

In connexion with this inquiry the committee visited various industrial centres, namely, Manchester, Glasgow, Stoke-on-Trent, Sheffield, and Swansea, and took evidence of manufacturers as well as of their victims. Moreover, two members of the committee—the chairman and Mr. E. D. Simon—visited some of the industrial centres of Germany, and a copy of their report is appended.

In the recommendations concerning industrial smoke the committee does not propose any new legislation, but to modify the existing law in the following respects:—That the Minister of Health should be given clearly-defined power to compel or act in place of any defaulting authority which refuses to perform its duty in administering the law with regard to smoke; that the general legal obligation on all manufacturers, users, and occupiers of any business premises or processes, engines or plant of any description whatever, should be to use the best practicable means, having regard to all the circumstances of the case, for avoiding the pollution of the air by smoke, grit, or any other noxious emission (questions of cost being taken into account in determining what is practicable). That the Minister of Health should be empowered to fix standards from time to time, and in any case in which the emission exceeds the standard so fixed the onus of proof that the manufacturer is using the best practicable means should lie with the manufacturer; that the duty of enforcing the law with regard to the pollution of the air by smoke should be transferred from the local sanitary authorities, in whose jurisdiction it now rests, to the county authorities, i.e., the councils of counties and county boroughs; minor authorities should still have power to take proceedings if they so desire; that the Minister of Health should be empowered to constitute joint committees consisting of two or more councils in cases where it appears to him that this course would lead to the better administration of the law with regard to smoke in a given area; that the Minister of Health should assign to one or more competent officers the duty of advising and assisting local authorities and manufacturers concerning difficult smoke problems; these officers should report annually on the steps which are being taken and the progress which has been made in the suppression of avoidable smoke; that the law should enable much larger fines to be imposed than at present; and, finally, that the existing statutory provisions should be consolidated in one measure.

In regard to noxious vapours it is recommended that the Alkali, etc. Works Regulation Act, 1906, should be amended so as to apply generally to all manufactures from which noxious vapours might come; that a list of such noxious vapours should be included in the Act and that the Minister of Health should be empowered to add to the list from time to time other noxious vapours after due inquiry; that a general obligation be placed on every manufacturer to use the best practicable means for preventing the escape of noxious or offensive vapours; that the present system of registration should be continued and the Minister of Health should be empowered to require the registration of classes of works not at present required to be registered; that the Minister of Health should be empowered to fix standards from time to time after due public inquiry, and that these standards should have the same legal force as those relating to smoke.

In the last page of the report the committee reviews the causes which have led to the present condition of atmospheric pollution and its statements may be briefly summarised as follows—It is mainly due to the indiscriminate and wasteful use of raw coal for all purposes, industrial and domestic, to widespread indifference or resignation to a condition of things which people believe to be unavoidable, or to a common delusion that smoke spells prosperity.

This attitude of indifference is reflected in the apathy of the great majority of local authorities throughout the country which have failed to do their duty. The committee regards the inaction of the central authority as the chief factor in the failure to deal with the smoke evil, and says that no Government has taken any action for many years except to appoint committees whose labours have led to little or no result.

It is to be hoped that the Minister of Health will act upon the present report, and that it will not be consigned to that silent bourne to which the reports of so many departmental committees find their way.

INDUSTRIAL FATIGUE IN CHEMICAL WORKS.

E. F. ARMSTRONG.

Scientific control in a works must include the study of the human factor, particularly the health and the safety of the worker. Carelessness on the part of the worker, which may often arise from fatigue, is the cause of most accidents, and the occurrence of an undue proportion in any section of the works should always be investigated from this point of view. Similarly health, apart from the incidence of epidemics or unfavourable climatic periods, also has some connexion with fatigue. Labour statistics should be kept in every works, and, if intelligently studied, afford much information concerning the conditions unfavourable to efficiency. The most useful statistics comprise: the number of employees classified according to sex and age (adults and juveniles under 18), and for each of these classes the number of hours per head per week—or month—of time lost due to (a) bad time-keeping, (b) sickness, (c) slackness of work; the hours per head of overtime worked; the number of accidents, recorded as severe or slight; the labour turnover, i.e., the number started each month expressed as a percentage of the number employed. Such figures are, of course, compiled departmentally, but it is sufficient to review them as a whole.

The term "Industrial Fatigue" has of late years been used in a special and restricted sense to denote some of the effects of repetition work in which certain operations involving a minimum number of muscular movements are repeated with maximum rapidity, such as occur especially under piece-work conditions. During the war there was a good deal of work in the performance of which the human being became very nearly the equivalent of a machine, and it was possible to study the effect on output of meal times, rest periods, shorter daily hours and other factors. Some attempt was then made to study these problems on scientific lines, at first by the Health of Munition Workers' Committee, and subsequently by the Industrial Fatigue Research Board, appointed in July, 1918. In the main the investigations have been confined to industries in which piecework is the rule and processes are regulated by machines. In the chemical industry repetition work is less common and the shift workers who manipulate the continuous processes must needs be men with a certain amount of intelligence, far removed from mere machines; even in the best-conducted processes variations due to raw materials, steam pressure, and a variety of known and unknown causes, are always likely to occur. In such cases common sense and experience are brought into action, and the knowledge of the foreman or "old hand" proves valuable.

In the ideal factory most of the process-men would be of superior education with a sufficient knowledge of the process and of chemistry and

physics to ensure yields and technical figures beyond our present attainment, though it must be confessed that the present younger generation makes up in carelessness and indifference for any superiority in learning it may possess over its fathers.

