week of the nightshift fortnight than in the first week, whilst on the other hand it was distinctly higher in the second week of the dayshift fortnight than in the first week." The difference in output shown in the figures cited, however, do not in all cases follow the rule, and in the average do not amount to more than 2 or 3 per cent. Further statistical evidence seems to be needed of this possible "lag" in the harmful effect of night work on output.

§ 5. *Effect of Methods of Wage Payment and Other Incentives*

Among the social working conditions the basis on which the management decide to pay wages is probably of greatest importance in influencing the rate of output. We say "probably" because there is little in the way of published statistics to establish the differential effect of the various incentives. So far as the evidence goes, however, five or six practical points are indicated.

x. A lower output is likely to result from the payment of wages on the basis of time spent in the plant rather than on the basis of work done. A table I prepared for the British

Health of Munition Workers Committee, which was published in their interim report (2, p. 72), gives a clear example of the effect on output of introducing piece rates among a given group of workers at a given operation. Averaging the output of the five full working days in the case of two consecutive weeks, we find that immediately they were put on piece rates, 17 girls drilling fuses on dayshift increased their output 24 per cent., and 17 girls drilling fuses on nightshift increased it 40 per cent. ; and that three girls retapping fuses on dayshift increased their output 28 per cent., and three girls on nightshift increased it 48 per cent.

Even in cases where time wages are used in combination with piece wages, e.g. as a guaranteed daily minimum, Vernon (26, p. 133) found the same lack of incentive. In a certain shipyard during the war, when the demand for workers was greater than the available supply, records showed that three-fourths of a group of riveters earned less than 60 per cent. of their pay. That is, if no daily time wage had been paid and the riveters had been solely dependent on their piece-wage earnings, their output at the prevailing piece rates would have entitled them to only a fraction of the wages they actually received. It was Vernon's opinion that this deficiency in output was caused by the particular system of wage payment, because "when the guaranteed time rate was abolished the number of rivets put in by the men was very nearly doubled."

I found a similar state of affairs in a small munition factory near London.

Though piece wages were nominally being paid both on an 8-hour and a 12-hour shift, girls working the short shift were in certain processes being remunerated in fact only by a time wage, since they knew, or thought they knew, beforehand that they could not produce enough output in the shorter hours to earn more than the minimum hourly time wage which was guaranteed them by a trade union agreement. On the long shift, therefore, girls were likely to be "trying" much harder than on the short shift. (18, p. 50.)

As a result the output per hour on the 12-hour shift was, on the average, actually higher than the output per hour on the 8-hour shift.

Beside the straight piece-wage system, where the same

rate of pay is earned per piece regardless of the total number of pieces made, sundry schemes have been adopted in which the rate of payment varies. Where time-study has indicated a definite task that the worker is able to perform (i.e. a given output in a given time), the rate is often increased if the task is accomplished in less than the given time. Examples of such "progressive" piece-rate schemes are Taylor's differential piece-rate system and Gantt's task and bonus system. Under "degressive" schemes such as the Halsey and the Rowan plans of premium bonus, the rate tends to decrease as the total output increases.

These various schemes are described in detail in numerous text-books, but it is seldom that we are given any scientific information as to the specific measure of success in increasing output or decreasing output costs. Changes in method of payment are usually introduced with changes also in organization, in methods of work, in training, or in other items of the scientific management repertory; so that however sensational the improvement in efficiency may be, it is impossible to attribute it to any one factor.

Theoretically, it might be supposed that when compared with time-rate wages, progressive piece rates would yield an increase in output even greater than the straight piece-rate plan, while degressive piece rates would yield an output somewhere between time rates and the straight piece rate. Statistical confirmation, however, is lacking.

In the course of the next few years there will no doubt be a further instalment of books describing over and over again the subtleties of this or that system. May we urge prospective authors to devote less time to this recapitulation, and more to collecting and disentangling actual results?

2. When piece rates, particularly of the progressive type, are paid, a preliminary time-study is often made to determine what is the "task" or fair day's work that can reasonably be expected. It is probable that if the task set is too high the only result will be to discourage the worker. Time-studies based on the fastest records of the fastest workers would have to be subjected to a threefold modification to allow for the facts as observed at any rate on lathe work:

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- (a) that the fastest record of one worker varies appreciably from the average time maintained by him for a whole run (see section D, § 3) ;
- (b) that the average time maintained by any one individual during a run varies by a further and wider gap from the average time kept up by him during a whole day (see section D, § 3) ;
- (c) that the average times taken by different individuals are very different ; the differences obeying a further definite law of variation (see section BC).

3. Where piece rates are paid, with or without time-study, they will not afford the proper incentive unless the following conditions are fulfilled—conditions which, however simple and obvious they may seem, have not by any means always been satisfied in the plants with which I am familiar.

- (a) The worker must be quite confident that his own output is not likely to be confused with the output of others, and that it is correctly measured and valued when the piece wage is assigned.
- (b) The system of piece rates that prevails must be clearly intelligible to each individual worker. Particularly where premium bonus systems or other devices of a " scientific " nature are installed and the rate of wages earned does not increase in direct proportion to the output, the worker is often in the dark as to the results of his efforts. Sometimes he is under the impression that output beyond a certain point will not increase his earnings at all. For in trying to simplify the mathematical formulæ involved in these systems foremen may make matters worse by fixing a definite output as the goal, leaving the impression that a greater output would not yield any increase in wages.
- (c) The worker must be confident that his output is being measured for no other purpose than to ascertain his piece-rate earnings ; particularly that the measurement is not made with a view to cutting the piece rates if his wages threaten to increase more than the employer likes.

As Dr. Addison, Minister of Munitions during the recent war, once stated :

Nothing in the relations between capital and labour gives rise to more difficulties and distrust than two customs which are dependent on one another. The first is the cutting of rates of pay on piece work so as to limit the rise of earnings when improved methods of manufacture leading to greater output are introduced. It is not the practice of the best employers, but it is adopted by many. This practice, or the fear of it, has inevitably led to the second and retaliatory practice of the restriction of output. The influence of these two practices in our industrial life is thoroughly poisonous.

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In the large factories, one English and one American, where I found (cf. p. 219) restriction of output, occasional resort to piece-rate cutting was combined with a complicated premium bonus system apparently unintelligible to the average workman. In the American 10-hour metal plant (9)

the wage system prevailing only a year before the investigation, the so-called "premium bonus" system, under which the higher the output the lower was the rate paid per hundred, may, by its logical discouragement of effort, have been the origin of the present artificial limitation of production. The same system formerly used in one of the largest munition factories in England resulted, according to official report, in a similar restriction of output, with a similar recurrence of exactly the same output, at successive periods of observation, by the same workers.

4. Workers value wages for what they will buy, and if no leisure is provided for buying desired objects or enjoying their possession, or if no facilities for pleasures are afforded by the locality in which they live and work, or again, if every effort of the worker to raise his standard of life—by buying a piano or indulging in some other luxury—produces an outcry among the employing class, then employers cannot expect the wages they pay to offer any great incentive to the workers. The dull and depressing surroundings of the countryside have been held by many to account for the rural exodus of the more enlightened workers. But more striking evidence is given by figures showing the output of piece workers just before a holiday. The rise in output that occurs during the full working weeks preceding the holiday weeks, as shown, for instance, by Vernon (26, pp. 57-58), has puzzled those who are studying a supposed fatigue; but the rise can undoubtedly be explained by the desire to accumulate a fund for spending during the holiday. Corroborative evidence is furnished by the drop in output during the few days *just* preceding the holiday. The piece wages earned for this output are not drawn until after the holiday is over.

5. The so-called economic motive is not the only incentive to work, and deficiency in output may be a manifestation of that lack of non-financial incentive in modern industry to which attention has already been called.

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Investigation has been made into the effect of "interesting" the employee in his work. When the operation itself is admittedly dull, interest may yet attach to it owing to its significance in the whole process of production, or owing to the chance of suggesting more efficient methods for its performance.

Vernon quotes an instance in an English open-hearth steel plant (26) :

The interest of the men in their work was stimulated by the formation of a Men's Society. Lectures relative to steel production were given by workmen and by managers, new methods of working were suggested and discussed, and if, after due trial, they were found to be of practical value, they were permanently adopted. In consequence of these improvements, and of the extra keenness of the men in working the furnaces, the output of the hand-charged furnaces gradually increased to about 70 per cent. above its previous value. This striking result, be it noted, was achieved without any substantial alterations of plant whatever. Moreover, the casting of the steel was so much improved that the net final yield of saleable steel was raised some 30 per cent. above the old level.

Tead and Metcalf (25) mention the case of one American company which

trained twenty-five of its men from the engineering, finance and sales departments as guides and with their aid routed the entire working force of thirty-five hundred employees through the plant. The groups were small, and were each guided for three hours. It took two months to give all the employees a personally conducted tour, but when the work was completed it had proved so stimulating that the company decided to extend the privilege to the families and friends of the labourers. About twenty-five thousand more people were accordingly taken through, and the intelligent interest that was aroused by the whole affair more than justified the trouble. In addition, instead of retarding the processes of production it stimulated them, for during the period when the trips were being made the output was 5 per cent. above normal.

The work of Mr. Robert Wolf in the American and Canadian paper and pulp industry is perhaps the best known in this connection. He advocates the careful recording of each individual's progress in efficiency as a guide to the individual himself. His most striking results were obtained, however, in improving the quality and the economy of output, and will be discussed in the next chapter.

6. To complete the refusal of all incentives to employees in the plant is the example, often too evident, of technical mismanagement. It is highly probable that in an atmosphere of inefficiency, workers otherwise efficient will acquire slack habits. If, for instance, materials are not brought up on time, so that workers have to wait about for long periods with nothing to do, they may not see the point of working intensively (particularly for a time wage) when the probable result will be to exhaust the supply again a little later on.

§ 6. *Effect of Type and Living Conditions of Worker Employed*

In the scheme of investigation outlined in Chapter IV, working conditions such as hours, methods of work, and physical, social and economic environment were not the only factors considered; the type of worker hired, his training and his living conditions, were assigned equal importance in the investigation of industrial efficiency. The effect of these "personal" factors on output has not been subjected, however, to the scientific research it deserves, and we must be content to cite the conclusions of some rather isolated experiments, the forerunners, it is to be hoped, of larger results.

Scientific management has always insisted on the close relation of careful selection of workers to a high output, and many amazing increases in output are reported by Taylor, Gilbreth, Gantt and others as a result of scientific selection taken in conjunction with changes in the hours of work, in training and in the method of wage payment. This very "conjunction" unfortunately prevents us from appraising the specific effect of the various changes taken separately; but the lack of scientific method among scientific managers must not blind us to the fact that one or more of these changes, and possibly to a certain extent all of them, have led to a very important increase in output.

Under more truly scientific auspices Muscio (4, No. 16) measured the physical strength of 2,300 youths in Manchester and industrial Essex.

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He points out that many forms of work make special physical demands on the worker, and that inadequate muscular development induces unnecessary fatigue and inefficiency (he is concerned with physical strength and not endurance), and in particular suggests tentatively that with regard to the subjects tested, possibly 10 per cent. of those who become engineering apprentices do not possess the physique required for engineering work, so that some decrease in fatigue and inefficiency could be effected by guiding these into vocations where physical strength is not required and by substituting for them others of more adequate physique. (5, No. 2.)

The suspicion that the happy-go-lucky methods of hiring workers practised by most business concerns result in unsuitable appointments is not one, perhaps, that needs extended statistical verification. As Sidney Webb points out,¹ the assumption underlying the lack of scientific selection of workers is "that one man will do as well as another; that character and conduct are of no consequence in 'mere' workmen"; or even, we might add, a preliminary test of his capacities. The consequent fall of productivity which, in discussing lack of system, jobbery and graft in political appointments, critics never cease to emphasize, is too often ignored as a possibility in the precincts of private enterprise.

There is one occasion when the average employer does have to plan on some principle whom to select for employment on a given job, and that is when the choice lies between men and women. So far as the relative output and efficiency of the sexes goes, statistical evidence is hard to come by. Men and women are seldom both put on to the same work in the same factory at the same time, and when, on any job, women are substituted for men and vice versa, other changes are usually introduced at the same time. Perhaps the fairest comparison is given by Vernon, and refers to a national factory producing 9·2-inch howitzer shells, where women were gradually replacing men. The operations studied were of the man-operated lathe type, but involved long periods of time when the lathe "machined" automatically. There were three operations, boring, rough turn and groove wave, where the women had worked for a sufficiently long period to establish a stationary output

¹ *The Works Manager To-day*. Longmans, 1918.

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week by week ; but though they worked a 44½-hour week as against the men's 63½-hour week, the women showed in the three operations an hourly output of 5 per cent., 6 per cent. and 21 per cent. below that of the men. The machining time was much less in the latter operation, 15 minutes only being required for the whole operation as against 40 and 70 minutes respectively for the other two.

Both men and women were assisted by men tool-setters and labourers working on a two-shift system, and Vernon suggests that the inferior output of the women was due partly to their inability to compel as much attention from the men tool-setters and labourers as the men operators on the lathes were able to do. Vernon concludes, however, that " more probably the women were not quite so handy at doing small jobs for themselves as the men were, but relied to a greater extent on the tool-setters. This would normally entail more delay. Whatever the explanation, the fact remains that the women did not attain so great an hourly output as the men, in spite of their much shorter hours of work " (4, No. 6).

Of equal importance with the selection and training of the employee is the question of his living conditions, and this, as we have pointed out, is dependent mainly on the scale of wages that is paid. The economy of high wages is a principle made familiar by the work of Lord Brassey. He was never tired of pointing out how the wages paid per hour, day or week are no indication of the labour " cost." This cost can only be calculated by relating the wages paid to the output. The labour cost is the sum paid to the labourer *per given unit of output*. In his *Work and Wages*, for instance, Lord Brassey shows the success, economically, of his father's policy of paying high wages to the navvies engaged in constructing the new railways.

In making the South Staffordshire Railway, the navvies employed by Mr. Day, my father's resident agent, were paid from 3s. to 3s. 6d. a day. A few years later Mr. Day was engaged in the construction of a line from Enniskillen to Bundoran ; and on that line the labourers were paid at the rate of 1s. 6d. to 1s. 8d. a day. Yet, with this immense difference in the rate of wages, subcontracts on the Irish Railway were let at the same prices which had been previously paid in South Staffordshire.

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Excluding the possible factor of race, Lord Brassey gives further instances :

At the commencement of the construction of the North Devon Railway, the wages of the labourers were 2s. a day. During the progress of the work their wages were raised to 2s. 6d. and 3s. a day. Nevertheless, it was found that the work was executed more cheaply when the men were earning the higher rate of wage than when they were paid at the lower rate. Again, in London, in carrying out a part of the Metropolitan Drainage Works in Oxford Street, the wages of the bricklayers were gradually raised from 6s. to 10s. a day ; yet it was found that the brickwork was constructed at a cheaper rate per cubic yard after the wages of the workmen had been raised to 10s. than when they were paid at the rate of 6s. a day.

The facts as to the economy of high wages recorded by Lord Brassey and a host of business men before, during, and after his time ² are capable of several interpretations. But if the different levels in output are associated solely with the differences in the wage level, and not also with differences in mechanical equipment (as occurs in all too many of the cases cited), then we may suppose that higher wage levels either increase the working capacity or willingness of the original workers, or else attract a new and more willing or capable type of worker.

Higher wages act on the working capacity of the original workers presumably by increasing their chance to spend money on suitable food, clothing and house-room ; but the possibility must not be shirked that living conditions might be more effective even with the same wages. The habits and personal hygiene of the British working-classes have certainly not been spared criticism. The brunt of the censure falls upon a certain predilection for alcohol ; but the heavy and standardized diet and equally heavy and ill-ventilated clothing of the men (4, No. 21), the high-heeled shoes of the women (4, No. 22), and the universal fear of open windows, have all on one occasion or another been held accountable for inefficiency. Exact observation of the results of these personal predilections and habits has scarcely yet been undertaken, but a modest study of tea-drinking may here perhaps be introduced.

I observed the output of a typist writing letters from a

² E.g. Redfield : *The New Industrial Day*. Gantt, *passim*.

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dictaphone on four afternoons when she obtained a cup of tea, and four when she did not. In both cases she typed from 2 to 4 o'clock at about the same rate of two lines per minute (2 lines on afternoons without, and 2.03 on afternoons with tea). On tealess afternoons her speed from 4.30 to 5.45 o'clock averaged 1.95 lines, but when tea was obtained (from 4.15 to 4.30) her speed from 4.30 to 5.45 averaged 2.61 lines per minute.

Tobacco smoking has also been studied, and Martin and Baumberger (16, 1920) report that among twelve men sending and receiving Morse-code messages in an American telegraph office, the hourly output curve of the heavier smokers falls off more markedly than that of the lighter smokers.

"Common-sense" experience is perhaps a superior authority in these matters to a few meagre researches, but yet not altogether. Among working-class tendencies is affiliation to a trade union, and it is commonly assumed by the general public that the deliberate restriction of output implies such affiliation, and, almost, that the workshop practice imposed by a union membership is the one obstacle to unlimited speeding up. It will come as a surprise to many that the two examples of very extensive restriction referred to above (pp. 219-22) occurred among non-unionists. Indeed, in the American case, the factory was a so-called open shop, i.e. one closed to those wishing to work under trade-union conditions.

CHAPTER IX

THE LOSS BY DEFECTIVE OUTPUT

THE additional losses in production involved by an increase in the proportion of the work that is defective has not yet received adequate study. This may partly be due to the modern idolization of mass production and quantity rather than quality. Certainly the mediæval guild system offers a telling contrast with its elaborate search for defective goods and their seizure when found, its sealing or hall-marking of goods passing the test, the seven-year apprenticeships, and the setting of essay pieces in craftsmanship. These practices, which have to-day fallen out of use, were part of the organization to produce a well-wrought article. Yet if under defective output is included not merely output that ought to be scrapped or done over again, but also break-ages and premature wearing out of tools, i.e. the economy with which work is done, it is clear that even under modern mass production this source of loss cannot be neglected. In fact, when account is taken of the accuracy with which machine parts, structural steel, munitions of war, scientific instruments, etc., have to be finished, it is doubtful whether, on the whole, quality is not more important now than ever before.

The neglect of quality is probably better accounted for by the difficulties of the outside investigator in obtaining accurate records, and indeed there is, in all likelihood, no such neglect in the business man's mind. Since for purposes of publication the record remains meagre, we can give but a brief analysis of the specific costs involved, followed by an account of scattered investigations into the effect upon defective output, of changing conditions such as the hours of work, lighting, the method of operation, and the amount of alcohol consumed.

THE COST OF DEFECTIVE OUTPUT

It is clear that in so far as work is spoiled, it is equivalent to a deficiency in the quantity of effective or saleable output. But to all the expenses involved in deficient output, defective output adds a positive waste of labour and of raw material.

Hitherto we have not had occasion to consider the costs of raw material. In most manufacturing industries these costs are often heavier even than the costs of direct labour. Among the industrial processes listed in Table 5, for instance, where shoes for men, women and children have a direct labour cost of \$0.551, \$0.677 and \$0.244 respectively, their cost in leather alone was \$2.564, \$2.630 and \$1.226 respectively. Again, in the manufacture of blue denim, while the direct labour cost was \$0.47 per piece, the cost of materials was \$0.39.

The relative importance of raw material depends largely on the number of processes through which it must pass before the finished product of the industry emerges. A larger number of processes will increase overhead and labour charges more or less proportionately, but will not add in the least to the cost of the raw material. Hence charges for raw material fall heaviest on the industries that include only a few stages in production. However, since at each stage the material is subjected to a fresh risk of being spoiled, it follows that in industries where the charge for raw material is lowest the proportion of raw material wasted will often be highest. The waste of raw material tends in this way to be equally heavy in all industries.

There is also a waste of effort on the part of labour. While deficient output at least offers the possibility that the worker may have obtained needed rest and recuperation by relaxing his efforts, no such comfort can be derived from defective output. There is comfort in missing the morning train by sleeping overtime, but none in missing the train after running for it! The worker on piece wages is usually not paid for his defective output, and yet this misdirected effort may have involved as much exertion as his effective efforts. Sometimes, where the defect is remediable by

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further work, it is only time, effort and labour that is wasted and not materials at all.

Defective output also involves greater overhead charges than does deficient output. The fall in quality of output is not balanced by any fall in the wear and tear of machines; the power and the machine, just like the human worker, are used to the same extent in producing defective output as in producing satisfactory output. A rise in the proportion of spoiled work involves an increase in every class of overhead costs per saleable unit produced, and the distinction made in Chapter V between the variable cost of wear and tear and the constant costs of obsolescence and exposure cannot be maintained in the face of the all-pervading burden of defective output.

To attempt entirely to eradicate defects would probably cost more than it would save. The employer must, as in the case of other losses, balance the cost of prevention or repair against the cost of neglect. No business man would dare to adopt a policy of entire neglect. If he were working to specification, he would risk breaking his contract, and in any case the good will of his business would suffer. He usually resorts to the "cure" of assigning a large proportion of his employees to the work of inspecting the output produced by the remaining employees, and of rejecting whatever defective output they find—a cure that is often most expensive. In Table 2 inspectors and gaugers are seen to form 13.7 per cent. of the total working force of a factory—a number almost equal to all the labourers employed or all the craftsmen. Possibly, therefore, the employer would find it more economical in the long run to turn to prevention. Prevention is probably largely a matter of proper training and supervision, but adjustments in certain other conditions under the employer's control would seem related to a better quality of output, and to these relationships consideration may now be given.

EFFECT OF HOURS OF WORK

One early association of hours and defective output is cited by Bentinck and Hutchins and Harrison. J. L. Kennedy,

in reporting to the (second) commission on children's employment in 1843, referred to a firm who tried to run their mill 15 hours a day, and found that after the first month output began to fall off both in quantity and quality. By the fourth month of the trial *the spoiled work had doubled*, and the production had fallen from 100 per cent. to 90 per cent. "The amount of spoiled work increased to such an alarming degree that the parties referred to felt themselves compelled to shorten the hours of labour to avoid loss."

More modern evidence refers not to the effect of changing the total length of the working day, but to the effect hour by hour of continued work in the course of a working day. One investigation conducted by Pieraccini and Maffei¹ at Florence (1905) has been quoted over and over again.

The errors of four compositors were observed during the *first* seven hours of their usual working day² which extended over thirteen hours, and except for a drop from the first to the second hour of the day, their errors were found to rise sharply and continuously in each spell in spite of a falling quantity of output. Although a laudable pioneer effort, this observation was apparently only made on one day, and further data are required before a curve of errors can be considered as established.

More extensive researches have recently, indeed, been undertaken. Link (16, 1919) found that on re-inspection of shells passed as sound, twice as many were found defective (5.3 per cent. of shells passed) in the last working hour as in the first hour of the afternoon spell. Baumberger (16) observed eighteen women clerks writing in names on pay checks with pen and ink and typing in the amounts with a machine, the name and amount being obtained from the payroll. The working day lasted from 8 to 12, and 1 to 5, and records were taken for each of the four hours in each spell. The number of errors was some 10½ per cent. higher in the afternoon spell than in the morning, though the

¹ "La Curva Della Produzione Utile Esterna sul Campo del Lavoro," read at the International Congress of Industrial Diseases, Milan, 1906, and quoted (usually as though by Pieraccini alone) by Goldmark (20), Vernon (26) and others.

² Not as e.g. Vernon (26) says, "during the course of their usual 7-hour working day."

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output was $5\frac{1}{2}$ per cent. lower. Within both spells the second hour showed the lowest number of errors (as low as 23 per cent. below the average for the day in the second hour of the first spell), and the last hour of each spell showed some 10 per cent. above average. The first hour of the afternoon spell, however, had the greatest number of errors, almost 12 per cent. above the average for the day.

Miles and Eyre of the National Institute of Industrial Psychology (15, Vol. 1, No. 4) report an investigation into breakage of dishes, etc., in the tea-shops of a well-known London catering house, said to have had an annual bill of £80,000 for broken china.

Records were taken every two hours of the ratio of "direct" breakages, where an individual was immediately responsible, to the total number of articles handled at the time. From 10 a.m. to noon these breakages averaged 2.2 per thousand articles handled; from noon to 2 p.m., 3.3; from 2 p.m. to 4 p.m., 2.2; and from 4 p.m. to 6 p.m., 5.7. In addition to the continued hours of work, the intensification of work at lunch and tea time, obvious to any frequenter of such places, probably played a part in these large variations in the proportion of breakages.

In the American 10-hour metal factory, where so many output curves were obtained, Dr. Ryan and I investigated hourly curves of spoiled work in three or four different operations. On full working days this factory worked from 7 to 12 in the morning, and from 1 to 6 in the afternoon. The spoiled work percentages were determined for each hour by dividing the actual number of pieces which each individual spoiled by the actual total number of pieces which the same individual produced.

This investigation is so much more detailed and extensive than previous work on the relations of hours and defective output, that full quotation may be made from the account read before the British Association at Hull in 1922 (15, Vol. 1, No. 5).

The three types of operation will be referred to as grinding springs, footpress assembly and roll thread. The details as to the steps involved in the work, the way in which spoiled work occurred, and the number of operators observed are as follows:

The grinding springs operation consisted in grinding a flat surface on the two ends of a short spiral spring. The grinding was done on an emery wheel, and spoiled work resulted if the spring was ground either too little or too much.

Thirteen women were observed for fifteen full working days each; during this period they were gradually increasing the amount of their output but were not improving in quality of output. Seven of these workers, forming Group B, were being used as subjects for a certain physiological test, and their work was thus slightly interrupted at intervals; the remaining uninterrupted operators form Group A.

The footpress operations consisted in stamping together or "assembling" small parts by means of a footpress. Four women were observed, for from five to ten days, two of them stamping small rivets into a piece of wire gauze held in a metal shell, and two of them stamping together gauze and a spreader to assemble a carrier. In both groups the parts were brought together and adjusted by hand previous to stamping. Here the "product" would be spoiled either by the parts being misplaced under the stamp, or by another piece getting in the way of the "stripper." This "stripper" removed the shell when the footpress was released. If the shell remained under the edge of the stripper, it was the duty of the operator to knock it away. Failure to do this resulted in crushing the shell in the next operation.

In the case of thread-rolling, an intensive study was made on one man for two days. This operation consisted in grasping a tube about one inch in diameter and four inches long, and sliding it on a die. A wheel then came down, rolling a thread upon the end. Though there was, strictly speaking, no work actually spoiled here, much time would be lost by failure of the operator to get the tube on the die or to remove it on the first trial, thus necessitating a repetition of the act.

The result of averaging the percentage of spoiled work to total output found during each hour for each worker is given in Table 30.

The percentage of spoiled work in general is seen to be lowest in the footpress operation, next lowest in the roll thread, and highest in the grinding springs.

In spite of these differences in the general daily level of spoiled work, we find that, as a rule, the percentage of spoiled work is high at the beginning of each spell, decreases during the first three hours, and rises toward the end of the spell. The two hours at the end of each spell show, in general, a comparatively high spoiled work proportion; occasionally the fourth hour is the higher of the two.

Exceptions to this general rule occur (*a*) in the morning spell of the footpress assembling, which gives irregular fluctuations, and (*b*) in the roll thread operation where the spoiled work percentage is low at the beginning of the spell and rises practically continuously throughout the spell. There is evidence for believing that the early fall usual in the other operations occurs here also, but very early, within the first hour. This operation is the only one where much difference

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is to be seen between the two spells taken as a whole. Here the afternoon has a definitely higher spoiled work percentage.

Where interruptions occur, e.g. when the physiological test on Group B grinding springs is introduced, a rise in the proportion of spoiled work is generally found to occur in the hour following, save where the interruptions took place in the first hour of the spell.

An analysis of the evidence at hand leads us to believe that the "shape" of these hourly spoiled work curves is not due to changes in the environment or in factors other than hours or types of work.

TABLE 30

RELATION OF HOURS OF WORK TO DEFECTIVE OUTPUT: AMERICAN
10-HOUR METAL PLANT
Percentage Spoiled Work to Actual Output

Hour of Day.	Grinding Springs.		Footpress Assembly.		Roll Thread on Tube.
	Group A.	Group B.	Rivets.	Carriers.	
7-8	7.8	12.4	1.48	0.366	1.58
8-9	6.5	11.5	1.05	0.270	1.88
9-10	5.0	9.9	1.73	0.288	2.22
10-11	6.6	12.1	1.04	0.193	2.02
11-12	5.9	13.5	1.05	0.160	2.36
Average for first spell ..	6.4	11.9	1.27	0.255	2.19
1-2	6.2	13.1	1.50	0.300	2.24
2-3	5.7	12.3	1.36	0.296	2.62
3-4	4.5	10.1	1.02	0.200	3.32
4-5	7.0	12.0	1.19	0.216	3.35
5-6	7.7	17.3	1.11	0.277	3.32
Average for second spell	6.2	13.0	1.23	0.258	2.96

Records were also made of the time voluntarily and involuntarily wasted (Table 29) per hour per worker, of the corrected output, and of the average speed attained while actually working. This was done to provide a check on the previous data, so as to ensure that any increase in the percentage of spoiled work was not due to diminished total output arising from "rests."

EFFECT OF TYPE OF WORK, INCENTIVES AND OTHER CONDITIONS

It is noteworthy that the operations studied involve different psycho-physiological demands upon the worker,

and Ryan and I have stated our belief (15, Vol. 1, No. 5) that the differences observed in the daily level and hourly curve of spoiled work are connected with these psycho-physiological differences inherent in the several types of work.

Thus, in grinding springs where the general level of spoiled work is highest, and the early fall and later rise in spoiled work are most marked, sensory discrimination is finest, both for visual and for kinæsthetic stimuli. The ends of the springs are ground at the rate of about two a minute, and a deviation of about one-sixty-fourth of an inch in the amount ground off would condemn the spring as spoiled work.

In the case of the footpress assembly, with a low proportion of spoiled work and a less marked hourly curve, the differences to be discriminated were certainly larger than in grind springs. This is important inasmuch as mechanical devices, standards and methods of contrast or comparison may often be devised, whereby the fineness of sensory discrimination may be reduced.

Roll thread shows a proportion of spoiled work intermediate between that of the other operations, and an hourly curve rising steadily throughout the spell and to some extent throughout the day. But here a fast pace was set by the machine, a factor not occurring in the other two operations—so that it is difficult to compare it with the other operations on the basis of sensory discrimination.

Besides the hours of labour and the intensity of labour conditions that have been held to influence the proportion of spoiled work are non-financial incentives, lighting conditions, alcohol consumption, and, of course, methods of work and training.

The claim that non-financial incentives may be used to improve quality of output and also economy in the use of materials is associated with Mr. Robert B. Wolf's efforts in the Canadian paper-making industry.¹ The particular form of incentive in question was that of publishing records of comparative efficiency. In Mr. Wolf's own words,

The problem was to produce a desire upon the part of the machine crew to get the required results, so we put on each shift a man (one for every two paper machines) to take samples every time a reel was changed from the front, middle and back of the sheet, these three samples being weighed and recorded.

¹ Robert B. Wolf: *Modern Industry and the Individual*. A. W. Shaw Co., Chicago, 1919. "Non-Financial Incentives," American Society of Mechanical Engineers, *Transactions*, New York, 1918.

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The tests were for weight and moisture, and were taken every forty minutes or so on each machine. The results of these tests in graphical form were posted so that the worker could follow his own productivity hour by hour and day by day, and Mr. Wolf claims, as a result, an enormous increase in interest, and a substantial improvement in the quality of the work performed, and in the economy of materials.

Lighting has been found to play a part in defective output from coal mines. Defective output in this case refers to a large admixture of dirt with the coal, and Farmer, Adams and Stephenson report (15, Vol. 1, No. 5) a decrease of 21.9 per cent. in the dirt mixed with the same amounts of coal when a porch lamp having six times the lighting power of the standard miner's lamp was used. Reversion to the standard lamp increased the dirt by 47.6 per cent.

The effect of alcohol was studied by Kraepelin¹ in the training of soldiers to shoot straight—essentially a question of quality. Comparing days on which a squad of soldiers drank 40 grams of alcohol early in the morning and afternoon, with the days on which they drank only water, Kraepelin found slightly less precision in the shooting on the former days, particularly twenty-five to thirty minutes after the soldiers had taken alcohol in the morning.

Rivers, however, held that many of the supposed effects of alcohol are really due to the suggestion, interest, excitement and sensory stimulation accompanying the taking of the drug,² and Kraepelin's results may indicate the importance of psychological rather than physiological factors.

The effect of different methods of performing a given operation was studied by Ryan and myself in the series of operations already quoted. In the grinding springs operation large variations occurred between individual operatives in regard to the quantity of output and percentage of spoiled work, and it was found that four of the five workers producing the *highest* percentage of spoiled work made only one application of the spring to the grinding wheel. Their average percentage of spoiled work was 12.3; whereas

¹ *Inter. Monat. z. Erfor d. Alkohol, etc.*, October–November 1916.

² Dr. C. S. Myers in *Nature*, October 7, 1922.

three of the five producing the *lowest* percentage—the average percentage of the three being 5·4—were in the habit of applying each end of the spring to the grinding wheel twice but no more ; that is to say, a partial grinding was followed by a visual inspection and a second and final grinding. Five other workers who applied the spring more than twice showed an average spoiled work percentage of 9·4. Here obvious differences in the method of work are seen to be associated with differences in the quality of the work produced.

Again, in the investigation into breakages in tea-shops (15, Vol. 1, No. 4) a great reduction was found to follow alterations in the arrangements for routing the work, washing the dishes, stacking the cups, etc. The daily quota of direct breakages fell over 75 per cent. in the case of one article and over 53 per cent. on the average, and the steep rise in the hourly curve between 4 and 6 p.m. was wiped out. Instead of a breakage rate of 5·7 per thousand in these two hours, the rate was reduced to 1·58. It was held by the investigators that the alterations made the work less irritating and reduced the need for attention and care.

CHAPTER X

THE LOSS BY INDUSTRIAL ACCIDENTS

ACCIDENTS are often enough accepted as a dispensation of Providence. This may be true of earthquakes, volcanic eruptions, storms and tempests, but in the humanly created conditions of industry, accidents must take their place beside turnover, lost time, and deficient and defective output as a symptom of human inefficiency.

In the control exercised by the State the responsibility of the technical engineer has long been realized and is now perhaps over-emphasized to the comparative neglect of the responsibility of the employer for the general conditions of employment. The collection of accident statistics has been insisted upon by Government departments, led by the English Home Office, as the first step in prevention, and these statistics now constitute an important body of evidence. Yet official investigations often confine their interpretation of cause to the type of machine or object inflicting the injury without inquiry into the action of the object and of the human victim immediately preceding. The gradual recognition of variations in accidents as a measure of the injured worker's bodily and mental state, and of the influence upon him of industrial conditions, has led to some readjustment, not unattended by confusion.

In the approved American accident form (8, No. 264) Accidents Causes are classified as I Machinery, II Vehicles, III Explosions, etc., IV Poisonous Substances, etc., V Falls of Persons, VI Stepping On or Striking Against Objects, VII Falling Objects, VIII Handling of Objects, IX Hand Tools, X Animals, XI Miscellaneous Causes.

While headings III, IV, V, VI, VII and VIII clearly refer to the process or action causing the accident, i.e. the circum-

stances proper, headings I, II, IX and X tell us only the agent of the accident, and we have no means of knowing how far the injured person was himself a contributing factor in the process of causation. Thus Cause IX includes accidents due to "glancing or slipping of tool in use," a case in which the injured man's state of mind or body may have had considerable influence, and also accidents due to "breaking or coming apart of tool," a case where the human factor could have had little to do with the circumstance.

Until the relation between accidents and the behaviour of the human factor is more exactly elucidated—a plan is suggested in Chapter XIII—industrial accidents must be studied as a whole with the assurance, based on their statistical regularity, that variations in industrial accidents and variations in the state of the human factor are closely connected, and that the direct obtrusion of external nature plays but a subsidiary part.

A—THE COST OF AN INDUSTRIAL ACCIDENT

Turnover, absence, and defective and deficient output are primarily a cost to the employer; an accident is primarily a cost to the worker. Pain, maiming and disfigurement are involved and the possibility of death. Nor do these physical costs exempt the victim from the economic costs of lowered earning capacity suddenly confronting him. An accident is a cost to the worker both directly as a sentient and self-respecting being, and indirectly as a wage-earner. It is only with the growth of workmen's compensation laws that this indirect cost has been shared by the employer as a matter of principle and without question of liability.

Apart from compensation, accidents involve expense to the employer by increasing labour turnover, absence, and deficiencies and defects in output. A temporary partial disablement, the "first-aid" case, may result in continued presence at work but a lowered quantity and quality of output; temporary total disablement results in an absence from work that is clearly measurable; and fatal or permanently disabling accidents naturally result in increased turnover.

The exact cost of these labour losses to the employer has already been considered, but where the losses are due to industrial accidents the element of compensation is added, owing to the workmen's compensation laws that are now almost universal in all European countries and in most States of the American Union.

The actual compensation granted the employee for total disability is usually from half to $\frac{7}{8}$ ths of the wage he would have earned during the time of disability. Compensation for partial disability is scaled down in proportion. In America, standard tables of compensation for various partial disabilities, loss of hand, eye, etc., have been drawn up that read like the old Saxon wergild—so much compensation for killing an earl, so much for a bishop, so much for a king. Compensation for death when dependents are left is based in America on the total number of days of earning power estimated to be lost in the average case. The English practice is to pay within certain limits the equivalent of three years' wages; in 1920 the average sum paid in death claims was £214. Compensation may also include the cost of funerals, or medical service in attending the injury.

If the practice of insurance did not exist the compensation to be paid to an injured employee would fall to its full extent on the employer. As a matter of fact, quite a number of employers on a large scale do pay compensation directly to their employees. Under these simple circumstances there can be no question in the employer's mind that increases in accidents involve a direct increase in expense.

The device of insurance, however, has obscured this connection. To cover risks of compensation employers may insure themselves either with a private insurance company or with some State fund. In most American States such insurance is compulsory, and in some the insurance is carried exclusively by the State. The insured employer pays, not compensation, but a premium, and this premium, for any one employer in any one year, may or may not correspond to the compensation that his employees can claim. The premia charged by the insurance carriers to employers as a whole must, of course, cover administrative expenses and profits—often a high ratio of the sums paid in

claims.¹ But the cost of his insurance to any one employer is not related to his compensation claims, except indirectly. Direct relationship will occur only when the rates of premium that the employer has to pay are modified according to the specific risk, i.e. to the number and severity of accidents that are likely to occur in his plant in the future, or that have occurred in the past. Inattention to the prevention of accidents will then result in a direct money penalty on the employer.

The rating of the risk in England is regulated according to the rules of the Accident Offices Associated. These rules may be modified according to special circumstances,² but no schedule of modification is published, and in practice the special rates probably depend more on the relative bargaining power and skill of the contracting parties than on any objective differences in risk of accident.

In several American States these modifications have been most thoroughly worked out. In fact the process of computing a proper insurance rate on employees' accident compensation claims forms an interesting example of the use of accurate records and analysis. As Mr. Blanchard puts it:

Statisticians collect and arrange data of past experience; actuaries with past experience as a guide construct new rates for the future; engineers assist in measuring mechanical and structural hazards; while underwriters lend their judgment in the quotation of rates for which no accurate mathematical basis is available.³

Indeed the most important group of stock insurance companies finds it necessary to maintain the National Workmen's Compensation Service Bureau organized to gather statistics of workmen's compensation insurance, to translate these statistics into manual rates, and to develop systems of schedule and experience rating.

¹ An investigation of 21 American States and 2 Canadian provinces undertaken by the U.S. Bureau of Labor Statistics showed the average expense ratio of stock companies to be 37½ per cent., of mutual companies about 20 per cent., of competitive State funds about 12½ per cent. and of exclusive State funds from 5 to 7½ per cent.

² See J. L. Cohen: *Workmen's Compensation in Great Britain*, p. 108.

³ R. H. Blanchard: *Liability and Compensation Insurance*. D. Appleton & Co., London and New York, 1917.

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The actual building up of the premium rate for accident insurance proceeds by several stages :

(1) A standard *manual* rate is quoted for different industries.

For instance, some of the Bureau's base rates per \$100 payroll, filed in 1914 with the Industrial Commission of the State of Wisconsin² were \$0.68 for boot and shoe manufacturing, \$1.27 for machine shops with no foundry, \$4.18 for electric light and power companies, \$4.37 for logging and lumbering, \$15.85 for logging railroads. The rate obviously follows an estimate of the hazardous nature of the industry.

(2) A schedule *merit* rate may modify the "manual" rate for a given plant if, on inspection of the plant, certain conditions are found fulfilled.

This scheme of a differential rating for separate plants has been adopted by several of the American States which provide insurance, notably by Pennsylvania and Washington. We may quote from an official (and somewhat complicated) summary of a law passed by the State of Washington in 1917 (11, May 1919) :

The measure provides that every workman employed in industries classified under the Compensation Act shall have, first, a safe place to work; second, the machinery with which they work shall be so safeguarded as to reduce injury to a minimum; and third, that these workmen shall receive educational instruction *by qualified safety engineers to the end that they will know the dangers incident to their employment and be alert to these dangers always.*

The merit-rating features of the measure are fourfold in character.

1. Providing for *safe place* standards or *safe place* of work, providing that establishments fully complying with the same shall receive a merit reward of 5 per cent. of the total of the contribution of the establishment so complying to its class accident fund, and inversely, those establishments not complying shall be penalized 5 per cent. of their total annual assessment.

2. Those establishments placing into effect *the safety device* standards or *machinery safeguards* will receive a merit reward of another 5 per cent. of their total contribution. . . .

3. Establishments fully placing into effect within their establishments and amongst their workmen the *educational features* of the bill, will be rewarded an additional 10 per cent. of their annual contribution,

² *Workmen's Compensation Insurance*. Bulletin issued August 7, 1916

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or penalized 10 per cent. if they fail to do so. This will make it possible for an establishment to receive [or lose] under the above three rules a total of 20 per cent. of their contribution . . . or they may have the reward or penalty under any one or two of the above rules.

The fourth feature of the merit-rating scheme provides for additional rewards and penalties according to compliance or non-compliance with the above three rules, coupled with the actual experience of accidents in the establishment. In the words of the summary :

It is possible for an establishment under the provisions of this act that has fully complied with all of its rules, and whose experience has proven of the best, to receive a reward of a total of 30 per cent. of its entire contribution to its class accident fund annually.

(3) A general *experience* rating may further modify or possibly cancel the other rates. In this case the rating of any particular plant depends not on the presence of certain meritorious conditions visible by inspection, but on the actual accident experience of a plant over a given period. It is a rating that is based on direct records and statistics of the plant.

Under the Washington law above quoted, " the experience rating is made to cover an experience period of five years, and for this purpose a statistical department is created for the purpose of compiling an experience table from the files and records of the industrial insurance department."

The system of experience rating was also adopted in Ohio (8, No. 210), where it is considered definitely superior to the system of merit rating in encouraging the prevention of accidents.

To sum up : Insurance against the payment of accident compensation does not necessarily blur the connection between an accident and economic loss to the employer. Where the rate of premia for any industry is modified for any single establishment according to an analysis of the risks or to the actual accident experience of that establishment, where, in short, the costs of compensation are equitably distributed among the several plants, there the costs of accident must be as evident to the employer in the long run as though insurance had never been thought of.

B—THE AVERAGE LOSS BY INDUSTRIAL ACCIDENTS

The usual comparisons of aggregate accident rates of different establishments, industries or countries are often vitiated by different conceptions of what constitutes an accident. Measured by the number of days the victim is disabled from working, accidents may be of any degree of severity from a scratch requiring first (and no second) aid and causing no period of disability, to permanent disablement and death; and individual establishments and States draw the line at different points between accidents that are and are not reportable. In England the official line is drawn differently according to the causes of the accident¹; and many plants both in England and America have first-aid stations where a record is made of every wound dressed, even if it involves an absence from work of only half an hour.

The "International (i.e. American and Canadian) Association of Industrial Accidents Boards and Commissions" defines "tabulatable" accidents as "all accidents causing death, permanent disability or loss of time other than the balance of the day, turn or shift on which the accident occurred." This definition limits "accidents" to injuries causing something like a full day's absence and all cases of accidents would accordingly result in death, permanent disability, either total or partial, or some amount of temporary absence.

This is the definition of accident that we shall accept, unless otherwise stated. The reader may be reminded, however, that since the proportion between accidents of various degrees of severity remains fairly constant, it is always possible to estimate the frequency of accidents of a specified seriousness from a given frequency of another degree of seriousness, just as in warfare the number of men wounded can be roughly judged from the number killed. These constant proportions have been given in Table 22, Chapter VII.

¹ For purposes of notification, accidents are divided into (a) those due to machinery moved by mechanical power, or to molten metal, hot liquid, explosion, escape of gas or steam, or to electricity, and which necessitate absence throughout at least one whole day; (b) those due to any other cause, and which necessitate absence for more than seven days.

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American Experience

The average loss by accident experienced in the United States as a whole can be only roughly estimated. Hoffman (8, No. 157) calculated that in 1913 there had been about 25,000 fatal accidents among American wage-earners, just over half the total battle deaths of Americans in the recent war. Of accidents not resulting in death, Hoffman estimated that 700,000 had involved more than four weeks' disability. Employing the proportions given in Table 22, this would

TABLE 31
INDUSTRIAL ACCIDENT RATES: AMERICAN EXPERIENCE

Types of Industry. (1)	Frequency Rate per 1,000 Employees.		Days Lost in Temporary Disablement per 100 Work- ing Days, or 1,000 Working Hours. (4)
	Cases of Accident resulting in Death or Permanent Disability. (2)	Cases of Accident resulting in Temporary Disablement of 1 Day or more. (3)	
<i>Manufacture.</i>			
Machine building, 194 plants, 1912	3.9	114.1	0.37
Locomotive engines, etc. ..	—	139.2	0.47
Electrical apparatus	—	96.8	0.33
Machine tools	—	61.0	0.17
Ships	—	215.0	0.77
Machine building, 5 plants, 1907-12	—	75.4	0.23
Machine building, 4 plants, 1910-13	—	77.9	0.23
Iron and Steel Industry :			
1910-14	5.1	172.5	0.7
1915-19	4.2	120.6	0.6
Mines (1912)	3.91*	181.64†	

* Excludes permanent disability.

† Includes permanent disability.

indicate something like two million accidents involving at least one day's disability in one fairly normal year.

In particular industries such as that of machine building and iron and steel making very careful investigations have been made by Chaney and Hanna (8, Nos. 256, 298), and it is possible to give not merely the frequency rates, i.e. the number of accidents per year per thousand employees, but also the so-called severity rates, i.e. the number of days lost per year per thousand employees. The results are summarized in Table 31.

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In machine building the frequency is seen to range from 75 to 114 accidents per thousand men—that is, one out of every nine to a dozen men is injured every year. In the iron and steel industry rates have improved from 172 to 120 per thousand, but even the latter figure indicates an injury to one man in eight every year. Within the machine-building group, shipbuilding exceeds the loss in the iron and steel industry; the rate is 215 per thousand, or one man in less than five disabled (for a day at least) every year.

Experience of accidents is commonly analysed by industry,

TABLE 32
COMPARATIVE ACCIDENT RATES IN VARIOUS DEPARTMENTS
Accident Frequency Rates per 1,000 300-day Workers

Department.	Machine Building—194 Plants in 1912.		Iron and Steel *—Over 400 Plants, 1910-14.	
	All Accidents.	Death and Permanent Injury Only.	All Accidents.	Death and Permanent Injury Only.
Yard	221·1	8·2	152·1	6·4
Power house	103·8	4·6	70·6	3·3
Mechanical department	108·1	3·7	188·2	5·1
Forge shops	169·9	5·8	177·2	4·4
Foundries	140·0	4·3	190·8	5·6
Total	118·0	3·9	176·7	5·1

* The figures are quoted from (8, No. 234) Table 99.

but it is probable that within each industry the several occupations or departments show wide differences in the rate of accidents. Moreover, the same type of occupation such as general labour or machinist, or the same type of department such as power house or engine room, yards, machine shops, etc., probably have very similar rates, even though occurring in different industries. The detailed inquiry of Chaney and Hanna into the accidents of the American iron and steel and machine-building industries enables us to isolate certain of these departments and occupations.

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In so far as it is possible to generalize from these two industries it appears that power houses have a relatively low accident rate, foundries a relatively high rate, and mechanical departments or machine shops an average rate. Somewhat baffling to generalizations, however, is the fact that yards have the highest tabulated departmental rate in machine building, but the lowest except one in iron and steel. Forge shops, though ranking very differently among the departments of the two industries, have much the same actual rate.

American experience also permits comparison between the risks of common labour and of more skilled occupations.

In the blast furnace departments of a group of iron and steel plants (8, No. 298) the frequency of all accidents in 1905-14 was 200.6 per thousand employed; the rate for common labourers only was 250.5, while among the mechanics the rate was only 128.1. In the open hearth department with a general rate of 192.4, the rate for common labourers only was 467.7; and in the tube mills with a general rate of 188.9, the rate for common labour was 661.3.

Again, in a machine-building plant (8, No. 256, p. 43) with an average rate of accidents from 1907 to 1913 of 97.8 per thousand, the rate for labourers was 136.1, while for machinists and helpers it was only 74.0.

It is clear that common labour is distinctly and often vastly more hazardous than the general run of occupations in an iron and steel mill or in a machine-building plant.

English Experience

The accident rate probably fluctuates with fluctuations in business activity, but in recent years in England the determining event has undoubtedly been the reduction of hours.

In 1919 the 8-hour working day replaced the 9-hour or 10-hour day and *ipso facto* decreased the length of the *exposure* of workers to accident. During the years of the war information was insufficient, but the overall frequency rates of fatal or non-fatal accidents disabling a week or more in shipping, factories, docks, mines, quarries, constructional work and railways, can be calculated from the

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official statistics¹ for 1911 as 58 per thousand, for 1912 as 57·8 per thousand, for 1913 as 64 per thousand, and for 1914 as 62·6 per thousand. There was no sign then of any reduction in accidents. But in 1919, when the 8-hour day became almost universal, the overall rate fell to 43·8 in spite of the trade boom, and in 1920 this rate was 46·2. The fall as between 1911 to 1914 and 1919 to 1921 averages as much as 25 per cent., i.e. from about 60 to about 45 per thousand employed, a fall which seems more than proportionate to the reduction in hours.

When the fall in accidents between 1912 and 1920 is analysed industry by industry as in Table 33, the rate of fall appears much greater in the transport and mining industries, where it is of the order of 50 per cent., than in manufacture proper, where the fall is only about 10 per cent. The 8-hour day for transport workers probably involved a greater reduction of hours than did the 8-hour day in manufacture, but no useful conclusion can be arrived at as to whether reduction of hours reduces accident *per hour* and why, until (1) the comparative output of the different years is known, (2) changes in technique and equipment, possibly affecting the safety of workers, are better recorded.

In Table 33 the experience of 1912 is placed side by side with that of 1921, since the hours worked in England in 1912 are more comparable to those worked in America, when the figures in Table 31 were obtained. Obviously we must endeavour to standardize the exposure on the basis of hours worked, not merely on the basis of numbers employed. In America, indeed, an accident frequency rate based on a million hours of exposure has been largely adopted.

It appears that in England in 1912 one man in every seven was disabled by accident for a week or more in mines, one man in ten on docks, and one man in eleven in engine and ship building. In 1920 such severe disablement overtook one man in nine in mines, one man in fourteen on docks, and one man in sixteen in engine and ship building.

At the other extreme are the textile, paper and printing, and shipping industries with small rates of accident. In

¹ Statistics of Compensation and of Proceedings under the Workmen's Compensation Act, 1906, and the Employers' Liability Act, 1880.

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shipping, however, the rate of *fatal* accidents only is the highest; here one man in every two hundred is killed on the average each year.

The aggregate expenses involved in accident compensation in these English industries was in 1912, £567,107 for fatal cases, and £2,606,994 for cases not fatal but lasting over

TABLE 33
INDUSTRIAL ACCIDENT RATES: ENGLISH EXPERIENCE, 1912 AND 1920

Type of Industry. (1)	Frequency Rate per 1,000 Employees.			
	Cases of Fatal Accidents.	Cases of Accidents resulting in Permanent or Temporary Disablement of 1 Week or More.		Cases of Accidents resulting in Temporary Disablement of 1 Day or More (estimated).*
	1912. (2)	1912. (3)	1920. (4)	1912. (5)
<i>Manufacture—</i>				
Cotton	0·09	21·6	17·5	34·5
Wool and other textiles	0·04	12·4	11·6	19·8
Paper and printing	0·07	14·5	15·8	23·2
Metal (including extraction)	0·38	78·5	61·3	125·4
Engine and ship building	0·60	92·8	62·4	148·2
Other metal works	0·18	49·5	42·3	79·1
Three metal groups	0·33	67·0	52·4	107·0
Total manufacture	0·20	35·9	32·4	57·3
<i>Transport—</i>				
Shipping	2·02	32·6	21·1	52·1
Docks	1·42	107·0	70·3	170·9
Railway servants †	0·95	63·0	37·5	100·5
Mines	1·15	154·6	107·8	246·9
<i>Building—</i>				
Constructional work	0·74	53·0	41·6	84·6
<i>Office—</i>				
Railway clerical staff	0·04	0·8	0·6	1·3

* Figures in Column 5 found by multiplying figures in Column 3 by $\frac{99}{99-37}$ in accordance with proportions given in Table 22.
† Exclusive of clerks.

one week; and in 1920 with the rise in wages and therefore in compensation rates the expenses were £755,657 for the fatal cases and £5,222,352 for the cases not fatal. When compared with the number of persons employed in the total of industries where compensation was paid, the rate of compensation for all cases was in 1920 14s. 4d. per person

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employed. In factories this rate was only 9s. 3d. per person employed, but on railways it was 11s. 8d., on constructional work 13s. 5d., in shipping 16s. 6d., in docks 29s. 5d., and in mines 37s. 3d. Calculated in relation to the wage bill, the cost of compensation worked out in 1921, at 3'3d. per £1 of wages in coal mining ; as regards railways information obtained from one large company indicated that the amount of compensation paid per £1 of wages would be about 1d.

As the official report points out, however,

The figures given above represent only the actual amount paid to workmen or their dependents, and not the total charge on the industries in respect of compensation. To compute the total charge it would be necessary to take account of the administrative expenses and medical and legal costs of employers, insurance companies and mutual indemnity associations, the amounts placed in reserve, and the sums set aside by insurance companies as profits. These constitute a large proportion of the total charge. For example, it appears from the returns furnished by the insurance companies to the Board of Trade in respect of employers' liability insurance business that in the year 1920 the income of the companies from premiums was £8,851,607 or, including the interest from reserves, £9,047,559, but that only £2,980,755 went in payments under policies, £2,921,959 being spent in payments for commission and expenses of management, £1,476,869 being transferred to the reserves, and £1,667,976 being set aside for profits. (These figures apply to the whole of the employers' liability insurance business of the companies, and not merely to the seven industries scheduled under the Act.) It is estimated that if all the charges and expenses referred to above are taken into account, the total charge for compensation in the seven great industries cannot have been less than £8,500,000.

Taking into account the fact that the seven industries hitherto considered employ only about half of those coming within the scope of the Act, and that in every trade there are many employers who do not insure against claims, Cohen¹ considers £12,000,000 a conservative estimate of the total of employers' liability for the year 1920. It has, indeed, been estimated by some to amount to over £16,000,000.

C—MINIMUM LOSS BY INDUSTRIAL ACCIDENTS

Those best acquainted with the circumstances are agreed that the number of industrial accidents could be enormously

¹ J. L. Cohen: *Workmen's Compensation in Great Britain*, Post Magazine Co. London, 1923.

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reduced. Mr. Gerald Bellhouse, H.M. Chief Inspector of Factories and Workshops, says that 75 per cent. of the accidents that occur could, with reasonable precaution, be avoided. Chaney and Hanna (8, No. 298) go even farther: "Spend enough upon the engineering problems and serious and fatal accidents will be very largely eliminated. . . . It is possible to conceive industry conducted under conditions so safe that the occurrence of severe injury will excite the surprise that its absence now does."

The Theoretical Minimum

Various ideals may be set as to the minimum to which industrial accidents can be reduced. The most ambitious ideal is that of no industrial accidents at all! That is to say, no greater risk of accident for the occupied than for the unoccupied. The word "accident" by its very derivation denotes something which should not happen at all. As Lord Macnaghten puts it, "the expression 'accident' is used in the popular and ordinary sense of the word as denoting an unlooked-for mishap or untoward event which is not expected or designed," and all industrial accidents arising out of and in the course of employment might be considered as avoidable by the employer.

In some occupations this ideal is undoubtedly obtained. The rate of accident for clergymen, for instance, is probably no higher than for unoccupied men of similar social standing. According to the United States census in 1910 there were 117,333 (male) clergymen. In the course of 1908 and 1909 70 clergymen died by accident. This gives an annual rate for death by accident of 0.30 per thousand.

But the occupations in which the majority of Englishmen and Americans engage undoubtedly add to the risk of accident. A glance at Table 31 shows the fatal death rate among American miners in 1912 to have been 3.91 per thousand, and this by accident *occurring only in the course of employment*. Human nature pursuing the duties of a clergyman is practically immune from death by accident. Human nature pursuing the duties of a miner sustains casualties almost comparable to those of a battlefield.

The different risks of different industries, professions or

occupations is unquestionably due largely to certain physical material possibilities rather than to variations in human working capacity. To revert to the diagram given in Table 3, variations in industrial conditions may (line B) be associated with variations in accidents without implying any variation in human working capacity. The presence of objects such as power-driven machines, furnaces, hot liquids and explosives is enough to ensure higher rates of accident apart from any change in the intrinsic liability of the human factor. And as these instruments are necessary to industrial efficiency, our ideal minimum must be abandoned for something more practical.

To arrive at a practical minimum we might subtract from total accidents certain classes that are obviously preventable, such as, for instance, accidents caused by defective instruments or machines not properly inspected. Comparatively few industrial accidents, however, are caused in this simple way.¹ Human nature being what it is—dull, careless, forgetful, if you like—it is the presence of objects *that become dangerous if misunderstood, mishandled or misjudged* that constitute the more common accident risk in industry.

These mistakes can no more be dismissed as unpreventable by the employer or manager than the presence of defective equipment. Machines must be made, if not fool-proof, at any rate human-nature-proof, and it is essential to draw the line between what can be and what must not be expected from human nature.

A certain "normal" amount of misjudging, misunderstanding and mishandling is tacitly allowed when explosives are isolated, machinery is fenced, and warning notices are posted; but if we want to calculate this allowance more

¹ For the American iron and steel industry Chaney has calculated the frequency of accidents from causes as classified by the International Association of Accident Boards and Commissions (8, No. 298). The frequency of accidents from all causes was rated in 1920 as 23.1 per million hours' exposure. The rates for the various classes of causes were in order of importance: object dropped in handling, 4.4; handling tools with sharp points and edges, 2.9; falls of worker, 2.5; hot substances, 2.4; cranes, etc., 1.9; flying objects, 1.4; caught between object handled and some other object, 1.3; lifting, 1.1; vehicles, 1.1; caught in working machine, 1.0.

These causes taken together account for a rate of 20.0 out of the rate of 23.1 for all causes.

exactly the methods of reporting how an accident happened must be greatly improved. Under any of the official classifications of accident causes it is impossible at present to assign an accident to foolishness or normal human nature by mere inspection of the record. Changes that would make reports more helpful are suggested in Chapter XIII, but for the present we must be content to obtain a working minimum from the experience of those who have carried preventive measures into practice.

The Practical Minimum

Any evidence on a large scale must come from America. The rapidity with which American employers as a whole have, in the last twenty years, plunged from complete neglect of the safety of their employees into the enthusiastic adoption of "Safety First" must seem odd to those who fail to note the sting of the recent American compensation laws. But from whatever motive, sordidly economic or philanthropic, there now exist several national organizations devoted to spreading the gospel of safety, and the managers of plants as a matter of course give their best thought to the avoidance of accidents. This is particularly true in the iron and steel industry, and here Chaney and Hanna (8, No. 298) have been able to trace the course of accident occurrence onwards from the year 1907 when, as they remark, "there were no compensation laws and the study of industry with intent to make it safe had not begun."

The facts disclosed by these investigators are that in the entire industry from 1910 to 1914 the frequency of accidents was reduced from 224.0 cases per 1,000 300-day workers to 150.1 cases. In the special plants in which it was possible to cover the period back to 1907 the changes were from a rate of 242.4 cases in 1907 to one of 101.3 cases in 1914.

The possibility of reducing accidents to a minimum is again strikingly illustrated by comparing the accident rates of plants having well-organized safety-first systems with plants having no such systems, both within the same industry. Chaney (8, No. 256) makes a comparison of this kind in the machine-building industry.

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"The comparison is limited to three groups of plants employing the largest number of workers—electrical apparatus, locomotives and engines, and machine tools—inasmuch as the relatively small size of the other groups would render the results of questionable value.

"As a basis for this comparison careful study was made of the various plants, their methods of mechanical safeguarding, their committee organizations, and their safety education work. With the knowledge thus obtained the plants were divided into two classes.

"In Class A were placed those plants having in considerable measure the requisites of a good safety organization, namely :

1. Safeguarding by signs, warnings and mechanical contrivances.
2. Adequate safety inspection.
3. Safety committees of superintendents, foremen and workers.
4. Emergency and hospital care of the injured.
5. A compensation or relief system.

"In Class B were placed the plants in which some important element of this combination was lacking."

Among plants making electrical apparatus those in Class A had an average accident rate of 65.1 per thousand employed per year; those in Class B, a rate of 185.5. Among plants building locomotives, those in Class A had an average accident rate of 119.5; those in Class B, a rate of 141.7. Among plants making machine tools those in Class A had an average accident rate of 42.1; those in Class B, a rate of 123.4.

Chaney also gives the results of the same method of comparison used in an earlier Government report on the iron and steel industry. Here the plants were divided into three classes according as the safety system was (a) well developed, (b) in process of development, or (c) not developed at all. In the classification of machine-building plants, classes (a) and (b) correspond to those in the iron and steel report; there was no class (c) inasmuch as all the machine-building plants had more than a beginning in safety work and safety organization.

In the iron and steel industry the average annual accident rate was found to be, for plants in class (a) 167.1 per thousand

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employees, for those in class (b) 272·4, and for those in class (c) 507·9.

The conclusion is that in the iron and steel plants taking full safety precautions the accident rate is but one-third of that of the *laissez-faire* plants, while machine-building plants taking certain additional precautions incurred accident rates lower than the less cautious plants by one-seventh in the case of locomotive works and by as much as two-thirds in the case of the tool and electrical works.

Although the experience published in England is more fragmentary, the Reports of the British Safety First Association and of H.M. Chief Inspector of Factories leave no doubt as to the large percentage of avoidable accidents in unregenerate plants. Mr. Buchan, the Inspector of Factories for Liverpool, reports the following rates of accident per employee in a factory after the formation of a safety committee: in 1916, 3·67 accidents per person; in 1917, 1·59; in 1918, 1·49; in 1919, 1·13; in 1920, 0·78. The reduction of accidents throughout the period is by four-fifths. As a result of their safety campaign Lever Brothers report¹ a reduction in the number of accidents of 50 per cent. in 1917, another 12 per cent. in 1918, and another 5 per cent. in 1919.

The *time lost* through avoidable accident is recorded by a firm of paper manufacturers who "created an organization, including a Plant Committee, Safety Engineer, Safety Inspector, etc." In the first year employees lost 4,234 days through accidents, but in the next year this figure was reduced to 1,225 days. The actual severity rate fell in fact from 1·43 and 1·49 in the two halves of the first year to 0·93 and 0·58 in the second year. Another instance is that of a large firm who commenced a safety-first campaign in the latter half of 1919. In 1919 the hours lost on account of temporarily disabling accidents per thousand hours' work was 3·05, in 1920 1·5, in 1921 1·3, and in 1922 0·7.

To sum up. Industrial accidents are usually neither wholly humanly circumstanced nor yet wholly mechanically, but arise most commonly from the fact that potentially

¹ The campaign was largely a matter of organization and propaganda rather than of direct "engineering revision." Cf. the report of H.M. Inspectors of Factories for 1918, cmd. 340, p. 16.

errant human nature is employed on potentially dangerous operations. Anticipation of the likely errors and dangers has substantially reduced the accident rate in several industries and plants, and the adoption of this safety policy by business houses indicates the possibility and the economy of minimizing accident.

D—CONDITIONS OF EXCESSIVE LOSS

§ 1. *Effect of Hours of Work*

There is only limited evidence as to the effect on accidents of an increase in total scheduled hours, and it is still a matter of controversy as to how long working hours must be before they materially influence the rate of accidents. There is, to be sure, a general consensus of opinion that where women are concerned, at least, so long a period as a 12-hour shift clearly increases the rate per hour. In a fuse factory (No. 21) Vernon shows that women's accidents were nearly three times more numerous when a 12-hour period was being worked than in the subsequent 10-hour period, or if due allowance be made for the longer period of work, they were two and a half times more numerous. He also shows that in the 12-hour day women's accidents increased so rapidly that in the last hour of the morning spell they were five times more frequent than in the first hour.