Much of the chemical process-work is classed as light work, though certain operations, such as furnace work, involve heavy physical effort. The current practice is to divide the day into three shifts of eight hours, the shifts being relieved at 6 a.m., 2 p.m., and 10 p.m. The shifts change about at the week-ends, two of them usually working an extra half-shift, whilst the third shift has the week-end off. The former practice of running twelve-hour shifts with a full twenty-four hours' work at the week-end passed away finally at the instance of the Chemical Trade Joint Industrial Council, and, it is hoped, will never return.

Experience has shown that change in the shift does much to break down any monotony in the work; the men profit to the full from the daylight periods when they are off work, and most of them keep allotments or have other outdoor hobbies. In works where careful statistics of sickness are kept, there is no evidence that the shift men are better or worse in health than the day men. The week's holiday with pay which has long been a custom in the chemical industry—generally coupled with some condition as to good time-keeping—is also a factor in promoting the health of the employees.

Industrial fatigue is also reduced by another factor, namely, that in the course of a period of years in an old-established works most of the jobs on a chemical plant become filled by men who are temperamentally fitted for the particular work, the less suitable either throwing up the work themselves or being weeded out by the management. The vagaries of the plant provide as much or as little excitement in the daily routine as the worker prefers, so that the feeling of monotony—due so often to un congenial employment—does not arise. Moreover, it is only under very abnormal conditions, such as prevailed during the latter stages of the war, that the plants are run at such intensity as to cause actual overstrain of the workers.

The avoidance of the effects of industrial fatigue in such cases where repetition work does occur, as, for example, in packing into small tins, is not very difficult if ordinary common sense, plus a little science, be used. Long hours or prolonged periods without a rest are to be avoided, and good lighting and ventilation are especially necessary when chemicals are handled. The time at which juveniles start work should not be so early as to prevent them from obtaining a proper breakfast. The rest periods of a few minutes, so frequently advocated, are of doubtful utility, as the worker will take them of his or her own accord if the need be felt. When a process involves more than one operation worked by a team, a change-round should be made periodically.

Work requiring greater care, *i.e.*, more use of the intelligence, cannot be done as piecework, but must be paid for as daywork, a reasonable standard of quality and output being required. In a well-managed works with a large number of employees, workers will be specially selected for this purpose, and they will be found usually to represent a slightly better class socially, and to have had a better education than the mass of the workers. Under these conditions carelessness, the outward expression of industrial fatigue, will occur but rarely. As a general rule, repetition work of all kinds is better performed by girls than by boys; the whole nature and outlook of the latter is essentially foreign to such work, which for them is largely to be regarded as a blind-alley occupation, once the lesson of discipline and co-ordinated movement to be learnt from it has been acquired.

It is perhaps desirable to emphasise that to-day, owing to the short hours of employment and the general disinclination of the worker to exert himself, genuine industrial fatigue is very rare. A noticeable effect of the reduced hours in industry has been the tendency to undertake a second job and to misuse the increased leisure period; on its introduction individual workers exhibited greater fatigue and kept worse time than before.

The chemical industry, like other industries, has its occupational diseases, but the precautions necessary to minimise the risk of these, and to alleviate their effect, are, generally speaking, well-understood and properly enforced.

THE MANUFACTURE OF TNT DURING THE WAR.*

T. M. LOWRY.

The manufacture of TNT by the Ministry of Munitions affords a fascinating illustration of the evolution of a typical laboratory preparation in organic chemistry into a fully-fledged manufacturing process, yielding in its final stages over 1000 tons per week of the finished product. This evolution hinged very largely on a detailed physico-chemical study of the processes of nitration and purification. Thus, whilst on a small scale trinitration may be carried through in one operation and the finished product separated in a solid form, this method is extremely wasteful as a manufacturing process, since the acid used for nitration must be able to absorb all the water set free in the various stages and yet at the end be strong enough to effect the complete trinitration of the compound. This can only be done by the use of oleum, and it was largely to avoid this that the two-stage process of nitration was worked out. Again, when nitration has been completed, the mere precipitation of the finished product by drastic dilution with water is a crude and wasteful operation which could not be maintained in large-scale manufacture.

The actual process adopted was an ingenious device of nitration in two (or even three) stages, a conspicuous feature being the use of the less nitrated material, both to extract the more highly nitrated products from the waste acids and to utilise in the most effective way the nitric acid which they contained. Thus, in the first stage, toluene, or Borneo petroleum containing toluene, was used to extract the nitric acid and any partially nitrated toluene from waste acids resulting from "mononitration," after diluting to about 25 per cent. of water and cooling to 30° C.; this operation, which gave a product containing about 50 per cent. of MNT (commonly referred to as " $\frac{1}{2}$ NT"), was regarded as essentially an extraction rather than a nitration. In the second stage the " $\frac{1}{2}$ NT" was nitrated to about " $\frac{1}{3}$ NT" at about 50° C., the actual nitration being carried beyond the stage of mononitration in order to relieve the final stage of trinitration from some of the dilution consequent upon the introduction of a second nitro-group. For this nominal "mononitration" of toluene, the waste acid from "trinitration" was used, after diluting somewhat to precipitate the TNT and adding more nitric acid, *e.g.*, by using dilute nitric acid instead of water to effect the precipitation of the TNT. The final trinitration is by far the most difficult operation; the " $\frac{1}{3}$ NT" resulting from

* Technical Records of Explosives Supply, 1915-1918. No. 2. Manufacture of Trinitrotoluene (TNT) and its Intermediate Products. Pp. 116. Ministry of Munitions and Department of Scientific and Industrial Research. (London: H.M. Stationery Office, 1920.) Price 17s. 6d. net.