Vernon does not admit, however, that men's accidents per hour will increase in a longer working day, nor does he think the length of hours of much importance in the case of women, except in extreme instances such as the 12-hour day.

In contrast to the question of changing the schedule of hours, evidence abounds as to the effect on accidents of continued hours of work *within the same schedule*. When drawing up the first report of the British Association Committee on Fatigue (12) I included a number of such hourly accident "curves." Of these the most important, by reason of the numbers involved and the fact that the exact limits of the hours of work were legally imposed, were the accident curves collected from official sources for the Lancashire cotton industry in 1907-8. The hours of work in these

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years for practically all the mills and sheds of the district were from 6 to 8, from 8.30 to 12.30, and from 1.30 to 5.30 ; and the accidents for men and women showed a most marked upward trend in the course of each of these three spells of work.

The addition of the figures from all sources of information gave the following results : from 6 to 7 there were 240 accidents ; from 7 to 8, 467 ; in the next spell there were 158 in the first half-hour, equivalent to an hourly rate of 316, and 372 in the next hour, but in the final two hours and a half of the spell the average hourly rate was 645. In the afternoon spell, the first half-hour showed an hourly rate of 222, the next full hour 335, and the next two hours an average of 524. In the final half-hour accidents occurred at the hourly rate of 615 !

The ratio between the hourly rate of accidents in the afternoon and morning spells has been worked out by Vernon in the case of many of these hourly accident curves collected for the British Association Report, and he attempts to show that "the accident frequency was practically no greater in the afternoon than in the morning." This may often be true, but the method Vernon adopts to prove it is not admissible. Most of the statistics on which he bases his comparison were drawn from the official documents of American States covering a multitude of factories, many of which observed a Saturday half-holiday. As I stated in the Report itself (pp. 25-26), "In all the American State figures the frequent but not universal Saturday half-holiday may account for the comparatively fewer afternoon accidents." The exact proportion of plants working Saturday afternoons being unknown, I was unable to "correct" the afternoon figures, but where accidents were collected from individual firms this correction was made in tabulating. Three of these tabulations are used by Vernon, two collected in American motor-car plants and one in an English engineering factory ; all show a higher accident rate in the afternoon—117 per cent., 105 per cent., and 107 per cent. respectively of the morning rate.

Hitherto hours, or other equal periods of time, have been taken as comparable in respect of accidents whenever the

same number of persons were at work in each period; but it is evident that, as in the case of defective output, a ratio based on the quantity of output produced at the time, would be more significant. Otherwise hourly variations in accidents may simply be reflecting the hourly variation of output. Accordingly, in comparing the 8-hour with the 10-hour plant for the U.S. Public Health Service (9), we calculated not merely the accidents per hour, but the accidents *per given output* per hour, and we traced this accident per output ratio throughout different hours of the day. In both factories the accidents per output were found in general to rise as the hours of the day proceeded, and the ratio rose further in the 10-hour plant than in the 8-hour plant.² Expressing the first hour of the day as 100, the course of the ratio of accident to output in the two factories is traced in Table 34.

While at the 8-hour plant the average of the whole of the first spell as compared with the first hour is 114.5 per cent., and the average of the second spell is 126.0 per cent., at the 10-hour plant the first spell average is 121.8 per cent. compared with the first hour, and the second spell average is 137.0 per cent.

As the working day proceeds, accidents increase faster on heavier work than on light. In the 10-hour plant the ratio of accidents to output was recorded separately for three types of work, namely, work requiring muscular exertion, work requiring dexterity, and work on machines.

² The possible relationship of speed of production and accident has been the subject of some controversy. It is, of course, not necessarily one to one, i.e. doubling the output per hour might more than double the accident risk owing to the possibility (1) that the least dangerous steps in the operation cannot be speeded up proportionately, and that the more dangerous would be (in the case chosen) more than doubled in speed. (2) That increased speed increases the chance of inaccurate and dangerous movements.

It is by no means axiomatic that the steps of an operation that are fixed in speed, such as the machining steps, are always the least dangerous to the human worker. However, we made some attempt towards an objective test (9, p. 132); but even the extreme hypothesis that an x per cent. increase of production would increase the chance of accident $4x$ per cent. failed to explain the rise in accidents in the course of the spell.

At present the objection to the ratio of accident to output rests largely on theoretical considerations insufficiently supported by objective evidence. Reference may be made to an article on "Recent Researches in Industrial Fatigue" (*Economic Journal*, June 1923), where I summarize the conflicting contentions. This article also contains a reply to criticism directed against our method of obtaining the hourly ratios.

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Here again the first hour's accident per output ratio was represented by 100. The rise above the first hour for the two spells, in each type of work, is best shown as a percentage increase :

	Muscular.	Dexterous.	Machine Work.
1st spell	61·8	26·2	23·9
2nd spell.. ..	101·1	42·8	38·1

The muscular work obviously shows much the highest rise in the ratio during the day, the next highest rise being on dexterous work. The least rise occurs in machine work,

TABLE 34
EFFECT ON ACCIDENTS OF CONSECUTIVE HOURS OF WORK

Hour of Spell.	Hourly Ratios of Accident to Production Relative to the First Hour's Ratio.				
	1st.	2nd.	3rd.	4th.	5th.
<i>First Spell.</i>					
8-hour plant, all operations ..	100	122·3	124·2	111·4	—
10-hour plant, all operations ..	100	120·2	136·5	140·3	112·2
10-hour plant, muscular work ..	100	147·7	179·9	206·7	174·6
<i>Second Spell.</i>					
8-hour plant, all operations ..	*	127·7	132·9	117·4	—
10-hour plant, all operations ..	115·1	133·5	139·4	139·8	157·0
10-hour plant, muscular work ..	134·7	175·4	197·5	224·5	273·3

* Not calculable owing to variations in incidence of lunch break.

where the positive physical exertion of the human being is probably least.

In the course of nightshifts of ten and a half hours' duration, accidents, as far as the evidence goes (4, No. 19), seem on the whole to fall both for men and women; and since records of output taken at the same time and place show a tendency to rise, the ratio of accident to output is subject to a still more pronounced fall. This evidence is confined to a somewhat narrow range of operation, namely, lathework in munition plants, and further experience is required before generalization is possible.

The days of the week have also been compared with respect to industrial accidents. In 1915 I reported to the

British Association (12) a mass of statistics relating to different industries in various American States and in England and Belgium.

Vernon (26) sums the results up conveniently by showing that, as regards full working days, the maximum frequency was generally observed on Monday and Friday, and minimum frequency on Wednesday and Thursday. Here we might add that in Belgium, where a full Saturday was worked, this day showed in several industries the maximum frequency; while in Germany, according to official data for 1897 and 1907, accidents are most frequent on Monday but next most frequent on Saturday.¹ It must be realized, however, that the difference between the days is small indeed compared to the difference found between hours; and evidence recently collected need not modify the contention (12) that "the accidents of the different days that work full time never vary more than 10 per cent. from one another."

§ 2. *Effect of Social and Physical Working Conditions*

The reduction of accidents following the introduction of preventive measures in the plant has already been described in estimating how far the danger of accidents in industry is actually reducible. These preventive measures were of wide scope, and it is difficult to attribute any measured reduction in accidents to adjustments of any one isolated condition or class of conditions. Statistical evidence does exist, however (1) in the case of physical changes in temperature; (2) in comparing night work and work during the day; and also possibly (3) in the case of such "social" circumstances as awakening a sense of danger among workers and arousing their interest in safety first by the formation of safety committees.

Collis and Greenwood (17) remark that "undoubtedly the most important step to take is a psychological one, viz. to interest the workers themselves in their own safety," and the evidence on head (3) may be taken first.

Observations of the effect of increased interest apart from mechanical adjustments are, unfortunately for scientific

¹ Bulletin No. 92 of the U.S. Bureau of Labor, pp. 23-27.

precision, not frequent. We are told that a two weeks' "drive," in October 1918, on the American railroads of the North-Western region resulted in a reduction of 67 per cent. in casualties,¹ and presumably few mechanical changes could have been made in such a short period. Remarkable reduction in rates of accident consequent upon a safety organization² have already been cited, but we do not know how far such organizations may have installed mechanical devices and reduced accidents in that way.

In default of actual experience as to the effect of interest in safety isolated from mechanical safeguards, reliance must be placed on the analysis of the causes of accidents. Bellhouse,³ after stating that in English factories in 1918 twice as many non-machinery accidents occurred as machinery accidents, considered that not less than 65 per cent. of the latter might be attributed largely to such causes as negligence, carelessness, want of thought, and, perhaps more than all, to a lack of proper appreciation of danger.

In America, Watkins⁴ even goes so far as to state that many years of experience with safety-first movements in this country indicates that 45 per cent. of the results in reducing accidents have been obtained through effective organization including a proper attitude on the part of the management and officials, safety committees, and inspections by workmen; 30 per cent. through educational methods such as instruction of employees, prizes, signs and bulletins, and lectures; and 25 per cent. by safeguards including safety devices built about machines, proper lighting systems and cleanliness.

The effect on accidents of variations in temperature when other conditions were equal has been extensively studied by Vernon. Summarizing his observations in a British fuse factory (26), he states that, on the average, accidents were at a minimum when the factory temperature was about 67° F., though they were only slightly more frequent as long as it lay between 60 and 70 degrees. At temperatures above these limits they began to increase more rapidly in number, and at 77 degrees were 30 per cent. more numerous. At lower temperatures they likewise increased, being 18 per cent. more numerous at 56 degrees.

¹ *Lancet*, January 17 1920.

² Pp. 290-1 above.

³ *Lancet*, January 17, 1920.

⁴ *An Introduction to the Study of Labour Problems*. Harrap & Co., 1923.

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At a projectile factory (4, No. 19) Vernon found the minimum accident rate at a temperature of 72 degrees, and here again with the fall of temperature the accidents gradually increased until at 52 degrees they were 35 per cent. more numerous. At temperatures above 72 degrees they increased very rapidly for men but only slightly for women.

This conclusion is supported by the seasonal variations in the accident rate found in industries throughout a whole year. The heaviest accident rates occur at the extremes of temperature; there is usually a peak in the summer and a slighter peak in the winter. In three machine-building plants studied by the U.S. Bureau of Labor Statistics (8, No. 256), the highest accident rates were in August and September; in a steel plant similarly studied the highest rates were in August, October, January and February. The steel plant certainly had more outside work in yards, etc., than the machine-building plants, and its accidents would thus be particularly affected by winter cold.

Lighting and the conditions of visibility obviously have a peculiarly direct connection with accidents,¹ and many studies have been undertaken to find how far the conditions of artificial lighting make night work more hazardous. Until recently the evidence has been distinctly conflicting. A review of previous work by Chaney and Hanna (8, No. 298) shows two cases of higher accident rates by day (one American steel plant and some miscellaneous industries in Dusseldorf, Germany) to set against the four somewhat similarly distributed cases with higher rates by night.

However, the thorough investigations for the U.S. Bureau of Labor Statistics seem to establish night work as very definitely more hazardous than day work. In one large steel plant the annual frequency rate of accidents during the years 1905 to 1913 averaged in the dayshift 142 per thousand workers, in the nightshift 214 per thousand. In a machine-building plant the annual rate for the years 1907 and 1910 combined was, in the dayshift 75.87 per thousand workers, in the nightshift 146.94. In another machine-building plant where accidents not disabling from

¹ For a chart illustrating the probable direct and indirect effects of lighting on accidents see 18, p. 67.

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work were counted in, the rate for the year 1913 was, in the dayshift 413.58 per thousand workers, in the nightshift 624.29.

Analysing the separate departments of the large steel plant, the greatest excess of night accident rates over the day was found in the mechanical departments (389 as against 122 per thousand) and the yards (399 as against 139 per thousand). In explanation of this Chaney and Hanna write:

The high frequency rates at night among *mechanics* is doubtless the result of two factors: (1) The night force is almost entirely engaged in what is called field work. Shop work on lathe and planer is not undertaken as a rule at night, except in cases of extreme urgency. The force is kept on duty mainly for imperative repairs needed to keep the mills running, and consequently demanding all possible speed. (2) The lighting factor. Often the repairs must be made in places which do not call for careful lighting on operative grounds. Some hurriedly improvised lighting must be supplied. The probability that it will be unsatisfactory is very great. This need for emergency lighting may be a point to which lighting engineers should give further attention.

The extremely high night accident rates in *yard* operations must be very largely due to the difference in lighting. The moving of the cars, the loading and unloading, and the shifting of materials which go on at night must be very much dependent for their safety upon lighting which enables the worker to avoid the obstacle over which he may stumble, and to place properly the objects which he handles.

Accident records at the 8-hour motor-car plant investigated for the U.S. Public Health Service (9) showed that in each of three months "the rapid descent of the accident curve in the afternoon due to the decreasing number of men at work is abruptly checked within the hour and a half preceding sunset." This suggests that the twilight period just before lighting-up time is peculiarly hazardous.

§ 3. *Effect of the Experience, Literacy and Type of Worker Employed*

Numerous statistical investigations have demonstrated the increased risk of accident run by the inexperienced, newly hired "green" hand. In my investigation for the U.S. Public Health Service (9) I showed how similar were

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the fluctuations in the month's rate of accidents per man and the proportion of new men hired the same month in several departments of the 10-hour metal-working plant; also that, whereas 47 per cent. of the total working force had been employed at the plant less than a year, 56 per cent. of the accidents befell this inexperienced minority. The U.S. Bureau of Labor Statistics presents a still more startling case (8, No. 298). Of all the accidents in a large steel plant, 52.4 per cent. happened to those with less than a year's experience who, in this case, numbered only 22.4 per cent. of the total working force.

Dr. Slichter (23) quotes evidence of a similar kind collected among railway trainmen, where, of course, accident involves the public as well as the employee. The Public Service Railways of New Jersey found that in the year 1911 34.5 per cent. of their motormen and conductors had been in their employ for less than a year, and these were responsible for 61 per cent. of the accidents. During eleven consecutive months of 1913 and 1914 the New York Street Railways (Rochester lines) found that the number of accidents experienced per 100 trainmen of less than six months' employment was from 40 per cent. to 90 per cent. greater than the number experienced by 100 trainmen of all lengths of employment.

In America the employment, mainly on unskilled work, of large numbers of immigrants unable to speak English forms an added danger. The U.S. Bureau of Labor Statistics (8, No. 298), in an investigation of accidents at a steel plant from 1906 to 1913, demonstrates the effect of this factor. The frequency rate per year was 9.07 per hundred men for the American-born, 9.87 for the foreign-born who could speak English, and 21.26 for the foreign-born who could not speak English. The difference in the accident frequency of English-speaking and non-English-speaking sections of the foreign-born is particularly significant. As between foreigners and American-born, the comparison is vitiated by the different kinds of work usually engaged in by the two groups.

Even when workers have equal experience and can all understand orders, there is evidence, according to Greenwood

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and Woods (4, No. 4), for supposing that certain of them are naturally more liable to accident than others. It is impossible to enter into the methods used for demonstrating this point; briefly speaking, these investigators consider three hypotheses that might possibly explain the way accidents are distributed among individuals: (1) That accidents are distributed by chance and without particularity; (2) that accidents affect those particularly who have already had one accident; (3) that accidents affect those particularly who are inherently susceptible from the beginning. The conclusion is that the third hypothesis most nearly fits the actual distribution. The importance of the whole subject is especially evident where, as in the handling of explosives or in heavy transportation, hundreds of persons may be at the mercy of one or two individuals. But further evidence seems to be required to show that the irregular distribution of accidents is not caused by details in the nature of the work engaged in, such as the curious idiosyncrasies of certain machines among a group technically of the same pattern. Those employees habitually working on machines with some dangerous trick or other would naturally suffer peculiar damage.

CHAPTER XI

THE LOSS BY INDUSTRIAL ILL-HEALTH

ILL-HEALTH is measurable in physical deterioration, death rates, superannuation, invalidity, and in temporary sickness which may be distinguished from invalidity by the exclusion of ill-health continuing beyond a certain limit, such as the half-year.

Unlike the case of industrial accidents, it is not possible to settle "by eye" whether a case of ill-health is industrial or not industrial. It is a matter of statistical comparison between the rate of ill-health experienced by the industrial population and that experienced by the other classes of the community.

Evidence will be presented which certainly suggests the existence of a net industrial residue of ill-health. Among the industrial classes death rates seem to be higher, superannuation more rapid and physique more defective than among the population in other walks of life or the population in general. Owing to the difficulties of definition, paucity of comparable records, and different economic status, the same net residue cannot be demonstrated in the rate of *sickness* of the industrial class as against other classes of the population, though it might be expected from the residue found in the case of death rates. Specific occupational diseases can, however, be established by statistical correlation combined with physiological diagnosis, and the gross rate of sickness among the industrial classes as evidenced by sickness insurance schemes can at least be definitely set forth for the sake of future comparison; at present it is the subject of the wildest guesses.

In attempting to account by means of statistical association for the residue or excess of ill-health beyond the

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minimum set by the non-industrial classes, we shall indicate occupational conditions apart from conditions underlying the officially recognized and physiologically established occupational diseases. While the adjective "industrial" has been used to include the general circumstances of the worker in industry—his relative poverty, chance of recreation, economic security, etc.—the adjective "occupational" will be used to refer only to those conditions involved in the work itself. The occupational conditions whose effects can be more or less isolated are the heaviness of the work and the physical environment, i.e. whether indoor or outdoor and, if indoor, whether subject to any prevailing hazards.

Other conditions that can be isolated and associated with the excess in industrial ill-health are variations in the hours of work, variations in earnings, the degree of medical supervision, if any, and the sex, age and race of the workers employed.

Before proceeding to probe into the conditions of industrial ill-health, the cost of ill-health to the worker himself, to the employer and to the general public will be inquired into. This cost has appeared heavy enough to some humane and public-spirited employers to justify preventive and remedial measures in their own factories; nor have the expenses involved been without return. And this action of employers has been paralleled by that of Government departments and the workers' own organizations. Thus the economics of industrial ill-health takes on a new aspect. It is not a doleful recital of the sordid sufferings of the long-suffering poor, but a challenge to clear-sighted action.

A—COST OF INDUSTRIAL ILL-HEALTH

The cost of ill-health, like the cost of accidents, falls first and foremost on the worker. He bears the pain and suffering and has to meet whatever pecuniary expenses are involved in medical attendance and hospital treatment. Added to this, he is unable to work, and thus unable to earn and maintain himself and his dependents.

It is only in such countries as Germany and England, where health insurance of individual workers is compulsory,

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that any attempt is made to distribute at least some of the pecuniary expenses among employers and at least indirectly among the public. In England the funds against which sickness and disablement benefits are drawn are contributed to every week on the following scale, instituted July 5, 1920; the State in certain circumstances also adds a small contribution:

Rate of Wage per Day.	Insured Men.		Insured Women.	
	Employer.	Insured Person.	Employer.	Insured Person.
3s. and under	10d.	0d.	9d.	0d.
Over 3s. to 4s.	6d.	4d.	6d.	3d.
4s. and over	5d.	5d.	5d.	4d.

But the benefits received in each case of illness do not cover, and are not meant to cover, even the mere financial loss to the worker. Since July 5, 1920, 15s. a week has been the sum paid to men, and 12s. a week to women for sickness benefit, and 7s. 6d. to both men and women as disablement benefit after twenty-six weeks of sickness. These sums are clearly less than the usual rate of wages and less than the subsistence minimum unless the worker has no dependents. The medical service provided is only such as may "be properly undertaken by a general practitioner of the usual professional skill," so that there is often a balance to be paid by the worker for special medical attention.

In countries like the United States, where no national compulsory health insurance scheme prevails, it seems at first sight as though the whole weight of the financial costs of sickness falls on the worker as well as all "non-financial" suffering. The worker may insure himself in a friendly society, trade union, or profit-making commercial company, but in every case, unless there is some form of State aid, the insured client has to pay a premium commensurate with the "risk."

On second thought, however, the immunity of the employer

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and the public does not appear quite so complete. The public either through charity or taxation have to maintain hospitals and infirmaries, and the employer suffers in pocket through the turnover, absence and deficient and defective output for which sick men are so largely, though indirectly, responsible.

In Chapters VI to IX, the minimum losses to be expected from workers' ill-health have been placed at a 5 per cent. turnover on account of death, invalidity of over twenty-six weeks, and superannuation for reasons of health; some 2 per cent. of total time lost owing to temporary absence of a day to twenty-six weeks; and a considerable loss, difficult to measure, in the quantity and quality of output on account of minor ailments not severe enough to cause actual absence. If the ill-health of his employees is neglected, these losses form a heavy expense to the employer. A 5 per cent. turnover, according to our estimate, involves a loss of a quarter per cent. of the wages bill—no inconsiderable item when calculated as a proportion of the net profits; and both absence and defective and deficient output involve considerable cuts into profits too.

The employer, however, has the alternative of not neglecting his employees' ill-health. Besides adjusting industrial conditions so as to prevent much ill-health, he can institute a factory medical service to deal promptly with his employees' ailments and thus reduce materially the probability of loss from turnover, from absence, and from deficient and defective output.

The cost of such medical service is of course direct and obvious, but when the indirect costs are set against it the plan of "repair" rather than neglect may well prove in the long run a paying proposition. The actual direct cost of maintaining medical departments, which, of course, would deal with industrial accidents as well as illness, was inquired into by the American National Industrial Conference Board¹ in 1919 and 1920. Salaries of doctors, nurses and attendants accounted for 69.5 per cent. of the costs of this medical service, the remainder being due to outside medical and

¹ "Cost of Health Service in Industry," Research Report No. 37, New York, May 1921, 33 pp.

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hospital service and to equipment and supplies. In manufacture, the annual cost per person employed was as follows: Metal manufacturing (62 plants), \$3.75; textiles (18 plants), \$3.59; electrical apparatus (16 plants), \$3.15; iron and steel (14 plants), \$4.10. Four mining plants seem to have done the thing on a grand scale and spent \$24.40 per employee on their medical service, but the average for the 297 plants inquired into was \$4.43.

The Norton Company of Worcester, Massachusetts, made a careful investigation of the first year's work of their Department of Health and Sanitation in order to estimate the results of their expenditure. The company compared the time lost by men who used the hospital and were ill enough to lose time, and those who lost time by sickness or accident and did not use the hospital. At the end of the year it was found that the average *time saved* by each man *losing time* and using the hospital was 19.2 hours per man per month. It must be remembered that this does not represent the time saved by the men who used the hospital and were thereby *prevented from incurring any loss of time*—a loss that might have averaged from one to three or four days. Very many such cases were found to occur each week.

In fact, the Norton Company came to consider their Department of Health and Sanitation not as a "welfare work but as an economic proposition," and many employers have arrived at the same conclusion.

BC—AVERAGE AND MINIMUM INDUSTRIAL ILL-HEALTH

§ I. *Physical Deterioration*

To measure the physical deterioration for which industry is responsible we have agreed to take as a datum line some non-industrial class. A good example of such a class is presented by the English public-school men. The English public schools, it must be explained to American readers, are not public in the American sense that no fees are charged, but on the contrary are so expensive as to exclude all but the sons of "gentlemen," i.e. the relatively well-to-do. Men who have been to the public school, there-

fore, would distinctly *not* be of the industrial class. According to H. J. Wilson (16, January 1921) the average height of a large sample of these public-school men aged 20 to 30 was found to be 5 feet 9 inches, and their average weight 11 stone 1 pound (155 pounds).

This height is fairly similar to that found to be the average for professional men by the Anthropometrical Committee of the British Association in investigations made half a century ago. At 18 years of age men of the professional class were found to average 5 feet 8½ inches; at 20, 5 feet 9 inches; and at 40, 5 feet 9¼ inches.

Very different are the results of measuring Englishmen of the working-class. The Anthropometrical Committee gives 5 feet 5½ inches as the average height for men of the artisan class at the age of 18, 5 feet 6½ inches at 20, and 5 feet 6¾ inches at 40. The difference is about 2½ inches at each age! Taking the population as a whole with the working-class predominating, it is striking to observe that the medical boards examining men of military age in 1918 stated that "there is already sufficient evidence to show that a combination of height 5 feet 6 inches, weight 130 pounds, chest girth 34 inches, will be found approximately the average measurement of the Grade 1 men of military age." In other words, the fittest grade, those capable of enduring physical exertion including severe strain, to which only 36 per cent. of all men examined could be assigned, has an average height 3 inches below the public-school men, fit or unfit, and a weight 25 pounds below.

Unless, indeed, the industrial population is to be considered as a completely different race from the gentlefolk of England, why should we not take a height of 5 feet 9 inches and weight (at the age of 20 to 30) of 11 stone 1 pound as an attainable ideal, variations from which are avoidable by the community?

Height and weight are, of course, not the only measure of physical fitness to be found by medical examination, and in grouping recruits during the late war, account was also taken of chest girth and the presence of deformity and disease.

It is a pity that a sample of "gentlemen's sons" was

not graded separately on the same principles for the sake of forming an actual standard. Some light is thrown upon the comparative physique of the industrial classes by the distribution into the four grades of 261,137 youths who became 18 years of age in 1918, when contrasted with Keith's standard distribution which is the result of measurements of height of a thousand Cambridge students—again presumably sons of gentlemen. The population of England as already pointed out is predominantly industrial in character and these boys formed about two-thirds of all boys reaching 18 in 1918.

The results showed "a deficit according to standard expectations of nearly 13,000 Grade 1 youths," that is to say, youths capable of enduring physical exertion suitable to their age; "and an excess of over 6,000 Grade 4 youths," or almost double the number of youths unfit for service—totally and permanently—than were to be expected under the Keith standard.

These deficiencies in height, weight and other proportions appeared in youths, and were not the result of long-endured working conditions. They show rather the extent of the cost during adolescence of industrial living conditions. "We cannot doubt," said the medical boards, "that these proportions would be greatly improved by better conditions of life and environment during childhood, boyhood, and especially (as the results of army training have demonstrated) by better food and better opportunities for physical development."

Great deficiencies were also shown in the physique of older men recruited in England between November 1917 and 1918, but these figures are open to the suspicion that the men were, physically speaking, the "dregs" being strained again through the military sieve. Great differences in physical deficiencies occur in different trades, but it is impossible to say whether tailors, for instance, are as a group physically deficient because they are tailors, or tailors because they are physically deficient. All we know is that those born and bred in the poorer classes under industrial conditions—conditions that are largely avoidable—are deficient physically as compared with those born and bred

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“gentlemen,” or in possession of an equivalent income. How much is inherited, how much inborn—that is, affected by the mother’s industrial environment—and how much inbred is, of course, a further question; but unless one is prepared to affirm a difference in race between the industrial and non-industrial classes as a whole, the industrial environment must take the lead in responsibility for physical deterioration.

§ 2. *The Industrial Death Rate*

The possibility of the human race enjoying—or at least enduring—a long yet busy life, is shown by the mortality rates (corrected for the different age distributions) among certain professions favoured by the well-to-do, or among certain country and open-air occupations. Deaths from accidents have already been considered, and should here be subtracted from the death rates from all causes. Now this non-accidental corrected death rate for schoolmasters, aged 25 to 65, was for England and Wales in 1900 to 1902 only 64·4 per cent. of the overall death rate of all occupied males of the same age, and for agricultural labourers it was only 56·8 per cent. Where comfortable circumstances and a country life are combined, as in the case of farmers and clergymen, these percentages are as low as 56·0 and 51·5 respectively.

Against these figures must be set the corresponding percentages among industrial workers. Coal-miners aged 25 to 65 have a corrected non-accidental death rate of 76·2 per cent. as compared with all occupied males. Textile workers grouped together have a corrected non-accidental death rate 102·5 per cent. of the overall death rate for all occupied males between the same ages; metal workers grouped together, 98·4 per cent.; transport workers grouped together, 107·3 per cent.; general labourers, 211·6 per cent.!

Much has been written of the difficulty of extracting any significant tendency from such occupational mortality figures as these. One source of confusion was removed in the figures for 1900 to 1902 which we have quoted, by including those retired from any occupation with those still in harness. An occupation can no longer escape indictment

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owing to the retirement of its personnel prematurely. But still a comparatively high death rate for any one occupation may quite as well mean that less healthy people move sooner or later into that occupation, as that the occupation itself is unhealthy.

There are, however, certain groups of occupations between which there is very little chance of moving. These groups of occupations are largely reserved for or else relegated to distinct social grades. Economists, as for instance Professor Taussig, distinguish four or five grades, but the method of classifying occupations for registration purposes allows us to be sure of only three distinct grades :

- (a) Manual wage-earners, skilled or unskilled.
- (b) Clerks, shopkeepers, employer-farmers.
- (c) " Professional " people.

Now within each grade there are occupations with a high mortality and occupations with a low mortality, some presumably the resort of the feeble within the grade, others the realm of the strong and healthy. In the manual grade there are general labourers and agricultural labourers with comparative mortality rates (including accidents) of 223·5 per cent. and 62·1 per cent. respectively of the death rate for all occupied males. But the average rate of mortality in the professional grade as a whole is undoubtedly lower than in the middle grade as a whole, and that of the middle grade as a whole lower than that of the manual grade.

Of the 106 different occupations and groups of occupations listed in the Supplement of the English Registrar-General's Report for 1900 to 1902 five of the six distinctly professional occupations—clergymen, schoolmasters, civil servants (officers and clerks), barristers, artists and architects—appear among the first twenty-nine occupations in respect of low mortality rates, or to be specific, 1st, 8th, 9th, 16th and 19th respectively. The remaining profession of " physician, surgeon and general practitioner," which appears 51st, is subject of course to special risks.

Of the occupations which can with some certainty be assigned to the middle grade—farmers, graziers and farmers'

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sons, railway officials and clerks, shopkeepers in general, commercial clerks, law clerks, commercial travellers, and musicians—five are in the longest-lived two-fifths, and all but one in the best three-fifths. The eight occupations appear respectively 2nd, 22nd, 23rd, 33rd-34th,¹ 39th, 58th, 62nd, and 90th² in order of corrected mortality rates.

Whether matters could be so adjusted in this world that all professions, occupations and employments, industrial or otherwise, could enjoy a death rate as low as the clergy and the farmers we hesitate to say. But there need be no hesitation in pointing out the possibility of avoiding much of the present mortality among the industrial classes.

Sir George Newman, in his *Report on the State of the Public Health* for the year 1921, sums up the matter:

In the first place, though mortality at young ages has greatly decreased, mortality at later adult ages in this country is discreditable to us. We have failed to keep pace with some other nations. In the second place, this discreditably high mortality affects particularly the centres of our most productive industries, such as Lancashire and the West Riding of Yorkshire. In the third place, there is no very close relation between the excessive mortality and ordinary statistical evidences of economic poverty nor reason to attribute the whole of the excess to specific industrial hazards or to climatological conditions beyond human control. In the fourth place, the fact that in some countries, notably Sweden, where later adult age mortality was higher than in England and Wales a generation ago, and is now lower, together with the fact that mortality at adult ages has declined even in England and Wales, but only since 1870, are evidence that we have not reached the irreducible minimum of mortality at this period of life.

In America, death rates among the industrial classes of given ages have been compared with those of the population in general at the same ages. This population in general includes of course the industrial population, and the excess of the industrial rates would presumably have been larger if they had been compared with groups not industrial at all.

Table 35 gives the mortality rate of the male population in general within the United States registration area

¹ When the various types of shopkeeper are grouped together, their comparative mortality is 87.2 per cent., which is between the 33rd and 34th occupation in order of mortality.

² Musicians consist largely of members of theatrical orchestras, etc., and show a penchant for death by alcoholism.

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compared with the mortality of an *industrial* male population as recorded by the New York Metropolitan Life Insurance Company.¹ In the third line of the table is given the ratio of the second to the first line, i.e. the percentage preponderance of the *industrial* death rate above the *general* death rate; and in the fourth line this preponderance is given as measured in the death rate from tuberculosis only.

It will be seen that the death rate is higher at all ages among the industrial population and that the difference tends to get wider with age, until in the group aged 35 to 44 the hazard is 58·2 per cent. higher among the industrial

TABLE 35
EFFECT OF INDUSTRIAL EMPLOYMENT ON DEATH FROM ALL CAUSES AND FROM TUBERCULOSIS ALONE

	Age Groups of White Male Population.				
	15-19.	20-24.	25-34.	35-44.	45-54.
(A) <i>Death Rate per 1,000 from all Causes.</i>					
1. General population U.S. registration area ..	3·72	5·42	6·81	10·05	16·03
2. Industrial experience (Metropolitan Life) ..	3·76	5·97	9·24	15·90	23·64
(B) <i>Relation (per cent.) of Industrial Death Rate to General Rate.</i>					
3. All causes of death (line 2 ÷ line 1)	101·1	110·1	135·7	158·2	147·5
4. Deaths resulting from tuberculosis only ..	107·5	139·0	180·0	221·6	194·1

population than among the general population. When we turn to the death rates from tuberculosis only, we find the preponderance in the death rate of the industrial population over the general population to be greater still. The preponderance increases with age, until in the group aged 35 to 44 the industrial death rate is 121·6 per cent. higher than the general death rate.

It is strange (and yet perhaps intelligible on a materialistic interpretation of upper-class activity) that more research has not been directed specifically to these measurable effects

¹ *Mortality Statistics of Insured Wage-Earners and their Families*, Louis I. Dublin, New York, 1919.

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of poverty and industrial status. Interest is sometimes evidenced in the striking contrasts between the death-rates of neighbouring wards of one city according as they are "residential" or "industrial." In the forties Neison compared the death rates of St. George's, Hanover Square, and St. George's in the East. Investigating more recently, Bowley compared the death rates of wage-earners at Bolton and Warrington, where on the whole higher wages are paid, with the death rates of wage-earners at Reading, where on the whole lower wages are paid, and found the death rates at Bolton and Warrington to be higher. Yet this is simply a comparison of two neighbouring levels of poverty, and the difference in earnings is slight enough to be overborne by differences in working conditions, in over-crowding, in climate, in the amount of sunshine permitted to come through the smoke of factory chimneys, and so on. What is wanted is a comparison between the death rates of entirely different classes or grades. Such a comparison was attempted for Dublin by Grimshaw and the results are reported by Humphreys (14, 1887) as follows ;

Corrected for difference of age-distribution, and taking 1,000 to represent the mortality represented by Dr. Farr's English Life Table (No. 3), the recorded mortality in Dublin during the three years 1883-85 was equal to 632 in the Professional and Independent Class, to 1,093 among the Artisan Class, to 1,333 among the Middle Class, and to 1,659 among the General Service Class, which in Dr. Grimshaw's classification includes all the inmates of workhouses. Thus mortality in the General Service Class in Dublin is nearly three times as great as that in the Professional and Independent Class.

The effect of class influence in each of the various age-periods is very striking. Thus, the mean annual mortality among children aged less than 5 years is just five times as great in the General Service Class as in the Professional and Independent Class. At the next age-period, 5-20 years, the difference of mortality between these two classes is very nearly as great, and in each of the three following age-periods of adult life the rates of mortality appear to be more than twice as high in the General Service Class as in the Professional and Independent Class.

On the continent of Europe (where possibly the open discussion of class advantages is not "bad form") many more such comparisons have been made. At Copenhagen,

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for instance, Sorensen¹ divided the male population into three groups: (1) workmen, populace (Gesinde), paupers; (2) lower officials, teachers, clerks, master workers; (3) higher officials and officers, doctors, large-scale dealers, etc. At ages 25 to 35 the death rate in group (1) was 9.6 per year per thousand as against 7.3 and 5.8 in groups (2) and (3). At ages 45 to 55 the death rate was 35.6 in group (1) as against 17.3 and 15.9 respectively in the other groups. And at ages 65 to 75 the death rate was 106.0 in group (1) as against 72.5 and 56.5 in the other two groups.

Hitherto the death rates of men occupied in industry proper and of men occupied in professions and more "middle-class" pursuits generally, have been contrasted. A detailed investigation (8, No. 251) by Dr. Perry in America permits us now to compare the death rates of women occupied in industry with those of women not so occupied but belonging to the same industrial class. Here is Dr. Perry's own summary:

In the age-groups within which operatives and non-operatives are fairly comparable, female operatives have a decidedly higher death rate than non-operatives. This is most marked in respect to tuberculosis, the death of female operatives from this cause being in general more than twice that of non-operatives, and in some of the race and age-groups running up to many times as high. Thus in the age-groups 15 to 24 years, 25 to 34 years, and 35 to 44 years, the death rates from tuberculosis per 1,000 were, respectively, two and one-fourth times, two and one-half times, and five times those among women of the same age-groups outside the cotton industry.²

§ 3. Superannuation and Invalidity

Superannuation and invalidity in common with death imply a permanent disappearance; in fact, in the new industrial parlance they all imply turnover. While death is a disappearance from the world in general, superannuation is a disappearance from a given industrial organization or plant, and invalidity is a disappearance from industry in general; both invalidity and superannuation mark the end of industrial life. Statistics of industrial superannuations

¹ Quoted from Westergaard in Prinzing: *Handbuch der Medizinischen Statistik*, part iii, chap. ix. Accounts of other investigations of this type may be found in the same chapter.

² *Fall River Globe*, Fall River, Mass., U.S.A., May 29, 1913.

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for reasons of health are not published on a large scale, but one may point to the relatively low age of the bulk of male factory workers when compared with the age distribution of all adult males, as some indication of a failure to attain reasonable expectations of life in the factory.

In the American registration area, if the number of the male population in their twenties (i.e. 20 to 29) is taken as standard, then men in their thirties should number 80 per cent. as many, men in their forties 58 per cent., and men of all ages above 49 years 70 per cent. Actually in the 8-hour American motor plant, where over 30,000 men were employed, men aged 30 to 39 numbered only 73 per cent. of those in their twenties instead of 80 per cent.; men aged 40 to 49 only 26 per cent. instead of 58 per cent., and men above 49 years of age 8 per cent. instead of 70 per cent. In fact, 48.3 per cent. of all men employed were 29 years of age or less, and 83.7 per cent. 39 or less. "Too old at forty" was more than a newspaper headline here!

The average age in this motor plant was about thirty, and this does not seem exceptional. Among the twelve American metal works surveyed by Mr. Alexander (see page 138 above) the average age of the men was $31\frac{1}{2}$; in a large American steel plant¹ an average age of $31\frac{1}{2}$ was reported with only 23 per cent. of the employees above 40; and in a large American brassworks I found the average age to be between 30 and 31.

As a rule the average age of men seems lower in the factory or manufacturing plant proper than in trades less centralized. Thus Austrian statistics (7, No. 24) collected in 1890 give the average age of those employed in ironware factories as 31.3 years with 21.5 per cent. of employees over 40, and in textile factories as 32.2 years with 26.1 per cent. of employees over 40; but in the building trades the average age is 35 years and in steam railways 36.7 years—34.3 per cent. of the employees being over 40 in this case.

Collis² quotes the fact that in England and Wales

¹ "Conditions of Employment in the Iron and Steel Industry." Senate Document 110, 62nd Congress, 1st Session.

² *The Lancet*, September 3, 1921, p. 487.

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22.5 per cent. of occupied agriculturists are aged 55 and over, but that only 6.9 per cent. of cotton operatives, 6.6 per cent. of printers, 7.5 per cent. of coal-miners, 9.8 per cent. of metal workers and 12.1 per cent. in the building trades are thus advanced in years.

The relative absence of older men among factory employees must be due to a turnover into other industrial occupations or into positive invalidity. Statistics of invalidity and disability are gradually accumulating. Among the eight million men and four million women insured during the early years of the English and Welsh insurance scheme, the number added to those on "disablement benefit" appears to have fluctuated widely from year to year; but onwards from 1916 when the amounts involved were somewhat more stable, the average yearly increase in the men's disablement benefit (calculated at the old £13-a-year rate) was about £100,000. This would mean that about 7,700 men were invalided per year in excess of the number of invalids who either died or got well again. A similar calculation in the case of women shows the yearly increase in disablement benefit at the old rate of £13 a year as about £69,000. This implies about 5,300 women invalided per year in excess of invalids who either died or recovered.

These figures probably underestimate the actual invalidity because of the low scale of benefit obtained (£13 a year up to July 5, 1920; £19 10s. since) when compared with wages that even a semi-invalid might earn in good times. Evidence for this belief is afforded (1) by an increase in the yearly (excess) invalidity since benefits were increased in 1920, and (2) by the higher invalidity of women in proportion to the number insured. Compared with possible wages, 7s. 6d. is a higher figure for a woman than for a man.

§ 4. *Comparative Rates of Sickness*

The possibilities of a low rate of sickness are difficult to measure, owing to the confused ideas as to what constitutes sickness. Sickness should at the outset be distinguished from invalidity by excluding ill-health which drags on over the half-year, and further, for the sake of objective

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measurability, we can consider only sickness that disables for work. Even then there is the same vagueness as to when illness is severe enough to justify "cutting" work. Among those whose daily bread does not depend on punctual attendance at work, the phrase "malingering" or "shamming sick" is in frequent use to explain away high sickness rates. Actually the facts seem to warrant the invention of a term to mean the precise opposite of shamming sick—shall we say, shamming health? Where there is no insurance against sickness, industrial employees cannot afford to be ill. Instead of the disability rate of the professional classes setting an impossibly low standard for the absence-by-disability rate among the industrial population, we often find the industrial rate to be the lower of the two.

Take such a clear example of a non-industrial population as the United States standing army. The astonishing fact has been brought out that the "army disability rate is considerably in excess of the rates reported for industrial workers." The rate of days that were lost was 1.861 per cent. exclusive of disability from accident in 1913, and 1.884 per cent. in 1914; whereas in a survey conducted by the Metropolitan Life Insurance Company covering 308,009 persons (white) in middle and Western Pennsylvania, the rate of sickness preventing work, inclusive of disability from accident and of permanent disablement, was for males between 15 and 24 years of age 1.11 per cent. and for males 25 to 34 years of age 1.41 per cent.¹

As Drs. Warren and Sydenstricker of the U.S. Public Health Service point out, the higher sickness rates among the military of similar age and sex occurs in spite of the fact that "certain important considerations would indicate that they should be lower rather than higher than the rates for industrial workers." The army is a carefully examined group of men and many soldiers are discharged for disability, so that few weak or sickly persons are included,

¹ Community surveys were made also in seven or eight cities and districts such as Rochester, N. Y.; Trenton, N. J.; North Carolina; Boston, Mass.; Chelsea neighbourhood of New York, and Pittsburgh, and all showed unexpectedly low rates of disabling sickness. However, the survey for middle and Western Pennsylvania made in March 1917 is by far the most extensive.

whereas in the industrial population, defectives remain on the payroll as long as it is possible.

The fact seems to be that sickness must be severe before an employee will entirely absent himself from the factory and thus forfeit either the total amount of his wage or else, where he is insured, the difference—usually quite considerable—between his wage and his sick benefit. In a précis of evidence prepared by the British Medical Association in connection with the introduction of National Health Insurance,¹ the view is expressed that “there is a general agreement that patients are now doing what many of them have never been able to do before, namely, staying away from work until really fit to return. . . . Even the medical profession has been surprised at the number of cases of persons who have never had medical attendance before . . . and who really needed rest and sickness benefit.”

Where there is no question of a loss of income, as in the army, much milder cases of sickness will come under review.

“The economic incentive,” quoting Drs. Warren and Sydenstricker again, “which often forces the industrial worker to continue at work while sick or to return to work before complete recovery, is absent in the case of the soldier who receives full pay while disabled.”

This contrast with the army experience is all the more valuable since malingering would hardly be possible under such trained and constant observation. The army sick rate is probably as genuine an index as we have of the physiological susceptibilities of the physiologically soundest portion of the population.

The number *claiming* to be ill seems therefore only to correspond with all who *are* ill, either when the wolf is not too near the door or when liberal benefits are obtained in case of illness. The wolf, unfortunately, is never very far from the industrial wage-earner, so that for a true picture reliance must be placed only on statistics collected under insurance schemes.

¹ A memorandum presented by Mary McArthur to the English departmental committee on Sickness and Benefit Claims, 1914.

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§ 5. Rates of Insured Sickness

Statistics of sickness have been published (1) for the German and Austrian compulsory insurance schemes, (2) for English friendly societies, (3) for the English compulsory insurance scheme, and (4) for various American insurance societies.

(1) The most famous and detailed statistics of health insurance are those of the Leipzig Sick Fund from 1887 to 1905, and those for the whole Austrian system in 1890. Figures may also be quoted for the whole German Empire from 1904 to 1908. In Germany account is taken of each working day lost up to twenty-six weeks by all cases that involve three days of disability or more; but the Leipzig statistics take account also of disability lasting only three days, and in the latter half of the period studied the limit is placed at thirty-four weeks. The Austrian statistics take no account of cases lasting less than four days. Of other cases they take account of every day's disablement up to twenty weeks only.

The experience of the Leipzig Sick Fund is given under various occupations for a selected age-group in Table 36. Taken for all ages over the whole German Empire in 1904 to 1908 and the whole Austrian Empire in 1890, the average number of days of disability per year per member was found to be as follows:

All disability—

Austria 1890: Men, 7·60 days; women, 8·50 days.

Germany 1904 to 1908: Men, 7·74 days; women, 8·35 days.

Disability from sickness and non-industrial accident only—
(This is estimated by subtracting the 11 per cent. for men and 2·2 per cent. for women which was found by analysis of the statistics at Leipzig to represent the proportion of time lost by industrial accident.)

Austria 1890: men, 6·75 days; women, 8·30 days.

Germany 1904 to 1908: men, 6·90 days; women, 8·17 days.

These days of disability per calendar year amount in Austria and Germany respectively to 1·85 per cent. and 1·89 per cent. of total time in the case of men; 2·27 per cent. and 2·24 per cent. in the case of women.

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(2) The rate of sickness among the English male industrial population, usually given is much higher than this. Thus Bowley, in his *Division of the Product of Industry*, uses twelve days a year as the average sickness on which to base his calculations. This estimate was drawn from the experience of the Hearts of Oak Friendly Society; and friendly societies in general often include disability from accident under sickness, usually have a higher age constitution than the industrial population as a whole, and almost invariably include "invalidism" in their sickness rates.

The experience of several friendly societies was reported by Sutton in 1896 and that of the Manchester Unity of Oddfellows by Sir A. Watson in 1903. These are perhaps the most important investigations of the kind. Watson's report, indeed, is said to have formed the basis for the payments planned under the National Health Insurance Acts. From these reports Rusher is able to segregate the time lost by the first six months of sickness from that lost by "invalidity" after the first six months.

In the successive age-groups 20 to 24, 25 to 29, 30 to 34, 35 to 39, 40 to 44, and 45 to 49, which would include the bulk of industrial employees, this temporary sickness among men is, according to Sutton's data, 5·20, 5·18, 5·69, 6·49, 7·38, and 8·76 days per year respectively; according to Watson's data, 5·60, 5·57, 5·89, 6·47, 7·36, and 8·47 days per year respectively.

Owing to the relatively high subscription, and the physical examination and other tests of good health required, members of friendly societies are a somewhat selected group among the industrial population. Also many of the friendly societies are of only local importance, and are restricted in the occupations in which the members engage. For these reasons the experience of compulsory health insurance of national scope must form a better guide to the sickness disabling for work that is suffered by the industrial classes; and however inadequate the information vouchsafed us, some attempt must be made to estimate the amount of sickness among the men and women included in the English National Health Insurance scheme.

(3) The Chief Medical Officer of the Ministry of Health

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reports during the years 1913 to 1921, for England and Wales only, an average minimum of 6,217,927 weeks of sickness per annum for men, and a corresponding average of 3,763,340 weeks for women. Sickness benefit is not paid after the 26th week of illness, when invalidity is held to commence, nor is it paid for the first three days of sickness.

The number of men insured in England and Wales in 1913 was 7,853,034, and in 1920, 8,637,095; the number of women in 1913 was 3,363,755, and in 1920, 4,481,517. Averaging these two years to form a standard basis for the period, we obtain in round numbers 8,245,000 insured men and 3,923,000 insured women. The rate of sickness for which benefits were paid would then appear to be: per man per year, 0.754 weeks or 5.28 days; per woman per year, 0.960 weeks or 6.72 days.

The yearly weeks of sickness we have quoted from the report are described as a minimum average and they undoubtedly understate to some extent, but *only* to some extent, the actual sickness prevailing among those insured.¹

¹ It is true that the total of the benefits paid each year vary greatly. In the case of the insured men the figures for the years 1915 to 1919, according to the report, are "lower than they would have been had not a considerable proportion of the total male insured population been serving with the forces." But the women's total benefits also fall as much as 35 per cent. (from £1,770,371 in 1913 to £1,157,523 in 1917), though many more women must have been insured in the third year of the war. Since no great influenza epidemic occurred in these years like that of 1918 and 1919, we cannot suppose the actual rate of sickness to have fluctuated as much as this. The probable explanation is the varying discrepancy between *claims* to sickness benefit and sickness itself, due mainly to the varying economic situation. Sickness benefit was probably paid in 1914 to many who were confirmed invalids but who had previously "put in" sufficient weeks of work to qualify them as insured persons.

After 1914 the discrepancy between claims to sickness benefit and sickness itself would tend to vary with the comparative advantage of working and earning wages on the one hand, and lying up and getting benefit on the other. The original scale of benefits paid was based on the wages and cost of living of 1912; but with the rise in cost of living and in wages that set in between 1914 and 1919, the relative value of a benefit fixed in terms of money would fall, and many would not claim to be sick who were really justified in doing so. In July 1920, the money to be paid in benefits was raised and during 1921 unemployment increased and wages and cost of living fell; hence the relative value of benefit rose.

But even in this year, if the correction in the official reports is made to allow for increased scales of benefit, it does not appear from the total benefits paid that the number of days lost is much greater. The "total" sickness benefit when "corrected" (i.e. the benefit payable under the old scale) is £3,207,000 for men and £1,420,000 for women; sums only slightly exceeding the figures for 1915 and 1919, and actually exceeded in 1913, in 1914 and (for women only) in 1918. And these sums in the year

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Under the English Insurance scheme the first three days of disability are excluded from benefit in all cases. To make an exact allowance for this unrecorded sickness we must (a) add three days for each single case of sickness for which benefit was paid, and (b) add the days lost through unbenefited sickness of three days or less.

These very short cases (b), if we can trust Heym's Table (see Table 23), are relatively not frequent. There are more cases of sickness lasting between a week and two weeks (for men 30 per cent. of all cases) than cases lasting a week or less (17 per cent. of all cases), and presumably a greater number lasting between a half-week and a week than a half-week or less. In forming a rough estimate these short illnesses may probably be neglected.¹

(a) Under the Leipzig scheme described above, the average duration of disability per case was found to be, for men 21.6 days and for women 24.6, so that, considering the rough similarity of the two schemes,² we may estimate that the 5.28 days per year lost per male member would represent $\frac{5.28}{21.6}$ or some 0.24 cases per male member, and the 6.72 days per year lost per female member would represent $\frac{6.72}{24.6}$ or some 0.27 cases per woman member per year. Since each of these cases must have had three uncompensated days of sickness there is added 0.24×3 or 0.72

economically most favourable for claiming sickness benefit, represent on the basis of the numbers insured in 1920 a loss of only 5.2 days per year among men and 5.9 among women.

Though it is impossible to make any allowance for the men serving abroad, or for those who may possibly have failed to claim benefit, in view of the figures for 1921 we see no need to modify the figure arrived at as the average "benefited" lost time per member experienced since the inception of the scheme, namely: 5.28 days per year for men and 6.72 for women.

¹ These very short cases lasting one day to three days and averaging, say, two days, would presumably not form more than half of the 17 per cent. of all cases lasting less than a week—say 8 per cent. of all cases; and the remaining 92 per cent. of cases are shown in the text to attack a male member at the average rate of 0.24 per year. Hence the days lost by the very short cases would average $0.24 \times \frac{8}{92} \times 2$ days per year, i.e. 0.04. Among women, according to Heym's Table, short cases are relatively still less frequent.

² At Leipzig shorter cases (down to two days' duration) and longer cases (up to 34 weeks) were included, but these two differences would have a counterbalancing effect on the average.

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days lost per year for men and 0.27×3 or 0.81 days for women.

When these additions are made the number of days lost per member on the average for the seven years would be, for men $5.28 + 0.72 = 6.00$ days per year; for women, $6.72 + 0.81 = 7.53$ days per year. The six days per year for men tallies with the days lost for members of friendly societies aged about 35 years, which is probably about the average age of those employed in industry, and the lost days of both women and men are in keeping with the German and Austrian evidence. The benefits under these continental schemes are calculated to equal about half the normal wage and are more liberal than the flat English rates of benefit; the slightly lower proportion of days lost in England need not surprise us. With falling wages the present English benefits are now approaching the standard of half the normal wage, and there is no reason for dismissing the proportions of time recorded as lost by sickness in Germany and Austria (roughly 1.85 per cent. for men and 2.20 per cent. for women) as inapplicable to England.

(4) In America the figure usually given as the proportion of time an industrial worker is disabled by sickness or accident is nine days per year. The final report of the Industrial Relations Commission, for instance, concludes as a result of "investigations which have been conducted by the commission under the direction of Dr. B. S. Warren, of the Public Health Service," that "each of the thirty odd million wage-earners in the United States loses an average of nine days a year through sickness."

It is not quite evident where this figure of nine days per year has been obtained. The First National Conference on Industrial Diseases held in Chicago in 1910 estimated that there were in that year 284,750,000 days of sickness among the 33,500,000 men, women, and children then engaged in gainful occupations in the United States. This would make an average of eight and a half sick days per worker per year. These figures are said to have been obtained by adapting to the United States the sickness insurance of the German industrial population, and it would be more satis-

factory to have less indirect evidence. Since in America there is as yet no national or even State system of health insurance, facts as to sickness rates of those industrially employed can be gleaned only from establishment funds, mutual insurance societies and trade unions paying benefits. It must be remembered that mutual societies usually accept as members only those who, in insurance parlance, are a "good" risk. Physical examination is, in fact, often insisted upon previous to acceptance of the risk.

Most of the important American experience as to the average days lost per year may be summarized from a publication of the U.S. Public Health Service.¹ In all cases time lost as a result of industrial accidents is unfortunately included, except in case (2).

- (1) 3.24 days lost by employees under the "Employees' Benefit Association" of the International Harvester Company in 1911 to 1915. Here only those cases were considered that lasted from one week to fifty-two, and non-industrial accidents were excluded.
- (2) 4.06 days lost by men under the Workmen's Sick and Death Benefit Fund 1912 to 1916. This excludes days lost by non-industrial and industrial accidents. Source (8, Nov. 1919.)
- (3) 4.40 and 4.56 days lost by male members of trade unions in New York State (1904 to 1914) and Massachusetts (1908 to 1914) respectively.
- (4) 4.82 and 8.90 days lost by men and women respectively in the Government offices in Washington, 1914.
- (5) 8.15 days lost by women (mainly) employed in the office of a large corporation of the Middle-West. The average age was 23.7 years, and each case was diagnosed by the medical department of the corporation or the family physician. Source (10) March 10, 1922.

These figures certainly give an impression of a lower rate of sickness in America than was estimated for European countries, even where insurance against ill-health does exist. The days lost per year are never above five on the average, except in the case of women.

To sum up:

The differences that appear in the Austrian, German, English and American experience of insured industrial sickness would probably be largely eliminated if in each

¹ (10, No. 335.) Where the experience is drawn from other publications, the source is stated in the text.

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country the benefits obtained by insurance and the age distribution, occupations and physical qualifications of the insured persons were more similar.

The rates of sickness in Austria and Germany are higher than in England, and those in England higher than those in America. But this order is also more or less the order of liberality of benefit when compared with wages in the same place or country, and it seems also to be the order of age—and age as is shown below is a very important factor.

It can then be concluded that temporary sickness under European compulsory systems of health insurance exclusive of industrial accidents accounts for an average disability among an industrial population of mixed ages of six to seven days per year for men and seven to eight and a quarter days for women. This is a minimum, since none of the insurance schemes under which statistics were obtained fully compensated the industrial worker for his loss of time. However, to name one figure for the sake of reference we may arrive at six and three-quarter days for men and eight days for women as the days lost per year by reason of sickness and non-industrial accident not lasting more than half a year. Calculated as a percentage of total days

the days lost would be $6.75 \times \frac{100}{365} = 1.85$ per cent. for men,

and $8 \times \frac{100}{365} = 2.2$ per cent. for women.

§ 6. *The Occupational Diseases*

From the standpoint of economic costs, the exact diagnosis of an illness of any given length and outcome may perhaps not matter unless it can be shown that certain types of disease are economically avoidable and only occur under certain industrial conditions. This is the case with the so-called occupational diseases. The economic responsibility of the employer is here so generally recognized that compensation to the sick workman is legally enforceable just as though the case were one of industrial accident.

Numerically, it is true, the compensatable occupational diseases are contemptible. In the United Kingdom in 1920, 10,452 cases of compensated disease were reported

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as against 375,000 odd compensated accidents. But the economic principle involved in compensation, and the possibility of its extension to a larger number of diseases, compels further attention.

A disease may be termed occupational if it is distinctly more prevalent among workers in certain occupations than among people in general, and if this greater prevalence established statistically can be specifically accounted for by physiological analysis as well. Actually the border line between the diseases that are considered occupational and those which are not, depends largely upon the state of scientific discovery.

Occupational diseases have been traced specifically to the type of work and the actions involved in its performance, as in the case of miners' beat hand, beat knee and beat elbow; or to the action of the materials used, as in the case of lead-poisoning by gradual absorption, dermatitis by irritation, and anthrax by the penetration of bacteria from wool and skins; or to physical environment such as the lack of illumination which is the probable cause of the affection of the eyes known as miners' nystagmus. In 1920 miners' beat hand, knee and elbow accounted for 2,336 of the 10,452 cases of compensated occupational diseases, lead-poisoning for 265, dermatitis for 408, and nystagmus for 7,028.

But the type of work, the materials handled and physical environment probably underlie many other complaints that have not yet been raised to the dignity of legally compensated occupational diseases. Waitresses, shop assistants and floor-walkers are said to suffer peculiarly from flat feet, motor-drivers from eye strain, labourers from back strain; and office clerks working long hours on close print or other fine work in badly lighted or unventilated rooms are often found suffering from headaches.

But far more important than these complaints is the scourge of consumption, and it is gradually being realized by scientific men that certain types of consumption may be traced statistically and physiologically to certain kinds of dust connected with specific industries. Professor Collis estimated that among the 70,000 men employed in silica

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dust trades the death rate from phthisis is five times the normal rate.

Dr. Frederick Hoffman (8, No. 231) has used the mortality rate in the United States registration area and the industrial experience of the American Prudential Life Insurance Company from 1897 to 1914, in order to compare the death rates in specific industries where certain kinds of dust were involved, with the death rates of all occupied males. His conclusions may be quoted for one important age-group among males only, namely 35 to 44 years.

The Prudential Company found that 32.9 per cent. of all deaths were due to tuberculosis among occupied males in general, but that 59.5 per cent. of all deaths were due to tuberculosis among grinders, and 39.4 per cent. among those occupied in the whole group of metallic dust industries, including compositors and typesetters. The experience in the United States registration area shows an altogether lower level in the proportion of deaths due to tuberculosis, but the preponderance of hazard in the metallic dust industry is much the same—28.6 per cent. as against 24.0 per cent.

In the mineral dust industries the percentage of deaths due to tuberculosis is less than in the metallic dust industries according to the Prudential experience, i.e. 36.1 per cent. as against 39.4 per cent., but more according to the United States registration area experience, i.e. 32.2 per cent. as against 28.6 per cent. In both cases, however, the deaths from tuberculosis in the mineral dust industries form a much greater proportion of all deaths than they do among males occupied in general.

A furious controversy has raged in the pages of the *London Times* as to whether the susceptibility to phthisis of printers and compositors who are included by Hoffman as occupied in a dusty trade is really to be traced to the silica dust found in the "list" accumulating from the compositor's soft iron frames, or merely to the lack of ventilation and sunlight in the workshop, the sedentary nature of the occupation, and the crowded homes in crowded districts.

Analysis of the physiological condition and suscepti-

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bilities of printers, and the fact that bookbinders, shoemakers and tailors working in much the same physical environment have also a very high rate of mortality from phthisis, lends support to the theory of a lowered general, rather than local, power of resisting infection; but should silica dust be established as a specific cause, printers' phthisis might well be classed officially as an occupational disease, as indeed (and with better evidence) might phthisis in all trades involving certain mineral or metallic dusts.

In all probability the extension of the principle of compensation to cover more and more diseases will continue. In 1910 only six diseases were legally recognized in the United Kingdom; in 1920 there were twenty-seven recognized. Should consumption eventually be included, or even certain types of consumption, the numerical importance of occupational disease and its recognized costs as measured by compensation would be enormous.

Among the men insured in the Leipzig Sick Fund (7, No. 24), 7 per cent. of all days of sickness were due to consumption; and the severity of this disease as measured in the mortality rate is still more striking, at least 20 per cent. of all deaths among the male industrial population being usually attributable to this cause.

D—CONDITIONS OF EXCESSIVE LOSS BY INDUSTRIAL ILL-HEALTH

§ I. *The Effect of Adjusting Hours of Work*

At their chemical works at Northwich, Messrs. Brunner, Mond & Co. changed in 1890 from a system of two 12-hour shifts to one of three 8-hour shifts, and furnished (according to Rae) ¹

some striking particulars to the Departmental Committee of the Home Office on the health of chemical workers. The figures of the sick club connected with the works show that during the summer quarter in 1889, before the introduction of the three shifts, the percentage of men who received sick pay was 7·1, while during the same quarter of 1893, after the introduction of the three shifts, the percentage was only 5·1, making a reduction of 28·32 per cent. In 1889 the men attended by the doctor amounted to 10·12 per cent. of the whole, but in 1893 it was only 5·1 per cent., showing a reduction of 49·6 per cent.

¹ John Rae: *Eight Hours for Work*. Macmillan & Co., 1894.

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More widely quoted has been the experience of the Engis Chemical Works near Liège. When a 10-hour day was worked the sick benefit fund established by the management was in continual financial difficulties. But when, in 1892, the hours of work were reduced to seven and a half a day, there was an excess of receipts over expenditure which gradually increased from year to year (20, p. 151).

Early in the period of increased hours which in England followed the outbreak of the recent war, I observed the parallel course often run by the total scheduled hours of work and the hours lost by sickness. In the manufacturing departments of a highly organized English engineering firm employing 1,000 to 1,400 workers, the average hours of work scheduled were in August 1915 46 a week, and 2.8 per cent. of this time was calculated to be lost by reason of sickness. In September and October under pressure of war orders the hours were increased to $49\frac{1}{2}$ and then 53 per week, and the percentage of time lost by sickness rose to 3.2 and then 3.85; but when finally in November and December the hours were reduced again to $51\frac{1}{2}$ and then $46\frac{1}{2}$ per week, the percentage of sick time paralleled the reduction by falling to 3.1 and then to 2.77.

Indirect evidence as to the effect of hours of work on sickness can be obtained from Tables 19 and 20, which distinguish the percentage of unavoidable lost time found in English factories during the recent war. Unavoidable lost time, according to the compilers of these tables, included only that due to sickness and accidents—and accidents, we know, can account for only a fraction of this.

Among women the hours worked in the war period were roughly of three classes of length: hours totalling 42 to 44 per week (as in items 3, 6 and 7, Table 20) signifying an 8-hour day; hours totalling over 60 hours signifying a 10-hour day (as in item 5), or else the two-shift system (as in item 8); and, lastly, an intermediate total of hours as in the case of item 1.

Now without exception the least unavoidable lost time is found in the 42- to 44-hour week, where it is in no case above 3.3 per cent., and the highest unavoidable lost time is found in the two cases of a 10-hour and

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two-shift day, where it is 6.4 per cent. and 6.0 per cent. respectively.

Among the men only the longer or the intermediate hours of work are to be found, but the variation is enough to show the effect on unavoidable lost time. Of items 2, 5, 6, 7 and 9 in Table 19, each with hours totalling above 55 per week, only one case (8) shows unavoidable lost time less than 5.3 per cent.; of the remaining cases with hours of work totalling 54 or less per week, none has unavoidable lost time above 4.3 per cent.

In short, as hours are increased nominally, a limit is approached to the actual hours worked until the hours lost almost equal the hours (nominally) added. It is like the frog who climbed three feet up the well every day only to slip down two every night. The course of events is particularly evident in the case of men where a change of hours from about 52 to about 60 a week results in increasing unavoidable lost time from about 4 per cent. of the 52 hours, i.e. about 2 hours per week, to anywhere between 5½ per cent. and 7 per cent. of the 60 hours, i.e. about 4 hours a week. In fact, about one-quarter of the additional hours is lost by sickness and unavoidable causes alone.

These figures are sufficiently significant; but recent investigations suggest that the average *level* of sickness recorded during long hours among a continually changing personnel conceals an upward gradient of sickness among those particular employees "sticking it out."

In their study of turnover the Industrial Fatigue Research Board (4, No. 13) found that in a factory where women worked 12-hour shifts (9½ hours actual work by day, 10½ by night) the cases of sickness increased almost inexorably, relatively to the number exposed, the longer the women stayed in the factory. Among single women 8.80 per cent. were ill in the first quarter year of their employment at the factory, 11.69 per cent. in their second quarter, 12.58 per cent. in their third, 12.11 per cent. in their fourth, 15.03 per cent. in their fifth and 19.34 per cent. in their sixth quarter year of employment. Among married women it is the same tale: 11.90 per cent. were ill in the first quarter year of their employment at the factory; 14.10 per cent. in

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their second; 12·12 per cent. in their third; 15·90 per cent. in their fourth; 22·33 per cent. in their fifth; and 32·00 per cent. in their sixth quarter year of employment. These figures (which exclude influenza cases whose incidence is irregular) lead inevitably to the conclusion that long hours of work exercise a cumulative effect and gradually but progressively wear down employees subjected to their influence.

Minor ailments are also affected by changes in the hours of work. Vernon¹ describes an alarming increase in cases of faintness among women working a 12-hour day. In this period the women

were treated at the ambulance room for faintness nine times more frequently than the men, whilst in the subsequent 10-hour-day period they were treated only three times more frequently. Again the women were given sal-volatile—almost always as a restorative—no less than twenty-three times more frequently than the men during the 12-hour-day period, but only three times more frequently during the subsequent 10-hour-day period.

A regular hourly curve of faintness cases is discernible, on the lines of the output and accident curves. With an early start for work, breakfast is often somewhat uncertain, and the peak of faintness which occurs in the last hour of the morning spell is perhaps chiefly influenced by lack of food.

§ 2. *Effect of Different Types of Work and Physical Working Conditions*

The disability rates of different occupations were distinguished in the Leipzig Sick Fund Statistics (7, 24th Report), and for the sake of comparison the figures for men of one age-group only are given in Table 36. The table refers to the principal occupations only, but disability due to accident is noted separately for each occupation.

In order to restrict the sickness rates to genuine illness, these accident rates refer to all injuries, whether "occurring in the course of employment and entitled to compensation" or not.

In the industries tabulated, the days of disability from pure sickness per 1,000 members vary from a minimum of

¹ Vernon: "Industrial Accidents: their Causation and Prevention," *Quarterly Review*, 1920.

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5,485 for office and shops to a maximum of 10,476 for printing and publishing. The more "mental" and more sedentary occupation of office employee and salesman thus seems to be distinguished by a low sick rate. This may be due to the absence of any "heavy" operations in these trades, as well as to the better pay. Finlaison, in an analysis of the temporary sickness experienced by English Friendly Societies

TABLE 36

ABSENCE BY SICKNESS AND BY ACCIDENT IN DIFFERENT INDUSTRIES AND OCCUPATIONS: EXPERIENCE OF LEIPZIG INSURANCE FUND, 1887-1905

Industry.	Days Lost per Year per 1,000 Insured Male Persons aged 35-40.		
	By all Disability.	By Accident Only.	By Sickness Only.
<i>Manufacture.</i>			
Printing, publishing, etc.	11,081	605	10,476
Paper	10,863	1,607	9,256
Metal working.. .. .	11,117	2,370	8,747
Clothing and cleaning	8,621	634	7,987
Food and drinks	9,608	1,938	7,670
Wood and cut materials	9,176	1,733	7,443
Textiles	8,889	1,567	7,322
<i>Building.</i>			
Building trades	11,653	2,758	8,895
<i>Transportation.</i>			
Street transport	9,826	3,305	6,521
<i>Agriculture.</i>			
Gardening, agriculture, forestry ..	10,223	2,473	7,750
<i>Office and Stores.</i>			
Office employees, salesmen, etc. ..	5,830	345	5,485
<i>Personal Service.</i>			
Hotels and restaurants	8,770	1,015	7,755

from 1846 to 1850, showed that members occupied in light labour lost 8.53 days per year if exposed to weather and 9.55 days if not exposed, but members occupied in heavy labour lost 10.65 days if exposed and 10.81 if not exposed. Where heavy labour is combined with exposure to great variations in temperature, a particularly heavy excess in ill-health may occur.

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In an investigation of the health of 22,000 English iron and steel workers for the years 1913 to 1918, Vernon and Rusher (26) found that,

The steel melters and pitmen showed 23 per cent. more sickness than the average, the puddlers 20 per cent. more, the tinplate mill men 12 per cent. more, and the rolling mill men 8 per cent. more. All of these groups of men, and especially the first three groups mentioned, are employed on heavy work carried out at high temperatures, whilst the remaining two groups, the engine and crane men, and the "other workers," who are to a large extent general labourers, are for the most part employed on lighter work, carried out under normal conditions of temperature.

The death rates for the same period also gave the steel melters the worst bill of health; they had a mortality 26 per cent. above the average of the whole group of steel workers.

Workers engaged in these occupations and particularly the puddlers seem especially subject to respiratory diseases and rheumatism, and Vernon suggests that the susceptibility of the puddlers may be due to "alternating periods of extremely hard work generally of about twenty minutes' duration, with periods of similar length in which they rest or do light work."

Unfortunately it is not possible to adduce further evidence on the score of heavy versus light and sedentary labour. Where rates of sickness have been worked out in mental and sedentary occupations—as, for instance, by Hart (14, 1922) for London teachers—the results are not comparable with the rates in manual occupations owing to different terms of compensation for sickness, different bases on which to calculate the rate, and indeed, to different definitions of sickness itself.

Next to office employees, salesmen, etc., transportation has the lowest sickness rate in the Leipzig figures, and it certainly does not appear that the outdoor industries—building, transportation and agriculture—are in any worse case as a whole than the indoor industries. And from Finlaison's analysis it is evident that this differentiation, though less important than that between light and heavy labour, is slightly in favour of outdoor work. Where

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ill-health is largely traceable to the tuberculosis due to silica dust, the same type of occupation if carried on out of doors exhibits considerably lower death rates from this disease than if carried on indoors. Collis shows that among Aberdeen granite cutters 25 per cent. of all deaths of those engaged out of doors in building are due to tuberculosis; but of the deaths of those engaged indoors on monumental work tuberculosis accounts for 38 per cent.

As between the indoor departments of a factory, the rate of headaches reported to the first-aid stations may often serve as an index to the comparative wholesomeness of the conditions prevailing.

Indeed, headaches are by no means a negligible occurrence in industry. Mock¹ reports that at the Sears Roebuck "mail order" house of Chicago, 24 per cent. of all cases of lost time among women were due to headache and 19 per cent. of the cases among men. In an American factory, Cobb and Parmenter (16) report that of all employees asking for medical attention 10 per cent. to 15 per cent. complained of headache. My own experience in America includes complaints of headache by men in certain departments of the 8-hour motor plant at the rate of 4 per cent. and even 4.5 per cent. of the total employed per month; where departments were "mixed" as in the 10-hour brass plant rates for single departments were as high as 6.6 per cent. (9).

At these two plants I was able to investigate the effect of the prevailing departmental conditions on the headache rate in the same way as their effect on turnover rates and absence rates. The headache rate was found to average considerably higher in departments where conditions involved eye strain. The average headache rate per month for all the men's departments of the motor factory was 1.42 per cent.; for all the men's departments of the brass factory 1.22 per cent.; and for all the women's and mixed departments of the brass factory 2.58 per cent. In the departments with conditions involving eye strain the equivalent rates averaged 2.10 per cent., 2.38 per cent. and 3.86 per cent. respectively. In the motor plant headaches in depart-

¹ E. H. Mock: *Industrial Medicine and Surgery*. Philadelphia, W. B. Saunders Co., 1919.

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ments with bad lighting, averaging 1.95 per cent., were also well above the overall average of 1.42 per cent.

Whether industrial occupations are confined within doors or not, the outdoor atmospheric conditions changing with the season of the year account for a large variation in sickness rates.

The exact amount of the seasonal variation can be learned from organizations that keep accurate records month by month. The experience of four such organizations may be quoted (10, No. 335), three of them being industrial in character: the Trade Unions of New York State from 1904 to 1914; the Carpenters' and Joiners' Society, U.S.A., in 1913 and 1914; the British Trade Unions 1910 to 1915; and the United States Army. In spite of their differences in circumstance, the seasonal variations in sickness experienced by these organizations show a surprising unanimity. If for each "experience" the average sickness rate of the whole year is expressed as 100, the winter rates were all found to be above 107 (respectively 107, 110, 117, and 116); the spring rates all between 102 and 99 (respectively 101, 102, 99, and 100); the summer rates all below 95 (respectively 92, 94, 90, and 91); and the autumn rates all below 95 also, with the exception of the New York Trade Unions (respectively 100, 93, 94, and 92).

Owing to this large tendency to variation it is obviously dangerous to infer annual sickness rates from a sample of two or three months. Thus if the sample were taken in the summer when the average variation is 8 per cent. below average, it is obvious that yearly sickness rates will be greatly underestimated.

§ 3. *Effect of Medical Supervision in the Factory*

The work of medical supervision in industry consists mainly in the treatment of the ailments of the working force, and in the selection of members of this working force with reference to the conditions in which each must actually work.

Most ill-health is probably unconnected with conditions employment and the employer naturally cannot feel

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responsible for every ailment of his employees. Yet it must not be overlooked that there is *some* ill-health, like infection from industrial accident, which is the result of employment; and moreover, *all* ill-health is costly to the employer, as we have already had occasion to point out. Medical supervision in the factory is therefore by no means merely a charitable fad, and may be examined farther as an economic proposition.

The amount of ill-health which is the aftermath of accident is not sufficiently realized. As one authority puts it: "The majority of industrial injuries is slight, but owing to the desire of the workman to continue with his job infection of untreated and unprotected injuries is practically certain to occur."

Accident septic cases account for over 10 per cent. (51 out of 449) of all cases of sickness to single women in an English munition factory (4, No. 13, p. 76).

In two American Sick Benefit Societies infections rank fifth and thirteenth in order of the amount of benefit paid out, and Mock quotes the evidence of some insurance companies as to the percentage of disability from accident caused by infection of the hand only. One company reported 15 per cent., another 7 per cent. to 9 per cent., another 5 per cent., and another 15 per cent. to 20 per cent. A fifth insurance company reported that out of 27,500 accident claims, 2,700 were septic cases, of which 2,000 followed wounds of the hands.

Neglect of open wounds in the midst of the kind of substances handled in factories thus becomes an expensive business both in the matter of compensation and of increased lost time. The English compensation law is quite definite that "incapacity is held to result from an injury if complications arise some time after an accident."

With medical service infections may be almost entirely eliminated. In 1910, when safety work was in its infancy, a large proportion of the injuries in industry became septic wounds; the present record of the Bethlehem Steel Company shows that during 1920 not a single case of infection appeared in many thousands of cases treated in the company hospital.

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The Norton Company in 1917 reported that during five years of operation of the medical department not a single case of sepsis had occurred, and Mock, reporting on the same point in another large industry, says :

The number of infections following injuries has been reduced from 28.6 per cent. in 1912 to 7.57 per cent. in 1916. The time lost from infections in 1912 amounted to 1,987 days, or an average of $2\frac{3}{4}$ days per case, while time lost from this cause in 1916 amounted to 816 days, or an average of $1\frac{1}{4}$ days. This was accomplished in spite of the fact that the working force had increased approximately one-fourth during the same period.

With complete neglect in the treatment of accidents may be classed the provision of a cheap (and nasty) supervision. Dr. Magnuson (8, No. 264) recounts how, in a Chicago stockyard, by "boosting" the expense of the surgical department almost \$900 and undertaking "tendon sutures, nerve grafts and tendon transplantation" instead of amputation and other such simpler expedients, only one lawsuit was filed as against thirty-one the year before, and "a total saving of \$20,000 was achieved in the claim department."

A more systematic computation of the saving in cost of compensation was carried out in an English engineering factory employing about 2,500 men and women. The management decided to carry their own insurance against accidents for all claims less than £100. The part-time services of a medical officer were retained, and the rule laid down that all accidents, however slight, were to be reported and immediately dressed by volunteer nurses under the supervision of the medical officer. In the course of the first year of the scheme the number of cases *reported* naturally increased—according to the rule; but subsequently the compensation actually paid was reduced so materially that even after the medical expenses were added, the saving over insurance at the usual rate was in the second year just above £300; £1,947 16s. was actually spent as against a cost of outside insurance which would have amounted to £2,250. The later employment of professional nurses cut down this net saving, but failed to wipe it out.

Mitigation of the consequences of accident is only part of the economies the medical department can introduce by

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treatment of the working force, and attention has already been drawn (p. 306) to the reduction of time lost through illness in general, effected by the Health and Sanitation Department of the Norton Company.

In the selection of employees medical examination is, from an economic standpoint, a most important item. There are many diseases such as consumption, hernia, flat foot and other deformities which are likely to involve physical disability, inefficiency, and final resort to dismissal if the patient is placed on unsuitable work, but which may involve no loss if the work is properly selected. Reviewing the results of the physical examination of 118,900 candidates for employment in American industries, Mock found that while 55.6 per cent. had no disabilities and 9.7 per cent. had to be totally rejected for work because of their disabilities, 34.7 per cent. had disabilities which did not interfere with *selected* work. As a result of this elimination of misfits at the outset, Mock estimates a saving in cost of turnover much larger than the out-of-pocket expenses of the entire medical service.

The Hood Rubber Company show (11, Oct. 1921) that the original classification of employees by physical examination corresponds closely with the comparative rates of absence through sickness.

Some idea of the extent to which American firms have found it "good business" to introduce all these various forms of health supervision has already been given in recounting (p. 305) the amount spent on medical service per employer in 300 odd American plants. Most of these plants would probably agree with the Norton Company in considering medical supervision not as welfare work but as a sound "economic proposition."

§ 4. *Effect of Employment of Various Types of Worker*

Sex and age are recognized by life insurance companies as two of the three variables to be considered in fixing health insurance rates; the other variable, occupation, has already been dealt with.

There is no question that the rate of sickness increases

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with increasing age, and attention has already been drawn to the difference in the sickness rates of members of English Friendly Societies according to their age (BC, §5, p. 320). In the case of men, however, the increase is more uniform than among women, and it is impossible to trace the effect of age without taking into consideration the different effects of age on the two sexes. We shall therefore treat the factors of sex and age together.

As measured by death rates, it is only when employed in industry that women seem to succumb to ill-health more than men. Perry (8, No. 251) summarizes his findings among cotton operatives at Fall River, Massachusetts, as follows :

For the thirty-year age-period from 15 to 44, in which the great majority of operatives are found, the death rates of males and females in the general population are almost identical, the male rate being 6.19 and the female rate 6.18. A comparison of the death rates of male and female non-operatives shows the rate for the males to be 22 per cent. in excess of that for females (male rate 6.48 ; female rate 5.31). When, however, the comparison is confined to the death rates of operatives, the female rate shows an excess of 33 per cent. over the male (male rate 5.74 ; female rate 7.63) despite the younger ages of the female operatives.

When measured by sickness rates, the comparisons of health are often vitiated by the inclusion of disability from accidents. Even the very full American account of the experience of the Leipzig Insurance Fund in the matter of the number of days lost includes accidents in the general disability rates, though in special tables the accident rates are specified for men and women separately by different age-groups. We are able, therefore, to subtract the accident rates from total disability rates, and to obtain the pure sickness rates shown in Table 37.

It will be noticed that the women's sickness rates exceed the men's rates very greatly at all ages up to 55, though the tendency for women's rates to increase more slowly with advancing age is apparent. In fact between 35 and 64 the average days lost per year by women remains almost stationary at 14 per individual person.

In the professional classes the difference between sickness rates of men and women seems to be still greater. Among

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London school teachers Hart (14, May 1922) reports a loss of 4.6 days of the working year on the part of men with an average age of 41½ years, but a loss of 8.2 days on the part of single women aged 35 on the average, and of 9.3 days (exclusive of maternity cases) on the part of married women with an average age of 42.

Marriage, or more exactly motherhood, helps of course to increase the sick rates of women in the prime of life. The Hood Rubber Company (11, October 1921) quote 8.35 working days in the year as lost by sickness among women employees as against 4.43 days for men (equivalent to the 2.78 per cent. and 1.48 per cent. of working

TABLE 37

DAYS OF SICKNESS EXCLUSIVE OF RESULTS OF ACCIDENTS AT DIFFERENT AGES FOR EACH SEX

Experience of Leipzig Insurance Fund, 1887-1905

Ages.	Days per Year.	
	Men.	Women.
15-24	4.848	8.051
25-34	6.186	12.447
35-44	8.221	13.888
45-54	11.118	13.972
55-64	16.200	14.332

time given in Table 21 above); but while single women lost only 6.56 days on the average, married women lost 13.07. That this high rate is not entirely due to age is shown by the comparatively low rate of 10.47 days remorselessly worked out for the widowed and divorced, who would, if anything, be older than the married. There is no question that many industrial occupations, especially those involving lifting and stretching, may complicate parturition. Yet much industrial work is probably less exacting than the housework ordinarily assigned to married women.

Where, as in the Eastern States of America, employees born in many different countries work side by side, the effect

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of race on health is clearly visible, though the probable effect of different scales of wages must not be overlooked. According to Perry's investigation,

For the 15 to 44 aged population as a whole, and for every five-year age-group subdivision except two, the situation as to racial mortality may be thus summarized: Of all the races and peoples, the Americans exhibit considerably the greatest, and the Irish much the least, physical resistance to fatal influences, the former having been about one-third less and the latter about two-thirds more liable to die from all causes than the general population; the English were about one-quarter less liable to death than were the individuals of all races on the average; and finally the French Canadians exhibit slightly less and the "other races" slightly more combative resistance to death than is shown by the average of individuals of all races.

TABLE 38
EFFECT OF COMBINED "HAZARDS" IN AMERICAN TEXTILE MILLS ON DEATH FROM ALL CAUSES

	Death Rates per Thousand in Age-Groups.		
	15-24 Years.	25-34 Years.	35-44 Years.
<i>Total Population.</i>			
Non-operatives	2.66	5.59	7.85
Operatives in mills	4.40	7.95	10.48
<i>Married Women.</i>			
Non-operatives	2.44	5.80	7.58
Operatives in mills	10.96	14.44	14.20
Irish operatives	*	40.24	25.00

* Less than 30 cases.

Persons industrially employed who combine in themselves the sex, age, race and also "marital condition" most prejudicial to health will be found to have alarming death rates.

In Table 38 I have selected a few figures from Perry's study of the Fall River textile mills, which illustrate the cumulative effect when these factors are superimposed.

The average person not working in a mill, aged between 15 and 24, has a death risk of 2.66 per thousand. The factor

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of working in the mills taken alone increases the death rate from 2·66 to 4·40; working in the mills and an age of 25 to 34 increases it further to 7·95; being a married woman under these circumstances increases it further to 14·44, and being an Irish woman into the bargain brings the combined hazard to 40·24! The combination of these prejudicial characteristics increases the death rate from 2·66 to 40·24 per thousand—a fifteen-fold multiplication in the chance of death!

Individuals vary, of course, in their susceptibility to illness quite apart from their age, sex and race. Hart (14, 1921) shows that among the London teachers 21 per cent. of the persons studied were responsible for 88 per cent. of the aggregate days lost on account of illness and 3 per cent. of them were responsible for 43 per cent. of the days lost. In a lecture before the Royal Society of Arts,¹ Sir Kenneth Goadby suggests that the same unequal distribution of susceptibility is true also of industrial poisoning. The majority of workers exposed to lead poisoning, for instance, seem to develop a "tolerance" in the course of the first three months or at any rate the first year of employment, but some apparently do not.

While the incidence of all reported cases of lead poisoning from 1900 to 1920 showed a steep fall, the fatal cases showed an almost steady line, and might be taken as representing the extremely susceptible persons, and suggested that the population contained a considerable proportion who showed individual susceptibility towards the poison.

In the opinion of the lecturer these peculiarly susceptible persons might be detected by certain general blood tests, and if they were prevented from working among the poisons to which they were susceptible some trades now regarded as dangerous might be rendered comparatively safe.

§ 5. *Effect of Poor Wages and Living Conditions*

The wage-earning "industrial" classes have already been shown to suffer more in general from ill-health than the richer classes, and the debilitating and decimating

¹ *The Times*, May 31, 1921.

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associations of poverty can be traced to the bitter end by comparing the sickness and mortality rates of the poor with those of the very poor, i.e. by comparing within the industrial population the rates among earners of higher and of lower wages.

An investigation by Sydenstricker, Wheeler and Goldberger (10, No. 492) into disabling sickness among the population of seven cotton mill villages of South Carolina, makes a very careful analysis of the family income of the persons studied in relation to the family needs. Among the poor most of the income must go for food, so that needs depend mainly on the number of members in the family and their age and sex—a man eating more than a woman, and an adult more than a child. Accordingly, the family is regarded as so many male eating-units, women and children being assigned fractions of a unit according to the Atwater scale. The income of each family is then compared to its needs by dividing income by the number of eating units comprising the family, and four classes of poverty are formed according as to whether the half-monthly family income per male eating-unit is (1) less than \$6, (2) \$6 to \$7.99, (3) \$8 to \$9.99, (4) \$10 and over.

In Table 39 following, the average days lost is given for each of these four classes, wage-earners only being considered. It will be seen that days lost from disability increase steadily as the inadequacy of the income increases.

In Johnstown, Pennsylvania, a large industrial centre, the general infantile death rate in 1911 was 134 per thousand births. In families where the father was earning \$1,200 per annum or over, the rate was 102.2, but where the father earned \$900 to \$1,199 it was 142.3, and where he earned \$780 to \$899 and \$625 to \$779, it was 168.4 and 163.1. In the poorest families where the father earned \$521 to \$624 or even under \$521, the infantile deaths were as high as 193.1 and 197.3, respectively, per thousand born—almost one death in five births, and almost double the rate among families with the highest wage.

A similar investigation was made about the same time in seven other American cities, and though the general level of mortality was lower, the combined results confirm

TABLE 39

EFFECT OF WAGES ON DAYS LOST BY DISABILITY

Number and per cent. of possible working days lost from disability by wage-earning members of families in seven cotton mill villages of South Carolina from January to May 1916. The wage-earners are classified according to family income.

Half-Month Family Income per Adult Male Unit.	Average Number of Wage-earning Persons per Month.	Total Number of Possible Working Days.	Days not at Work.				Percentage of Total Days not at Work Lost on Account of Disability.
			From all Causes.		From Disability.		
			Number of Days.	Percentage of Total Possible Working Days.	Number of Days.	Percentage of Total Possible Working Days.	
Less than \$6	395	49,753	7,736	15.5	2,938	5.9	38.0
\$6 to \$7.99	349	44,948	4,631	10.3	1,611	3.6	34.7
\$8 to \$9.99	306	39,191	3,114	7.9	1,005	2.6	32.3
\$10 and over	491	50,026	5,326	10.6	1,153	2.3	21.6
All incomes	1,541	183,918	20,807	11.3	6,707	3.6	32.2

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the experience at Johnstown as to the variation of the death rate with the earnings of the father. Where the father was earning over \$1,050 per year, the infant death rate in the eight cities was 64 per thousand; and this rate rose steadily as the annual earnings of the father fell. Thus: earnings \$850 to \$1,049, death rate 84; earnings \$650 to \$849, death rate 108; earnings \$550 to \$649, death rate 118; earnings \$450 to \$549, death rate 134; earnings under \$450, death rate 168.

Physical examination has also disclosed the relationship of physique and diseased condition to wages. As a result of the examination of male garment workers in New York City, Warren and Sydenstricker (10, No. 341) reported that the greatest number of poorly nourished, anæmic, tuberculous workers in an extremely seasonal industry were in that group composed of the lowest paid and the least regularly employed.

In Cincinnati, Robinson and Wilson¹ include among their findings the following conclusions:

- (7) . . . We believe that the factory environment of the majority of workers is superior to the home environment, and as a corollary that,
- (8) Bad housing has a marked influence on the high tuberculosis death rate and this, in turn, is dependent in great part upon:
- (9) Poor economic conditions, the financial status of the people being such that they are unable to obtain better home conditions. . . .

Poor housing is thus indicated as a condition of ill-health co-ordinate with poor food: and accurate measures of house accommodation have been used to interpret death rates. Overcrowding can be measured more particularly by the rooms lived in per family, and more generally by the density of population or inhabitants per acre. J. B. Russel² found that at Glasgow in 1885 the death rate per thousand persons was 11·23 among those living in houses of five rooms and upward, and 19·45 among those living in three- or four-roomed houses, but 27·74 among those living in one- or two-roomed houses or in institutions.

¹ Public Health Bulletin No. 73, Washington, Government Printing Office.

² Arthur Newsholme: *Elements of Vital Statistics*. London, 1899.

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Again, the 55th report of the English Registrar-General shows that in covering a population of 27 millions, death rates increase step by step with increased density of population. Thus among persons living 138 to the square mile the death rate per thousand persons per year was 12.70; at 149 to the square mile, the death rate was 13.45; at 187 to the square mile, 14.48, and so on, until at 5,722 to the square mile the death rate was 26.22 and at 19,584 to the square mile, 33.0.

A sparse as against a dense population is often a question of rural against urban living conditions, and this suggests the significance of yet a third condition of life among many of the poorer industrialists, the lack of fresh air.

The comparatively low mortality of agriculturalists has already been shown, and American statistics of medical examination for the military draft of 1917 and 1918 show an average of 528 defects¹ per thousand men in rural districts, but a rate of 609 defects per thousand men in urban districts. It is well known also that for men over 35 the death rate from phthisis is enormously greater in towns than in the country. For women and younger males the difference is not so great, and Collis and Greenwood (17) suggest that this greater susceptibility of the older males is due to a combination of urban living conditions with their almost universal industrial employment.

On his wages depends the worker's subsistence, the amount he can spend on food and living conditions; and when these wages are high enough in relation to cost of transit, even a home in the country is not impossible for those employed in urban industries, as Belgium shows.²

To sum up, then. Though the statistical material is meagre and fragmentary enough almost to suggest professional ca'canny, the evidence, such as it is, discloses an average wage-level all too close to the very minimum for subsistence. Every dip in earnings is immediately associated with heavier and heavier sickness and heavier mortality of children and adults.

¹ One man might have more than one defect. For the United States as a whole 557 defects were found per 1,000, but only 468 defective men.

² B. S. Rowntree: *Land and Labour: Lessons from Belgium*.

CHAPTER XII

THE SIGNIFICANCE OF FATIGUE AND UNREST

WITH physical deterioration, sickness, disablement and the shortening of working life, the chapters of industrial losses may fitly close.

Each loss has been shown to involve business costs as well as human suffering and want ; and in every case the average loss prevailing in English or American industry has been found greatly in excess of the unavoidable minimum.¹ The average turnover measured by the ratio of employees annually replaced by a factory to the average numbers employed, ranged in America from 63 per cent. to 201 per cent. in the years 1910 to 1919, and in English war industries employing women exclusively, from 27 per cent. to 212 per cent., according to the factory. But the minimum unavoidable rate of turnover was estimated at not more than 25 per cent. The average absence in a factory, calculated as a proportion of total scheduled working hours, was found in England or America (with a few exceptions) to be anything from 5 per cent. to 12 per cent. The unavoidable minimum due mainly to temporary illness and accident up to six months' duration was calculated—somewhat elaborately—to be below 3 per cent. for men and 3½ per cent. for women. Fluctuations found in the quantity and quality of output and in accidents, from place to place and time to time, cannot be explained away as phenomena natural to the human factor or necessary to industrial technique, and the ill-health and death rates suffered by the industrial population are found grossly in excess of the rates customary to the non-industrial classes.

¹ This minimum is largely determined by the influences marked C. and D, in Table 3, Chapter IV.

The conditions found by statistical investigation to be associated or correlated with these excessive losses of all kinds are multitudinous enough to necessitate grouping. Following the scheme outlined in Chapter IV, the evidence which can only be summarized at some length is classified as the effect of seven types of industrial conditions: 1 and 2, the hours of work—divided, owing to the wealth of evidence, into the effect of the total of hours as a whole and the effect of the cycle of consecutive hours of work and rest; 3, the type of work performed; 4, physical working conditions; 5, incentives and employment policies; 6, type and experience of worker; 7, low wages and poor living conditions. Cross-references are given to the chapters and sections summarized.

THE FINDINGS OF STATISTICAL INVESTIGATION SUMMED UP

I. Effect of Adjusting the Total of Hours Worked per Day

A reduction of hours increases hourly output (VIII D, § 1) and decreases absence (VII D, § 1) and accidents per hour (X D, § 1).

Reduction of hours to eight per day increases *daily* output in occupations where speed depends mainly on the human factor or in a factory of mixed operations, such as the Zeiss Optical Works; but may fail to do so where the machine sets the pace or the completion of the operation depends on chemical processes, e.g. in the class of occupations numbered 5 *e* and *f* in Table 2.

Reductions of hours below eight per day does not increase hourly output sufficiently to increase the daily total, unless, possibly, speed depends purely on the human factor and work is of a heavy type.

The effects of a reduction of hours just described may follow only after a period of adjustment.

Increase of hours has the reverse effect. Hourly output falls and daily output also, at any rate if the working day increased was already of eight hours or more (VIII D, § 1). The fall is immediate, i.e. there is usually no period of adaptation. Rates of absence, especially of unavoidable absence due to sickness, tend to rise (VII D, § 1) when the scheduled

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hours are increased, so that the number of hours actually worked may not as a net result be materially advanced. Unavoidable absence, presumed to be due to sickness and accident, is generally lower in munition factories working shorter hours (XI D, § 1).

Sporadic overtime added to a 10-hour day lowers the hourly output throughout the day, and even throughout any normal day that follows (VIII D, § 1); and since overtime is usually paid at a higher rate of wage, the cost is out of proportion to the gain in total output.

The introduction of rest pauses of ten minutes in the middle of 5-hour spells increases the *daily* output. Rest pauses may not have this effect in 4-hour spells where speed is mainly set by the machine.

II. Effect of Cycle of Consecutive Hours of Work and Rest

In the course of the daily round of work the quantity and the quality of output, and also the frequency of accidents per unit of output, show characteristic curves. Table 40 presents in graphical form output, spoiled work and accident curves as they occurred at one and the same American metal plant working a 10-hour day.¹

During the course of each spell of four and five hours output usually rises until the second or third hour, and then falls; while the rate of accidents rises continuously until the last hour but one, and then shows a slight decline. The proportion of spoiled work falls until the middle of the spell, then rises. Thus, as a rule, in a 5-hour spell, the first hour has a poor quantity and quality of output, but the minimum of accidents; the second hour a high output of fair quality and comparatively few accidents; the third hour a high output of good quality but many accidents;

¹ References are to VIII D, § 2, IX, and X D, § 1, describing the effect of hours on quantity of output, spoiled work and accidents respectively. The curves in Table 40 are all formed from published figures; Accident curves at top from Tables 18, 19, 20 of Public Health Bulletin 106 (9); the figures for muscular work only are given above, Table 34. Output curves in centre from (9) Tables 2, 4 or 14, or from (19) Table C as explained page 238 above. Comparative curves at foot of diagram from Table 22 for output (production) and accidents; and for spoiled work from Table 30 above, Col. 1 being reduced to percentage variations.

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the fourth hour a middling quality and quantity of output and the maximum of accidents; and the fifth and last hour a very poor quantity and quality of output and still many accidents.

In shorter spells than five hours, and shorter working days than ten hours, output is better maintained and more stable. In general, the *curve* of output and accident is less conspicuous during shorter periods of work and more so during longer spells and days.

Where restriction of output prevails, a peculiar hourly output curve has been obtained, featuring a spurt in the penultimate hour of each spell.

As between whole spells the ordinary afternoon spell tends to be slightly deficient in output when a 10-hour day is worked, and if any spells are worked before breakfast or in the evening these tend to be markedly deficient in output.

In the course of a nightly round of work, output has been found to fall very violently towards the end of a 12-hour shift, but in shorter shifts, where lathe work is concerned, accidents seem to fall while output remains, on the whole, stationary.

In the course of the weekly round of work as measured in day-by-day records, relatively slight variations are found in accidents, output and absence. The first day of the week has a low output and a relatively high rate of accidents and absence; it has been branded Blue Monday. The last full working day also shows deficiency in output and an excess of accidents, and might be called Black Friday, or on the continent, Black Saturday.

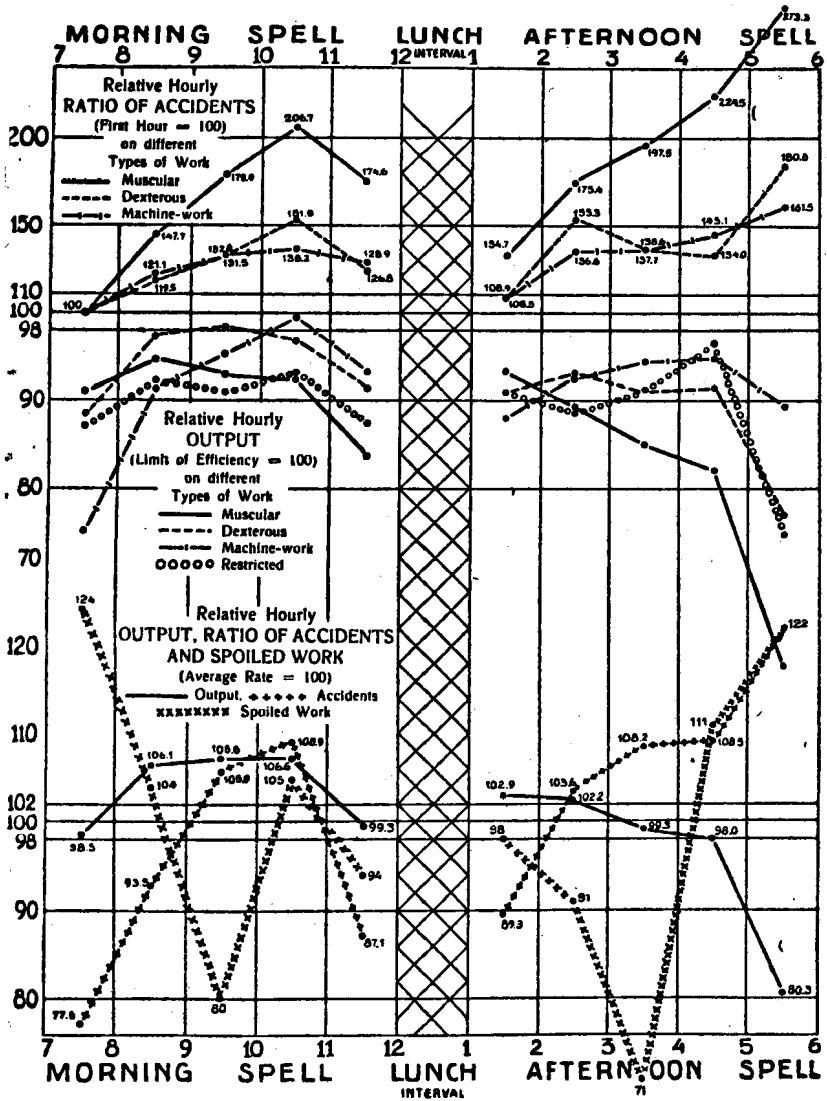
III. Effect of Type of Work Performed

When the work is muscular, continuous activity seems to decrease the output and increase the accidents in the later hours more than when the work is dexterous, or performed with machines (VIII D, § 2, and X D, § 1), and Table 40 presents these differences in the hourly curves in graphical form. When the work is heavy, reduction in hours tends to increase the hourly level of output more than where the work is light (VIII D, § 1). Among records of English Friendly Societies a higher rate of illness was found in

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TABLE 40

Hour by Hour Curves of Accidents, Output and Spoiled Work
American Ten-hour Plant



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"heavy" occupations than in "light" (XI D, § 2), and among minor ailments headaches were found to be particularly high in factory departments with "close" work involving eye strain.]

By motion-study changes can often be effected in the method of performing a given operation which increase the output in a given time and reduce the effort involved in each unit of output (VIII D, § 3). Rhythm in the sense both of a swinging type of movement and of regularity of repetition is here an important factor and has recently been submitted to accurate measurement.

A smaller proportion of defective output has been observed in the work of women grinding springs when their inspection of the finished work followed a regular plan and was neither perfunctory nor yet over-careful (IX).'

It has been suggested that by varying the type of work of any given individual in the course of the working day more interest might be aroused, and hence more output, but no exact evidence is to hand.

The effect on output of changes in machine design and the use of labour-saving apparatus must not be overlooked, nor yet the effect of mechanical safety devices in reducing accidents. These modifications in the nature of the work, however, do not act through changes in human working capacity and are proper to engineering policy.

IV. Effect of Adjusting Physical Working Conditions

Ill-ventilated and also noisy departments of a factory show relatively high rates of turnover (VI D, § 1) and absence (VII D, § 1).

In various industries there is a middle range of temperature most conducive to efficiency, and temperatures varying either above or below this range are found associated with increased rates of accident and greater deficiency in output (X D, § 2) and (VIII D, § 4).

Excessive humidity may also decrease output (VIII D, § 4), as also artificial lighting, at any rate in textile weaving.

Seasonal variations, though they cannot be controlled in the plant by the employer, may yet be guarded against

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by proper heating and ventilation, and output has been stabilized throughout the year by these means (VIII D, § 4). Sickness among the industrial classes is found to rise in the winter months, to remain fairly high in the spring, and to be lowest in summer and autumn. Work out of doors cannot be shown to affect the general level of sickness rates appreciably (XI D, § 2).

Work at night with its reversal of habits and its artificial illumination is usually, though not universally, found associated with a higher accident-rate (X D, § 2). The comparative output at night depends on the method of working nightshifts. If the shifts rotate, i.e. if men or women work night and day for alternate periods, little difference is found, at any rate in light repetition work. *Continuous* nightshifts may, however, bring with them a marked decrease in output, particularly in the case of women (VIII D, § 4). Here the suspicion enters that women workers engage in domestic duties during the day.

Factories and workshops with the most harmful physical conditions are precisely those where investigation is likely to be least encouraged; and often, as in the sweated trades, the mere detection of such conditions presents great difficulties. The effect on output, health and other economic losses of the extremes of temperature, overcrowding, etc., that undoubtedly exist in certain industries is therefore as yet unascertained.

V. Effect of Introducing Various Incentives and Employment Policies

Straight piece wages increase output as against time wages (VIII D, § 5), but restriction of output is often found associated with complicated piece-rate systems, particularly if these are digressive in tendency. The practice of rate-cutting may also be a factor in the restriction of output. Home-visiting and bonuses offered for good attendances have had (VII B, § 1) some success in reducing absence.

The view that most industrial employment gives so little scope for human faculties as to induce a baulked disposition, has inspired attempts to supply an incidental interest other

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than that of the receipt of wages. The publication of records of individual efficiency has been found associated with improved quality of work (IX), and information about connected industrial processes, with improved quantity of output (VIII D, § 5).

Selection of new employees by physical examination reduces days lost by sickness and turnover. Turnover has also been materially reduced by psychological test, by vesting the function of hiring and firing employees in the central management, by a system of transferring workers at their own request from department to department *within* a factory, and by organizing various other employment policies (VI D, § 2).

The special training of those new to any job increases output faster than does the usual practice of letting them "pick it up" (VIII D, § 3). Medical supervision (XI D, § 3) effects a material reduction in the time lost on account of disability, particularly that due to infection from injuries; and in the prevention of accidents the education of the workers by posters and general propaganda is found quite as important as the mechanical safeguarding of equipment.

*VI. Effect of Type and Experience of Worker*¹

Women have higher rates of absence and sickness than men (XI D, § 4), but lower rates of turnover. Their gross rates of turnover are less in spite of the fact that they probably suffer a higher unavoidable minimum (VI D, § 4).

Married women in industrial employment have a higher turnover than single women and higher rates of sickness (XI D, § 4) and death. This is probably due to their double rôle of mother (or expectant mother) and industrial worker. Sickness increases with age, and is almost double for men aged 45-54 than for men aged 25-34. The increase is not so regular for women. Race may also be a factor in turnover, sickness and mortality from particular types of disease (XI D, § 4); and ignorance of the vernacular increases the liability to accident (X D, § 3).

¹ The effect of purely individual variations on output, accidents and sickness (VIII B; X D, § 3; XI D, § 4) may also be cited.

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Workers new to industry *in general*, such as young persons leaving school, have a very high turnover rate, and workers newly hired into a given organization have a higher turnover (VI D, § 3) and higher accident rates (X D, § 3) than workers who have served longer in the same firm. The type of previous occupation also seems to influence the numbers surviving any period within a firm. Unskilled workers in general have a lower turnover rate than the skilled, but this may partly be due to the difference in wages (VI D, § 4).

Membership in a trade union is not synonymous with restriction of output. Restriction is found in America and England among employees unaffiliated to any unions (VIII D, § 6). Nor is union membership necessarily synonymous with absence by strike (VII D, § 2).

VII. Effect of Low Wages and Poor Living Conditions

The entire income of an industrial employee consists, as a rule, in his wages, and, where he has to maintain a family, more than half this income is spent on food, and a further considerable proportion on housing; nor is this expenditure excessive when measured in nutritive values and sanitary needs. On the level of wages, therefore, must depend the whole standard of life.

Experience of business men has emphasized the economy of high wages (VIII D, § 6) in reducing the labour cost of a unit of output. Increased rates of sickness are suffered by wage-earners and higher death rates by their infants as lower levels of wages are reached (XI D, § 5). Labour turnover seems to be higher among the poorer paid employees and is certainly increased in an occupation like the Civil Service, where the rate of pay remains fixed, while the pay of similar occupations is rising (VI D, § 4). On the other hand, an increase in wages may under certain circumstances be associated with increased lost time (VII D, § 2).

In occupations of the poorest grade, higher mortality rates are found than in middle grades or professional occupations, and young men of the industrial classes show an inferior physique. These differences are significant enough

to warrant the notion of industrial sickness over and above that of the general population.

The spending of wages on drink, tobacco, tea, and other not strictly vital needs has been much blown upon, but, large as is the part these habits play, scientific investigation into their economic effects is only fragmentary.

THE INTERMEDIACY OF HUMAN FATIGUE AND UNREST

These associations of variation in industrial conditions with variation in economic losses can qualify to fit the theory of fatigue or unrest only if they can be shown to trace their association through the human factor.

Certain of these economic losses involve the human factor much more obviously than others. In the case of turnover and absence it is the human being who leaves and who is absent, and in the case of ill-health it is the human organism that is involved. Deficient and defective output, on the other hand, is a loss in material, and we have to go below the surface to discover the human factor. A case of accident comes somewhere between these extremes; it is generally a contact—often a violent contact—between the human and the material or mechanical factor, either of which may be the source of the fatal variation from normal routine.

The circumstances of the economic loss by deficient or defective output or by accident are thus peculiarly difficult to interpret unless proper care is taken that conditions do not affect output or accidents merely mechanically, i.e. without passing through the human factor.

This short-circuiting of the human factor is particularly difficult to detect where the *feasibility* of work is changing without any change in the type of work.

The direct physical effect of a dry atmosphere in breaking cotton thread has already been mentioned, and examples may be multiplied. An incident during the recent war frequently quoted in support of the theory of fatigue was that of the two squads who undertook a trench-digging competition (I, No. 7).

Two officers at the front recently, for a friendly wager, competed in making equal lengths of a certain trench, each with an equal squad of men. One let his men work as they pleased, but as hard as possible.

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The other divided his men into three sets, to work in rotation, each set digging their hardest for five minutes and then resting for ten, till their spell of labour came again. The latter team won easily.

Vernon quite rightly questions whether the race was not lost simply because the men who did not work in shifts got into one another's way. If this was the case, though the task of the two squads was the same, the "feasibility" of each task was different.

The possible effect of lighting on accidents is also a difficult case and one that I have illustrated elsewhere by a diagram (18, p. 67). Inferior lighting will probably increase accidents both because men's eyes suffer from the additional strain, and because, when objects are not clearly visible, the safe performance of the task becomes less feasible.

In short, it is not the objective output or the tale of actual accidents, or even the ratio of accidents per unit of output (see above, p. 294), which is here the decisive measure of human capacity and willingness, but the output and ratio of accidents in relation to the feasibility or danger of the task.

Variable feasibility presents itself in industry also when the speed of a machine is altered. Output from an automatic lathe or a furnace may be lower at one time than another, because the machine revolves more slowly or the coal burns less effectively, and not at all because of any change in the human factor. Conversely, if machines are speeded up mechanically a higher rate of output will be shown, but this cannot be taken to indicate anything definite about the operator of the machine; in fact, under such conditions, a higher rate of accident and a lower quality of output would probably contradict the evidence of the quantity of output.

No results where variations in feasibility could be suspected have been included in the preceding chapters and summarized above; the circumstances appear in all cases to have been sufficiently controlled to ensure that the co-variation of industrial conditions and economic losses was effected through variation within the human factor.

The next question is how far this variation within the human factor constitutes fatigue and unrest.

Fatigue is taken (Chapter IV) to refer to the decrease

in the human factor's capacity to produce that accompanies increased production ; and unrest to refer to any decrease in the human factor's willingness to produce that may occur in the course of production.

The qualification applied to fatigue, that it must accompany *increased* production, suggests that the industrial conditions of increasing hours of work is more closely related to fatigue than other conditions, such as, say, increase in temperature or the payment of lower wages. The effect of hours of work on output, accidents and sickness has as a matter of record occupied more of our attention than the effect of any other class of conditions, and this is in agreement with the general use of "fatigue." Lee¹ examines the effect of motion-study, lighting, ventilation, food, and various sanitary conditions in a chapter entitled *Secondary Causes of Fatigue* ; the same terminological policy had been consciously adopted by the British Association Committee in their 1915 report (12), which regards "duration of work" as the main factor, and the other industrial variables as "predisposing conditions enabling excess of work or lack of rest to take effect to different degrees." Admittedly "a strong individual on easy work and in pleasant surroundings may after five hours' work be much less fatigued than is a weakling after three hours on hard work and in noxious surroundings."

This admission emphasizes the integral action of the industrial system. All the conditions of employment that have been distinguished form part of one complex situation affecting the human factor.

Increase in hours would not have the economic effect it appears to have if "secondary" conditions were otherwise ; if, in fact, the outcome of the Industrial Revolution (traced in Chapter II) had been different as far as labour was concerned, or if there had been no Industrial Revolution at all. There can be no increase in hours *in vacuo* ; though other conditions may not be varying, they are none the less present. Which conditions are taken as variable and which as constant is largely a matter of methodological convenience.

¹ F. S. Lee: *The Human Machine and Industrial Efficiency*. Longmans, New York, 1918.

Though in a narrower sense the term "fatigue" may be considered applicable only where hours (or intensity) of work are varied, it can in a wider sense be taken as measurable in diminished working capacity wherever industrial conditions of *any kind* are being adjusted.

The abiding question in the theory of fatigue and unrest may, then, be re-submitted: how far the losses by turnover and absence, by deficient and defective output, and by accident and sickness which were found associated with variations in every class of industrial condition, can be interpreted in terms of the human factor's diminished capacity and willingness to produce.

Now capacity and willingness are essentially physiological and psychological phenomena, and the accuracy of the proposed interpretation can only, in fact, be tested by submitting the results of certain scientific measurements of the inward reactions of the human being as distinct from observation of his overt outward behaviour.

Methods of measuring what is going on "inside" the human organism to account for these external causes and effects are of many kinds, but may be broadly divided into tests and questionnaires.

Muscio¹ divides tests into performance tests and non-performance tests, the distinction being that in a performance test the subject is required to do something, while non-performance tests are directed to the measurement of certain non-voluntary phenomena. Performance tests can be further divided into muscular and mental tests, though one of the most frequently used, i.e. the reaction-time test, does not readily fall under either of these heads.

Among *muscular* performance tests are tests of muscular rapidity such as tapping, tests of muscular precision such as dart-throwing, and the use of the McDougall dotting machine; and tests of muscular strength such as the dynamometer,² the Martin spring balance,³ the ergograph described by Mosso and elaborated by Ryan and Agnew,³ and many others.

¹ *British Journal of Psychology*, 1921 (xii, 1).

² See (4, No. 16) for description and criticism of this method as applied in industry.

³ *American Journal of Physiology*, vol. 42, No. 4, p. 599.

Among the better-known *mental* performance tests are those of visual and auditory acuity used by Stanley Kent in his Report to the Home Office¹; and the tests of mental processes² such as arithmetical calculations, group number checking and cancellation developed by Kraepelin, Thorndike and others, and applied wholesale to American recruits during the recent war.

The chief non-performance tests are measurements of variation in blood-pressure as used by Stanley Kent,¹ Ryan's vascular skin reaction tests,³ analysis of the excretions—particularly the urine—measurements of muscle-tonus, and calorimetry or measurement of the expiratory discharge of carbon dioxide. Physical examination to disclose specific diseases under given conditions and the observation of habits such as times and duration of sleep, might also be included in non-performance tests.

Possibly a more important distinction than performance or non-performance is one that refers to the particular conditions under which the test is applied. Tests whether of performance or non-performance type may be interpolated in the course of ordinary industrial production, e.g. before and after a spell of work in the factory; or else they may be made on persons in the course of activity under conditions especially designed for the purpose. In the latter case the test takes the form of a laboratory experiment.

The chief difficulty in attempting to detect industrial fatigue by laboratory experiments is to reproduce the industrial "atmosphere." Several French scientists have taken the whole of some simple industrial operation such as carrying sacks on a wheelbarrow, and by attaching measuring devices both to the wheelbarrow and to the subject under investigation have sought the exact connection between the external work of trundling and the expenditure of energy inside the trundler. Bogardus, again, has attempted to reproduce the physical and psychological conditions of an accident by means of a sort of booby-trap liable to hit the fingers.

¹ Report on an Investigation of Industrial Fatigue by Physiological Methods. Cd. 8335.

² B. Muscio: "Fluctuations in Mental Efficiency," *British Journal of Psychology*, July 1920.

³ Proceedings American Physiological Society, Minneapolis, 1917.

Too often, however, the work of laboratory physiologists and psychologists is "the reverse of illuminating for the problems of industry" (13),¹ and even if external industrial conditions are approximated it is next to impossible to ensure a psychological attitude in the subject at all resembling the attitude of the industrial employee at his ordinary work.

Nor is the method of tests applied to the industrial worker while at his work free from criticism. There still remains the possibility of variation in the observer making the tests and of temporary excitement or even faking on the part of the workman undergoing the tests. And in the end the particular form of test may not always find contact with the type of facts required.

The questionnaire method elicits the state of feeling expressed in "word-reactions." For instance, a man would be asked his "reasons" for leaving employment (and swelling the turnover), for being absent and for striking; and he might be asked retrospectively for his thoughts just before an accident or for his feelings of tiredness in conjunction with output records during the course of working hours. Or the employer might be asked his reasons for dismissing employees or for declaring a lockout.

Feelings of fatigue have been a subject for questions as far back as Aristotle's day. Indeed, the feeling of fatigue as distinguished from a (supposed) physiological concomitant and a (hypothetical) result on production is probably the more popular definition of fatigue. "Why are short turns of walking fatiguing?" asks Aristotle in his *Problems Pertaining to Labour and Weariness*. "Is it because we frequently stop, and are not equably moved about the joints? But a thing of this kind is fatiguing." "Why does the way seem to be longer when we walk not knowing than when we know how far we have walked?" "Why is it more difficult to run than to walk? Is it because he who runs carries a greater burden? For, being elevated from the ground, he has all the weight of the body upon him. But he who walks is supported by the ground, like one who rests on a wall."

¹ See also my criticism of the tests for susceptibility to accident used by the Industrial Fatigue Research Board, *Economic Journal*, June 1923.

TABLE 41
REASONS FOR QUITTING: AMERICAN EXPERIENCE

Plant and Reference.	Total Number of Quits Considered.	Percentage of Total Quits for Specified Reasons.						Not Specified.
		Personal.			Unavoidable.	Industrial.		
		Changed Place of Residence.	Needed at Home, Back to School, Marriage.	Compulsory Military Service.		Death and Disability, Need Rest.	Dissatisfied.		Better Position Elsewhere.
1. Metal working "A" (23), 1913-16	5,364	15.2	4.5	—	3.7	51.0	25.6	—
2. Metal working "C" (23), 1913.. .. .	1,239	27.6	—	—	6.2	33.8	30.5	1.9
3. Six metal plants (11), Cincinnati, Ohio, March 1919	8,140	5.6	1.6	9.0	5.7	40.6	12.1	25.4
4. Two metal plants (11), Cleveland, Ohio, January 1919..	Not given	—	—	2.0	27.0(a)	55.0	8.0	8.0
5. Eight-hour plant (b) (9) ..	10,246	11.8(c)	2.0	0.0(b)	11.9	48.5	26.0	—
6. Large motor vehicle plant (d)	2,619	14.3	1.2	19.6	5.2	23.3	23.1	13.2
7. Department (d) store on the Pacific Coast (11), November 1919	1,075	14.0	21.0	4.0	15.0	27.0	13.0	6.0
8. 1,473 children in their first industrial (23) position, 1913	1,473	4.5	3.9	—	8.4	64.7	17.4	1.1

(a) Includes physical disability and work too hard.

(b) Percentage of discharges plus quits in original charged to percentage of quits only not counting military service.

(c) "Employee dissatisfied with locality."

(d) U.S. Federal Board for Vocational Guidance, Bulletin 46. This Bulletin also gives the same figures as appear in item 7, but attributes them to a Pacific Coast establishment "engaged in the manufacture of agricultural implements and machinery," and the source is said to be an unpublished report in the files of the Bureau of Labor Statistics.

This method of questioning is obviously less suitable for disclosing the facts about fatigue, i.e. physical incapacity to produce, than those of unrest, i.e. unwillingness to produce. Specific reasons for unrest come to the surface and are openly expressed on two occasions of economic loss: the strike, and turnover due to individual employees quitting on their own initiative.

This quitting is already known to us as a larger and more constant source of turnover than either discharges or lay-offs. The tables in Chapter VI make this abundantly clear. In England during the war period the cases of quitting among women usually ranged between 60 per cent. and 80 per cent. of all cases of turnover. Among men, and in the prewar and postwar periods, the percentage of quits is if anything higher. The wider American experience definitely establishes quitting on the part of the employee as the predominant manner of leaving employment.

But the exact reasons for quitting can only be discovered with a "follow-up" system of questioning all employees who leave; and the experience of the American "ten-hour" plant (9) is probably typical of all establishments where no such follow-up is undertaken.

An effort made by the U.S. Public Health Service to learn reasons for terminating employment among 10,434 employees leaving in the half-year from January to June 1917, showed that while 6 per cent. were dismissed and 4 per cent. quit work for various reasons, 9,442 or 90 per cent. left for "reasons unknown to firm."

Answers obtained by the "follow-up" show that quits owing to dissatisfaction of some sort form a large proportion of the turnover. Table 41 gives the percentages of quits from dissatisfaction as compared with other reasons in a few American establishments where these percentages have been made public. Reasons for leaving are grouped as unavoidable only when due to such definite physical obstacles as death and disability. Other causes, conventionally grouped as unavoidable, have been classed as personal, the distinction being that in the unavoidable cases the employee could not have continued at work even if he had wished to—he has to bow, in legal phrase, to *force majeure*;

in the personal cases the employee's wish may or may not have been a determining factor. At any rate, had the work in the factory been sufficiently attractive, that fact might have outbalanced other difficulties in continuing work.

In estimating the proportion of quits due to the workers' unrest it would be a mistake to confine our attention to the column marked "dissatisfied." The percentages of quits in this column are high enough in all conscience, varying from 23.3 per cent. to 55 per cent. in factories proper. Yet it is certain that a good deal of dissatisfaction also enters into the cases in the other columns. Thus "better position elsewhere" is a matter of comparing the present position with the prospective one, and it is not certain whether the employee would have left if the present position had been a little more attractive; it might then have been the better position of the two. Again, in the "personal" group, an employee might have continued in his old place of residence or might have hired someone to help with the family if his position in the plant had been made worth while.

For the sake of being definite, only the cases grouped as industrial may be considered an indication of dissatisfaction with, or indifference to, the position in the plant. In the manufacturing group, then, the quits for industrial reasons form anything from 46 per cent. to over 70 per cent. of all the quits; in the department store the proportion is 40 per cent., and among children 82 per cent.

Thus, while quits form the bulk of the cases of turnover (cf. Chapter VI), dissatisfaction is the main reason for the quits. On the American evidence there is no doubt of a strong case for unrest as the chief factor underlying the economic loss by turnover.

In English industry inquiries into the reasons for quitting are limited to the experience of women in munition factories during the late war. Though the rate of turnover due to dissatisfaction was considerable, ill-health and domestic reasons attained (Table 12) quite equal importance.

Reasons for strikes are inquired into by the English Board of Trade (later the Ministry of Labour), and Table 42 gives the proportion of workers directly involved on account

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of the various reasons during the years 1899 to 1913. The U.S. Department of Labor also keeps a record of the reasons for strikes, and the percentage of strikes (not of workers involved) for various reasons during the years 1916 to 1921 is entered in the second column of the table. The American records often give two or three matters as "in dispute," where the issue is not clear-cut. To single out each cause of strike and estimate its importance individually, the procedure has been adopted, where two causes are involved together, of crediting each with half the cases, and where three matters are in dispute of crediting each single issue with one-third the cases.

THE FINDINGS OF TEST AND QUESTIONNAIRE

I. Effect of Total Hours Worked per Day

It has been the main object of most "fatigue" tests and experiments to discover the specific effect of duration or intensity of activity, i.e. of continued repetitions of an activity during shorter or longer periods, at slower or faster speeds, or with heavier or lighter loads.¹

Long-continued activity tends to effect certain physiological changes which might possibly constitute the basis of a physiological definition of fatigue. A condition of exhaustion can be distinguished in which an excessive proportion of available organic energy has been transformed into heat or work. But more important are certain chemical products of activity, of the nature of organic poisons which are found to accumulate in the muscles or other organs that have been active, a condition aptly compared (1, No. 7) to the clogging of the wheels in some mechanism by dirt.

But in ordinary voluntary activities of the human organism as a whole this easily measurable manifestation of fatigue is not likely to occur owing to the action of the

¹ Professor Spooner (*Cassier's Magazine*) usefully analyses "the labouring power or the mechanical daily duty of a man" as "the product of three quantities—the effort, the velocity and the number of units of time during which the work is performed." Abbé, in interpreting the results of his shortening of the working day at the Zeiss works, distinguishes between fatigue due to mere standing or "being on duty" which would be reduced proportionately to the reduction in hours, and the fatigue due to activity itself. With the increasing output obtained per hour fatigue from this source might well have increased.

nervous system. The impulses to activity springing from the brain cannot bring the muscles far towards complete fatigue before their sources are themselves fatigued (1, No. 7) ; and even when impulses are repeated by artificial means in an experiment, they " will still fail to produce more than partial fatigue in the muscles, for fatigue advances faster still in certain structures known as the end-organs which connect nerve fibre and muscle ; there the impulses become blocked so that the muscle again escapes from further activity."

No single rapid and convenient test has, in Muscio's opinion, yet been discovered capable of measuring fatigue without requiring considerable material.

Continuous activity may ultimately contribute to illness and breakdown. True, there is no disease of overwork as such, but the modern view is to regard overwork as the second partner in disease. If a germ is the active partner it is fatigue that above all else may lower the bodily resistance to its attack. As an example, Lee¹ quotes an experiment on rabbits.

When rabbits were inoculated with pathogenic bacteria and were then made to run several hours each day in a wheel they died, while other rabbits similarly inoculated but not exercised survived. In the over-exercised rabbits the condition of the blood which signifies the degree of susceptibility of the organism to bacterial infection was gradually reduced and cessation of exercise for even a day resulted in a partial recovery.

Where human beings, not rabbits, are concerned, there is scope also for investigation by direct questioning.

When the recess periods described in Chapter VIII were introduced in the American 10-hour plant, the opinion of the workers affected was canvassed, and general approval was manifest in spite of the fear that piece-rate earnings might be diminished by the loss of working time.

M. S., for instance, declared : " You don't feel so tired, and you feel like working all day." She used to " *get lazy* " in the middle of the spell. Now she thinks she is less tired

¹ F. S. Lee : *The Human Machine and Industrial Efficiency*. Longmans, New York, 1918.

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at night and feels better all the time. Mrs. D., when working on certain operations, considered the rests "the two bright spots of the day, for she almost died she got so tired sitting." Mrs. M—s found she "was not so tired. When 11 o'clock comes now, we have recess, and I can do more the last hour." Mrs. M—n felt "like working" after the recess and "she doesn't if she just sits thinking all day."

Table 42 shows that a considerable proportion of the strikes (7.5 per cent. of all strikers) in the United Kingdom from 1899 to 1913, and 13.4 per cent. of the strikes occurring in America from 1916 to 1921, were called in support of an increase or against a decrease of hours of work.

The agitation for shorter hours is of course not necessarily due to feelings of fatigue. Sometimes the object is not the shortening of the actual hours worked but simply a shortening of the "basic" time during which the normal rate of wage is paid and an extension of the working period during which overtime rates prevail. At other times the chief appeal is the desire for leisure to pursue hobbies and by-occupations, or to help with or facilitate¹ household duties or to cultivate social and family relationships.

One of the strikers against the 12-hour day in the American Iron and Steel Industry gave as his reason "the fact that his little daughter had died within the last few months; he said he had never known the child because he was at work when she was awake, or else he was asleep during the daytime. He was determined that he would know the other children, and for that reason felt that it was imperative that he should have the 8-hour day."²

The fact remains, however, that increased leisure may be valued as a relief to monotonous and exacting work, and it is significant that 16.2 per cent. of the telephone operators who resigned in New York State in the year 1919 gave long hours of work as a reason. When resignations due to "other employment" or to marriage, home duties, returning

¹ A case in point is the tenacity with which working-men cling to a two-break working day rather than the one-break system that eliminates the spell before breakfast. (Cf. Factory Inspectors' Report, 1918.) Under the old system a working man's wife had time to prepare breakfast and get the children off to school before her husband came back for breakfast.

² *The Steel Strike of 1919*. Interchurch World Movement.

to school, or "leaving the city," are subtracted, the hours of work appear as the reason given in 433 cases out of 812, i.e. 53 per cent.

The additional time snatched from industry when hours are reduced is often enough "taken out" in sleep, and the fact that most hobbies and leisure occupations need a certain residuum of energy makes the distinction between the "leisure" and "fatigue" motives in the short hours movement somewhat academic. The attainment of increased leisure is a barren victory unless fatigue is also reduced.

II. Effect of Cycle of Consecutive Hours of Work and Rest

By means of mental tests, chiefly of the calculation type, Kraepelin and his school have distinguished what they call the psychological components of the work curve, and the question arises how far these can account for the curves of output, accident and spoiled work.

These components appear or disappear in the course of continued hours of work. Chief among them are practice and fatigue; but minor components have also been distinguished, such as incitement, settlement and spurts.

Major and minor components can all be grouped for our purposes under three heads: (1) Tendencies to increased efficiency as work is continued; (2) contrary tendencies to lowered efficiency as work is continued; (3) tendencies affecting efficiency apart from mere continuance of work.

While fatigue represents type (2) and spurt type (3), practice, incitement and settlement are all of type (1). As Myers¹ puts it, "when work is resumed after a longer rest, there occurs not only the loss of incitement, not only the loss of practice, but also the loss of a further factor which may be usefully distinguished as 'settlement.'"

The distinction between these components of the same type seems to have become somewhat blurred, but may be taken to refer to the period during which each effects a recovery in output upon a resumption of work. Incitement increases output immediately after a short pause; practice more gradually, say after a night's rest or a lunch interval;

¹ Paper read before Royal Society of Arts, January 12, 1921, Abstract in *Lancet*, January 22nd.

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settlement is the still more gradual process of settling down after, say, a whole week-end of rest. In any case, as Kraepelin insists, these three components that increase output by improvement in motor machinery must be sharply distinguished from the factor of learning—that is, the acquisition of new skill largely through sensory impression.

Spurt acts like practice to increase output, but its incidence bears no direct relation to the continuance or interruption of work. According to Myers,

No one puts forth his maximal power of work. Our muscular or mental capacity seems always to be held in restraint; our reserve powers are inhibited by higher control. In certain circumstances this higher control is itself fatigued or inhibited. Therefore, occasionally in conditions of fatigue an increased amount of work may be performed. Again, owing to extreme excitement due to emotional states, or as the result of increased interest or effort, a temporary spurt may affect the work curve. Two such spurts, "initial" and "end" spurts, may occur quite involuntarily.

Whether passing as practice or incitement there is no question that something does occur in the human factor to increase industrial output in quantity and probably quality in the first hour or two of the work spell, particularly the morning spell. But the presence of settlement and spurt is perhaps not so clearly manifested in industry. Possibly, however, settlement may be recognized in the maintenance of output near the maximum for more than one hour in the middle of the spell and for more than one day in the middle of the week; and end-spurt in the peak of output in the penultimate hour of the spell wherever deliberate restriction prevails (p. 240).

The industrial accident curve, surprisingly enough, does not seem to admit of any practice effect; the first hour's record is seldom, in fact, improved upon. But a form of end-spurt may account for the decline in accidents in the last hour of the spell.

In my report to the British Association I suggested that in the last hour of a spell owing to an "anticipatory excitement" on the part of the (spell-bound) workers, "attention awakes and the control over the muscles is braced up—danger is better perceived and more quickly avoided."

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Watts¹ has since identified this interpretation of the fall in the accident curve with end-spurt.

It is when a worker becomes conscious that he is nearing the end of his task that "end-spurt" begins to show itself either in a quantitative increase of effort to maintain output, or in a qualitative increase of the accuracy of his co-ordinated movements, or in both. The prospect for the worker of an early release from labour, the realization that he will be able to get through his task with less fatigue than he had anticipated, may revitalize and re-energize him.

How the anticipatory end-spurt works in the mind of a copying clerk is vividly depicted in *The Autobiography of Mark Rutherford* :

There was a clock within a hundred yards of my window which struck the hours and quarters. How I watched that clock! My spirits rose or fell with each division of the day. From ten to twelve there was nothing but gloom. By half-past twelve I began to discern dinner-time, and the prospect was brighter. After dinner there was nothing to be done but doggedly to endure until five, and at five I was able to see over the distance from five to seven.

Fatigue, according to the psychological analysis of the work curve, clearly has to contend single-handed against a multitude of processes. What with spurt, incitement, practice and settlement on resumption of work, and the possibility of end-spurt later on, output curves might, on the whole, be expected to show a continuous rise and accident curves a continuous fall. Bedford (16, Vol. IV, No. 6), indeed, considers that the ideal of an output curve rising throughout the spell, day or week, is not unrealizable, and is in fact actually realized by the more productive workers in the shoe industry.

If this view is accepted the final fall in output and the rise in accident commonly observed must indicate a very marked predominance of fatigue in the long run.

The chief muscular tests whose results have paralleled the work-curve of industrial output consist in the artificial stimulation of a single isolated muscle at regular intervals, and the use of the ergograph to record voluntary muscle contraction.

¹ *An Introduction to the Psychological Problems of Industry.* George Allen & Unwin, London, 1921.

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In the electrically stimulated contractions of the isolated muscle, to quote F. S. Lee,¹

the preliminary rise, called the "treppe" or "staircase," represents an improvement in working power due to chemical and physical changes within the muscle; the gradual fall represents the diminution of working power involved in fatigue, which is due in turn to chemical and physical changes within the muscle. These events within the muscle are purely objective phenomena; in the human machine there are added to the objective muscular contractions the subjective phenomena of the nervous system which complicates the physiological situation enormously. Nevertheless, the apparent similarity between the two curves suggests, although it does not make certain, a similar fundamental interpretation.

The ergograph, to quote Myers,² "enables us to study the onset and course of 'fatigue' in a single muscle of the human body. It yields a record of the extent of successive contractions" . . .

When a muscle is voluntarily contracted, it sends impulses up certain nerve fibres to a nerve centre in the spinal cord, the effect of which is increasingly to inhibit (i.e. to suppress) the nervous impulses which would normally travel down other nerve fibres and produce further contractions in that muscle. This is what occurs when a single muscle is exercised to lift and lower a given weight by a series of willed rhythmical contractions. The contractions become less and less, until at length the inhibition set up by them is so great that no amount of voluntary effort can produce further movement in the muscle.

As a result of his own and his pupils' investigations with the ergograph, Mosso³ claims that the intensity of fatigue is seldom proportionate to the intensity of the external cause, and that as the spell of work is increased in length a more than proportional interval of rest is required to annul the exhausting effects. This "law"—significant as it might be—and indeed all ergographical results, undoubtedly require further investigation into their industrial applications.

Muscio⁴ found by questionnaire that among women

¹ *The Human Machine and Industrial Efficiency*. Longmans, New York, 1918.

² *Mind and Work*. University of London Press.

³ Mosso: *Fatigue*. Translated by Drummond. George Allen & Unwin, London, 1915.

⁴ *British Journal of Psychology*, October 1921.

medical students and typists feelings of tiredness increase in the course of the working day. He calibrated the degrees of tiredness complained of (e.g. "fit" was expressed by four marks, "fairly fit" by three, "a little tired" by two, "very tired" by one), and obtained a regular curve of feeling tone hour by hour. A definite tendency was indicated for this curve to fall during the first spell, to revive with the interval, and to fall still farther in the second spell, thus marking a growing unpleasantness of feeling in the course of work. This synchronizes closely with the typical curve of hourly output, except that no practice effect was manifest—a difference for which Muscio finds adequate explanation. Although feeling tone, in so far as it is dependent upon fatigue feelings, may become more and more unpleasant from the very beginning of a spell of work, it is probable that effort as measured by output may not be relaxed until a certain degree of intensity in the painful feeling is reached.

III. Effect of Various Types of Work

Outside observers are often shocked by the monotony which appears to be involved in highly specialized, uniform operations that have to be frequently repeated. These observers are often "intellectuals" who by introspection imagine themselves at the worker's task. It is doubtful how far the worker himself feels this monotony, or objects to it if he does. In all probability some types of mind react one way, some another; but the extension of general education has probably increased the proportion of those who notice and dislike monotony. Miss May Smith (4, No. 22) tested a laundress with a dotting machine, and found that her errors when engaged on her favourite work were only a little over half her errors when engaged on work that she disliked.

With a few exceptions the work she disliked was monotonous; the work she liked was that which repaid her labour by looking pretty when finished. As far as one could judge, during the monotonous period she sank into a state of acquiescence in existence and mental lethargy, which is reflected in the dotting by a characteristic inability to focus attention; when her mind had been really occupied, she was

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mentally alert and better able to concentrate. These variations would effectually mask any fatigue which might have been present.

Münsterberg thought the worker often avoided the feeling of monotony by noticing idiosyncrasies in his machine or his material which escape the outsider, and the experience of a copying clerk recounted in *The Autobiography of Mark Rutherford* illustrates the point. This clerk

would feed upon the prospect of the most childish trifle because it would break in some slight degree the uniformity of his toil. For example, he would sometimes change from quill to steel pens and back again, and he found himself actually looking forward with a kind of joy—merely because of the variation—to the day on which he had fixed to go back to the quill after using steel.

The evidence collected on the spot seems to show that the feeling of monotony is often banished by day-dreaming. To employees who knew him, Scheffel put the question casually while they were at work, "What are you thinking about at the moment?" (16, September 1920).

Out of thirty-one replies only three related directly to the work which was being done, and the conclusion that "most of the replies indicate clearly enough that the minds of these workers were upon almost anything but their work," seems warranted by the sample answers of men and women.

Men: Thinking about phonograph records out for March; thinking about forthcoming prize fight; what time of day it is; what work he will be put on after this job is done.

Women: Thinking about a dance she is going to to-night; whether it will clear up or continue to rain; how she is going to get home without rubbers.

Miss Mona Wilson suggests that monotonous work offers an escape into the life of fantasy, and Professor Winifred Cullis considers that many people enjoy monotonous work "because it gives them time to think their own thoughts."

The excitement occasioned by games and gambling is also held (5, No. 3) to act as an escape from or "compensation" for the monotony and dullness of industrial work, and to account partly for the devotion of the British (and to a less extent, the American) proletariat to sporting activities and betting.

This absent-mindedness certainly conforms to the theory that an unconscious rhythm actuates the worker's movements in frequently repeated operations, so that output is produced automatically; though actually capacity to produce may be low. When investigating for the British Health of Munition Workers Committee, I found certain monotonous operations on nightshift where "girls tend to drop straight off to sleep immediately their machine breaks down and they need no longer work. They would appear, indeed, to be continually on the verge of sleep, and yet the output is maintained at the dayshift rate." This suggests that some momentum such as rhythm would give may be sustaining output in spite of the worker's state of fatigue.

Hardness or heaviness of work is sometimes the reason for dissatisfaction which leads an employee to quit. In the Cleveland metal plants (item 4, Table 41), 27 per cent. of all quits were attributed to physical disability and "too hard work." And among Chicago children (item 8) "work too hard" or "too heavy" accounts for almost a quarter of all the quits due to dissatisfaction. In all investigations, the nature of the work and monotony appear as more or less frequent reasons for turnover.

In Germany, Levenstein¹ recently issued questionnaires one by one to 2,000 miners, over 1,000 textile workers, and 1,800 metal workers, asking them how far they were interested in their work; 75 per cent. of the textile workers, 60 per cent. of the miners, and 57 per cent. of the metal workers, said they were not interested, and 14 per cent., 17 per cent. and 17 per cent. respectively said they were indifferent. Some few returned no answers and only 17 per cent. of the metal workers, 15 per cent. of the miners and 7 per cent. of the textile workers declared themselves to be interested.

In my own experience interest in factory work seems to be confined to the foreman, whom I have always found most eager to explain to the visitor the processes under his direction. Railwaymen and transport workers, and possibly also builders, appear to find points of interest in their work,

¹ *Die Arbeiterfrage*, Munich, 1912, quoted by Slichter (23), p. 195.

but on the whole, Irving Fisher's experience of the jeers that arise from a working-class audience on the bare mention of the joy of work is probably not exceptional.

IV. Effect of Physical Environment

Noise, if a laboratory experiment on guinea pigs is to be trusted, is physiologically harmful only when it involves vibration. Guinea pigs tended to lose weight and die when the continual ringing of a bell was combined with the vibration of a metal sheet on the floor of the cage, but continued to thrive when the bell alone was turned on.

Spooner proposes the use of a vibrometer to measure vibration in high-speed machinery; and considers the noise of machines in factories as a definite hazard to working capacity¹:

A period spent in the midst of working machines and mechanical operations causing deafening and strident sounds of a wide range with shock to the auditory nerves produces a feeling of sensory fatigue; and although this fatigue attacks primarily a single organ, it little by little extends to the whole nervous system, leading in some cases to such a feeling of weariness that it may impair the capacity for work in a greater degree than severe muscular fatigue.

Yet the factory operative is often oblivious to noises in surroundings in which the casual visitor can hardly "hear himself think," much less hear himself or others talk. Wyatt questions (5, No. 3) whether "the industrial worker . . . may not be using up energy in maintaining that state of oblivion"; if so, he concludes, "the energy required for this purpose might have been available for productive purposes." At present, however, the effect of noise is largely a matter of speculation, and the evidence from tests or experiments is not conclusive.

Natural light, if adequate in amount, must, according to Collis and Greenwood (17), always be preferred to artificial illumination for the sake of eyesight and also of general health.

Sunlight is known to be inimical to the life of most pathogenic organisms; a gelatine plate evenly sown with micro-organisms,

¹ *Educational Times*, December 1921.

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covered with a photographic positive, and set to incubate in the sunlight, will present a living reproduction of the picture, owing to the growth of the organisms being densest where least light penetrates, and least where most penetrates. . . . While daylight is harmful to microbic life, it stimulates a healthy skin reaction, and exerts a beneficial effect. . . . This effect is clearly demonstrated in plants, which decline to flourish in the absence of light. . . .

Where, as during night work, daylight cannot be had, or where even in the daytime it is supplemented for certain processes, many dangers to health and working capacity are associated with the artificial light that must be used. Absence of sufficient light is the source of miner's nystagmus ; exposure to intense light as among glass workers may lead to a form of cataract. And glare causes "annoyance, headache, and other trouble, and often, eventually, diminished ability to see."

The physical rather than the chemical properties of the air have been found, by the direct laboratory experiments of Dr. Leonard Hill and others, to exert an important influence on bodily capacity.

The conditions most favourable to working capacity are a cool temperature, low humidity, and movement of air. For instance (27), "When the temperature and humidity are raised (above 68°F. and 50 per cent. relative humidity) there is a falling off in efficiency in such functions as running a bicycle ergometer which indicates the exact foot-pounds of work accomplished, and in the manipulation of dumb-bells."

The velocity of the air combines with the degree of temperature and humidity in determining its cooling power (now measurable by Hill's katathermometer), and the effect of this combination is familiar in the general feeling of good health and vigour which results from exposure to a bracing wind (4, No. II).

Such a wind exerts a strong cooling action on the skin, and stimulates the nerve-endings. The result is that the blood, instead of flushing the vessels near the surface of the body, is deflected to the deep visceral organs. A cool skin encourages exercise required to maintain warmth, stimulates deeper breathing, increases the circulation of the blood, promotes more rapid and complete digestion, and so produces a gener-

ally improved state of health. A warm, stagnant atmosphere throws additional work on the heat-regulating mechanism of the body.

Sweating, feelings of lassitude, and drowsiness are certainly associated with the hot, humid and stagnant air of deep mines, and have a "hindering effect"¹; and willingness to work is likely to be lowered from similar causes in mental work where lowered capacity often cannot be experimentally proved.

Fluctuations in willingness to work as measured by a vote on strike policy have also been ingeniously correlated by Collis and Greenwood (17) with the risk of coal-mine catastrophies. They show that the percentage of voters in favour of the strike in the ballot of August 1920 was highest in those coalfields such as Lancashire and South Wales where deaths by accident were highest, and lowest in coalfields such as Nottingham, Derbyshire and Durham and Northumberland where deaths by accident were lowest.

But it must be admitted that physical working conditions do not usually arouse as much unrest as might seem justified. Only 4 per cent. of all strikes in America were due to working conditions (not necessarily all of them physical working conditions at that), and in England physical conditions are not officially classified as a cause at all.

Yet as a trade journal² recently remarked in reviewing the current Factory Inspector's Report,

Many of the instances given of insufficient sanitary convenience where both sexes are employed are resulting in a state of affairs which is nothing short of disgusting, and as a sociological as well as an industrial problem we suggest that there is a field for invaluable work by trades unions. If a strike were to be declared against some of the conditions mentioned in the chapter on Sanitation in the annual report of the Chief Inspector of Factories, there is little doubt on which side public sympathy would be.

¹ The hindering effects on men of the heat in deep mines depend, not on the temperature of the air, but on the wet-bulb temperature and the degree of stagnation of the air.

² "The data as yet available indicate that by properly designed ventilation and avoidance of leakage the hindering effect on men of the heat in deep mines can be obviated up to any depths at present contemplated in the working of coal or other minerals in this country."—Conclusions of Committee of the Institution of Mining Engineers, 1923.

³ *Mechanical World*, October 22, 1920.

*V. Effect of Introducing Various Incentives and other
Employment Policies*

The replies to questions put to the workers who stereotyped their output in the American 10-hour metal plant (Chapter VIII) showed that restriction was partly impelled by the fear that wage rates would be cut.

One girl said she could make more and not be tired. When asked why she did not do so, she replied, "Oh, it's enough and the other girls think I do too much." A second girl was pointed out, "When that little one came she worked so hard and fast that X and another girl told her not to do so much or they would cut the rate."

Mrs. M. said that although she completed almost 600 pieces in one hour, she was only supposed to make about 420. Question: "Why is that?" Mrs. M.: "Oh, if one makes too many the rate's cut." Question: "Do you believe they really do that?" Mrs. M.: "Sure they do. I've worked on jobs where they did."

Complaints to the official English Commission of Inquiry into Industrial Unrest (8, No. 237) are very largely concerned with systems of wage payment, methods of discipline and the autocratic management involved in the policy of diluting skilled men with semi-skilled men and women. That the extension of systems of payment by results was causing industrial unrest was forcibly represented to the Scotch Commissioners, and the "antipathy of certain sections of the skilled trades to the introduction of either piece rates or premium bonus" was recognized by the commissioners for the North East area. They believed, however, that the main objection was the workmen's apprehension that if they fully exerted themselves the rates would be cut.

In Yorkshire and the Midlands the methods employed in fixing the prices for the piece workers appeared to have been very haphazard and careless, often allowing the unskilled man or woman to earn much higher wages than the highly skilled.

The tactless and domineering methods of some foremen towards employees was quoted in Scotland; and in general a great deal of unrest was attributed to the workers'

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feeling of helplessness and inability to participate in control.

At the time of this inquiry unemployment did not enter into the calculations of English working people, but at the present moment (1923) realization of the insecurity of their "tenure of office" is one of the chief ingredients of unrest. A wage-earner can usually be laid off at a week's notice, and the unemployment he sees around him does not reassure him as to his ability to find a new position elsewhere.

To obtain recognition of trade unions by the employer was the object of over 10 per cent. of the strikes in America listed in Table 42. The employment of specific persons or groups of persons was the matter in dispute in another 8 per cent. of the strike cases; this "matter" would consist largely in objections to foremen and to the presence of non-union workmen.

VI. Effect of Type and Experience of Worker

Except for women's inferiority in muscular strength (and not necessarily in endurance at that), physiologists and psychologists have been unable to agree as to the relative efficiency of the sexes. J. B. Watson (27) sums up that "in regard to laboratory tests it has been shown over and over again that the differences if any are very slight," and he lists good-humouredly the various psychological and scholastic tests in which one sex or the other is "said to excel."

As to whether functional periodicity is a serious handicap to women, Watson remarks that "the common-sense view and the view of commercial houses is that it is a handicap. But if certain recent experimental evidence can be trusted (Hollingworth), there is no difference at such times either in speed or accuracy in the exercise of any given established habit or in the acquisition of habit."

Women working long hours in eleven English munition plants during the late war were physically examined by Drs. Janet Campbell and Lilian Wilson (3).

Among 1,326 examined in December 1915, 57.5 per cent. were classed as healthy, 34.0 per cent. as suffering

some fatigue or ill-health, and 8.5 per cent. as showing marked fatigue or ill-health. Among 1,183 examined in July 1916, the proportions were much the same: 58.5 per cent., 35.8 per cent. and 5.7 per cent. respectively.

The official report states that these percentages do not "represent the full burden of fatigue, for the following reasons: (a) Much earlier fatigue is latent and objectively unrecognizable; (b) the women most seriously affected tend to drop out of factory life before they have served for any long period, and therefore are not included; (c) women knowing themselves to be fatigued were not willing in all cases to subject themselves to examination; and (d) the examination was necessarily superficial and incomplete, and only such as could detect definite and obvious fatigue, amounting almost to sickness."

Unfortunately the men examined by Dr. Agnew under the same auspices were not classified in the same way, so that exact comparison of the physical state of health of the two sexes is not possible.

Even if women can be shown to suffer greater fatigue than men, it does not follow of course that this is due to the primary or even "secondary" sexual characteristics. There are what might be classed tertiary characteristics due to social custom which are usually avoidable: wearing of corsets that tend to restrict breathing to the costal region; lack of physical training in youth and differences in the things little girls are allowed to play with; and self-denial. "Most working women (3) have never acquired the habit of taking solid and regular meals, partly because when food is not abundant the woman goes short rather than the man."

These conventionally determined differences may affect willingness to work quite as much as physical capacity. At least among the mass of workers there is a difference in incentive which Watson (27) faces frankly:

The fundamental fact is that attractive women do not have to compete in vocational life, and nearly every woman has at least one man who passes a favorable judgment upon her. Hence, when business difficulties arise, when hard training periods face them, many women choose the seemingly easier road and allow some man to earn the bread for two. Having once accepted the sheltered position, there is again neither the incentive nor the opportunity to achieve in the

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field that men achieve in. There are exceptions, of course, to this general statement, but no more than enough to prove the rule, notwithstanding the fact that more and more positions are open to women. The labor turnover among attractive women is greater than among men, and probably always will be. Hence, all discussion of and experimentation upon the relative ability of men and women are really academic.

Though less true of England, where women outnumber men by over a million, than of America, where women are in a minority of two millions, it is probably no exaggeration to say that women are more often restive in industrial occupations, and can usually better afford to manifest their unrest by losing time or leaving.

It is agreed among physiologists that particular precaution is needed when employing girls or boys; adolescents need (1, No. 13) "a sufficient reserve of energy not only for the maintenance of health, but for growth." Boys and girls have not yet learned by experience what habits are harmful to their health; and the curtailment of their schooling may lead to immediate mischief—quite apart from the permanent impairment of mental capacity.

Examination by the medical officer to the London County Council¹ of 613 boys between 14 and 18 years of age who had already entered industry, disclosed that rickets and other types of deformity were much more prevalent among them than among boys just leaving school. The Health of Munition Workers Committee obtained evidence of the late hour at which boys often went to bed when removed from proper parental control. And the relation between juvenile employment and juvenile delinquency has been demonstrated in American statistics (8, No. 175). Although, according to the census figures, a large majority of children are not industrially employed, the records of juvenile courts and probation system in several large cities showed that over half the cases were "working" children.

VII. Effect of Low Wages and other Living Conditions

The reason given for the majority of strikes in England and America (Table 42) is the workers' desire for wages

¹ R. T. Wilson: *The Care of Human Machinery*. Oxford Press, 1921.

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higher than the employers offer. In the United Kingdom between the years 1899 and 1913, out of the aggregate number of workpeople directly involved in disputes, 54·5 per cent. were involved in disputes about wages. In America between the years 1916 and 1921 the proportion of strikes over wages was 62·9 per cent.

Dissatisfaction with wages is usually the chief reason for employees quitting, at any rate in America, where detailed evidence was obtained in several plants.

Among the establishments quoted in Table 41, dissatisfaction with wages formed 24·6 per cent. of all quits at

TABLE 42
RELATIVE IMPORTANCE OF VARIOUS REASONS FOR STRIKE

Matters in Dispute.	U.K., 1899-1913.	U.S.A., 1916-1921.
	Percentage of Workers directly involved in Strikes and Lockouts.	Percentage of 14,960 Strikes involving Specified Reason.
Wages: For increase or against decrease	54·5	62·9
Hours: For decrease or against increase	7·5	13·4
Trade Unionism: For recognition, etc.	16·0	10·8
Conditions: Working arrangements	10·6	4·5
Employment: Discharge of employees, etc.	9·2	8·3
Other disputes	2·2	—
	100	100

No. 3, 33 per cent. at No. 4, 21 per cent. at No. 7, and 20·9 per cent. at No. 8. Only one other establishment (No. 6) gave sufficient details, but here dissatisfaction with wages seems to have been a negligible reason for quitting—possibly because good wages were paid! In a special investigation made by the American Pulley Co., of Philadelphia, dissatisfaction with wages was given as the reason for 110 cases of turnover out of 137 where the reason was specified.

Each of the eight local commissions inquiring into industrial unrest in England during the late war (8, No. 237) pointed to the rising cost of food in relation to wages as an important factor in unrest, and three pointed to the

insufficiency of housing accommodation. At least one local commission drew attention to the "good work" of the consumers' Co-operative Societies in eliminating profiteering and reducing the cost of living of their members.

Absolute poverty in terms of physiological need is reinforced as a basis of unrest by the *relative* poverty of the industrial class.

"Redistribution of national income in favour of those who are already wealthy is a profound and indeed fundamental cause of industrial unrest," remarks one of the local commissioners, and though this sense of social inequality is manifested in the vaguer political unrest rather than in measurable industrial occurrences, it cannot be omitted from consideration.

THE SCOPE OF FATIGUE AND UNREST

It is evident from the results obtained by tests, experiments and questions that workers' bodies and minds are affected by much the same industrial conditions as were found to be associated statistically with excessive turnover, absence, output, accidents and sickness. Moreover, the co-existence has often been established between the bodily and mental affections of fatigue and unrest and these external industrial losses.

Tests, experiments and questionnaires also clearly show how difficult it is to set any bounds between, and beyond, willingness and capacity to produce.

At one extreme appears ill-will, which may manifest itself in actual destruction of capitalists' property, i.e. sabotage; and at the other extreme is ill-health, manifested in the occupational diseases, or in the excess of sickness and deaths suffered by the working-class.

Unwillingness and incapacity shade off into one another through the intermediate stages of disgruntlement, suspicion and dissatisfaction manifest in absence by strikes, in restriction of output, and in quitting employment without warning or explanation. Indeed, the metaphor of shading-off has appealed to popular imagination so far as to suggest the figurative assignment of the shades.

At one pole is yellow, the symbol of hatred and ill-will ; at the other pole red, the danger signal of physiological breakdown and absolute incapacity ; and there is a continuous scale of colours all the way from yellow to red through green, blue and violet. Green is the symbol of envy, and also of a lack of self-reliance and a mental instability and restiveness often found in the raw " greenhorn " not at home in his environment. Blue is the symbol, not to say symptom, of a slightly more physiological *malaise* and despondency, a state of low stimulation midway between positive ill-will and positive ill-health. And violet, between blue and red, may symbolize the approach toward actual physical incapacitation corresponding most closely, perhaps, with the popular conception of fatigue.

Metaphor apart, unrest appears a convenient term to use in referring to all the middle ground between absolute ill-will and fatigue, ground that in itself presents many gradual changes from a vague psychological yearning for better things to an almost physical state of low spirits, indifference and lack of stimulus. The impossibility of drawing any line of demarcation between psychological and physiological phenomena is indeed fully recognized in scientific circles ; and the notion of a kaleidoscope of moods and conditions has been laboured here only as facilitating a solution of what may be called the variations in stimulus imbroglio.

The variability of stimulus among industrial workers would certainly have given less trouble to students of fatigue if the preliminary precaution had been taken not to use the term *utraquistically*¹ to denote two quite separable types of event : (1) variations in *external* incentive, such as the payment of a higher or lower piece rate or the approach of holidays ; (2) variations in the shade of capacity or willingness, i.e. in the inward stimulus or intensity with which the human being is working, variations which may or may not be the result of variations in some external stimulus.

In the first sense, variations in stimulus are an integral part of the study of co-variation in economic losses and

¹ Cf. Ogden and Richards : *The Meaning of Meaning*, Kegan Paul.

industrial conditions. Variations in piece rates or in the proximity of holidays are industrial conditions to which the human factor is subjected precisely as he is subjected to changes in hours or in temperature, and the effect of these variations on deficient output and other labour losses has already been described as far as the very limited statistical evidence allows. Of course, if the effect of varying one particular condition such as hours of work is to be isolated, care must be taken that the external stimuli are constant in force. But this is simply part, though perhaps the most difficult part, of the general scientific plan of controlling all extraneous conditions likely to interfere with results. The peculiar difficulty of controlling the degree of stimulus does not alter the nature of the problem.

It is the variation in intensity of activity, in internal stimulation without anything external or measurable, that presents the essential difficulty.

In modern industry the human being, though to some extent economically compelled, is not physically compelled to work. Before incapacity sets in at all seriously, i.e. before a condition of over-fatigue can be said to exist, his activity is likely to slacken, to lose in intensity, and this prevents the conditions ensuing that favour any further incapacitation.

The deliberate restriction of output has been called a physiologic defence against over-fatigue, and medical opinion seems agreed that nervous breakdown is unlikely to result from work *alone*—as work is commonly carried on.¹ Stanley Kent² suggests that workers maintain an equilibrium between the development and the expenditure of energy by

¹ "An individual is in an intolerable situation which he is constitutionally unable to dominate; the reaction of a neurosis sets in with depression of spirits, irritability, preoccupation, self-pity, etc., but a conventional cause for the decreased efficiency must be found to rationalize the situation, so the individual calls it over-work. Obviously with this idea of over-work in mind the symptom usually acquired is fatigue or asthenia. . . . The work may have determined the form of the symptoms, but there is no evidence that it has much to do with the development of the trouble. . . . Let us no longer fool ourselves into thinking that over-work, *per se*, is the cause of mental breakdown."—Cobb (16). An alternate view is that over-work lowers resistance to a normally tolerable situation and a neurosis supervenes which otherwise would have remained latent.

² Second Report on an Investigation of Industrial Fatigue by Physiological Methods, Cd. 8335.

"balancing" their application to the task in hand against the length of their working day.

If the worker were already doing his utmost before the introduction of overtime, he cannot supply extra energy for the extra labour and still continue to work at his old rate in the other periods of the day. Some readjustment must be made.

It has been shown that the only factor concerned in the maintenance of equilibrium which can be varied quickly and often is the degree of application of the worker to his task. This means of adjustment will be adopted consciously or unconsciously, and the men will work twelve hours a day instead of ten, but the closeness of their application will be less throughout the whole period.

Vernon (26), in accounting for "the astonishingly steady output" maintained by workers in such heavy operations as charging blast furnaces, posits an unconscious balancing of "pressure" between one hour and another.

Experienced industrial workers unconsciously adopt habits of work which tend to the production of a maximum output with the minimum of effort.

It is well known that work done at high pressure is relatively more exhausting than work done at low pressure. For instance, if a man walks at the rate of five miles per hour he needs to employ twice as much extra energy per mile of ground covered as when he walks two miles an hour. Hence, if the worker over-exerted himself in the first few hours of his working day so as to increase his output, he would get so over-fatigued that his output in the last part of the day would fall off by a more than proportionate amount, and the total output for the day would be less than if he had worked at a steady rate all through.

Certainly the industrial worker does not go "all out" all the time, any more than the long-distance runner. His intensity of activity is consciously or unconsciously adapted to the difficulty of the task ahead of him in relation to his own working capacity. But while we assume in the athlete a constant desire to win, we cannot under present industrial conditions assume any such constant stimulus to maximum production. Intensity of industrial activity is probably determined by a varying willingness to work, as well as by immediate or "long-run" capacity. Hence fatigue is difficult to separate from the other bodily and mental states which may so conveniently be summed up under the term "unrest."

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The two categories form part of one integral system, and the interrelations between them are manifold. Unrest may be caused by fatigue as reported in three areas in the official English investigation into unrest during the late war (8, No. 237). Fatigue in turn, if we are to believe psychologists, may be caused by unrest. And in the last analysis it is impossible to estimate the optimum efficiency with which the human machine is running without taking into consideration both fatigue and unrest. A man making a given output is most efficient (i.e. the ratio of product to real cost will be at a maximum) when the output is turned out with the least possible unrest, resistance or intensity of effort. Admittedly one of the chief difficulties in measuring fatigue by itself is the fact that merely counting the deficiency in output or any other economic loss does not take account of the difficulties the worker may encounter within himself. The same output may have been produced at very different levels of unrest, requiring the exercise of very different degrees of capacity.

Under the circumstances, fatigue and unrest is, perhaps, the shortest symbol that will include all the interrelated physiological and psychological states (short of absolute incapacitation and absolute ill-will) making for industrial inefficiency and economic loss.

A certain amount of fatigue and unrest may, of course, be present without affecting outward losses and a further "normal" amount may inflict losses that, practically speaking, cannot be avoided. Judging from the extent to which amateur athletics and travel for pleasure flourish in our midst, a certain degree of fatigue and unrest is positively desired. The industrial worker may not object to some fatigue at the end of a day's work so long as it does not limit his use and enjoyment of leisure hours; and certainly a workman entirely at rest in industrial surroundings would be thought unusually docile. It is all a matter of degree. One hundred per cent. productivity is no sort of ideal and some amount of "normal" fatigue and unrest must be

¹ Normal fatigue is not synonymous with necessary fatigue, and fatigue may often be necessary and yet abnormal and excessive. When Major Gilbreth distinguishes between necessary and unnecessary fatigue, his distinction is rather one of fatigue from necessary motions and fatigue from

allowed for even if it leads to a certain degree of economic loss.

The practical policy is to avoid or prevent degrees of fatigue and unrest leading to excessive losses. To gather evidence from past experience as to which losses are unavoidable and which excessive, and what conditions account for the excess, has been the object of the preceding chapters. But this past experience is not so adequate that it can be relied upon as a complete guide to industrial conduct, and further observation, investigation and experiment, must be carried on in the same spirit.

Fatigue and unrest must be viewed as a natural reaction to a definite situation which any average human being would exhibit if similarly placed.

The situation (secondly) must be understood in all its complexity as the result of historical growth and technical and economic exigencies. There must be thorough orientation as to the industrial conditions involved.

These industrial conditions (thirdly) must be regarded as variable and their variation as likely (through the intermediacy of fatigue and unrest) to effect a variation in the loss by turnover, by absence, and by defective and deficient output, and in the loss by accidents and ill-health.

Exact records must, therefore, be kept of alterations in economic losses, and these records linked up with exact records of alterations in industrial conditions. If hours of work are changed or a new system of ventilation or wage payment installed, measurements must be taken before and after the change just as though the efficiency of a new engine or process were being tested.

To obtain the right heat, an engineer adjusts his draughts and the supply of fuel by reference to a thermometer where heat is numerically recorded in degrees. Statistics of turnover, absence, output and ill-health may provide a similar "control" by reference to which industrial conditions may

unnecessary motions, i.e. a question of the causes of fatigue, which is by no means the same thing as the question of the normal amount of fatigue. Thus a nurse attending the sick day and night may be unable to secure enough rest and the amount of her fatigue will gradually accumulate till it becomes abnormal and no amount of rest can cure it; yet all the time she may have been performing her work with the utmost efficiency and with complete absence of "unnecessary" fatigue.

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be adjusted to obtain, not the right heat, but the right minimum of fatigue and unrest.

A POLICY OF RECORD-KEEPING

The procedure here proposed is not an entirely new-fangled system. A majority of large establishments keep systematic records of their technical processes, and though for the "personnel relations" some are content with the information the technical records may incidentally show, others find a certain minimum of direct information about the working force indispensable. The knowledge may be insecurely stored in somebody's head, but the knowledge is usually lodged somewhere and needs only to be systematically recorded upon paper.

Plants with pretensions to efficiency usually keep—

1. Records of daily or weekly output per person, on which to base piece wages.
2. Records of time spent in the factory by each person, on which to base time wages.
3. Some account of each employee, on the basis of which he was hired, e.g. former work for the firm, recommendations from other firms, etc.
4. Cost-office records; estimates of direct labour cost in making any given article.
5. Where scientific management, or some approach to it, has been introduced, a planning department is usually organized. The essential function of the planning department is to issue a standard plan of production based on previous scientific study, i.e. standard methods of work based on motion-study, standard "routing" based on the sequence of processes, standard tasks and efficiency ratings based on time-study. The degree to which actual performance falls short of this standard forms, of course, a most important measure of personnel efficiency. In scientific management shops there are, therefore, additional series of records ready made for our purposes.

To be of any value records require above all uniformity in treatment within the organization and uniformity, if

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possible, as between different organizations. It is for this reason that standard forms are insisted on.

Books must be kept and record forms devised and filled out, not from the sheer joy of red-tape, but for future use. In all too many record-keeping offices the files are looked upon like so many cases in a museum—as objects of veneration and fetish-worship scarcely to be handled by man.

On the contrary, a principal purpose of records consists in being man-handled and “boiled down” by well-marked stages into statistical data.

The original raw record is an entry in a case-book or a written notification either by the timekeeper or foreman that So-and-so was absent for so many hours; or was dismissed or laid off, or quit of his own accord, or has had an accident, or is ill. Note may also be made of a man's hourly, daily, or weekly output, and if required, details may be supplied as to the reasons for a man's absence or for his quitting, so far as they are known.

The gist of these individual entries or notifications is then tabulated for given periods, such as the week or month under the required headings. Names are now dropped, and the worker figures as a mere unit in the gradual summarization of the facts. In calculating labour turnover, for instance, the individual cases of men leaving may first be tabulated on a sheet for one department only for one month; these sheets are then collected in a summary sheet for the one department for the twelve months; and these summary sheets then further summarized in a final sheet covering the twelve months for *all* departments. The exact procedure of summarization must depend on the individual circumstances in each plant—the number of departments, the need of studying specially hazardous sections intensively, etc., but the final result must be expressed as a rate of loss or co-efficient that may serve as a comparative measure. The number of units occurring in any period agreed upon is considered in relation to the total personnel exposed, as in the case of turnover, or to the total time of exposure, as in the case of absence, or to the number of exposures, as in the proportion of spoiled output

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to total units of output. By this means the magnitude of the experience is given relatively to the magnitude of the possibilities of the case.*

The records have by this stage been transformed into the sort of statistics so often cited in the preceding pages. Their influence for good lies in the opportunity they offer of establishing scientifically the relationships existing between labour losses and the conditions under which labour is industrially employed.

What the practical employer wants to discover are the conditions that lead to excessive labour losses with a view to the *prevention* or *avoidance* of these hazardous conditions.

In the relation between preventable or avoidable conditions and labour losses he wants to know the truth, the whole truth, and nothing but the truth. As soon as variations in losses and conditions are reduced to exact numerical values or are indirectly "calibrated" this desideratum can be achieved by experiments in the co-variation or "correlation" of conditions and losses.

The plan is to find by observation or to induce by active experiment an exclusive association of measured variations in any of the labour losses with a measured variation in any of the preventable or avoidable industrial conditions.

Variations in the coefficient of, say, turnover, i.e. the number leaving *per* total working force employed, must be compared with variations in measurable conditions such as, say, the hours of work per day. If turnover constantly rises with an increase in hours when variations in other conditions are excluded, then the two may be said to be correlated and their correlation creates a presumption of causal relationship, so that every time hours of work are increased an increase in turnover may excusably be prophesied.

The exclusion of variations in conditions not for the time being under investigation is effected either by selecting a

* Carelessness in relating experience to exposure—in considering actual rates in the light of the risk—is perhaps the chief source of the belief that statistics can prove anything. The complete absence of tramway accidents in Cambridge might, for instance, be used to prove the extraordinary circumstances of a university town by those unwitting of the local triumph of the omnibus. Cambridge possesses no tramways and Cambridge citizens are simply not *exposed* to their escapades.

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time or place when these conditions are constant or by their control.² Without this exclusion results can only be ambiguous; the truth may be known, but only part of the truth—with something more than the truth added.

To be of practical value in the prevention or avoidance of fatigue and unrest numerical records must therefore be kept both of the several labour losses *and* of the industrial conditions with which to correlate these losses. Records of conditions include a survey of the working conditions facing the employee and also a file wherein the circumstances of the employee himself are recorded. The need for this dual set of records was indicated in Chapter IV and has not escaped the attention of other investigators.

For wise and effective industrial placement and occupational guidance two things at least are absolutely essential: First, definite knowledge of the physical and mental requirements (specification) of the job, and second, equally definite knowledge of the physical and mental characteristics and capacities of the individual to be placed.³

In our Laws of Organization, as they apply to the industrial unit, the Law of Personnel was defined as: *Analysing the requirements of given positions and finding men whose qualifications match the given requirements.*³

Forms for keeping a record of these two sets of underlying conditions are given in Chapter XIV, and it cannot but strike one what a variety of adjustment is possible, and what scope for industrial experiment. Losses that are not reducible by changes in hours or in types or method of work (e.g. by making an operation more rhythmical), or by changes in physical or social environment, may be due to the employment of persons not fitted for the particular task assigned to them, and such losses may yet be relieved by a different selection or a different training of workers.

In the end, perhaps, some combination of adjustments may in every case be arrived at that will enable work in

² For instance, where extraneous conditions vary uniformly, their variation may be allowed for and results corrected accordingly. Examples of "control" are multiplied in Chapters IV-VIII of my manual (18) under the heading of "Elimination of Ambiguity." The very uniformity so much complained of in modern industry is of great assistance in this statistical "control."

³ Majors Yoakum and Yerkes: *Army Mental Tests*. New York, Henry Holt.

³ C. E. Knoeppel: *Industrial Management*, February 1920.

the modern industrial system to be compatible with the health and enjoyment of every human being employed.

Any effective system of records requires of course an organization of persons to handle them. Records do not write themselves automatically. There must be men to think out the forms of records, men to obtain and fill in the information, men to sign, "O K," and be responsible for the facts obtained, men to receive the information and use it. We shall not presume to recommend or prescribe any one particular method of organization. The actual form of record given in the two chapters following is adapted for use by almost any type of organization, whether there is a distinct "functionalized" personnel or employment department, or whether the personnel functions are performed by the ordinary "line" organization; whether authority in personnel affairs is derived solely from the capitalist-entrepreneur-employer, or whether the employees have some measure of the joint control outlined in Chapter IV.

As the personnel department becomes more and more specialized and distinctive in function, it is quite likely that by a process of devolution the personnel of the plant itself or their representatives will gain increasing control over personnel relations. This, however, will not invalidate the need for keeping personnel records, or of deriving standards of efficiency from those records. Provided that the technical conditions of industry remain as determined by the Industrial Revolution, it is probable that those records would be necessary for any government of industry, however fundamentally it might differ from the present regime. This record procedure would apply just so long as economic exigencies continue to enforce production on a large scale and by mechanical means with hundreds of individual "specialists" marshalled under one authority, as in the modern factory. Precisely where the authority is vested, whether in the owner of the capital, the State, or the trade union or guild, does not alter the need for keeping records.

Is the issue of labour turnover, absence and low productivity likely to be any the less important in State-operated factories? Is there any the less need of knowing

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and recording the injuries and health of the workers and the danger or healthiness of their place of work? Some of the very record-forms we shall quote are based on the war-time practice of the U.S. Shipping Board's Employment Management Branch. Under a trade-union management, turnover and absence *might* be reduced and output increased; but is there any new factor introduced that would make a record of the extent and circumstances of these changes unnecessary and useless?

Indeed, it is precisely under new plans of industrial organization that the need for accurate record-keeping is greatest.

The humble tale of achievement in reducing inefficiency by adjusting this condition or that, has perhaps given us no conception of the possibilities of human capacity and human willingness when labour is placed on a different social footing and in a different psychological atmosphere. The minima of fatigue and unrest expected under the capitalist control may appear ludicrously portentous compared with the efficiency attainable when the enthusiastic co-operation of labour is enlisted.

Those who hold this faith should lose no opportunity of substantiating their doctrines; but substantiation can only come by watching and recording.

PART III

CHAPTER XIII

THE RECORD OF LABOUR LOSSES

MEASUREMENT OF LABOUR TURNOVER

Notification should be given of every case of an employee leaving and sufficient information supplied to answer the questions tabulated in Form I. If the employee's reason for quitting of his own accord is known, this may if required be tabulated also, and special reports may be called for as to reasons for lay-offs and discharges.

The formula for the coefficient of turnover is insufficient as a measure of efficiency unless note is made of the proportion of persons newly hired; hence the addition of columns *j*, *k* and *l*. The greater the proportion of those recently hired, the higher is the real exposure to turnover (see Chapter VI D, § 3).

MEASUREMENT OF ABSENCE

Notification should be given of every case of absence of more than one hour, and sufficient information supplied to answer the questions in Form II.¹

Where the reason for absence is known this may, if required, be specially tabulated. Special reports may also be called for as to reasons for lay-offs.

In filling out Form II, the expression "laid off" signifies all cases where temporary absence was required by the management for business reasons. "Leave" covers cases where the management granted leave of absence before-

¹ It is not sufficient merely to count heads "present" at any one given time. The hour when the census is taken may not be typical of the whole day. Persons may be temporarily away from, or present at, their work at that particular time only. A standard notification form and instructions for filling it out are given in my article on the "Control of Absenteeism" in the May 1921 number of *Administration*, New York. Ronald Press.

FORM I.

PERIODIC TABULATION OF LABOUR TURNOVER

Week or Month

DEPARTMENT.	NUMBER LEAVING BY SPECIFIED PROCEDURE.						TOTAL NUMBER LEAVING.	NUMBER HIRED BY SPECIFIED PROCEDURE.			AVERAGE NUMBER IN EMPLOYMENT DURING PERIOD.	TURNOVER RATE. (Coefficient) Formula: $\frac{(k) - (b)}{(m)}$
	By Lay-off.	By Discharge as Unfit.	By Transfer to other Departments.	By Quitting on Own Account.				Hired for First Time.	Re-hired.	Transferred.		
				Reason known to Foreman.	Reason Unknown.							
					Followed up.	Not Followed up.						
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(j)	(k)	(l)	(m)	
(1) Foundry												
(2) Machine Shop, etc.												

FORM II.

PERIODIC TABULATION OF ABSENCE

Week or Month

DEPARTMENT.	HOURS OF ABSENCE BY SPECIFIED PROCEDURE.					TOTAL HOURS OF ABSENCE.	SCHEDULED AGGREGATE MAN HOURS OF WORK.		RATE OF ABSENCE. (Coefficient) Formula: $\frac{(g) - (b)}{(h) + (j)}$
	By Lay-off. "Suspension."	By Leave.	Without Leave.				Normal.	Overtime.	
			Notified. "Reported Off."	Followed up.	Not Notified or Followed up.				
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(j)	
(1) Foundry									
(2) Machine Shop, etc. ..									

hand for reasons such as injury to the employee in the factory, sickness, vacation, family troubles, etc. "Reported off" would cover all cases where the employee reported his intention of being absent, either before or during his absence, without reference to the consent of the management. Probably the greater number of cases of absence, however, would not be notified.

If cases of tardiness are recorded this can be done by the gatekeeper and in less detail than in the case of absences, the date, check number (as shown on pass if these are used) and the time of arrival being sufficient. Where an automatic recording clock is used the date and the time of arrival would be punched on the employee's card.

MEASUREMENT OF OUTPUT

We wish to obtain a record of the quantity and quality of output :

- (a) of different individual persons.
- (b) of the same persons under different conditions.

Conditions are liable to change from week to week, from day to day and even from hour to hour, so that the unit of productivity which would be the most delicate indication of the effect of any given condition would be the productivity per man per hour. If we take less than an hour as the unit, the trouble involved would probably begin to outweigh the additional value obtained. If we cannot get this "man-hour" record we must be content with the man-day or even the man-week. If we cannot separate the individual contribution to any job we must be content with the gang-productivity—the group-hour, the group-day, the group-week.

The quantity of output is measured most simply as so many items or so much weight of product per man or group, per period. But this assumes that the product is of a uniform nature consisting of units frequently repeated. This is the case in so-called "repetition work," the kind of work on which piece rate wages can be paid, but it is not the case in large assembly jobs. Here the rate of output must be measured in terms of the time spent per job.

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Two different types of record forms must therefore be used—one for “repetition work,” the other for “job work.” These two forms are similar in arrangement and do not differ radically from sheets adopted by planning departments, at any rate as far as Columns 1, 2 and 3 are concerned. In Column 5 correction is made only for time lost involuntarily (Column 4), and, if desired, for spoilt work (Column 3).

FORM IIIA.

RECORD OF OUTPUT PER TIME UNIT—REPETITION WORK

Date Time filed Slip No. or Mark
 Department Job
 Name of Man or Gang-boss Check No.

Hours or Days.	Gross Output.	Spoilt Work (Number of Pieces).	Time Wasted Involuntarily.	Corrected Output.	Time Wasted Willingly.
(1)	(2)	(3)	(4)	(5)	(6)
8-9					
9-10, etc.					
or					
Monday					
Tuesday, etc.					

FORM IIIb.

RECORD OF TIME SPENT PER UNIT OF OUTPUT—“JOB” WORK

Date Time filed Slip No. or Mark
 Department Job
 Name of Man or Gang-boss Check No.

Consecutive Operation.	Time Spent.	Spoilt Work (Time Lost).	Time Wasted Involuntarily.	Corrected Time Spent.	Time Wasted Willingly.
(1)	(2)	(3)	(4)	(5)	(6)
Cutting Gauges, etc.					

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Involuntary waste of time (or "waiting" time) means that the work did not take place because, physically speaking, it could not be performed; the worker and his equipment were not prepared for the task. In "correcting," the investigator must consider all the hours and minutes the worker was actually in a position to work, and only those, and base his rate of output on that as denominator. For instance, if the worker had the opportunity to work only for 40 minutes of the hour, his *output rate per hour* should be his actual output multiplied by $\frac{60}{40}$. The output is "corrected" in the same proportion as the nominal time was to actual time prepared for work.¹

Thus where output is reckoned up hourly the table might run somewhat as follows :

Hour.	Gross Output.	Time Wasted Involuntarily.	Corrected Output.	Time Wasted Willingly.
9-10	20 Boxes	9.30-9.35 machine stoppage	$20 \times 60/55$ = 21 9/11	Rest, 9.10-9.20
10-11	15 Boxes	10.40-11 Lack of materials	$15 \times 60/40$ = 22 1/2	Leave room, 10.20-10.25
11-12	12 Boxes	Call to Office at 11.40	$12 \times 60/40$ = 18	Talk, 11.30-11.35

Detailed instructions are necessary for filling in some of the columns in Forms IIIA and IIIB, and abbreviated symbols may often be used.

Column 4.—Time (to be corrected for) under "Time Wasted Involuntarily."

A.—Where physical equipment is not ready for work.

McS.—Machine stoppage.

MtS.—Materials not supplied.

PS.—Power stoppage.

B.—Where worker studied has not arrived yet, or has not yet prepared his equipment; where workers dismissed before the actual

¹ Where more than 20 minutes is wasted in the hour it is wisest to reject the whole record as likely to be unduly influenced by the long accidental rest the worker obtains. The large correction called for in such a case would tend to magnify this influence.

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hour; where workers called away by order; or engaged on other occupations.

LA.—Labour arriving.

LB.—Labour at by-occupation, not on regular work.

LC.—Labour called away by order.

LD.—Labour dismissed by leave.

Column 6.—Time (not to be corrected for) under "Time Wasted Willingly."

Where time lost voluntarily once work has started: O, worker gone out; R, resting; E, eating; S, sleeping; T, talking.

Fluctuations in the quantity of output of groups of persons can be measured indirectly by fluctuations in the power consumption.

The advantages of power consumption as an indirect measure of human productivity, particularly of human rapidity, are: (1) The uniformity of the unit of measurement. Instead of a multitude of various products the unit is here the kilowatt or horse-power which measures at any one moment the rate of work and reduces all kinds of output to a common denominator. (2) The possibility of covering the whole plant or any department of the plant required. From the central power-house feeders are run to the various departments to supply the power, and the meters attached to these feeders automatically record the power consumption of the area fed.

Almost all factories keep some sort of record of their power consumption in the interest of economy, and the meters are often made self-registering on a moving chart, similar to the barometric instruments seen in meteorological stations. This chart gives the power consumption for every moment of the working day, and is in itself a regular hourly curve of great value in investigating the course of productivity throughout the day.

The disadvantages of power consumption as an indirect measure of human productivity are: (1) That fluctuations in the power consumed measure fluctuations in the productivity of those men only who are engaged on power-driven machinery. Moreover, it is precisely those machines, such as automatic lathes, where the human factor has least influence on speed of production, that consume the greatest amount of power.

The types of operation in a plant to which this measure is limited are those marked *5c, d, e, and f ii*, in Table 2, Chapter II and certain cases of *5b* "man-steered." Investigators should beware of generalizing too liberally from this single section of industrial occupations. (2) That not all the power consumed varies directly with the work done. Power is used in a plant not merely as motive power for machines, but also for lighting, heating, ventilating, moving elevators, etc. Where the amount of power used for these purposes varies greatly from time to time—lighting is obviously a case in point—measures must be taken for isolating the power consumed strictly for driving the machinery. This is simple if there are separate feeders for each separate purpose, but if power is supplied for driving the machinery and for all other purposes by common feeders, then a special experiment must determine the proportion consumed for each purpose. The lights, ventilating fans, heating plant, etc., must be turned on for a short period with all other machinery shut off, and the power consumed for these purposes recorded and later subtracted from the total power consumption whenever lights, ventilation, heat, etc., are used.

Even then the resulting "net" power consumption will contain a large proportion used solely in driving the shafting of the machinery rather than the actual cutting tools, and a further experiment must be made in testing the exact power consumption for this purpose alone by suspending the actual work on the machines, while the shafting continues to run.

Some of the results found in these experiments are given in my manual (18, Chapter V). The proportion of power used for driving the shafting is shown to be very considerable, running from 17 per cent. to 48 per cent. of the total power consumed. Shafting, however, tends to remain constant throughout the working day, while heat, and particularly lighting, may vary considerably. Though there is less to subtract in the case of heating and lighting, it is far more difficult to know exactly how much to subtract at any given hour.

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MEASUREMENT OF ACCIDENTS

The notification of an accident must supply very detailed and exact information. The necessary questions to elicit the required facts are given in Form IV.

FORM IV.

ACCIDENT NOTIFICATION

Record No. or Mark

Date Time Happened Time Reported
Department Job
Check No. Name
Address

Hour injured person began work that day
Exact place of accident
Object causing accident
(If machine, etc., give name and specify whether guarded and whether
moved by mechanical power at the time)
.....

Specify safety instruction or protective clothing issued
How did accident happen?
.....

Signed (*Foreman*).

Describe injury, giving part of person injured
Treatment given
(*Continue on reverse side if necessary.*)

Amount of time lost Signed
(*Medical Supervisor*).

A "universal" standard form has been worked out by the International Association of Industrial Accident Boards and Commissions (8, No. 201).

This official form contains some twenty-eight questions, many of which are superfluous if the employee file and the survey of working conditions are kept. Accordingly Form IV omits all particulars of the employee which can be found in the employee file, such as age, sex, marital condition, dependents, race, ability to speak English, previous experience, date of employment in plant and department, rate and method of pay; and omits also all particulars as to the job which can be found in the survey (Chapter XIV), such as the hours worked per day and week.

To mention the object causing the accident is not a sufficient answer to the question, "How did the accident happen?" and care must be exercised in filling out details. A foreman, or whoever is charged with answering the question, is likely either to repeat his answer to some other question, i.e. give the object causing the accident, or is likely to be vague. In either case his answers will make any classification impossible. A definite "lead" is often needed to bring out the proportions in which the human factor or the "non-human" material factors were responsible for the accident. The point is of the greatest importance when it comes to schemes for preventing accidents. If the material factors are preponderant, the main line of attack is the invention of safety-devices and signs; if the human factors are important, attention must also be paid to all the conditions that affect human well-being—hours of labour, environment, adequacy of wages, etc.

An additional form may therefore be used in which possible circumstances (e.g. worker fell, got caught, dropped object) are stated ready for checking if corresponding with facts. I have published elsewhere (27, p. 274) an example of such a form together with a method of referring to each type of cause or combination of causes by a code number.

In accordance with a scheme put forward in my report to the British Association (13), it is assumed that the human factor had least influence in causing accident where there was unusual behaviour of the material itself (as in the case of a flying or falling object); and that it had more weight where the worker's behaviour was unusual, i.e. when he fell, stepped on or struck against objects; and most weight where the object did the injury, but was unusually handled by the worker himself, i.e. where a shell was dropped on the foot owing to a careless hold. If the equipment was defective and the worker not on regular work, it makes the human factor the less influential and introduces a further modification.

Accidents are *tabulated* with a view to obtain either a frequency rate or a severity rate or both. The basis of each of these rates is the number of persons employed or, better still, the aggregate man-hours worked; but while

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the frequency rate enumerates merely the bare number of cases of given severity, the severity rate enumerates the total days lost by reason of accidents. For purposes of calculating accident compensation the severity rate may include an arbitrary estimation of the loss in earning power by reason of death or *partial* disablement, expressed in terms of days of full disability.

MEASUREMENT OF SICKNESS

Sickness records can be obtained in any industrial plant that includes a hospital or medical first aid, though the information elicited can be thoroughly reliable only if sick employees are visited at home.

Notification of a case of sickness should specify (1) the date and hour when first reported; (2) name (or check number) of sick person and his department; (3) the nature of the illness; (4) its probable origin, i.e. antecedent history. Additional space should be left on the form for (5) report on progress and treatment of the case, and (6) date of final treatment.

The minima of knowledge required for tabulating useful sickness statistics, according to Drs. Warren and Sydenstricker, of the U.S. Public Health Service (10, No. 452), is as follows:

“ 1. Exposure in years or in months of the workers who should be classifiable according to sex, age and occupation. 2. The number of cases of sickness (at least those causing disability), including (a) sex, age and occupation of persons affected, and (b) cause of sickness with time of onset, length of disability and nature of termination.” To which we might add (c) the length of service of the person affected both in the plant and the industry.

The facts as to the “exposure” (i.e. the number and types of workers employed on the different days) will easily be ascertained if a proper employee file is kept, as is laid down in Chapter XIV; the facts as to the number of cases will be brought out by the notification recommended above.

The prevalence of sickness has been calculated apart from the labour losses of the industrial establishment;

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particularly where sickness is fatal or at least severe there are several sources of information outside the plant on whose experience we may draw.

1. The Life Insurance Companies, particularly those like the Prudential and the Metropolitan, who have published statistical researches in America.

2. Sickness Insurance schemes, Governmental or under the private enterprise of friendly societies, trade unions, industrial establishments.

3. Census of occupational mortality.

4. Special investigations of sickness conditions in communities.

CHAPTER XIV

THE RECORD OF INDUSTRIAL CONDITIONS

It was possible to simplify the forms recording the various labour losses by omitting all questions as to the employee concerned and the prevailing working conditions.

If a record answering such questions is kept on file at the central office, it is sufficient to name the employee and his job, and the details can then be looked up in the file. This central record is like a glossary of technical terms. It avoids the repetition of a full explanation every time a man or a job is mentioned.

The information required may all be obtained through the use of two forms—one eliciting the facts as to the employee, the other eliciting the facts as to the work for which the employees are engaged.

THE EMPLOYEE FILE

Information as to the persons employed or about to be employed is only relevant in so far as it indicates actual or probable efficiency in the plant, and is useful only in proportion to its accuracy. "Fancy" questions that throw only a very dim light, if any, on the worker's efficiency and vague answers that are mainly individual opinion should be eschewed. Above all, the employee file should not meddle with any part of the worker's life that has not a direct bearing on his efficiency in the plant.

Whittled down to the minimum business necessities, an employee's productiveness and attendance record in the plant might be considered a sufficient certificate of his efficiency. But in the case of new applicants, and where the productiveness of old employees cannot be accurately

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FORM V.

EMPLOYEE CARD

Identification. Check No.
 Name Telephone No.
 Address
 Languages Spoken (*where immigrants are employed*)

Personal.
 Sex..... Age..... Race.....
 Family Relations—Married..... Single..... Widow(er).....
 Dependents

 Supported partly by others

 Any Household Duties ?

Method of Transit to and from Factory *Time taken*

References

Specify own Preferences as to Type of Work

.....

Experience.
 Education
 Vocational Training
 Previous Employment

**APPLICANT TO WRITE NO FURTHER; REMAINDER FILLED IN BY
 EMPLOYMENT DEPARTMENT**

Results of Interview and Examinations
 Remarks of Interviewer

.....

Physical Examination

.....

Mental Tests

Character Tests (e.g. Rating Scale)

Trade Tests

Employment Record in Plant

Dates of Hiring or Transference between Departments.	Department.	Job.	Wage Rate.	Remarks: Personal History, Accidents, Vacations, Cause of Leaving, etc.
1.				
2.				
3.				
4.				
etc.				

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recorded, other indications of efficiency must be found which, when used in addition to production and attendance records, should serve to measure a *potential* efficiency. They may correct a false impression of efficiency or inefficiency gained by too narrow a concentration on the records of one job, and indicate an unsuspected efficiency for other jobs.

Form V is meant to be filled out stage by stage. Questions of a personal nature, including previous experience, would be answered by the applicant himself when applying for a position. If the applicant is interviewed and put through tests and examinations, the results can then be entered by the department in charge; and if the applicant is accepted his record in the factory would be entered subsequently. When an employee leaves, his card can be placed in a "dead" file for reference in case he should apply for re-employment.

The methods of hiring have in some large American plants reached a high stage of development, the very buildings of the employment department being carefully planned to "route" applicants into or past (and out of) the factory. Those routed in are said to be given a pleasantly worded introduction to their foreman.

Form V is suitable for simple as well as elaborate systems and for employment offices (public or private) used by groups of small factories as well as by the offices within a single large plant.

THE SURVEY OF WORKING CONDITIONS

Attempts towards a record form to complement and supplement the employee file that is more usually kept have appeared in America under titles such as a "factory inspection form," "report of factory hazards," "job-analysis," the "labor audit," though they often go farther in undertaking actual investigation of "results" and in making recommendations. Here, however, we are merely concerned in supplying a plain inventory of all the facts involved by working on a given job.

To lighten the burden and avoid repetition, it is advisable not to place all the facts about a job on one card, but

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to use a single departmental card for the facts common to all the jobs in one department.

Hours of work and physical and social environment are the working conditions usually common to all jobs in any one department.

FORM VI.

DEPARTMENTAL ANALYSIS

A: *Hours of Work.*

- Normal Length and Distribution
- (Actual Time of Starting and Stopping Spells of Work)
- Amount of Overtime
- Night Work
- Sunday Work

B: *Physical Working Conditions.*

- Is Work carried on *In* or *Out* of Doors?
- Is Work carried on *Below Ground*?
- Do the Materials Handled involve Danger of Occupational Disease?.....

Detailed Conditions:

- (1) Air: Temperature and Humidity: Ventilation and Room-space: Dust and Fumes (Exhaust Systems): Smell
- (2) Light: Volume, Concentration, Glare
- (3) Noise: Volume, Irregularity, Vibration
- (4) Accident and Fire Hazards: Safety Devices, First Aid
- (5) Sanitation and Tidiness: Cleaning and Drinking Water, Toilets
- (6) Seating and Rest Rooms

C: *Social Working Conditions.*

- Names of Foremen and Supervisors
- Number and Type of Workers in Department
- Provision of Facilities for Meals, etc.
- Methods of Discipline

It is important to measure physical conditions accurately and objectively. Thermometers should be used to record temperature, humidity and air-movement; photometers to record the degree of light; instruments have also been devised to measure noise. The accident hazard and the amount of room-space per person may be measured empirically, while the sanitary conditions, including dust, fumes and smell, can be analysed in the laboratory.

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FORM VII.

*For Routine Work.**

JOB ANALYSIS

A: Identification.

- (1) Name of Job
- (2) Department
- (3) Number of Similar Jobs
- (4) Permanent or Temporary
- (5) Can this Job be carried on with another Job by the same Person? ..

B: The Nature of the Work.

- (1) The Task: Description of Purpose of Job
- (2) Equipment; Machines. (Describe action and time spent in the actual machining process and note functions left to human worker.)†
- Materials and Tools
- Appliances to facilitate Work
- (3) Sequence and Times of Motions and Pauses of Operator.

Order.	Cue for Starting Motions.	Motions.	Part of Body Used.	Posture.	Time Required.
1.					
2.					
3.					
etc.					

- (4) Proportion of Time Spent
 - (a) In Pauses
 - (b) Under Load or Pressure
- Occasional Motions and Pauses
- Regularity of Repetition of Motions (Rhythm)

C: Physical Working Conditions.

(Apart from those common to whole Department.)

D: Speed and Load of Work.

- (1) Maximum Physical Possible Output
- (2) Expected Standard Output
- (3) Usual Actual Output Average
- Deviation

E: Learning Period Required to reach—

D: (2) Expected Standard Output ... D: (3) Average Actual Output ...

F: Pay.

Methods and Rate of Pay
 Usual Earnings per Week Average Deviation
 per Year Average Deviation
 Chances of Promotion; Scale of Increased Wages

G: Specifications as to Type of Worker Required.

(See Questions in Employee File.)

Personal

Experience

Similar to any other Job in this Plant?

* Different forms planned on the same principle must be used for—

A.—Office Work and Administrative.

B.—Trades (i.e. Crafts) and work not of a routine nature.

† This human part may be classified as either to drive, steer, operate, feed, stock or tend. See pp. 63-4 above.)

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Form VII gives the scheme for analysing a single job of a repetitive nature. Where the work is not repetitive, modifications would have to be introduced.

The somewhat complicated Section B of the form is particularly important in assigning suitable work to particular types of applicant. Its aim is nothing less than to discover the *different physical and mental requirements of various kinds of work: the kind of call that the work makes upon the human organism*. The actual operations of industry, taken as a whole, are not measurable in common terms; they cannot be graded quantitatively in terms of intensity of activity. Yet if we analyse operations from the standpoint of the call they make, certain simple types will be found composed of elements that *can* be graded quantitatively. Lifting pig iron on to a truck, for instance, consists of a call on the muscles of the back and limbs determined primarily by the *weight* of the material that is moved, lifted or sustained, by the *distance* and *direction* through which it is moved, and by the *time* during which the worker is under load—all quantitatively measurable, and comparable to similar elements occurring in other occupations.

The first essential therefore is to be able to assign any given operation in the factory to a definite class with common characteristics like muscular body work, dexterous hand work or rhythmical machine operating—such classification being based on the psycho-physiological requirements made upon the worker.

I have given elsewhere a detailed method of analysing the type of work and the application of the method to all the detailed occupations of an American metal factory (18, pp. 145-53, and 28, pp. 260-4). As a result a classification of operations similar to that supplied in Table 2 (Chapter II) may be arrived at which will prove useful in indicating the general type of activity in which workers are called upon to engage. Within each type of work it has proved important to note the proportion of time spent in rests on the one hand, and under actual load on the other; and when the operation is frequently repeated, the regularity of such repetition should be measured by the average deviation with a view to determining the degree of rhythm.

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The difficulties involved in measuring speed and load of work (Section D in Form VII) and their possible solution have been enlarged upon elsewhere (28, pp. 264-5). Speed is determined in some operations by the revolutions per minute at which the machine is set, in other operations by the method of wage payment; but in every case a time-study may elucidate the maximum output physically possible and accurate records will give the actual output obtained. If the average actual output is recorded, the average deviation of individual records from this average should also be stated to indicate how far the average is truly representative.

The ratio between actual and possible output gives some indication of the intensity of work. The load of work is indicated by the weight of the materials handled or by the number of automatic machines to be watched and tended.

The specification as to type of worker required (Section G) is for the use of those responsible for hiring applicants. The employment department is not expected to be familiar with all the operations of the plant, and this section is designed to give them a lead in their selection of men. Thus the circle is completed and the record of industrial conditions ends where it began, with the scrutiny of the human factor.

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